

Short paper

Notes on powdery mildew of evergreen spindle *Euonymus japonicus* in Iran

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Abstract: Since the beginning of the 20th century, several scientific names have been used for the causal agent of powdery mildew on evergreen spindle *Euonymus japonicus*. The nomenclature of this powdery mildew is reviewed and using *Erysiphe euonymicola* as current name for the species is suggested. Information on the history of occurrence, natural host range and distribution of *E. japonicus* powdery mildew in Iran is provided. Morphological differences between *E. euonymicola* and *E. euonymi*, a powdery mildew on other species of *Euonymus* in Europe is discussed.

Keywords: Nomenclature, Erysiphales, Fungi

Introduction

Evergreen spindle, *Euonymus japonicus* L. f. (Celastraceae) is an ornamental shrub with diverse cultivars, cultivated in many countries across the world. This shrub is commonly infected by a powdery mildew species almost worldwide. Arcangeli (1900) described this fungus as *Oidium leucoconium* f. *euonymi-japonici* (not as variety as usually cited in literature), based on collections from Florence and Livorno. Since 1900, some mycologists have recorded its occurrence in other European countries. The first observation in England was made by Salmon (1905) under the name *Oidium euonymi-japonici* (Arcang.) Sacc. Since that time powdery mildew of evergreen spindle was usually referred to as *O. euonymi-japonici*, and this name was widely used in mycological and

phytopathological publications. The first observation of this powdery mildew in North America dates from September 1897, based on a specimen collected by Magnus in San Francisco (Viennot-Bourgin, 1966). Nearly all reports of the powdery mildew of evergreen spindle from the 20th century, as well as all specimens deposited in herbaria, refer to the asexual morph (anamorph), i.e., the sexual morph (telemorph) was missing. Generations of mycologists and phytopathologists have tried to discover the teleomorph (chasmothecia) of this fungus in nature, but failed. Hara (1921, 1922) assigned *Oidium leucoconium* var. *euonymi-japonici* to *Microsphaera* and *Uncinula*, respectively, but just based on the asexual morph. Viennot-Bourgin (1966) was the first mycologist who observed ascomata on evergreen spindle powdery mildew on specimens collected in France and former Yugoslavia. However, he published the name "*Microsphaera euonymi-japonici*" without Latin description (Viennot Bourgin, 1966) [= nom. inval., Art. 39.1 (Shenzhen Code)]. Later

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he validated this name (Viennot-Bourgin, 1968), which was widely used since then (e.g., Braun, 1987, 1995). *Microsphaera euonymi-japonici* was the accepted name for evergreen euonymus powdery mildew till Braun and Takamatsu (2000) considered the genus *Microsphaera* a synonym for *Erysiphe*, based on results of phylogenetic analyses, and proposed the combination “*Erysiphe euonymi-japonici* (Vienn.-Bourg.) U. Braun & S. Takam.” [since 2012 (Melbourne Code), *Microsphaera euonymi-japonici* Vienn.-Bourg., 1968, is an illegitimate name (homonym of *M. euonymi-japonici* (Arcang.) Hara, 1921), so that the former combination *Erysiphe euonymi-japonici* has to be treated as new name only ascribed to U. Braun and S. Takamatsu]. Braun and Cook (2012) discussed the nomenclature and taxonomy of evergreen spindle powdery mildew and concluded that the connection between *E. euonymi-japonici* and the common anamorph on evergreen euonymus has never been proven and that the ascomata described by Viennot-Bourgin (1968) do not pertain to *Oidium euonymi-japonici*. The sexual morph of *E. euonymi-japonici* has never been re-collected and its type specimen could not be traced and is probably not preserved. Therefore, Braun and Cook (2012) rejected this name and put it into a list of doubtful and excluded taxa. Finally, Braun (in Braun and Cook, 2012) introduced the new species *Erysiphe euonymicola* on the basis of new anamorph and teleomorph material collected on evergreen spindle in France as causal agent of powdery mildew on *E. japonicus* (Braun and Cook, 2012). The fruiting bodies found on *E. japonicus*, embedded in mycelial patches and associated with the anamorph of evergreen spindle powdery mildew, were morphologically very similar to chasmothecia of *Erysiphe alphitoides* (Griff. & Maubl.) U. Braun & S. Takam. and *E. quercicola* S. Takam. & U. Braun, which makes sense since evergreen spindle powdery mildew was phylogenetically very close to the latter two species, but distinct on species level (Limkaisan *et al.*, 2006; Takamatsu *et al.*, 2007).

Evergreen spindle is cultivated in Iran for nearly a century and infected by powdery mildew almost everywhere. An overview of reports of powdery mildew on evergreen spindle in Iran is given in Table 1. The first documented Iranian collection was reported 70 years ago as *Oidium euonymi-japonici*. In addition to this name, *Microsphaera euonymi-japonici* and *Erysiphe euonymi-japonici* have also been used to name the causal agent of evergreen spindle powdery mildew in Iran. Recently, the powdery mildews (Erysiphales) of Iran have been keyed out by Abbasi and Salahi Ardakani (2017). They considered *E. euonymicola* as current name for *E. japonicus* powdery mildew (see Table 1).

The fungal nomenclature has been significantly affected by the Melbourne Code (McNeill *et al.*, 2012). Therefore, a detailed discussion of the history and nomenclature of evergreen spindle powdery mildew is necessary in the context of a survey on host range and occurrence of this species in Iran. Using Iranian specimens, comparative morphology between *E. japonicus* powdery mildew and *Erysiphe euonymi* DC., common powdery mildew on other *Euonymus* species in Europe, is also provided.

Materials and Methods

Numerous herbarium specimens and recently collected material were used for this study. Morphological examination of the specimens was conducted using procedures described by Abbasi *et al.* (2019). Anamorphic and teleomorphic states were observed separately under BH2 Olympus light-microscope, using lactic acid in glycerol mounting medium (Abbasi, 2013). All photomicrographs taken by Dino-Eye Eyepiece Camera using DinoCapture 2.0 software (AnMo Electronics Corporation, Taiwan). In each accession, 30 chasmothecia, conidia, and conidiophores were measured. Studied materials have been deposited at IRAN (Iranian Research Institute of Plant Protection) herbarium.

Table 1 Overview on reports of *Euonymus japonicus* powdery mildew in Iran.

Published name	Locality	Reference
<i>Oidium euonymi-japonici</i>	Ramsar	Esfandiari, 1948
<i>Oidium euonymi-japonici</i>	Iran	Steyaert, 1953
<i>Oidium euonymi-japonici</i>	Northern Iran	Khabiri, 1956
<i>Oidium euonymi-japonici</i>	Tonekabon	Eskandari, 1964
<i>Microsphaera euonymi-japonici</i>	Tehran, Karaj	Nader-Nejad, 1966
<i>Oidium euonymi-japonici</i>	Iran	Scharif and Ershad, 1966
<i>Oidium euonymi-japonici</i>	Esfahan	Daftari and Behdad, 1968
<i>Microsphaera euonymi-japonici</i>	Lahijan	Viennot-Bourgin <i>et al.</i> , 1969
<i>Oidium euonymi-japonici</i>	Tehran, Karaj	Mohammadi-Doustdar, 1969*
<i>Microsphaera euonymi-japonici</i>	Iran	Ershad, 1971
<i>Microsphaera euonymi-japonici</i>	Iran	Amano, 1986
<i>Oidium euonymi-japonici</i>	Iran	Amano, 1986
<i>Oidium euonymi-japonici</i>	Iran	Behdad, 1988
<i>Erysiphe euonymi-japonici</i>	Yazd	Samadi <i>et al.</i> , 2010
<i>Erysiphe euonymicola</i>	Iran	Abbasi and Salahi Ardakani, 2017

*The host mentioned as *Buxus sempervirens*.

Results and Discussion

The nomenclature of the powdery mildew on *E. japonicus* is extremely complicated and has changed based on the Melbourne Code. In any case, the correct name for this fungus is *E. euonymicola* described by Braun in Braun and Cook (2012). Its synonymy can be summarized as follows:

Erysiphe euonymicola U. Braun, in Braun & Cook, Taxonomic Manual of the Erysiphales (Powdery Mildews): 461, 2012.

= *Oidium leucoconium* f. *euonymi-japonici* Arcang. (as "*Evonymi japonici*"), Atti Soc. Tosc. Sci. Nat. Pisa, Processi Verballi 12: 109, ["1899-1901"] 1900 [non *Erysiphe euonymi-japonici* U. Braun & S. Takam., 2000].

≡ *O. euonymi-japonici* (Arcang.) Sacc., in Salmon, Ann. Mycol. 3: 1, 1905 [and Sacc., Syll. Fung. 18: 506, 1906, isonym].

≡ *Acrosporium euonymi-japonici* (Arcang.) Sumst., Mycologia 5(2): 58, 1913 [as "(E. S. Salmon) Sumst."].

≡ *Microsphaera euonymi-japonici* (Arcang.) Hara, J. Agric. Soc. Shizuoka Pref. 282: 29, 1921 [Herter, Estad. Bot. Reg. Urug., Florula

Uruguayensis, Plantas Avasculares: 33, 1933, isonym].

≡ *Uncinula euonymi-japonici* (Arcang.) Hara, Dendropathology [Jubyo-gaku Kakuron]: 22, 1922.

≡ *Pseudoidium euonymi-japonici* (Arcang.) U. Braun & R. T. A. Cook, Taxonomic Manual of the Erysiphales (Powdery Mildews): 461, 2012.

Misapplied name: *Microsphaera euonymi-japonici* Viennot-Bourgin, Bull. Trimestrielle Soc. Mycol. France 84(1): 118, 1968, nom. illeg. (ICN, Art. 53.1), non *Microsphaera euonymi-japonici* (Arcang.) Hara, 1923.

≡ *Erysiphe euonymi-japonici* U. Braun & S. Takam. [as (Viennot-Bourgin) U. Braun & S. Takam.], Schlechtendalia 4: 8, 2000 (Art. 58.1).

Notes: *Oidium leucoconium* f. *euonymi-japonici* (≡ *Oidium euonymi-japonici*) is, indeed, the oldest name for this fungus, but is not available any longer since blocked by the name *Erysiphe euonymi-japonici* U. Braun & S. Takam. [cited as combination but, according to the ICN (Art. 58.1), a new name (nom. nov.) based on *Microsphaera euonymi-japonici* Viennot-Bourgin which is an

illegitimate name (homonym of *M. euonymi-japonici* (Arcang.) Hara]. The name *Erysiphe euonymi-japonici* U. Braun & S. Takam. is also not available for this fungus since based on Viennot-Bourgin's name, which was based on chasmothecia not belonging to *Oidium leucoconium* f. *euonymi-japonici* (see Braun and Cook, 2012). The connection between the teleomorph described by Viennot-Bourgin (1968) and the common anamorph on *E. japonicus* has never been proven, and chasmothecia agreeing with Viennot-Bourgin's description have never been re-collected. Moreover, type material could not be traced and is probably missing. Braun (in Braun and Cook, 2012) has examined genuine chasmothecia associated with this powdery mildew and described it as *E. euonymicola*.

Morphological features (based on Iranian collections):

Only asexual morph (*Pseudoidium* type) present. Mycelium on leaves, amphigenous, forming patches, persistent, white, later greyish; hyphal appressoria lobed. Conidiophores 36-50 μm long, foot-cells straight or curved, 16-40 \times 5-6 μm , followed by mostly one or sometimes two cells of the same length, as the foot-cells, or shorter. Conidia formed singly, ellipsoid-cylindrical, 24-38 \times 8-14 μm , length/width ratio 1.8-3.3. Germ tubes mostly perihilar showing longitubus pattern. Conidial appressoria moderately lobed (Fig. 1).

Material examined

On *Euonymus japonicus*, Yazd (IRAN 15755, 14557, 14558, 14559, 13801, 13799, 14067, 13802); Esfahan (IRAN 15758); Fars (IRAN 17105); Kerman (IRAN 15757); Lorestan (IRAN 14372); Alborz (IRAN 17106); Golestan (IRAN 2683); Mazandaran (IRAN 2682).

On *Euonymus japonicus* 'Macrophyllus', Tehran (IRAN 17109).

On *Euonymus japonicus* 'Microphyllus', Yazd (IRAN 13800); Alborz (IRAN 17107).

On *Euonymus japonicus* 'Aureo Marginata', Alborz (IRAN 17108).

F. Petrak Mycotheca generalis No. 681 as *Oidium evonymi-japonici*, on *Euonymus japonicus* (IRAN).

Comparative morphology

We compared Iranian specimens of *E. euonymicola* with an exsiccate (F. Petrak Mycotheca generalis No. 669) of *E. euonymi*. Our comparison showed that conidia in *E. euonymi* were slightly wider than those of *E. euonymicola* (13-15 μm vs 8-14 μm). Chasmothecia were common in *E. euonymi*, mostly hypophyllous, abundant, partly immersed in mycelium layer. These structures were not present at any studied Iranian material of *E. euonymicola*. Finally, the infection pattern of the two powdery mildews was different. Mycelium in *E. euonymicola* showed patches on both sides of the leaves. However, in *E. euonymi* mycelium was mostly hypophyllous, effuse, scattered on the entire surface of the leaf (Fig. 1).

Comparison between *E. euonymicola* and *E. euonymi* based on morphological comparison in this study and information provided by Braun and Cook (2012) is summarized in table 2.

Host range of *E. euonymicola* in Iran:

The following cultivars of *E. japonicus* have been observed as host of *E. euonymicola* in Iran:

Euonymus japonicus 'Macrophyllus', *E. japonicus* 'Microphyllus', *E. japonicus* 'Aureo Marginata'.

Doubtful reports

Alikarami *et al.* (2014) reported *Oidium yenii* as causal agent of powdery mildew on *Buxus sempervirens* L., from Lorestan. The report seems to be incorrect and the host was probably *E. japonicus* 'Microphyllus' infected by *E. euonymicola*. Mohammadi-Doustdar (1969) also reported *E. euonymicola* (as *Oidium euonymi-japonici*) on *B. sempervirens* from Tehran and Karaj. These are undoubtedly additional misidentifications of the host plants, which were very probably *E. japonicus* 'Microphyllus'.

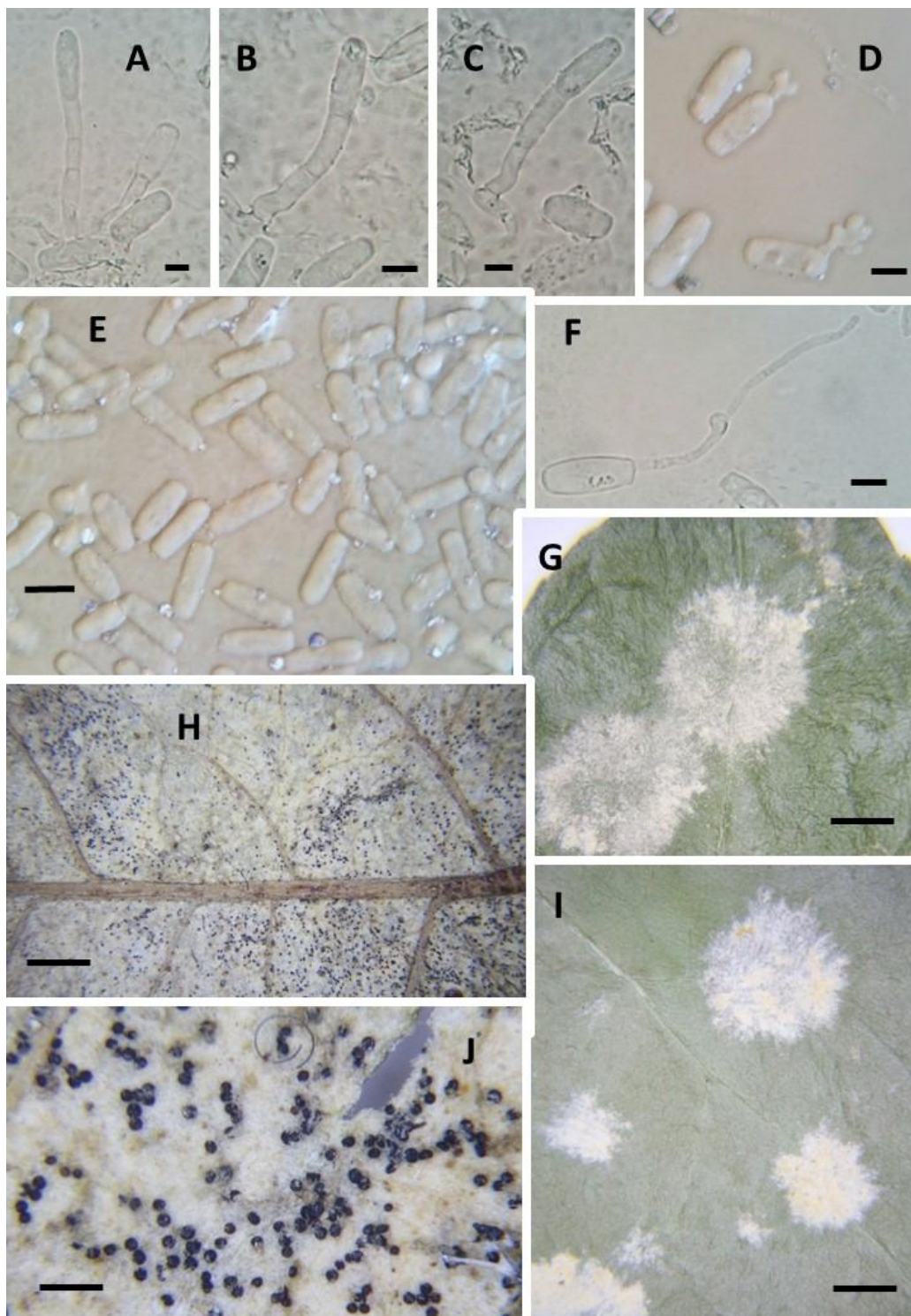


Figure 1 *Erysiphe euonymicola* [based on IRAN 17108], A, B, C. conidiophore bearing a conidium (Bar = 10 μ m), D. germinating conidia with lobed appressoria, F. germinating conidium showing longitubus pattern (Bar = 10 μ m), E. conidia (Bar = 20 μ m), G, I. patchy infection pattern (Bar = 3 mm); *Erysiphe euonymi* [based on Petrak, Mycoth. Gen 669, IRAN], H. infection pattern (Bar = 2 mm), J. chasmothecia (Bar = 0.5 mm)

Table 2 Comparison of *Erysiphe euonymi* with *E. euonymicola*.

Criteria	<i>Erysiphe euonymi</i>	<i>Erysiphe euonymicola</i>	Reference
Foot cell	Straight to mostly curved-sinuous, 20-30 x 6-8 µm, followed by 1-2 cells	Straight to moderately flexuous-sinuous (10-)20-30(-50) x 5-8.5 µm, followed by 1-2(-3) cells	Braun and Cook (2012), current study
conidia	Ellipsoid-cylindrical, oblong, 28-40 x 10-18 µm	Ellipsoid-cylindrical, (20-)25-40(-45) x (9-)12-18(-20) µm	Braun and Cook (2012), current study
Germ tube	Not mentioned	Terminal or subterminal, also showing longitubus pattern	Braun and Cook (2012), current study
host	<i>Euonymus atropurpureus</i> , <i>E. europaeus</i> , <i>E. latifolius</i> , <i>E. verrucosus</i>	<i>Euonymus fortunei</i> , <i>E. japonicus</i>	Braun and Cook (2012)
Infection pattern	Amphigenous, effuse or in patches	Amphigenous, usually forming patches	Braun and Cook (2012), current study
chasmothecium	Mainly hypophyllous, 80-115 µm diam., appendages 5-20, 2-7 times as long as the chasmothecial diam.	Mainly epiphyllous, 70-100 µm diam., appendages 4-8, 1-1.3 times as long as chasmothecial diam., usually occurs as anamorph	Braun and Cook (2012), current study

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گزارشی در مورد سفیدک شمشاد ژاپنی *Euonymus japonicus* در ایرانمهرداد عباسی^{۱*} و اووه براون^۲

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چکیده: از ابتدای قرن بیستم تاکنون نام‌های علمی متعددی برای عامل سفیدک پودری شمشاد ژاپنی *Euonymus japonicus* در منابع علمی به کار برده شده است. در گزارش حاضر نام‌گذاری این سفیدک پودری براساس آخرین ویرایش کد نام‌گذاری جلبک‌ها، قارچ‌ها و گیاهان برای اولین بار بررسی و مرور می‌شود. براساس این تحقیق و به دنبال مطابقت با آخرین تغییرات مقررات نام‌گذاری قارچ‌ها ضمن فهرست نمودن کلیه نام‌های به کار برده شده برای این گونه قارچی، نام *Erysiphe euonymicola* به عنوان نام رایج برای سفیدک پودری مذکور پیشنهاد می‌شود. علت عدم به کارگیری سایر نام‌های موجود برای این گونه براساس مواد قانونی کد نام‌گذاری بحث می‌شود. همچنین اطلاعاتی در زمینه تاریخچه وقوع سفیدک پودری شمشاد ژاپنی، دامنه میزبانی و پراکنش آن در ایران ارائه می‌شود. با توجه به حضور گونه‌های دیگر شمشاد در ایران و احتمال وقوع گونه اروپایی عامل سفیدک پودری شمشاد *Erysiphe euonymi* در ایران، ویژگی‌های ریخت‌شناسی *E. euonymicola* با گونه *E. euonymi* مقایسه و نحوه افتراق این دو گونه از یکدیگر ارائه می‌شود.

واژگان کلیدی: نام‌گذاری، Erysiphales، قارچ‌ها