

**Additions to the powdery mildew fungi of Iran**

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**Abstract**

*Neoerysiphe nevoi* on *Crepis kotschyana* and *Hedypnois rhagadioloides*, *Leveillula linariae* on *Linaria melanogramma* and *Golovinomyces asterum* var. *moroczkovskii* on *Symphotrichum squamatum* are newly reported from Iran. Nine new host-powdery mildew combinations are reported from Iran: *Neoerysiphe galii* – *Galium aparine*; *Podosphaera xanthii* – *Phlox paniculata*; *Erysiphe syringae-japonicae* – *Ligustrum* sp.; *Erysiphe cruciferarum* – *Barbarea* sp.; *Golovinomyces depressus* – *Centaurea depressa*; *Golovinomyces montagnei* – *Notobasis syriaca*; *Golovinomyces orontii* – *Papaver somniferum*; *Golovinomyces cynoglossi* – *Lithospermum arvense*; *Leveillula picridis* – *Launaea acanthodes*. The following host plants are reported as *Matrix nova* for their related fungal species: *Crepis kotschyana* and *Hedypnois rhagadioloides* for *Neoerysiphe nevoi*; *Phlomis herba-venti* subsp. *kopetdaghensis* for *Neoerysiphe galeopsidis*; *Euphorbia hebecarpa* and *Papaver macrostomum* for *Leveillula taurica* s.str.; *Paracaryum rugulosum* for *Golovinomyces cynoglossi*; *Euphorbia tithymaloides* for *Podosphaera euphorbiae*; *Iranecio paucilobus* for *Leveillula lappae*.

**Keywords:** Biodiversity, *Erysiphales*, fungi, mycobiota, taxonomy

**اطلاعات جدید در مورد سفیدک‌های پودری ایران**

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**خلاصه**

گونه‌های سفیدک پودری *Neoerysiphe nevoi* روی گیاهان میزبان *Crepis kotschyana* و *Hedypnois rhagadioloides* و *Leveillula linariae* روی *Linaria melanogramma* و *Golovinomyces asterum* var. *moroczkovskii* روی *Symphotrichum squamatum* به عنوان اعضای جدید برای میکوبیوتای ایران گزارش می‌گردند. نه ترکیب میزبان-سفیدک پودری به شرح زیر برای ایران تازه‌گی دارند:

*Neoerysiphe galii* – *Galium aparine*; *Podosphaera xanthii* – *Phlox paniculata*; *Erysiphe syringae-japonicae* – *Ligustrum* sp.; *Erysiphe cruciferarum* – *Barbarea* sp.; *Golovinomyces depressus* – *Centaurea depressa*; *Golovinomyces montagnei* – *Notobasis syriaca*; *Golovinomyces orontii* – *Papaver somniferum*; *Golovinomyces cynoglossi* – *Lithospermum arvense*; *Leveillula picridis* – *Launaea acanthodes* همچنین، گیاهان میزبان *Crepis kotschyana* و *Hedypnois rhagadioloides* برای *Neoerysiphe nevoi*؛ *Phlomis herba-venti* subsp. *kopetdaghensis* برای *Neoerysiphe galeopsidis*؛ *Euphorbia hebecarpa* و *Papaver macrostomum* برای *Leveillula taurica* s.str.؛ *Paracaryum rugulosum* برای *Golovinomyces cynoglossi*؛ *Euphorbia tithymaloides* برای *Podosphaera euphorbiae* و *Iranecio paucilobus* برای *Leveillula lappae* به عنوان میزبانان جدید (*Matrix nova*) معرفی می‌شوند.

**واژه‌های کلیدی:** تاکسونومی، تنوع زیستی، قارچ‌ها، میکوبیوتا، *Erysiphales*

## Introduction

There has been serious attention to the taxonomy of powdery mildews (*Erysiphales*) in recent decades. Publishing two world monographs (Braun 1987, Braun & Cook 2012), several regional checklists and monographs (e.g. Braun 1995) and many papers dealing with taxonomic aspects of this group showing their importance from mycological and plant pathological points of views.

The starting point of taxonomy of *Erysiphales* in Iran is based on specimens collected by Haussknecht during his couple of visits from Persia (Greater Iran) dated 1864–68. These specimens studied and published by Rabenhorst (1871). Since then, several authors studied powdery mildews in Iran and published miscellaneous publications about this group of biotrophic fungi. In order to get an overview of powdery mildews of Iran all these publications from the beginning till 2009 were critically studied and Fungus-Host checklist including 95 fungus species on 528 host species was provided (Khodaparast & Abbasi 2009). Since the last checklist of Iranian powdery mildews, the research on this group of fungi has been continued through the last ten years. Overview of these studies including newly recorded species to the powdery mildew mycobiota of Iran has been summarized in table 1. In the current paper, three new taxa are reported for Iranian *Erysiphales* mycobiota. Moreover, we report eight new host

records of powdery mildews in the world and nine new host records of the powdery mildews in Iran.

## Materials and Methods

Morphological examination of the specimens was conducted using procedures described by Meeboon *et al.* (2016) with minor changes. To examine anamorphic state of the specimens, powdery mildew mycelia including conidiophores and conidia were stripped off from the leaf surfaces with clear adhesive tape, mounted on a microscope slide, and examined in lactic acid in glycerol mounting medium (Abbasi 2013). Chasmothecia were also stripped off from the leaf surfaces with a clean needle, mounted on a microscope slide, and examined in the same mounting medium (i.e. lactic acid in glycerol). After boiling, the rehydrated fungal structures examined using a standard light microscope (BH2 Olympus compound microscope) and 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. Concerning identification of powdery mildews, species concept and taxonomy *sensu* Braun & Cook (2012) were followed. Studied materials have been deposited at IRAN (Iranian Research Institute of Plant Protection), and GUM (University of Guilan) herbaria.

**Table 1.** Additions to the Khodaparast & Abbasi (2009) checklist of powdery mildews (obtained from literature records)

Taxa	Host	Reference
<i>Blumeria graminis</i>	<i>Aegilops cylindrica</i> , <i>Agropyrum pertenuae</i> , <i>A. podperae</i> , <i>Avena barbata</i> , <i>Bromus</i> <i>rechingeri</i> , <i>B. scoparius</i> , <i>B. tectorum</i> , <i>B. tomentellus</i> , <i>Eremopoa persica</i> , <i>Heteranthelium piliferum</i> , <i>Hordeum</i> <i>violaceum</i> , <i>Lolium multiflorum</i> , <i>L. rigidum</i>	Sepahvand & Mohammadian 2013
<i>Erysiphe australiana</i>	<i>Lagerstroemia indica</i>	Sharifi <i>et al.</i> 2013
<i>E. betae</i>	<i>Dysphania ambrosioides</i>	Sharifi <i>et al.</i> 2013
<i>E. heraclei</i>	<i>Petroselinum hortense</i>	Sharifi <i>et al.</i> 2013
<i>E. malvae</i>	<i>Malva</i> sp.	Khodaparast <i>et al.</i> 2010
<i>E. quercicola</i>	<i>Quercus</i> sp.	Khodaparast <i>et al.</i> 2010
<i>E. rayssiae</i>	<i>Spartium junceum</i>	Sharifi <i>et al.</i> 2014
<i>E. robiniae</i> var. <i>robiniae</i>	<i>Robinia pseudoacacia</i>	Sharifi <i>et al.</i> 2014
<i>E. syringae-japonicae</i>	<i>Jasminum</i> sp.	Pirnia 2014, Sharifi <i>et al.</i> 2014
<i>E. ulmi</i> var. <i>ulmi-foliaceae</i>	<i>Ulmus carpinifolia</i>	Arzanlou & Torbati 2016
<i>Euoidium</i> cf. <i>agerati</i>	<i>Ageratum houstonianum</i>	Sharifi <i>et al.</i> 2014
<i>Golovinomyces ambrosiae</i>	<i>Dahlia</i> sp., <i>Zinnia</i> sp.	Sharifi <i>et al.</i> 2013
<i>G. ambrosiae</i>	<i>Helianthus</i> spp.	Khodaparast <i>et al.</i> 2010
<i>G. cf. orontii</i>	<i>Fraxinus</i> sp.	Sharifi <i>et al.</i> 2013
<i>G. cichoracearum</i>	<i>Symphyotrichum subulatum</i> var. <i>squamatum</i>	Mirhosseini <i>et al.</i> 2015
<i>G. cynoglossi</i>	<i>Symphytum asperum</i>	Khodaparast <i>et al.</i> 2010
<i>G. cynoglossi</i>	<i>Myosotis palustris</i>	Sepahvand <i>et al.</i> 2018
<i>G. fischeri</i>	<i>Senecio glaucus</i>	Khodaparast <i>et al.</i> 2010
<i>G. montagnei</i>	<i>Cirsium arvense</i>	Sharifi <i>et al.</i> 2014
<i>G. orontii</i>	<i>Antirrhinum majus</i>	Sharifi <i>et al.</i> 2014
<i>Golovinomyces</i> sp.	<i>Zinnia elegans</i>	Arzanlou <i>et al.</i> 2018
<i>Leveillula braunii</i>	<i>Eryngium noeanum</i>	Sepahvand <i>et al.</i> 2018
<i>L. lanata</i>	<i>Euphorbia virgata</i>	Sepahvand <i>et al.</i> 2018
<i>L. jaczewskii</i>	<i>Dodartia orientalis</i>	Khodaparast <i>et al.</i> 2016
<i>L. duriaei</i>	<i>Salvia multicaulis</i> , <i>Teucrium orientale</i>	Sepahvand <i>et al.</i> 2018
<i>L. taurica</i>	<i>Daphne mucronata</i>	Khodaparast <i>et al.</i> 2010
<i>L. taurica</i>	<i>Achillea tenuifolia</i> , <i>Dianthus macranthoides</i> , <i>Scariola orientalis</i> , <i>Serratula cerinthifolia</i> , <i>Silene caesarea</i> , <i>S. cholorifolia</i>	Sepahvand <i>et al.</i> 2018
<i>Leveillula</i> sp.	<i>Tropaeolum majus</i>	Khodaparast <i>et al.</i> 2016
<i>Leveillula</i> sp.	<i>Ficus carica</i>	Khodaparast <i>et al.</i> 2016
<i>Leveillula</i> sp.	<i>Cucurbita</i> sp.	Khodaparast <i>et al.</i> 2016
<i>Podosphaera clandestina</i>	<i>Prunus cerasus</i>	Arzanlou <i>et al.</i> 2017
<i>P. dipsacacearum</i>	<i>Pterocephalus plumosus</i>	Sepahvand <i>et al.</i> 2018
<i>P. euphorbiae-hirtae</i>	<i>Pedilantus</i> sp.	Sharifi <i>et al.</i> 2013
<i>P. leucotricha</i>	<i>Photinia serrutata</i>	Khodaparast <i>et al.</i> 2010
<i>P. xanthii</i>	<i>Dichrocephala integrifolia</i> , <i>Gerbera</i> sp., <i>Physalis alkekengi</i> , <i>Vigna unguiculata</i>	Sharifi <i>et al.</i> 2013

## Results and Discussion

- Enumeration of taxa

*Neoerysiphe galii* (S. Blumer) U. Braun

On *Galium aparine* L. (*Rubiaceae*), Fars province, 30 km of Estahbanat, Morghak pass, leg. M. Moussavi and F. Termeh (IRAN 37521).

As mentioned by Braun & Cook (2012), above plant species is the main host for *N. galii*. However, the plant occasionally also infected by *Golovinomyces riedlianus*. Due to observing chasmothecia with no developed asci and ascospores, we identified above specimens as *N. galii*. This is the first report of this powdery mildew species on *G. aparine* in Iran.

*Neoerysiphe nevoi* V.P. Heluta & S. Takam.

On *Crepis kotschyana* (Boiss.) Boiss. (*Asteraceae*), Fars province, Bamu National Park, Zarghan gate, 5 May 2006, leg. E. Ghasemi (10-19) (GUM1569); On *Hedypnois rhagadioloides* (L.) F.W. Schmidt (*Asteraceae*), Fars province, Kazerun, mountain besides Shahranjan village, leg. E. Ghasemi (15-18) (GUM1570).

Above powdery mildew species is a new member for Iranian mycobiota. Foot cell straight 44–50  $\mu\text{m}$ , conidia in chain, cylindrical, cylindrical-ellipsoidal to vase-like, 22.5–32.5  $\times$  13.5–17.5  $\mu\text{m}$ , germ tubes almost terminal, short, ending in a lobed appressorium. Chasmothecia scattered or in large groups, depressed in the lower part, 110–153  $\mu\text{m}$  in diam., with a distinctly meshed peridial surface. Appendages in the basal part of chasmothecia, mycelioid, hyaline to brownish, mainly numerous (Fig. 1). Asci immature in the current season. To our knowledge, the only powdery mildew species reported on *H. rhagadioloides* is *Golovinomyces cichoracearum*, reported from Italy and Jordan as *Erysiphe cichoracearum* by Amano (1986). We haven't seen any record of *Neoerysiphe* on *C. kotschyana* as well. It seems, *H. rhagadioloides* and *C. kotschyana* (both from *Cichoreae*) are new hosts (*Matrix nova*) for *N. nevoi*.

*Neoerysiphe galeopsidis* (DC.) U. Braun

On *Phlomis herba-venti* subsp. *kopetdaghensis* (Knorring) Rech.f., (*Lamiaceae*), Golestan province, Golestan National Park, Almeh, 1750 m, 19 Jul. 1991, leg. M. Abbasi & J. Fatehi (79-19) (IRAN 76752)

Mycelium mostly epiphyllous, covering the entire surface of the leaves; conidiophores up to 175  $\mu\text{m}$  long, producing conidia in short chains; conidia mostly doliiform, cylindrical doliiform or ellipsoid-ovoid, 25–37.5  $\times$  11.5–16.5  $\mu\text{m}$ ; chasmothecia mostly gregarious, 120–165  $\mu\text{m}$  diam.; asci were not present. To our knowledge, this is the first report of above powdery mildew on *P. herba-venti* subsp. *kopetdaghensis*.

*Erysiphe syringae-japonicae* (U. Braun) U. Braun & S. Takam.

On *Ligustrum* sp. (*Oleaceae*), Yazd province, Yazd, Azad university campus, 22 Dec. 2010, leg. Moshtaghiyoon (IRAN 15754F).

Only anamorph present. Mycelium mostly persistent on the upper surface of the leaves; conidiophores up to 55  $\mu\text{m}$  long, foot cells cylindrical, straight to curved mostly 20  $\times$  6.5–7.5  $\mu\text{m}$ , followed by two cells shorter or about as long as foot cell, sometimes by a single cell of about the same length of foot cell; conidia formed singly, ellipsoid-ovoid or cylindrical 26.5–42  $\times$  11–15  $\mu\text{m}$ , germ tubes terminal, short or showing longitubus pattern, conidial appressoria simple or lobed.

*Erysiphe syringae-japonicae* has been previously reported from Iran on *Syringa* (Braun & Cooke 2012, Abbasi & Salahi Ardekani 2017). However, this is the first report on *Ligustrum*. Infection pattern of above specimen is similar to *E. ligustri*, mostly persistent on adaxial, but other features convinced us to name it as *E. syringae-japonicae*.

***Erysiphe sesbaniae*** Wolcan & U. Braun

On *Sesbania punicea* (Cav.) Benth. (*Fabaceae*), Mazandaran province, Mahmud-Abad, 5 Jun. 1999, leg. D. Ershad (IRAN 10868F).

This species has been previously reported from Iran, Gilan province (Abbasi 2013, Abbasi & Salah Ardakani 2017). However, this is the first report from Mazandaran province. The fungus has straight to curved foot cells, 32–40 µm long, followed by 1–2 shorter cells. Primary (ellipsoid-ovoid) and secondary (narrowly cylindrical) conidia were present. Germ tubes were mainly terminal, short or showing longitubus pattern with septum. Probably this is the first report of conidial germination type of *E. sesbaniae*.

***Erysiphe cruciferarum*** Opiz ex L. Junell

On *Barbarea* sp. (*Brassicaceae*), Fars province, Sepidan, Cheleh-Gaah, 20 Aug. 2006, leg. E. Ghasemi (49-18) (GUM1571).

This is the first report of *E. cruciferarum* on *Barbarea* sp., from Iran. Conidiophores were mostly flexuous, sometimes straight, bearing conidia singly. Conidia (25–41.5 × 10–16.5 µm) were cylindrical, oblong-cylindrical or ellipsoid-doliiform. Flexuous character of conidiophores is missing on description provided by Braun & Cook (2012). However, this feature has been mentioned by Abasova *et al.* (2018).

***Erysiphe multappendicis*** (Z.Y. Zhao & Y.N. Yu) U. Braun & S. Takam.

On *Berberis* sp. (*Berberidaceae*), North Khorasan province, Shirvan, Namanlu, Gololsarani, Zoghaplan mount, 2100 m, 12 Sept. 1994, leg. Abbasi *et al.* (IRAN 10545F).

Chasmothecia scattered on both sides of infected leaves, 96–130 µm diam.; appendages 14–17, equatorial 1–2 times as long as the chasmothecial diameter, wall rough, sometimes brown in basal part, up to 3 µm thick below, thin above, rather loosely dichotomously at apex, at least some of mature tips recurved (Fig. 3 F & G). This specimen originally

identified as *Microsphaera berberidis* var. *berberidis*. However, having rather thick-walled stiff appendages with some recurved mature tips convinced us to name it as *E. multappendicis* which has been previously reported from Gilan and Ardebil on *Berberis* spp. (Khodaparast & Abbasi 2009). We have also studied other specimens at IRAN herbarium under the name *Erysiphe (Microsphaera) berberidis* viz. IRAN 2551, 2552 and 11282. All had chasmothecia with thick-walled, more or less stiff appendages with mature tips at least partly recurved. We would also consider all these specimens as *E. multappendicis*. This finding put question mark on occurrence of *E. berberidis* in Iran.

***Leveillula taurica*** (Lév.) G. Arnaud, *sensu* Braun and Cook (2012)

On *Diarthron vesiculosum* (Fisch. & C.A.Mey. ex Kar. & Kir.) C.A.Mey. (*Thymelaeaceae*), Hamedan province, Toyserkan, walnut orchard, 20 Oct. 2018, leg. A. Falatoury (48-18) (GUM1576).

Primary and secondary conidia were present showing typical features of *L. taurica* s.str. There is only one report of *Leveillula* on this host as *L. thymelaeacearum* Golovin from Kerman (Ershad 1995). However, the host-powdery mildew combination is reported here from Hamedan province.

On *Euphorbia hebecarpa* Boiss. (*Euphorbiaceae*), Chaharmahal and Bakhtiari province, Kuhrang, Bazoft District, 17 Aug. 2008, leg. A. Khodaparast (50-18) (GUM1572).

Braun & Cook (2012) keyed out five *Leveillula* species on *Euphorbiaceae*. Above specimen showing lanceolate primary conidia (59–69 × 14–18 µm, l/w ratio 4) and cylindrical or clavate secondary conidia (55–60 × 10–16 µm) with widest part usually in the upper half (Fig. 2). We would keep this specimen under *L. taurica*. Braun & Cook (2012) did not mention *Euphorbia* species among host range of *L. taurica* s.str. To our knowledge, this is the first report of *L. taurica* on *E. hebecarpa* (*Matrix nova*).

On *Papaver macrostomum* Boiss. & A. Huet (*Papaveraceae*), Fars province, Sepidan road, Dehpagah, 14 Jul. 2006, leg. E. Ghasemi (60-18) (GUM1573).

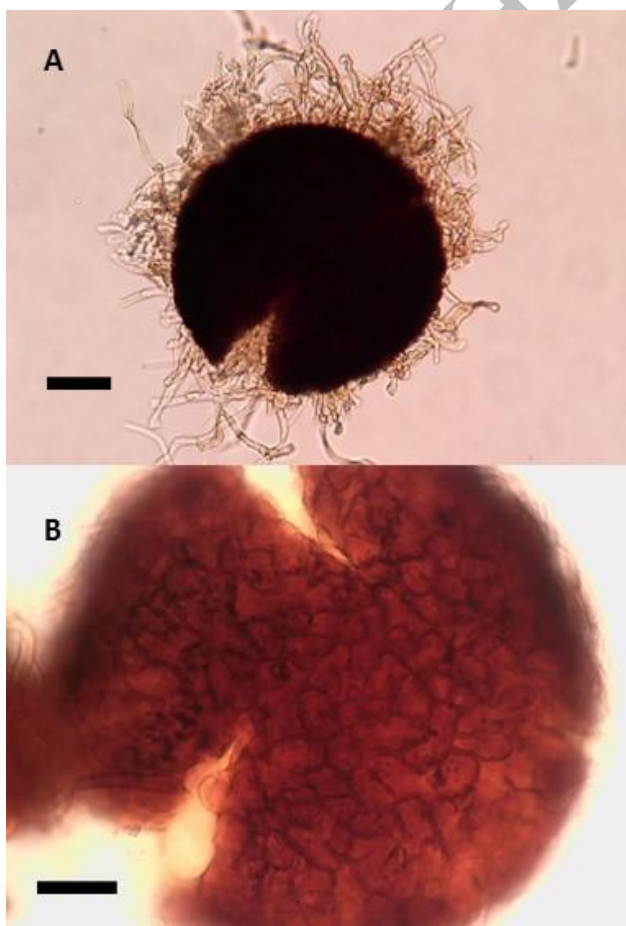
Lanceolate primary conidia ( $60\text{--}70 \times 14\text{--}18.75 \mu\text{m}$ , l/w ratio 3.6–5) and cylindrical or clavate secondary conidia ( $47.5\text{--}72.5 \times 16\text{--}17.5 \mu\text{m}$ ) fit well Braun & Cook (2012) description for *L. taurica* s. str. To our knowledge, above host is also new for *L. taurica* (*Matrix nova*).

***Leveillula linariae*** (Jacz.) U. Braun

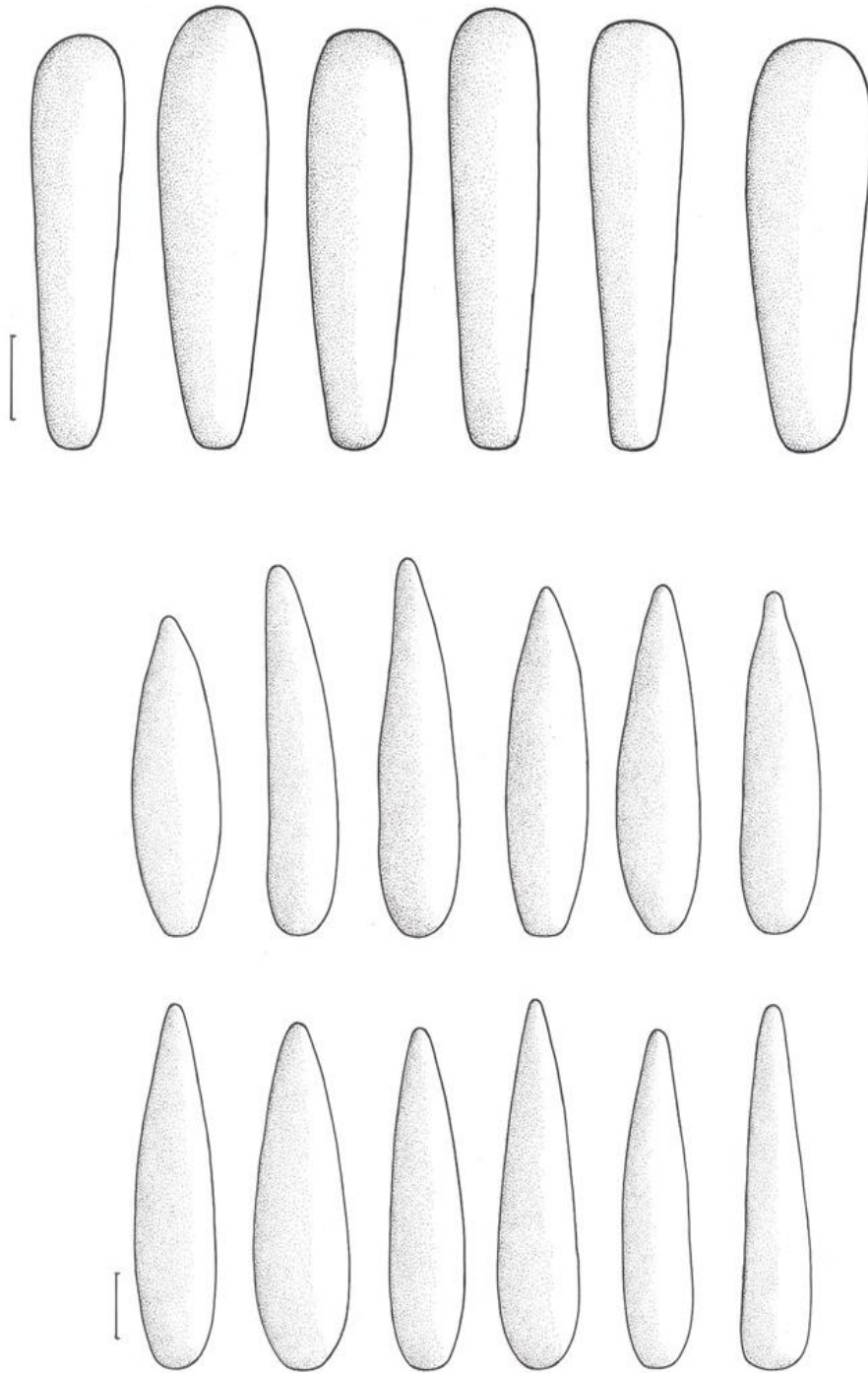
On *Linaria melanogramma* Rech.f., Aellen & Esfand. (*Scrophulariaceae*), Khorassan Razavi province, Torbat-e Heidarieh towards Mashhad, Kadkan, Sefid-darreh mount, 21 Sept. 1990, leg. Termeh *et al.* (IRAN 40961).

Above taxon is another new record for Iranian mycobiota. Dense, greyish patches of mycelium were mostly present on stems. Primary conidia ( $47.5\text{--}60 \times 14\text{--}17.5 \mu\text{m}$ , l/w ratio 3.4) lanceolate or ovoid-lanceolate with rounded to nearly truncate based and pointed tip. Secondary conidia ( $45\text{--}55 \times 15\text{--}18.5 \mu\text{m}$ ) cylindrical to clavate (Fig. 4 E). Chasmothecia immersed in dense mycelium,  $175\text{--}207 \mu\text{m}$  in diam., with numerous well developed appendages, which were hyaline or pigmented below.

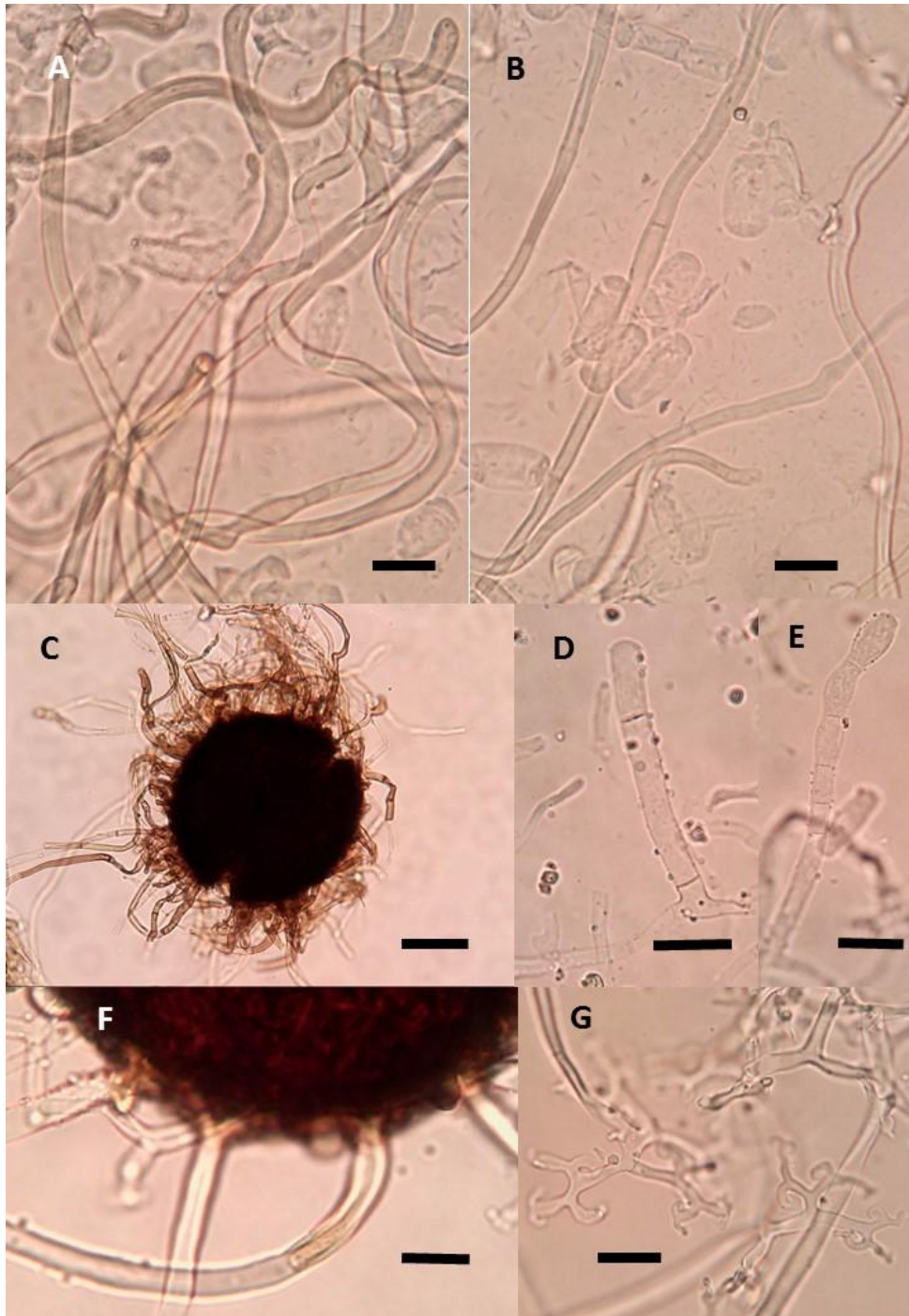
This powdery mildew species is distinguished from *L. taurica* by its host plant and smaller primary conidia (l/w ratio usually not larger than 3.5).



**Fig. 1.** *Neoerysiphe nevoi* on *Crepis kotschyana*: A. Chasmothecium (Bar =  $40 \mu\text{m}$ ), B. Distinctly meshed peridial surface of chasmothecium (Bar =  $25 \mu\text{m}$ ).

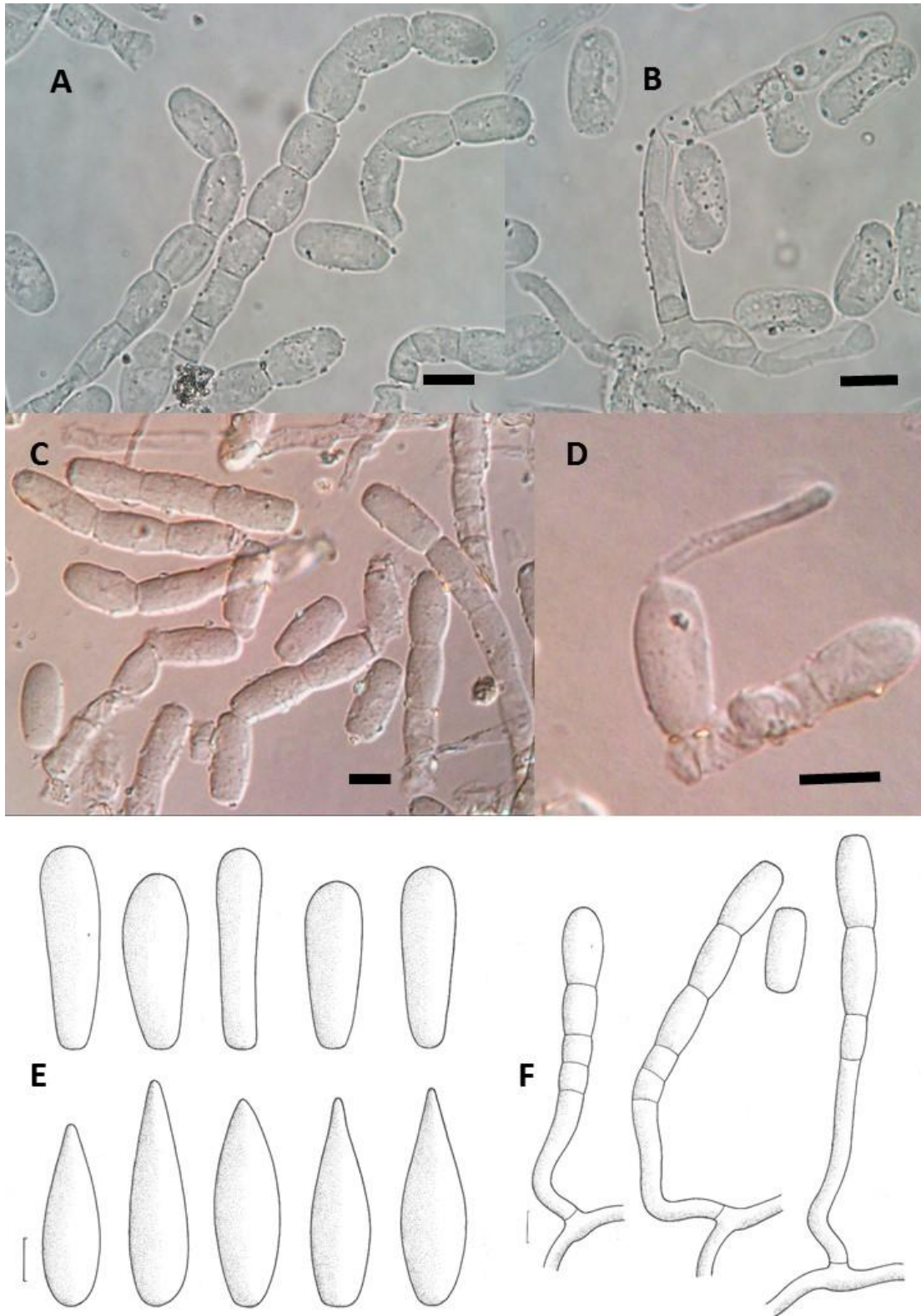


**Fig. 2.** *Leveillula taurica* on *Euphorbia hebecarpa*: Primary (on bottom) and secondary (on top) conidia (Bar = 10  $\mu$ m).



**Fig. 3.** *Podosphaera euphorbiae* on *Euphorbia tithymaloides*: A & B. Secondary hyphae and conidia (Bar = 10  $\mu$ m); *Golovinomyces montagnei* on *Notobasis syriaca*: C. Chasmothecium (Bar = 50  $\mu$ m), D & E. Conidiophores and chain of conidia (Bar = 20  $\mu$ m); *Erysiphe multappendicis* on *Berberis*: F. Basal part of appendages, G. Recurved tips of appendages (Bar = 10  $\mu$ m).





**Fig. 4.** *Podosphaera xanthii* on *Phlox paniculata*: A. Chain of conidia, B. Conidiophore and conidia (Bar = 15  $\mu\text{m}$ ); *Golovinomyces asterum* var. *morozkovskii* on *Symphyotrichum squamatum*: C. Chain of conidia, D. Germ tube, F. Conidiophores and chains of conidia (Bar = 15 in C & D and 10  $\mu\text{m}$  in F); *Leveillula linariae* on *Linaria melanogramma*: E. Primary and secondary conidia (Bar = 10  $\mu\text{m}$ ).

***Leveillula cylindrospora*** U. Braun

On *Bassia scoparia* (L.) A.J. Scott (= *Kochia scoparia* (L.) Schrad.) (*Amaranthaceae*), Yazd province, on the way from Yazd to Herat and Marvast, 14 Sept. 2012, leg. Mehdi Soltani (12-19) (GUM1577).

There is only one report of this powdery mildew on above host from Khorassan Razavi (see Khodaparast & Abbasi 2009). The species is clearly distinguished from other *Leveillula* species by having ellipsoid-cylindrical primary conidia with mostly obtuse, occasionally acute apex and cylindrical secondary conidia with rounded apex. The host-powdery mildew combination is reported here from Yazd province.

***Leveillula picridis*** (Castagne) Durrieu & Rostam

On *Launaea acanthodes* (Boiss.) Kuntze (*Asteraceae*), Yazd province, Nodooshan, 22 Oct. 2012, leg. Mehdi Soltani (61-19) (GUM1578).

There are couple of records of *Leveillula* on *Launaea* in Iran which all considered the powdery mildew species on this host as *Lev. taurica* (Samadi *et al.* 2010, Khodaparast *et al.* 2010). In above specimen primary conidia were more or less cylindrical with parallel sides and obtuse to somewhat pointed conical apex. These conidia measured  $47\text{--}74 \times 16\text{--}18 \mu\text{m}$ . Secondary conidia were clavate or more or less cylindrical and measured  $40\text{--}65 \times 12\text{--}16 \mu\text{m}$  (Fig. 5). Chasmothecia were missing. The above morphological features fit well with those of *Lev. picridis* described by Braun & Cook (2012). This is the first report of *Lev. picridis* on *Lau. acanthodes* from Iran. However, the genus *Launaea* has been mentioned among the host range list of *Lev. picridis* by Braun & Cook (2012).

***Leveillula lappae*** (Castagne) U. Braun

On *Iranecio paucilobus* (DC.) B. Nord. (*Asteraceae*), Yazd province, Shir-kuh mount, 5 Sept. 2012, leg. S.A. Esmailzadeh-Hosseini (58-19) (GUM1579).

Primary conidia broadly ellipsoid-lanceolate,  $44\text{--}55 \times 18\text{--}22 \mu\text{m}$ , apically pointed, sometimes abruptly constricted below apex, sometimes with vase-like (narrowed) base, widest part mostly in the middle. Secondary conidia  $37.5\text{--}50 \times 16\text{--}19 \mu\text{m}$  ellipsoid-cylindrical, broadly ellipsoid-cylindrical or cylindrical (Fig. 6). Chasmothecia immersed in the dense mycelium, appendages mycelioid, and simple or branched, mostly brownish, shorter than the chasmothecial diameter. To our knowledge, this is the first report of a *Leveillula* species on the genus *Iranecio*.

The specimen reported on *Cousinia eriobasis* Bunge from the same province (Yazd) as *L. taurica* by Samadi *et al.* (2010) has the same conidial morphology and should be renamed as *L. lappae*.

***Golovinomyces asterum*** var. ***moroczkovskii*** (V.P. Heluta) U. Braun

On *Symphotrichum squamatum* (Spreng.) G.L. Nesom [= *Conyzanthus squamatus* (Spreng.) Tamamsch.] (*Asteraceae*), Fars province, Bamu National Park, Sadi station, 18 Oct. 2006, leg. E. Ghasemi (4-19) (GUM1574).

Mycelium mostly caulicolous in white persistent patches; conidiophores having usually curved foot cell ( $42\text{--}60 \mu\text{m}$ ) following by 2–3 shorter cells; conidia in chain,  $27.5\text{--}37.5 \times 13.5\text{--}17.5 \mu\text{m}$ , subcylindrical or ellipsoid-doliiform, germ tubes terminal, mostly short, moderately long in some spores, with a swollen appressorium at apex. The main characteristic for this taxon *viz.* distinctly curved foot cells was clearly visible on studied material (Fig. 4 C, D & F). To our knowledge, this is the first report of above taxon from Iran. *Erysiphe cichoracerum* reported by Mirhosseini *et al.* (2015) on the same host from Golestan province, very probably belong to var. *moroczkovskii* and should be considered as a misidentification.

***Golovinomyces depressus*** (Wallr.) V.P. Heluta

On *Centaurea depressa* M. Bieb. (*Asteraceae*), Fars province, Malussjaan, leg. E. Ghasemi (11-18) (GUM1575).

Only anamorph present. Conidial chain with sinuate edge line, foot cells long (up to 150  $\mu\text{m}$ ) and lemon-shaped conidia common. All these features fit well with *G. depressus* (Abbasi & Salahi Ardakani 2017). *Centaurea depressa* is a new host for above powdery mildew species in Iran.

***Golovinomyces orontii*** (Castagne) V.P. Heluta

On *Papaver somniferum* L. (*Papaveraceae*), Tehran province, Evin, from green house, 21 Feb. 1970, leg. Ershad (IRAN 2699F, identified as *Oidium* sp.).

Mycelium amphigenous mostly in patches; conidiophores long (up to 168  $\mu\text{m}$ ), with straight to somewhat curved at the base foot cells (up to 105  $\mu\text{m}$  long) following by up to 3 shorter cells; conidia doliiform or doliiform-subcylindrical 28.5–40(–46)  $\times$  (10–)15–17.5  $\mu\text{m}$ , produced in chain, sinuate edge line was visible in chain of conidia, germ tubes arising from an end of conidia, usually short and curved with swollen appressorium at apex. Above anamorphic features quite fit descriptions of *G. orontii* on *Papaveraceae* members (Braun & Cook 2012, Abbasi & Salahi Ardakani 2017). To our knowledge, this is the first report of *G. orontii* on *P. somniferum* in Iran.

***Golovinomyces cynoglossi*** (Wallr.) V.P. Heluta, *sensu* Braun & Cook (2012)

On *Paracaryum rugulosum* Boiss. (*Boraginaceae*), Fars province, Shiraz towards Dasht-e Arzhan, Hossein Abad protected region, 8 May 2010, leg. E. Ghasemi (5-19) (IRAN 76754).

On *Lithospermum arvense* L. (*Boraginaceae*), Alborz province, Kalvan road, 2 km S of Kalvan, around the road, alt. 1900 m, 16 Jun. 1999, leg. Abbasi *et al.* (65-19) (IRAN 76753).

On *Paracaryum*: Mycelium amphigenous forming numerous limited white patches, conidiophores erect with straight foot cells (up to 100  $\mu\text{m}$  long), followed by 1–3 shorter cells; conidia in chain, 23–31.5  $\times$  13.5–19  $\mu\text{m}$  (dry material) doliiform to ellipsoid ovoid. Germ tubes develop at top end or near the end of conidium, short, often twisted. Chasmothecia were not observed.

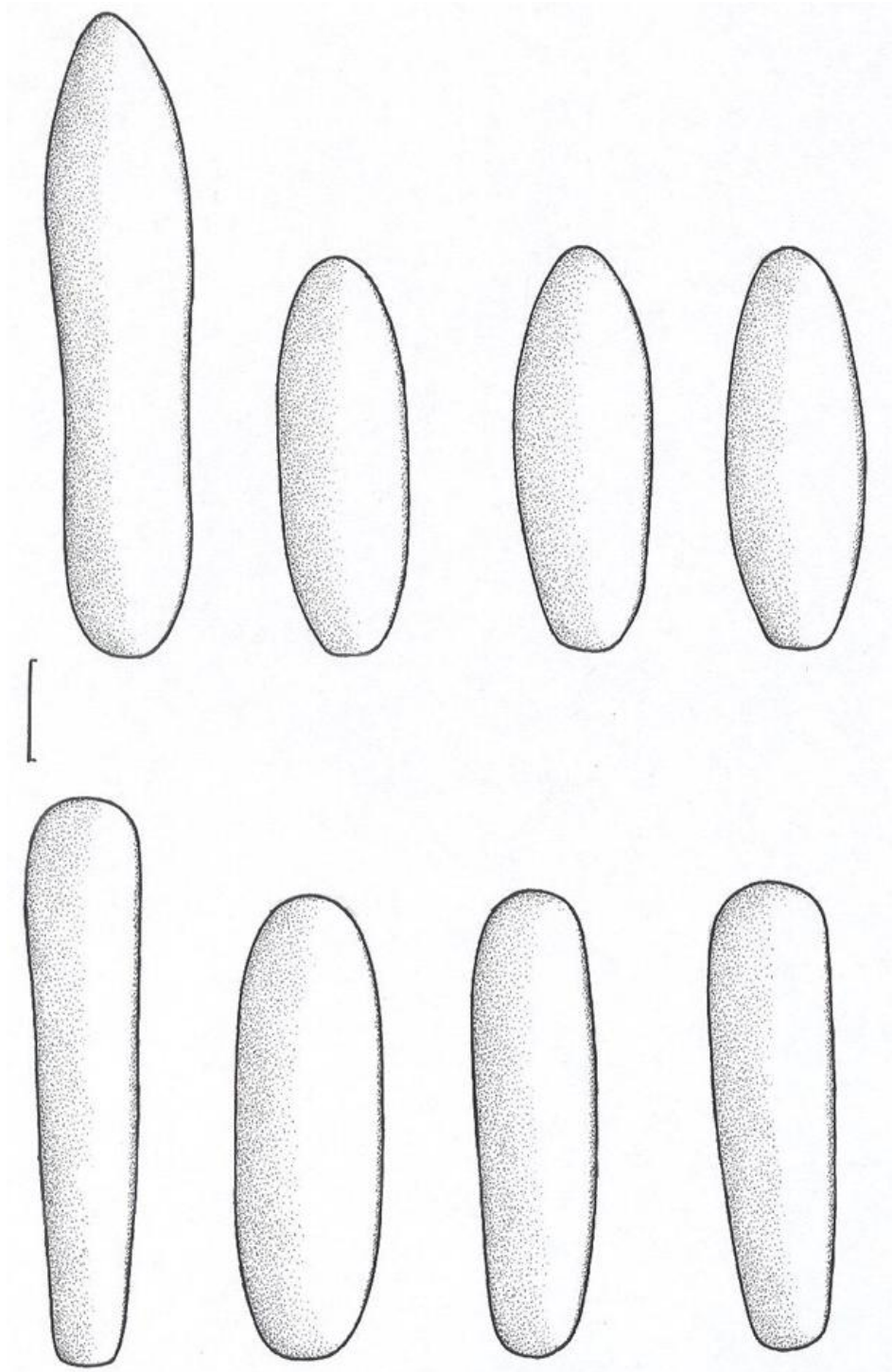
On *Lithospermum*: Mycelium on sepals, conidiophores erect with long foot 75–150 (–180)  $\mu\text{m}$  long, followed by 1–3 shorter cells; conidia in chain, 21–40  $\times$  13–17  $\mu\text{m}$  (dry material) doliiform to ellipsoid ovoid. Chasmothecia gregarious, often immersed in mycelial patches, up to 160  $\mu\text{m}$  in diam., with numerous mycelioid appendages.

We have only seen two following reports of powdery mildews on the genus *Paracaryum*, an unidentified anamorph on *P. himalayense* (Klotzch) C.B. Clarke, from Central Asia (Karis 1995) and *Oidium* sp. on the same host from former USSR (Amano 1986). This is the first report of *G. cynoglossi* on *P. rugulosum* (*Matrix nova*). This is also first report of *G. cynoglossi* on *L. arvense* in Iran.

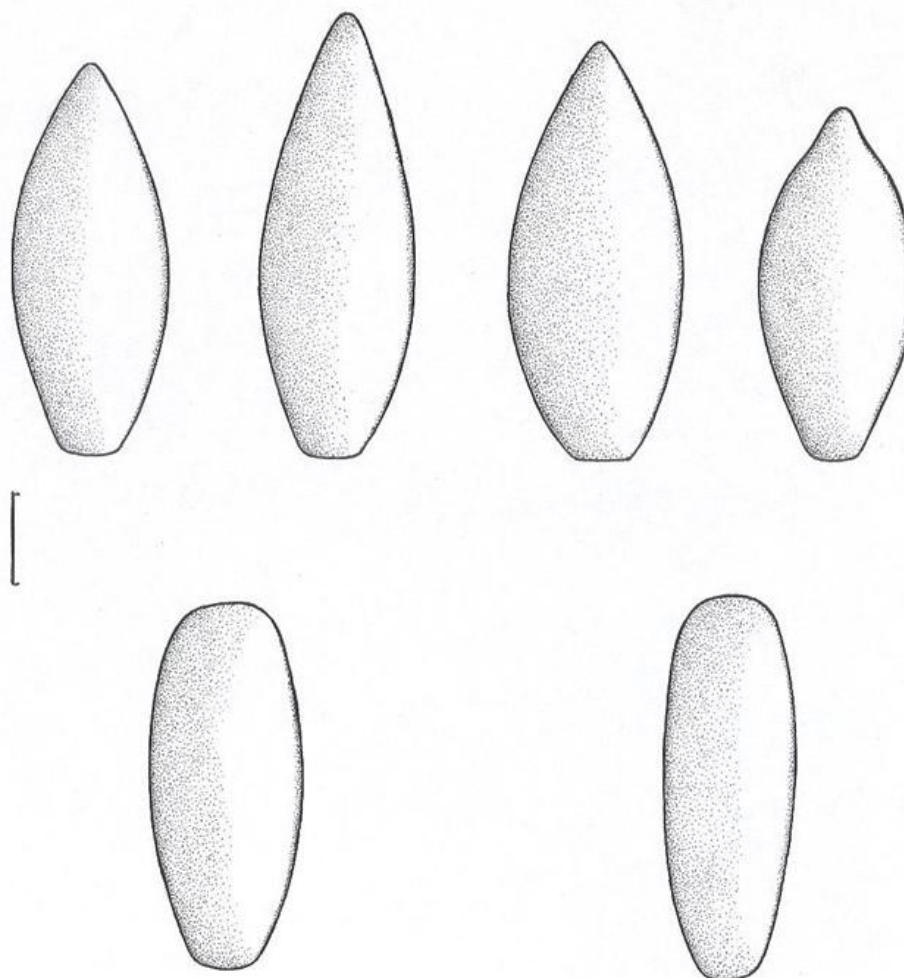
***Golovinomyces montagnei*** U. Braun

On *Notobasis syriaca* (L.) Cass. (*Asteraceae*), Ilam province, 11 Jun. 2003, leg. K. Noorelahi (IRAN 11622F)

Few traces of white mycelium were present on the lower side of infected leaves. Conidiophores with cylindrical foot cells, 40-57 (–80)  $\mu\text{m}$  in length, followed by mostly two shorter cells. Conidia in chain, doliiform, ellipsoid-ovoid to lemon-shaped, 26-38  $\times$  12-17  $\mu\text{m}$ . Chasmothecia on the lower side of the leaves, scattered, up to 150  $\mu\text{m}$  in diam., with numerous mycelioid brown to dark brown appendages, contained mostly 2-spored asci (Fig. 3 C–E). This is the first report of *G. montagnei* on *N. syriaca* from Iran (see Khodaparast & Abbasi 2009). *Golovinomyces montagnei* differs from *G. depressus*, another reported powdery mildew on members of *Carduoideae* in Iran, in having shorter conidiophore foot-cells and different type of conidial germination.



**Fig. 5.** *Leveillula picridis* on *Launaea acanthodes*: Primary (on top) and secondary (on bottom) conidia (Bar = 10  $\mu$ m).



**Fig. 6.** *Leveillula lappae* on *Iranecio paucilobus*: Primary (on top) and secondary (on bottom) conidia (Bar = 10  $\mu$ m).

***Podosphaera euphorbiae*** (Castagne) U. Braun & S. Takam.

On *Euphorbia tithymaloides* L. (*Euphorbiaceae*), Tehran province, Iranian Research Institute of Plant Protection campus, 6 Jan. 2019, leg. M. Eskandari (6-19) (IRAN 17403F).

Mycelium of two kinds dense, forming complete cover on stem; primary mycelium white, thin walled, secondary mycelium contains pigmented, coarse, twisting secondary hyphae, 3.5–7  $\mu$ m wide, thick walled; conidiophores erect, foot cells straight, cylindrical (up to 60  $\mu$ m long), followed by 1–3 shorter cells; conidia in chain with fibrosin bodies, doliiform to cylindrical, 22–29  $\times$  9–14  $\mu$ m, germ tubes short, terminal to subterminal positions (Fig. 3 A & B). These morphological features

fit well with description of *P. euphorbiae* provided by Braun & Cook (2012). Judging from the literature (Braun & Cook 2012, Farr & Rossman n.d.), this is the first report of *P. euphorbiae* on *E. tithymaloides* (*Matrix nova*). *Podosphaera euphorbiae* differs from *P. euphorbiae-hirtae* (U. Braun & Somani) U. Braun & S. Takam., the common *Podosphaera* species on *E. tithymaloides*, in having secondary hyphae and narrower conidia [10–18  $\mu$ m vs 13–23  $\mu$ m, mentioned by Braun & Cook (2012)]. *Podosphaera euphorbiae-hirtae* reported by Sharifi *et al.* (2013) on *Pedilantus* sp., from Northern Iran, mentioned as a taxon having secondary hyphae and narrow conidia (9–14  $\mu$ m), may also belong to *P. euphorbiae*.

*Podosphaera xanthii* (Castagne) U. Braun & Shishkoff *sensu lat.*

On cultivated species of *Phlox* (*Polemoniaceae*), Tehran province, Tehran (IRAN 2695F); on cultivated *Phlox paniculata* L., Tehran province, Darakeh (IRAN 2694F).

Mycelium amphigenous, often covering the entire lower surface of leaves, on upper side in irregular patches, more or less persistent; foot cells cylindrical, 54–100 µm, slightly constricted at basal septum,

followed by 1–3 shorter cells; conidia in long chain, showing crenate edge line, mostly ellipsoid-ovoid, 27–39 × 13–19 µm (Fig. 4 A & B). There are previous reports of *Oidium* sp. (Ershad 1971) and *Leveillula taurica* (Amano 1986, Mohammadi-Doustdar 1969) on *Phlox* spp. in Iran. This is the first report of *P. xanthii* on *Phlox* in Iran. *Podosphaera xanthii* usually occurs as anamorph on *Phlox* species across the world (Braun & Cooke 2012). Iranian specimens also showed the same feature.

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