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Three new host-fungus records for *Golovinomyces* species in Montana and Washington

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Abstract: The powdery mildews *Golovinomyces echinopis* on *Echinops exaltatus* (tall globethistle), and *G. biocellatus* on *Salvia officinalis* (common sage), are documented for the first time in Washington State. *Golovinomyces cynoglossi* on *Cynoglossum officinale* (houndstongue) is documented for the first time in the state of Montana.

Key words: common sage, *Cynoglossum officinale*, *Echinops exaltatus*, garden sage, globethistle, *Golovinomyces biocellatus*, *G. cynoglossi*, *G. echinopis*, houndstongue, powdery mildew, *Salvia officinalis*

Introduction: Reporting new host-fungus records benefits plant disease diagnosticians, regulatory officials, weed scientists, growers, and other plant health and plant production professionals (Dugan et al. 2009). Documented herein are three separate *Golovinomyces* species occurring on an ornamental plant, a noxious weed, and a garden herb, respectively.

Material and methods: Powdery mildew fungi were removed from host tissues with a razor blade, mounted in 3% KOH, and examined at 100-1000X with differential interference contrast (DIC) or bright field microscopy with an Olympus BH2 microscope equipped with a D5000 Nikon camera. For each specimen, measurements were taken at 400X for a minimum of 20 conidia and 10 conidiophores, with further measurements taken for outliers. Conidia, conidiophores, and appressoria were documented in photomicrographs. Names were applied to fungi by use of standard keys and descriptions (Braun 1987, 1995; Glawe 2006). Identification of plants from Manito Park was based on Park labels and confirmed by comparison with photographs and descriptions in the Plants Database of the USDA Natural Resource Conservation Service (n.d.). Identification of the Montana specimen was confirmed with Lackschewitz (1991).

Results: *Golovinomyces echinopsis* (U. Braun) V.P. Heluta (= *Erysiphe echinopsis* U. Braun) on *Echinops exaltatus* Schrader (tall globethistle, Asteraceae), Manito Park, Spokane, Washington, 25 September 2010. Collector, F.M. Dugan.

Colonies white, dense, ~0.5 cm diam to sometimes confluent, adaxial on leaves; conidia oval, elliptic to doliform (Fig. 1), in true chains (Fig. 2), lacking fibrosin bodies, (26.0-)29.5-38.0(-42.0) x 17.0-25.0 µm, germinating subapically; foot cells (28-)38-103 x 9-13 µm, often followed by 1-2 longer cells up to 98 µm, then 1-3 shorter cells (Figs. 3, 4); appressoria

nipple-shaped (Fig. 5). The teleomorph was not seen. Deposited as WSP 71936.

Braun (1987) lists only two powdery mildews on *Echinops* spp., *Erysiphe echinopsis* and *Leveillula taurica* (Lév.) Arnaud, although the possibility of being a host for *Golovinomyces cichoracearum* (DC.) V.P. Heluta 1988 (= *Erysiphe cichoracearum* DC.) is indicated by "? *Echinops*" in his host list for *E. cichoracearum*. The specimen keyed readily to genus *Golovinomyces* in Glawe (2006). Provided that conidiophores with 1-2 long cells subsequent to the foot cell are emphasized (cf. Braun 1987, fig. 69C, left two conidiophores), the specimen keys to *E. echinopsis* in Braun (1987, 1995). Approximately 30% of the conidiophores in this specimen exhibited the 1-2 elongated cells following the foot cell as described and illustrated by Braun (1987, 1995), with most of the other conidiophores similar to those of *G. cichoracearum*. Greatly elongated cells subsequent to the foot cell are neither described nor illustrated by Braun (1987, 1995) for *E. cichoracearum*. Moreover, the "very rarely a very long foot-cell followed by some shorter cells" (Braun 1987, fig. 69C, right conidiophore) was also occasionally observed in the Manito Park specimen. Based on this combination of characters, the name *G. echinopsis* is applied to the specimen. Although DNA sequences are readily available in GenBank for *G. cichoracearum*, none are available for *G. echinopsis* for comparison.

Kenneth and Palti (1984) noted that the distribution of downy and powdery mildews and rusts on *Echinops* (as opposed to distribution of the same pathogens on other tribes of Asteraceae) argued for the traditional classification of *Echinops* in the *Cynareae*. Farr and Rossman (n.d.) contain several records for *G. echinopsis* in Europe, but none for North America. This appears to be the first report of *G. echinopsis* in North America, although powdery mildew (not further designated) is mentioned on "globe

Figs. 1-5. *Golovinomyces echinopsis* on *Echinops exaltatus*. Fig. 1. Conidia. DIC. Bar = 25 μ m. Fig. 2. Conidia in true chain. Bright field. Bar = 35 μ m. Figs. 3 and 4. Conidiophores diagnostic for *G. echinopsis* have 1-2 long cells (between arrows) directly above level of foot cell. Bright field. Bars = 50, 35 μ m respectively. Fig. 5. Appressorium. Bright field. Bar = 12 μ m.

thistle" (*Echinops ritro* L., a closely related species) on a University of Illinois horticultural web site (<http://urbanext.illinois.edu/hortanswers>). Staff at Manito Park pointed out a senescing, unlabeled plant, also afflicted with powdery mildew and growing in an adjacent, weedy area. This plant was thought by the staff to be *E. ritro*, an identification which could not be confirmed to species because of the senescent nature of the material; the specimen is represented as WSP 71935.

***Golovinomyces cynoglossi* (Wallr.) V.P. Heluta [= *Erysiphe cynoglossi* (Wallr.) U. Braun] on *Cynoglossum officinale* L., (houndstongue, gypsyflower, Boraginaceae), Mt. Jumbo at terminus of Carriage Way, Missoula, Montana, 29 August 2010. Collector, F.M. Dugan.**

Colonies white, dense, ~0.5 cm diam to confluent, mostly abaxial on leaves and sepals; conidia oval, elliptic to doliform (Fig. 6), in true chains (Fig. 7), lacking fibrosin bodies, 24.0-28.5(-29.5) $\times$ (11.0-)15.5-17.0 μ m, germinating subapically (Fig. 8); foot cells (44-)66-83(-110) μ m; appressoria inconspicuous to nipple-shaped (Fig. 9). The teleomorph was not seen. Deposited as WSP 71856.

Braun (1987) lists only two powdery mildews on houndstongue: *Erysiphe cynoglossi* and *Leveillula taurica*. The specimen is congruent with the description of the former, but not with the dimorphic *L. taurica*, which has primary (lanceolate) and secondary (cylindric) conidia. Braun (1995) lists only three powdery mildews on Boraginaceae, and the Mt. Jumbo specimen keys directly to *E. cynoglossi* in Braun (1995) because the conidia are in chains (not single) and not

Figs. 6-9. *Golovinomyces cynoglossi* on *Cynoglossum officinale*. Fig. 6. Conidia. DIC. Bar = 30 µm. Fig. 7. Tip of conidiophore and conidial chain in air. Upper three conidia are disarticulating, lower two remain in true chain formation. Bright field. Bar = 40 µm. Fig. 8. Two conidia with germ tubes. DIC. Bar = 25 µm. Fig. 9. Nipple-shaped appressorium. DIC. Bar = 10 µm.

dimorphic. It readily keys to *Golovinomyces* in Glawe (2006).

Farr and Rossman (n.d.) contain records for *Erysiphe cichoracearum* auct. on houndstongue in Oregon, Utah and Wyoming. It is likely these

records actually pertain to *G. cynoglossi*, because *E. cichoracearum* DC. *sensu stricto* applies only to infections of Asteraceae (Braun 1987). Farr and Rossman (n.d.) contain multiple records for *G. cynoglossi* on houndstongue in Europe. The powdery mildew on houndstongue (as *E.*

cynoglossi) has been documented and used as an experimental biological control agent in British Columbia and Alberta (De Clerck-Floate 1999); in these experiments, the powdery mildew had negative effects (~65% reduction) on viable seed production. Some flowers appeared negatively impacted on this single Mt. Jumbo specimen.¹ Houndstongue is a Category 1 noxious weed in Montana and several other states (USDA Natural Resources Conservation Service n.d.). This seems to be the first record of *G. cynoglossi* on houndstongue from Montana. Glawe and Ammirati (2006) reported *G. cynoglossi* on *Omphalodes cappadocica* DC (navel seed) from Seattle, Washington and summarized reports of *G. cynoglossi* elsewhere in North America. The species has often been reported from Europe and Asia (Farr and Rossman n.d.).

***Golovinomyces biocellatus* (Ehrenb.) V.P. Heluta (= *Erysiphe biocellata* Ehrenb.) on *Salvia officinalis* L. (common sage, garden sage, Lamiaceae), Manito Park, Spokane, Washington, 5 October 2010. Collector, F.M. Dugan.**

Colonies white, dense to diffuse, ~0.5-1.0 cm diam to confluent, mostly adaxial on leaves; conidia 29.5-38.0(-42.0) x 15.5-21.0 µm, oval, elliptic to doliform (Fig. 10), in true chains (Fig. 11), lacking fibrosin bodies (Fig. 12), germinating subapically; foot cells (Fig. 13) 42-133(-160) (very

exceptionally 180) x 7.5-14 µm with base more narrow than upper portion and sometimes with lower septum up to 50 µm distal from aseptate junction of conidiophore with mycelium; foot cell nearly always followed by 1-3 shorter cells; appressoria nipple-shaped (Figs. 14, 15) or inconspicuous (Fig. 16). The teleomorph was not seen. Deposited as WSP 71934.

Using Braun's (1987) key to powdery mildews on the basis of host family, the specimen keys directly to *Erysiphe biocellata* on the basis of conidia in chains and nipple-shaped appressoria. Other powdery mildews listed by Braun (1987) on *Salvia*, *L. taurica* (with dimorphic conidia), and *Neoerysiphe galeopsidis* (DC.) U. Braun (with distinctly lobed appressoria), do not conform to the Manito Park specimen. With regard to the latter structures, Braun's (1987, 1995) drawings for *E. biocellata* document both the more conspicuous, papillate appressoria, and the less conspicuous, sub-acute type (corresponding with Figs. 14, 15 and 16 here). The specimen keys directly to *Golovinomyces* in Glawe (2006) on these same attributes and the absence of fibrosin bodies. *Golovinomyces biocellatus* is the only species currently assigned to *Golovinomyces* occurring on Lamiaceae in Braun (1987). Foot cells of *G. biocellatus* are described as (30-)40-75(-80) µm (Braun 1987), or 30-70 µm long (Boesewinkle 1980), with some subsequent reports giving similar lengths, (e.g., "[41.3-]55.2[-75]" in Marcum et al. 2010). The range of lengths of foot cells in the Manito specimen more closely approximated the upper range in Liberato and Cunningham (2007): 20-127 µm. Note that conidiophores (foot cells per se were not described) in Park et al. (2010) were given as 110-170 µm, longer than illustrated by Braun (1987, 1995).

Golovinomyces biocellatus has been reported from common sage in various countries in Europe, and (as *Erysiphe cichoracearum*, see note on Asteraceae above) in Argentina (Farr and Rossman n.d.). Prior formal reports from North

¹ Only one plant was observed. The author noticed the single specimen while accompanying friends on a dog walk. "We hate houndstongue because it gets all over the dogs. We pull up every plant we see! We've ripped out dozens of them. Not sure why we missed that one" (M. Dolack and M.B. Percival, personal communication, by way of apology for the paucity of specimens). On this Mt. Jumbo locale, dog walkers were apparently a more effective control than the powdery mildew! In the Missoula area, hand pulling "is a useful method for dealing with small infestations" of various weeds, including houndstongue (with students, conservation groups, and others actively participating), but sprays of metasulfuron and glyphosate are also used against this plant, which has high priority for control (Marler n.d.).

Figs. 10-16. *Golovinomyces biocellatus* on *Salvia officinale*. Fig. 10. Conidia. DIC. Bar = 25 μ m. Fig. 11. Conidial chain. Bright field. Bar = 40 μ m. Fig. 12. Apex of conidial chain, showing absence of fibrosin bodies in fresh material. Bar = 25 μ m. Fig. 13. Conidiophore with foot cell followed by two shorter cells and chain of conidia. Bright field. Bar = 40 μ m. Figs. 14 and 15. Nipple-shaped appressoria. DIC. Bars = 6, 4 μ m respectively; Fig. 16. Composite photomicrograph of two adjacent, indistinct appressoria with pores (arrows) in focal plane. DIC. Bar = 7 μ m.

America were not located, but "powdery mildew" (without further designation, except as occurring on sage or *Salvia*) is sometimes mentioned on gardening web sites, and a quality photograph of symptoms on *S. officinalis* is published (Pundt and Smith 2005).

Discussion: As indicated on the University of Illinois web site above, and by the photographs in Pundt and Smith (2005), formal reporting of a disease sometimes lags behind its recognition by gardeners or horticultural specialists. However, given that such publications have referred to the fungi on globethistle and common sage only as "powdery mildew" without identification to genus or species, and given that such reports were not found from the Pacific Northwest of the United States, the reports herein are submitted for the public record. The report on *G. cynoglossi* in

Montana is issued for the benefit of weed scientists. Determination of the scientific name of a powdery mildew on a given host should assist growers, weed scientists and others in determining which adjacent higher plant species might be at risk for infection.

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