

***Neoerysiphe galeopsidis* on *Stachys* species in Slovakia and the Czech Republic based on a re-examination of herbarium collections**

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On the basis of re-examinations of herbarium collections, species of the genus *Stachys* as host plants of the powdery mildew species *Neoerysiphe galeopsidis* in Slovakia and the Czech Republic were verified. A detailed description, illustrations, the host range and the distribution of this fungus are given.

Key words: powdery mildew, *Neoerysiphe galeopsidis*, *Oidium* subgenus *Striatoidium*, *Stachys*, host range.

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Na základe skúmania herbárových zbierok boli preverené jednotlivé druhy rodu *Stachys* ako hostiteľské rastliny múčnatkotvarej huby *Neoerysiphe galeopsidis* na Slovensku a v Českej republike. V práci uvádzame podrobný opis a fotodokumentáciu huby, jej hostiteľské spektrum a geografické rozšírenie.

INTRODUCTION

Stachys is a genus of about 300 species of annual and perennial herbaceous plants and shrubs in the family *Lamiaceae*. The distribution of the genus covers Europe, Asia, Africa and North America. The most common powdery mildew species parasitising *Stachys* species is *Neoerysiphe galeopsidis*. This fungus was first described in 1815 as *Erysiphe galeopsidis*. At present it is one of six species of the genus *Neoerysiphe* U. Braun (syn. *Erysiphe* section *Galeopsidis* U. Braun). Braun (1999) introduced five *Neoerysiphe* species: *N. chelones* (Schwein.) U. Braun, *N. cumminsiana* (U. Braun) U. Braun, *N. galeopsidis* (DC.) U. Braun, *N. galii* (S. Blumer) U. Braun, *N. geranii* (Y. Nomura) U. Braun, and designated *N. galeopsidis* as the type species. Bahcecioglu et al. (2006) introduced another

species, *N. rubiae* Bahc., U. Braun & Kabakt. The teleomorph of *N. galeopsidis* was described in detail by Braun (1995), Shin (2000) and other authors. It is characterised by having *Erysiphe*-like chasmothecia, a multi-layered peridium, mycelioid appendages and 2–8-spored asci. This species is known to form mature ascospores only after overwintering (Klika 1923, Junell 1967, Shin 1991). Based on detailed SEM examinations of conidium surface features of the anamorph of *N. galeopsidis*, characterised by having linear wrinkled conidia, *Oidium* subgenus *Striatoidium* was proposed by Cook et al. (1997) as the anamorph. In addition to morphological criteria and host range data, the identification of powdery mildews was supplemented with molecular phylogenetic analyses (Saenz and Taylor 1999, Mori et al. 2000, Cunnington et al. 2003, Cook et al. 2006b).

In November 2007, *Stachys byzantina* (syns. *S. lanata*, *S. olympica*, *S. sublanata*) was found attacked by the fungus *Neoerysiphe galeopsidis*. In the monograph of powdery mildews of Slovakia (Paulech 1995), *S. byzantina* is not included as a host plant of this powdery mildew fungus. We therefore assumed that it was a new record for Slovakia. However, Amano (1986) listed *N. galeopsidis* on *S. byzantina* in the former Czechoslovakia. As *S. byzantina* is neither mentioned as a host plant of this fungus in the monograph of Slovak powdery mildews (Paulech 1995) nor in the monograph of Czech powdery mildews (Klika 1923), we searched for the original data. The aim of this paper is to verify which species of the genus *Stachys* are parasitised by *N. galeopsidis* on the territory of Slovakia and Czech Republic (former Czechoslovakia).

Morphological features of the species are described and illustrated, and its host range and geographical distribution are summarised.

MATERIALS AND METHODS

Fresh leaves of *Stachys byzantina* and *S. sylvatica* infected with a powdery mildew fungus were collected in 2007 and 2008. Herbarium specimens were deposited in the herbarium of the Institute of Forest Ecology, Slovak Academy of Sciences, Nitra, Slovakia and the U.S. National Fungus Collections, USA (BPI).

In order to re-examine and confirm records of *N. galeopsidis* on *Stachys* species, 59 herbarium specimens were loaned (4 from BRNU – herbarium of the Department of Botany and Zoology, Masaryk University, Brno, Czech Republic; 11 from PRC – herbarium of the Department of Botany, Charles University, Prague, Czech Republic; 7 from PRM – herbarium of the National Museum, Prague, Czech Republic; 37 from SAV – herbarium of the Institute of Botany, Slovak Academy of Sciences, Bratislava, Slovakia). We did not find any other herbarium collections of this species on *Stachys* collected in Slovakia or the Czech Republic deposited in other Slovak and Czech herbaria listed in the Index Herbariorum database.

The collections were examined by a stereo microscope (SZ51, Olympus, Japan) and standard light microscope (BX51, Olympus, Japan). The herbarium samples were mounted in distilled water, pure lactic acid and lactic acid stained with lactophenol blue for microscopic examination.

Descriptions were made according to our own specimens collected in Slovakia (field collections) and re-examined herbarium collections. The values of taxonomic characteristics of *N. galeopsisidis* were compared to previously published descriptions. The morphological structures of this fungus and symptoms of attacked host organs were photographically documented. Based on literature data, the host range and geographical distribution of the fungus examined were established.

RESULTS AND DISCUSSION

Neoerysiphe galeopsisidis (DC.) U. Braun, Schlechtendalia 3: 50, 1999

Basionym: *Erysiphe galeopsisidis* DC., Fl. franç., Ed. 3 (Paris) 5/6: 108, 1815

Synonyms: *Alphitomorpha lamprocarpa* Wallr., Verh. Ges. Naturf. Freunde Berlin 1(1): 33, 1819. – *Erysiphe labiatarum* (Wallr.) Chevall., Fl. gén. env. Paris, Ed. 1, 1: 380, 1826. – *Erysiphe lamprocarpa* (Wallr.) Link, in Willdenow, Sp. pl., Ed. 4, 6(1): 108, 1824. – *Golovinomyces galeopsisidis* (DC.) V. P. Heluta, Ukrayins'k. Bot. Zhurn. 45(5): 62, 1988

Anamorph: *Oidium* subgen. *Striatooidium* R.T.A. Cook, A.J. Inman & C. Billings, Mycol. Res. 101(8): 998, 1997

Position in classification: order *Erysiphales*, family *Erysiphaceae*, tribe *Golovinomyceae*, subtribe *Neoerysiphinae*, genus *Neoerysiphe*

Studied specimens

Fresh material

On leaves of *Stachys byzantina* – Slovakia: Nitra, Zobor, front garden, 5 Nov 2007 and 6 May 2008, leg. H. Ivanová, det. K. Pastirčáková (BPI 878356).

On *Stachys sylvatica* – Slovakia: Muránska Planina Mts., Hrdzavá valley, 3 Sep 2008, leg. M. Pastirčák, det. K. Pastirčáková; Muránska Planina Mts., Cigánka, 7 Sep 2008, leg. M. Pastirčák, det. K. Pastirčáková.

Herbarium material

On *Stachys byzantina* (syn. *S. lanata*) – Czech Republic: Moravia, Lednice [Eisgrub], castle park, Sep 1904, leg. et det. W. Zimmermann (PRM 675080). – Slovakia: Ivanka pri Dunaji, 1965, leg. et det. C. Paulech (SAV).

On *Stachys germanica* – Slovakia: Modrová, Jun 1983, leg. et det. C. Paulech (SAV).

On *Stachys palustris* – Czech Republic: Bohemia, Kačina, Kutná Hora, 1854, leg. et det. J. Peyl as *E. lamprocarpa* f. *galeopsisidis* (PRC); Bohemia, Prague XIX, Šárka, Oct 1859, leg. et det. J. Schöbl as *E. lamprocarpa* f. *stachydis* (PRC); Bohemia, Nymburk district, Poděbrady, Polabec, sine dat., leg. et det. P. Havránek (PRC). – Slovakia: school forest, 4 Sep 1971, leg. et det. C. Paulech (SAV); Trebišov, Čongov forest, 7 Sep 1982, leg. et det. C. Paulech (SAV); Olchov, 9 Sep 1982, leg. et det. C. Paulech (SAV).

On *Stachys recta* – Czech Republic: Bohemia, Koda, 11 Sep 1920, leg. et det. J. Klika? (PRM 7976); Moravia, Brno, Hády hill, near Maloměřice, Aug 1924, leg. et det. J. Hruby (BRNU 244704); Bohemia, Velká hora u Karlštejna, Aug 1925, leg. et det. J. Klika (PRM 675104); Bohemia, České středohoří

Mts., Lovoš, Lovosice, 8 Sep 1956, leg. et det. V. Skalický (PRC); Bohemia, Beroun district, between Hudlice and Lísek, 10 Oct 1968, leg. et det. V. Skalický (PRC).

On *Stachys sylvatica* – C z e c h R e p u b l i c: Bohemia, Modřany, 28 Sep 1920, leg. et det. J. Klika? (PRM 7922); Bohemia, Chvalkov, 14 Sep 1942, sine leg. et det. (PRC); Bohemia, Skořice, Sep 1948, leg. et det. K. Cejp (PRC); Bohemia, Černošice near Prague, 31 Oct 1961, leg. et det. K. Cejp (PRC); Bohemia, Košíře, old cemetery, 21 Oct 1962, leg. et det. K. Cejp (PRC); Silesia, Ostrava district, Ludgeřovice, 6 Sep 1969, leg. et det. V. Skalický (PRC); Bohemia, Nymburk district, Poděbrady, 2 Aug 1988, leg. et det. P. Havránek (PRC). – S l o v a k i a: Modra, Harmonia, 2 Oct 1968, leg. et det. C. Paulech (SAV); Devínska Kobyla hill, 8 Sep 1970, leg. et det. C. Paulech (SAV); Vysoké Tatry Mts., Tatranská Lomnica, 10 Sep 1971, leg. et det. C. Paulech (SAV); Slovenský Raj, Čingov, 13 Aug 1972, leg. et det. C. Paulech (SAV); Malá Fatra Mts., Rozsutec, Tesná rizna, 3 Oct 1973, leg. et det. C. Paulech (SAV); Stučica, Hlboký potok, 16 Oct 1973, leg. et det. C. Paulech (SAV); Veľká Fatra Mts., Dedoňová valley, 3 Sep 1974, leg. et det. C. Paulech (SAV); Devínska Kobyla hill, 5 Sep 1974, leg. et det. C. Paulech (SAV); Veľká Fatra Mts., Dolný Harmanec, 9 Sep 1975, leg. et det. C. Paulech (SAV); Veľká Fatra Mts., Gaderská valley, 15 Sep 1975, leg. et det. C. Paulech (SAV); Veľká Fatra Mts., Hornojasenová valley, 24 Aug 1976, leg. et det. C. Paulech (SAV); Veľká Fatra Mts., Belianská valley, 27 Aug 1976, leg. et det. C. Paulech (SAV); Devínska Kobyla hill, 13 Oct 1976, leg. et det. C. Paulech (SAV); Veľká Fatra Mts., Necpalská valley, 29 Aug 1978, leg. et det. C. Paulech (SAV); Zvolen, Poľana, 1979, leg. et det. C. Paulech (SAV); Trebišov, Čongov forest, 7 Sep 1982, leg. et det. C. Paulech (SAV); Kašov, Javorový potok, 8 Sep 1982, leg. et det. C. Paulech (SAV); Vysoké Tatry Mts., Kežmarské dale, 5 Oct 1982, leg. et det. C. Paulech (SAV); Vysoké Tatry Mts., Polianka, 13 Sep 1983, leg. et det. C. Paulech (SAV); Vysoké Tatry Mts., Tatranská Lomnica, 13 Sep 1983, leg. et det. C. Paulech (SAV); Považský Inovec, Modrová, 26 Aug 1986, leg. et det. C. Paulech (SAV); Slovenský Raj, Biele Vody, 11 Sep 1986, leg. et det. C. Paulech (SAV); Veporské hills, Kokava-Háj, 13 Oct

Tab. 1. Biometric characteristics of *Neoerysiphe galeopsidis* on *Stachys* reported by other authors and of the Slovak and Czech material examined.

	Conidia (μm)	Conidiophore or its foot cell (μm)	Chasmothecia (μm)	Asci (μm)	Ascospores (μm)	Number of ascospores
Zheng and Chen (1981)	20–40.5 \times (10.5–)13–18(–19)	*	(85–)100–140 (–155)	(47–)51–75 \times (22–)27.5–38	not developed	
Salata (1985)	26–40 \times 14–21	*	98–160	50–80 \times 23–40	21–23 \times 14–15	(2–)3–6(–8)
Fakirova (1991)	27.5–35 \times 12.5–17.5	*	100–150	60–65 \times 30–35	21–23 \times 14–15	2–4(–6)
Braun (1995)	25–36 \times 13–22	25–50 \times 8.5–12.5 (foot cell)	(85–)100–160 (–180)	40–80 \times 20–45	21–23 \times 13.5–15.5	(2–)3–6(–8)
Grigaliunaite (1997)	27–36 \times 12–16.5	*	103–148	33–75 \times 18–33	*	(2–)3–8
Nomura (1997)	28–44 \times 13–23	90–135 \times 10–14	90–150	41–58 \times 17–25	25–28 \times 20–24	2(–3)
Shin (2000)	29–43 \times 15–19	114–200 \times 9–11	(92–)104–148	47–63 \times 19–29	18–27 \times 12–16	(4–)5–6
Bolay (2005)	(21–)25–39 \times 10.5–18(–22)	20–30(–50) \times 2–12 (foot cell)	(85–)100–160 (–180)	40–80 \times 20–45	21–23 \times 13.5–15.5	(2–)3–6(–8)
Voytyuk et al. (2006)	25–34(–40) \times 17–22	95–165(–180)	80–140(–160)	48–85 \times 20–40	not developed	
Examined material	23–42 \times 12–22	20–45 \times 8–12 (foot cell)	105–210	45–60 \times 20–30	not developed	

* microstructures were observed but not measured

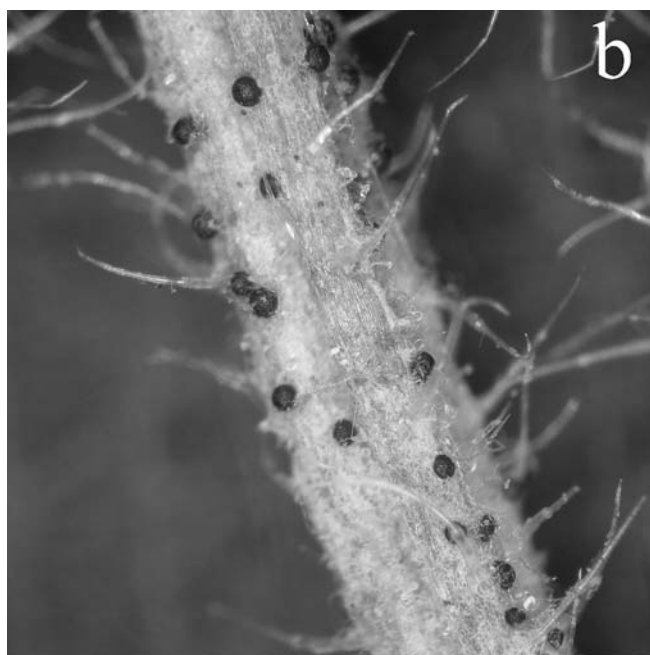
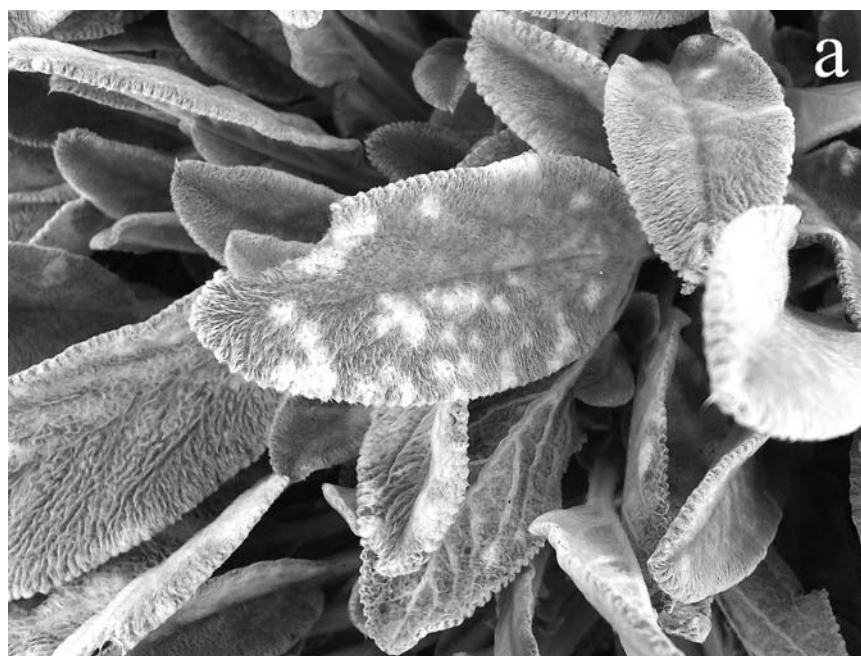


Fig. 1. Leaves of *Stachys byzantina* (a) and stem of *S. sylvatica* (b) attacked by *Neoerysiphe galeopsidis*.

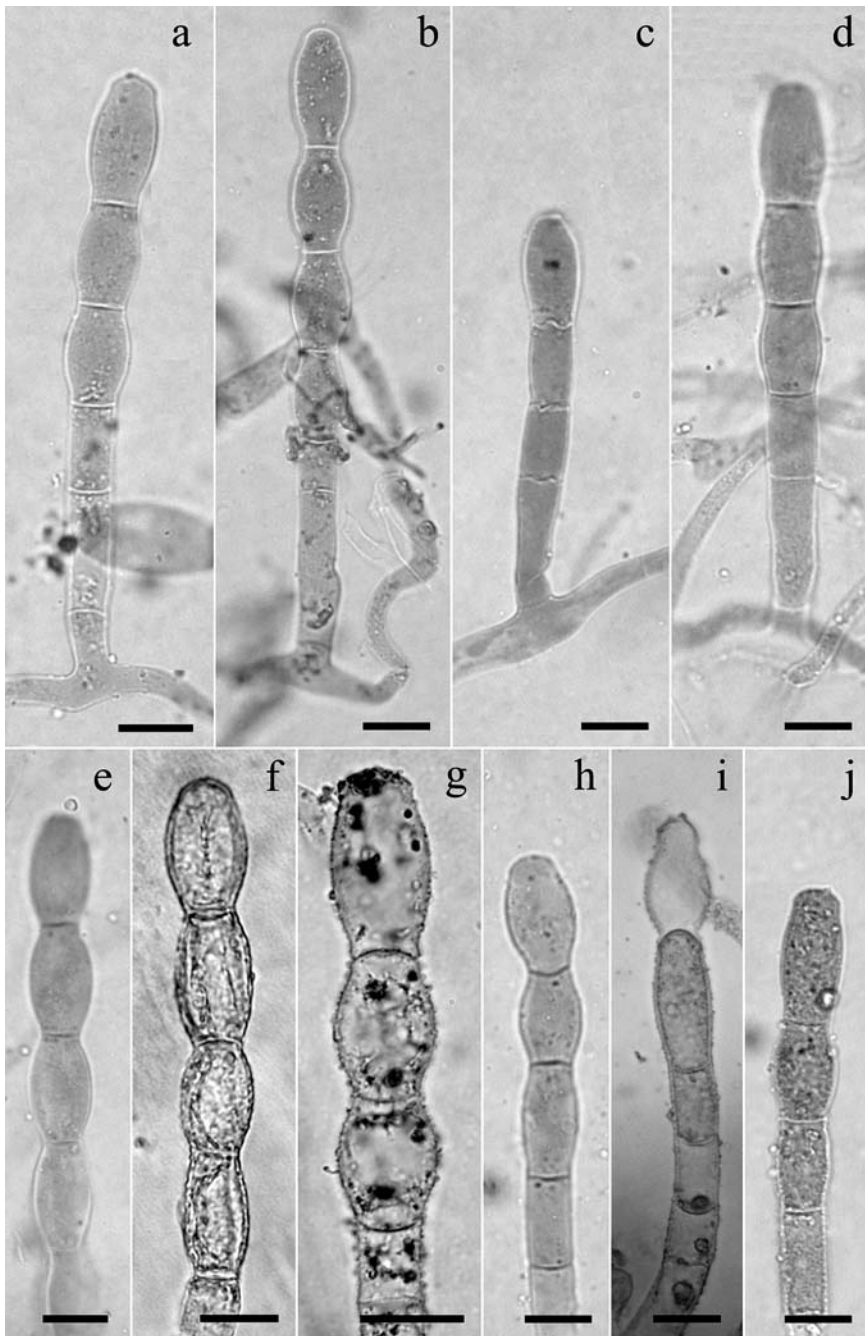


Fig. 2. *Neovrysipte galeopsidis* on *Stachys byzantina*. (a-j) Conidiophores and conidia. Scale bars = 20 μ m.

1986, leg. et det. C. Paulech (SAV); Hybe, 17 Sep 1987, leg. et det. C. Paulech (SAV); Malé Karpaty Mts., Biely kríž, 17 Oct 1987, leg. et det. C. Paulech (SAV); Malé Karpaty Mts., Biely Kameň, 17 Oct 1987, leg. et det. C. Paulech (SAV); Vysoké Tatry Mts., Nový Smokovec, 6 Sep 1989, leg. et det. C. Paulech (SAV); Belianské Tatry Mts., Tatranská kotlina, 7 Sep 1989, leg. et det. C. Paulech (SAV); Kokošovce, Prešov district, Dubová hora, 27 Sep 1990, leg. et det. C. Paulech (SAV); Pusté Pole, Sep 1990, leg. et det. C. Paulech (SAV); Považský Inovec, Modrová, 1990, leg. et det. C. Paulech (SAV); Bratislava, Železná studnička, 15 Oct 1998, leg. et det. V. Kučera (SAV).

On *Stachys* sp. – Czech Republic: Bohemia, Šárka, 19 Sep 1850, leg. et det. F.M. Opiz as *E. lamprocarpa* var. *labiatarum* f. *stachydis* (PRM 675079); Bohemia, Zlíchov, 9 Nov 1853, leg. et det. F.M. Opiz as *E. lamprocarpa* var. *labiatarum* f. *stachydis* (PRM 675067); Bohemia, Prague, Aug 1854, leg. et det. J. Kalmus as *E. lamprocarpa* var. *labiatarum* f. *stachydis* (BRNU 244739, BRNU 244749, PRM 675047). – Slovakia: Prešov [Eperies], 1854, leg. et det. B. Veselský as *E. lamprocarpa* var. *labiatarum* (BRNU 244705).

Notes

- (i) We identified the host plants (mentioned above as *Stachys* sp.) in specimens BRNU 244705, BRNU 244739, BRNU 244749, PRM 675047, PRM 675067 and PRM 675079 as *S. palustris*.
- (ii) BRNU 244704 and all collections from PRC were revised by F. Václavěk in 1983.
- (iii) As for synonyms, Wallroth (1819) replaced *Erysiphe* with *Alphitomorpha* but nowadays *Alphitomorpha* is regarded as a superfluous name (Braun et al. 2002). De Bary (1870) separated *E. galeopsisidis* from *E. lamprocarpa* because of its lobed appressoria and developing ascospores after overwintering.

Symptoms

The first symptoms appear in early May. The mycelium forms subcircular to irregular white to greyish patches on both leaf surfaces, a dense woolly mycelial felt, also present on stems (Fig. 1) and inflorescence.

Microscopic features

Mycelium amphigenous, i.e. it occurs on the upper and lower leaf surfaces. Superficial hyphae branched, septate, hyaline, 4–7 µm wide. Hyphal appressoria lobed to multilobed, single or in opposite pairs. Conidiophores erect, simple, hyaline, with straight foot-cells, 20–45 × 8–12 µm, followed by 1–3 shorter cells, and 2–4(–6) conidia in chains with sinuate edge line (Fig. 2). Conidia hyaline, unicellular, with faintly striated surface, without fibrosin bodies, 23–42 × 12–22 µm. First (primary) conidium ovoid with rounded apex and a flattened base, following (secondary) conidia mostly doliform and rarely subcylindric, producing germ tubes below the shoulder (Fig. 3). The anamorph belongs to *Oidium* subgenus *Striatooidium*.

Chasmothecia gregarious to subscattered, globose, blackish brown, 105–210 µm in diam. Appendages numerous (>25 per chasmothecium), mycelioid, septate,

hyaline, brown at the base, generally simple, rarely irregularly branched, arising from the lower half of the chasmothecium, 0.5–2 times as long as the chasmothecial diam., interlaced with each other (Fig. 4). Asci 6–12 per chasmothecium, oblong-elliptic, stalked, 45–60 × 20–30 µm. No mature ascospores were found in the collections examined.

Abundant chasmothecia of this fungus (with undifferentiated ascospores) were found on leaves and stems of *Stachys palustris*, *S. recta*, *S. sylvatica* and rarely on *S. byzantina* and *S. germanica*. No chasmothecia were produced in 12 out of 39 specimens examined on *S. sylvatica*. Based on the morphology of the fungus as well as the identity of the host plant species, the causal agent of this powdery mildew infection was identified as *Neoerysiphe galeopsidis*. Taxonomic characteristics of *N. galeopsidis* corresponding well to previously published descriptions are shown in Tab. 1.

Host range and distribution

Neoerysiphe galeopsidis has been recorded on plants from 12 families, mainly representatives of the *Lamiaceae* family: *Acinos*, *Agastache*, *Ajuga*, *Amethystea*, *Arischrada*, *Ballota*, *Betonica*, *Calamintha*, *Chaiturus*, *Chelonopsis*, *Clinopodium*, *Comanthosphace*, *Dracocephalum*, *Drepanocaryum*, *Elsholtzia*, *Eremostachys*, *Galeobdolon*, *Galeopsis*, *Glechoma*, *Lagopsis*, *Lallemantia*, *Lamium*, *Leonotis*, *Leonurus*, *Leucas*, *Lycopus*, *Marrubium*, *Melissa*, *Melittis*, *Mentha*, *Metastachydium*, *Monarda*, *Nepeta*, *Ocimum*, *Origanum*, *Panzeria*, *Phlomis*, *Physostegia*, *Plectranthus*, *Prasium*, *Prunella*, *Rosmarinus*, *Salvia*, *Satureja*, *Scutellaria*, *Sideritis*, *Stachyopsis*, *Stachys*, *Teucrium*, *Thymus*, and *Ziziphora* (Braun 1987, Braun 1995, Karis 1995, Farr et al. n. d.); according to Farr et al. (n. d.) also plants of other families: *Acanthaceae*: *Acanthus*; *Asteraceae*: *Arctotheca*, *Bidens*, *Cacalia*, *Eupatorium*, *Heliopsis*, *Ligularia*, *Senecio*, *Tagetes*; *Bignoniaceae*: *Catalpa*; *Cichoraceae*: *Crepis*; *Dipsacaceae*: *Dipsacus*; *Geraniaceae*: *Geranium*; *Malvaceae*: *Althaea*; *Pedaliaceae*: *Sesamum*; *Poaceae*: *Triticum*; *Scrophulariaceae*: *Calceolaria*, *Chelone*; *Verbenaceae*: *Verbena*. However, according to the current taxonomy, records on composites pertain to *Neoerysiphe cumminsiana*, and those on *Geranium* and *Chelone* spp. to *N. geranii* and *N. chelones*, respectively. *Althaea rosea* was recently recorded as a host in China by Liu et al. (2006), and collections on *Acanthus spinosus* and *Catalpa* spp. were recorded and described in Cook et al. (2006a, b). Records from hosts of other families are doubtful and not confirmed. The fungus has an extensive distribution range. It occurs all over Europe, Asia, Africa, North and South America, and New Zealand (Grigaliunaite 1997).

Tab. 2 provides an up-to-date list of all species and varieties of the genus *Stachys* attacked by *N. galeopsidis* reported in the world based on data in the literature.

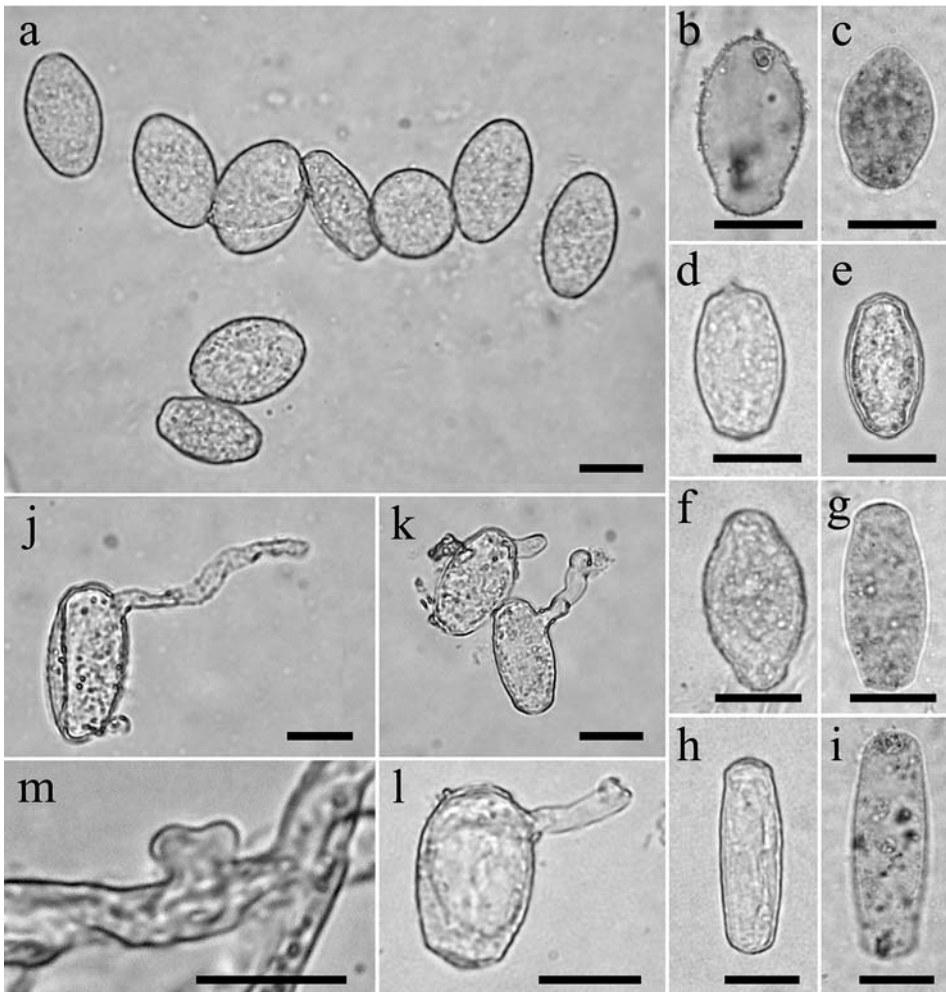


Fig. 3. *Neerysiphe galeopsidis* on *Stachys byzantina*. (a) Group of conidia, (b–c) ovoid conidia, (d–g) doliform conidia, (h–i) subcylindrical conidia, (j–l) germinated conidia, (m) hyphal appressorium. Scale bars = 15 µm.

In addition to *N. galeopsidis*, other powdery mildew species on *Stachys* have been recorded: *Golovinomyces cichoracearum* (DC.) V. P. Heluta (syn. *Erysiphe cichoracearum* DC.) on *S. arvensis*, *S. bullata*, *S. floridana*, *S. hirta*, *S. palustris*; *Podosphaera macularis* (Wallr.) U. Braun & S. Takam. [syns. *Sphaerotheca macularis* (Wallr.) Lind, *Sphaerotheca humuli* (DC.) Burrill] on *S. bullata*, *S. mexicana*; and *Leveillula taurica* (Lév.) G. Arnaud on *S. parviflora* (Amano 1986, Farr et al. n. d.). Records of *G. cichoracearum* probably belong to *G. biocellatus* (Ehrenb.) V. P. Heluta, another common powdery mildew on hosts of the

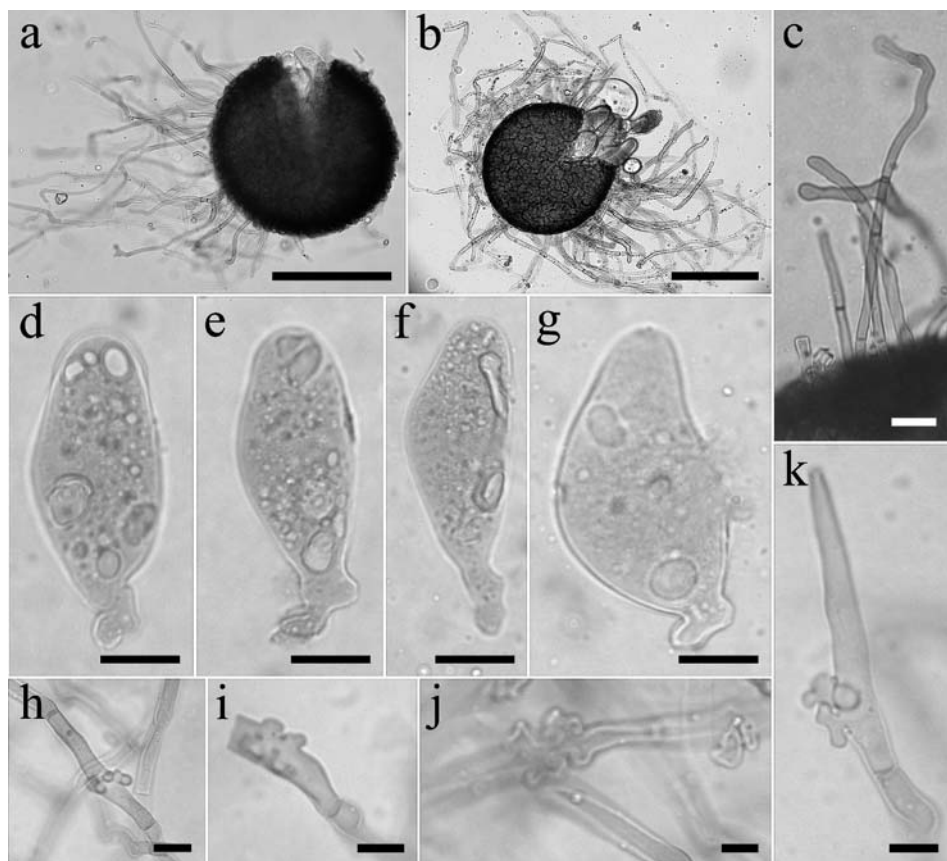


Fig. 4. *Neoerysiphe galeopsidis* on *Stachys sylvatica*. (a, b) Chasmothecia, (c) appendages, (d–g) immature asci, (h–k) hyphal appressoria. Scale bars = 100 µm (a, b), 20 µm (c), 15 µm (d–g), 10 µm (h–k).

Lamiaceae, previously referred to as *Erysiphe cichoracearum*. The occurrence of *P. macularis* on *Stachys* is very doubtful and not confirmed. In case chasmothecia are not produced, *N. galeopsidis* is easily distinguishable from *G. biocellatus*, also a species with a chain-forming anamorph, by having lobed appressoria (almost indistinct to nipple-shaped in the latter species) and the presence of longitudinal linear ridges on the surface of the conidia visible especially under SEM (Gorter 1987).

A record of *N. galeopsidis* on *Stachys glutinosa* in the former Czechoslovakia published by Amano (1986) and Braun (1995) is doubtful, because *S. glutinosa* grows neither in Slovakia (Bertová and Goliašová 1993) nor in the Czech Republic (Slavík 2000). Thus no herbarium specimen of this fungus on *S. glutinosa* is deposited in Slovak and Czech herbaria. *S. glutinosa* is native to the French island of Corse and the Italian islands of Sardegna and Capraia (Ball 1972).

Tab. 2. Species of the genus *Stachys* attacked by *Neoerysiphe galeopsisidis* in the world.

Geographic region	<i>Stachys</i>	References	
Europe	Austria	<i>alpina, germanica</i> *, <i>officinalis, palustris, recta</i>	Braun (1995), Farr et al. (n.d.)
	Belarus	<i>palustris, sylvatica</i>	Girilovich et al. (2005)
	Bulgaria	<i>alpina, germanica, leucoglossa, officinalis, palustris, recta, sylvatica</i>	Fakirova (1991), Braun (1995)
	Czech Republic	<i>annua, byzantina (lanata), palustris, recta, sylvatica</i>	Klika (1923), Amano (1986)
	Denmark	× <i>ambigua, byzantina (lanata), palustris, sylvatica</i>	Junell (1967), Braun (1995)
	England	<i>arvensis, byzantina (lanata), germanica, palustris, sylvatica</i>	Amano (1986), Braun (1995)
	Estonia	<i>byzantina (lanata), coccinea, palustris</i> *, <i>sylvatica</i>	Amano (1986), Braun (1995), Farr et al. (n.d.)
	Finland	<i>palustris, sylvatica</i>	Braun (1995)
	France	<i>alopeuros, alpina, annua, arvensis, germanica, glutinosa, marrubifolia, palustris, recta, sylvatica</i>	Braun (1995)
	Germany	<i>alpina, ×ambigua, annua</i> *, <i>byzantina (lanata), germanica, officinalis, palustris, recta, sylvatica</i>	Braun (1995), Farr et al. (n.d.)
	Hungary	<i>germanica, officinalis, palustris, recta, sylvatica</i>	Sz. Nagy and Kiss (2006)
	Italy	<i>alpina</i> *, <i>arvensis, germanica, glutinosa, marrubifolia, officinalis, palustris, recta, sylvatica</i> *, <i>uliginosus</i>	Braun (1995), Farr et al. (n.d.)
	Lithuania	<i>byzantina (lanata), melissaefolia, officinalis, palustris, sylvatica</i>	Amano (1986), Braun (1995), Grigaliunaite (1997)
	Netherlands	<i>palustris</i>	Braun (1995)
	Norway	<i>sylvatica</i>	Braun (1995)
	Poland	<i>byzantina (lanata), germanica, officinalis, palustris, sylvatica</i>	Salata (1985)
	Portugal	<i>arvensis, germanica ssp. lusitanica, hirta</i>	Braun (1995)
	Romania	<i>alpina, annua, byzantina (lanata), germanica, iberica, nitens, officinalis, palustris, recta, sylvatica</i>	Sandu-Ville (1967), Amano (1986), Braun (1995)
	Russia (European part)	<i>officinalis, palustris</i> *, <i>recta, sylvatica</i>	Gorlenko (1983), Amano (1986), Farr et al. (n.d.)
	Slovakia	<i>alpina, arvensis, byzantina (lanata), germanica, palustris, recta, sylvatica</i>	Amano (1986), Paulech (1995)
Spain	<i>alpina, arvensis, heraclea, hirta, palustris</i>	Braun (1995)	
Sweden	<i>arvensis, palustris, sylvatica</i>	Junell (1967), Braun (1995)	
Switzerland	<i>alpina, arvensis, byzantina, officinalis, palustris, recta, recta ssp. labiosa, sylvatica, tymphaea</i>	Braun (1995), Bolay (2005)	
Turkey	<i>alpina, arvensis</i>	Braun (1995)	
Ukraine	<i>cretica, germanica, krynkensis, palustris, sylvatica</i>	Heluta (1989)	
former Yugoslavia	<i>alpina, germanica, palustris, sendtneri</i>	Braun (1995)	

Tab. 2. – Continued.

Asia	Armenia, Azerbaijan, Russian Far East, Georgia, Kazakhstan, Kirgizia, Siberia, Uzbekistan	<i>aetherocalyx</i> , <i>baicalensis</i> , <i>balansae</i> , <i>betonicifolia</i> , <i>byzantina</i> (<i>lanata</i>), <i>grandiflora</i> , <i>hissarica</i> , <i>iberica</i> , <i>palustris</i> *, <i>sylvatica</i> , <i>turkestanica</i>	Amano (1986), Farr et al. (n.d.)
	China	<i>baicalensis</i>	Zheng and Chen (1981)
	India	<i>sylvatica</i>	Amano (1986)
	Iran	<i>arvensis</i>	Amano (1986)
	Iraq	sp.	Amano (1986)
	Israel	<i>distans</i>	Voytyuk et al. (2006)
	Japan	<i>aspera</i> var. <i>japonica</i> , <i>baicalensis</i> *, <i>japonica</i> var. <i>intermedia</i> , <i>japonica</i> var. <i>villosa</i>	Salmon (1900), Nomura (1997), Farr et al. (n.d.)
	Korea	<i>riederi</i> var. <i>japonica</i>	Shin (2000)
	Africa	Morocco	<i>annua</i>
North America	Canada	<i>ciliata</i> , <i>cooleyae</i> , <i>mexicana</i> , <i>palustris</i> , <i>palustris</i> var. <i>pilosa</i>	Amano (1986), Farr et al. (n.d.)
	USA	<i>aspera</i> , <i>aspera</i> var. <i>glabra</i> , <i>aspera</i> var. <i>japonica</i> , <i>bullata</i> , <i>byzantina</i> , <i>chamissonis</i> , <i>ciliata</i> , <i>ciliata</i> var. <i>pubens</i> , <i>drummondii</i> , <i>emersonii</i> , <i>floridana</i> , <i>glabra</i> *, <i>mexicana</i> , <i>palustris</i> , <i>palustris</i> var. <i>pilosa</i> , <i>riddellii</i> , <i>rigida</i> , <i>tenuifolia</i>	Amano (1986), Glawe and Koike (2007), Farr et al. (n.d.)

*records of herbarium specimens in the database of the U.S. National Fungus Collections (BPI)

Note: The currently correct name of *S. officinalis* is *Betonica officinalis* (*Lamiaceae*).

N. galeopsidis is the only powdery mildew on *S. byzantina* (syn. *S. lanata*) reported in world literature. Records of *N. galeopsidis* on *S. byzantina* are known from Armenia, Denmark, England, Estonia (Amano 1986), Germany (Braun 1995), Lithuania (Grigaliunaite 1997), Poland (Sałata 1985), Romania (Sandu-Ville 1967), Switzerland (Bolay 2005) and the USA (Glawe and Koike 2007). *Oidium* sp. recorded on this host plant from Portugal (Amano 1986) probably refers to the anamorph of *N. galeopsidis*. The source for Amano's (1986) record of *N. galeopsidis* on *S. byzantina* from the former Czechoslovakia could not be traced back, so it remains unclear whether it was a genuine record from the territory of the current Czech Republic or from Slovakia. Six *Stachys* species (*S. alpina*, *S. arvensis*, *S. germanica*, *S. palustris*, *S. recta* and *S. sylvatica*) are listed as host plants of *N. galeopsidis* in Paulech's (1995) monograph of Slovak powdery mildew fungi. Although *S. byzantina* is not included, a herbarium specimen collected by C. Paulech in 1965 is deposited in SAV. Our record of *N. galeopsidis* on *S. byzantina* collected in 2007 and 2008 again confirmed that *S. byzantina* is a true host plant for this powdery mildew species in Slovakia.

Paulech (1995) recorded *S. alpina*, *S. arvensis* and *S. recta* as hosts of *N. galeopsidis*, but he did not deposit any herbarium specimens that could confirm this. There are no records of *N. galeopsidis* on *S. annua* and hybrids (*S. ×ambigua*, *S. ×digenea*, *S. ×medebachensis*) from Slovakia.

Klika (1923) summarised the powdery mildew fungi recorded in the Czech Republic. He listed *N. galeopsisidis* on three species of the genus *Stachys* (*S. annua*, *S. recta* and *S. sylvatica*). No literature data on the occurrence of the fungus examined on other *Stachys* species in the Czech Republic were found. Another monographic work on Czech powdery mildews has not been published since 1923.

Although Klika (1923) recorded *N. galeopsisidis* on *S. annua* in Bohemia (Czech Republic), its herbarium specimen is not deposited in any Czech herbarium. Hitherto *N. galeopsisidis* has not been recorded on *S. alpina*, *S. arvensis*, *S. germanica*, and hybrids (*S. ×ambigua*, *S. ×digenea*) from the Czech Republic. The herbarium specimen PRM 675080 of this fungus on *S. byzantina* collected in 1904, on *S. palustris* (three specimens deposited in PRC) and on *Stachys* sp. (five specimens identified as *S. palustris*: BRNU 244739, BRNU 244749, PRM 675047, PRM 675067, PRM 675079) collected between 1850 and 1859 represent yet unpublished records from the Czech Republic. Thus *S. byzantina* and *S. palustris* are also host plants of *N. galeopsisidis* in the Czech Republic.

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