Ecological interactions between invasive alien vascular plants, and essential saprophytic and parasitic fungi in Bulgaria

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Abstract. The genus *Bricookea* is recorded on *Juncus tenuis* as new to the Bulgarian mycota. Concise information is presented about the interaction between eight invasive alien higher plants in the Bulgarian flora and nine saprophytic ascomycetous fungi (mostly with a known anamorphic stage) and one rust growing on living or dead plant organs (floral parts, leaves, twigs). The types of ecological interactions are pointed out in the host/fungus complex used additionally in biologic control over the alien species expansion across the country. An indication of trophic state of the fungi is defined.

Key words: *Bricookea*, parasitic, saprophytic fungi, invasive plants, ecological interactions

Introduction

Petrova & Vladimirov (2001) have presented relatively recent information on alien plant species in the Bulgarian flora, such as *Oenothera biennis* L., *Galinsoga parviflora* Grev. (both introduced from North America), etc., based on known literature data and authors' observations and conclusions. They have reported 80 % natural species (incl. apophytes), 14 % antropophytes and 6 % doubtfully native and probably antropophytes for the Bulgarian flora.

Recently, information about the distribution of 47 new alien taxa towards a total of 560 alien plant species in Bulgaria was announced (Petrova & al. 2012). No information about the interaction between the alien invasive higher plants and fungi growing on living or dead plant organs (floral parts, leaves, twigs) has been specially provided for Bulgaria. Zheng & al. (2006) suggested how to handle the interactions between insects, fungi and invasive higher plants with Asian origin in the USA. It is advisable to study such ecological interactions in the host/fungus complex (e.g. saprophytism, parasitism), which may serve as a starting point for understanding the biological control over the large-scale alien species expansion across Bulgaria.

Material and methods

This study is based on the collections of anamorph/teleomorph stages of the sac fungi and the rust *Puccinia xanthii* recently collected by the author, as well as of several older speciments (deposited by other mycologists from the former Institute of Botany) in the Mycological Collection of the Institute of Biodiversity and Ecosystem Research (SOMF). Collections were made following the standard methods for collection of fungi (Hawksworth 1974).

Semipermanent microscope slides were prepared with Lactophenol with the aid of Cotton Blue or stained only in distilled water (Stoykov 2012). The microphotographs were taken on Boeco T/SP-180 microscope, using Canon PS A460 digital camera. Measurements of

the perithecia, asci, ascospores, conidia, and teliospores and pedicels were taken with the help of specialized software for digital images Carnoy 2.0 (©2001 Peter Schols) and are presented mostly in the form: (min-) mean±1σ (-max), number (*n*), length/width ratio (L/w). Where known, the type of trophic connections is given.

Abbreviations of the authors of fungal names follow Kirk & Ansell (2004).

Results and discussion

During the examination of specimens from the Mycological Collection of the Institute of Biodiversity and Ecosystem Research (SOMF) and materials collected during field trips, 10 fungal species (*Arthrocladiella mougeotii, Bricookea sepalorum, Cucurbitaria elongata, Diaporthe oncostoma*, *Erysiphe cichoracearum*, *E. pseudacaciae, Massaria anomia*, *Mycosphaerella polygoni-cuspidati*, *Puccinia xanthii* and *Sawadaea bicornis*) on eight species of alien invasive higher plants (*Acer negundo*, *Helianthus tuberosus, Falopia japonica, Juncus tenuis*, *Lycium barbarum*, *Robinia pseudoacacia*, *Xanthium italicum, X. strumarium*) were selected. For each one, a concise note on the type of interaction (parasite, saprophyte) and anamorph/teleomorph connection is given, when possible. All studied materials fit well into the groups of trees/wood saprobionts and weak/strong parasites on leaves and twigs.

Arthrocladiella mougeotii (Lév.) Vassilkov, Bot. Mater. Otd. Sporov. Rast. Bot. Inst. Komarova Akad. Nauk S.S.S.R. 16: 112 (1963)

Powdery coating on leaves and twigs, at first whitish, later grayish to yellowish. **Conidia** broad ellipsoid to oblong cylindric, 25–26.5 (–30) × 12.5–15 (–17.5) µm, *n*=25.

Specimen examined: Living leaves of *Lycium barbarum* L. Sofia Region: Sofia, 10.08.2009, coll. *D.Y. Stoykov* (SOMF 29421); ibid., 28.09.2011, *D.Y. Stoykov* (SOMF 29419) & 1.11.2011, *D.Y. Stoykov* (SOMF 29336).

Note. Obligate parasite.

Bricookea M.E. Barr, Mycotaxon 15: 346 (1982)

Ascocarps black, formed in locules, globose-depressed, subepidermal, single. **Asci** in basal hymenium, oblong, bitunicate. **Pseudoparaphyses** narrow cellular. **Ascospores** hyaline, oblong to obovoid, septate.

Bricookea sepalorum (Vleugel) M.E. Barr, Mycotaxon 15: 346 (1982) Figs 1–2

Stromatic areas on rachises of inflorescences. **Ascocarps** single, subepidermal, subglobose, 150–160 µm in diam. **Asci** 55–75 × 12–14 µm, oblong, bitunicate. **Ascospores** (20.5–) 22.47±1.6 (–25.7) ×(5.5–) 5.77±0.3 (–6.5) µm, *n*=25, L/w (3.6–4.3), hyaline, oblong to narrowly ovoid, 3-septate, slightly constricted at the middle septum, biseriate in the ascus.

Specimen examined: Dry inflorescences of *Juncus tenuis* L. Sofia region: Sofia, in the yard of 27th Akad. G. Karaslavov High School, 01.10.2011, coll. *D.Y. Stoykov* (SOMF 29418).

Note. Saprobiont on dry inflorescences.

Juncus tenuis L. is the first record for *Bricookea sepalorum* known in Europe only on *Juncus filiformis* L. and *J. trifidus* L. (Holm 1957). In North America it is reported on *Juncus parryi* Engelmann (Barr 1982). In 1928, Lind (after Barr 1982) reported also *Luzula arctica* Blytt as substratum of *B. sepalorum* in Europe (Spitzbergen).

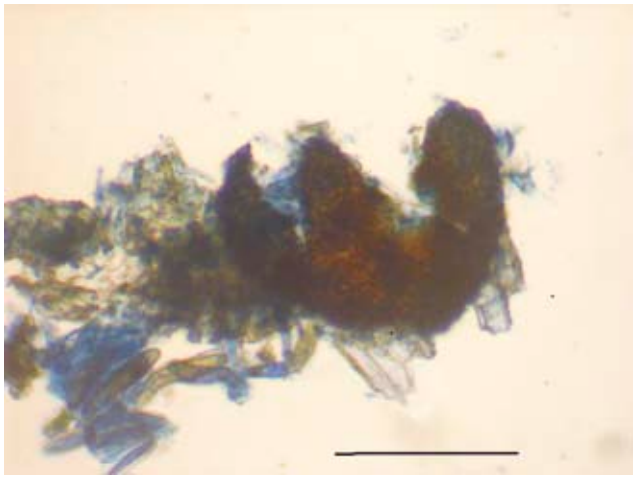

Fig. 1. Ascocarp of *Bricookea sepalorum*. Scale bar = 100 µm.

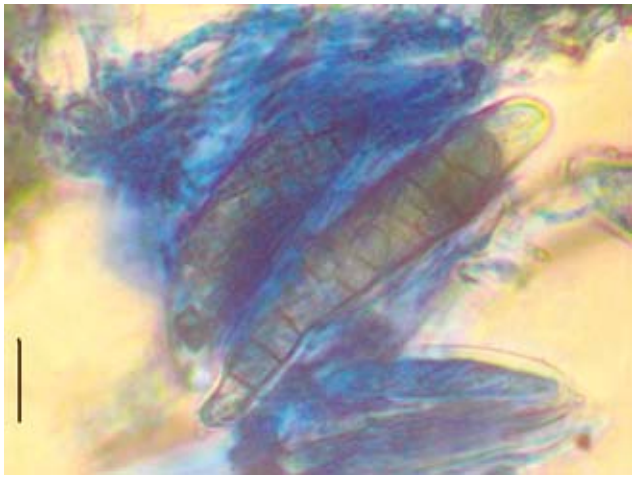

Fig. 2. Asci with spores of *B. sepalorum*. Scale bar = 15 µm.

Cucurbitaria elongata (Fr.) Grev., Scott. Crypt. Fl. 4 (37/48): pl. 195 (1826)

Ascocarps 400–430 μm in diam. **Asci** 126 × 13 μm. **Ascospores** (16.6–) 8.7±2.0 (–22.6) × (7.0–) 8.1±0.6 (–9.2) μm, *n*=50, L/w (2–3), measured in asci.

Specimens examined: Dead twigs of *Robinia pseudoacacia* L. Sofia region: Romcha vill., 24.09.1973, coll. & det. *V. Fakirova* (SOMF 13762); Kokalyane vill., 04.03.1979, coll. & det. *V. Fakirova* (SOMF 20591); Lokorsko vill., 02.12.1987, coll. & det. *V. Fakirova* (SOMF 20662); Mt Sredna Gora (*Western*): Mt Lozenska, 28.11.1976, coll. & det. *V. Fakirov*a (SOMF 13722); Dolni Lozen vill., 16.04.1980, coll. & det. *V. Fakirova* (SOMF 20592); German vill., 04.03.1979, coll. & det. *V. Fakirova* (SOMF 20734); Thracian Lowland: near Popovitsa vill., 10.06.1977, coll. & det. *V. Fakirova* (SOMF 13807).

Note. Saprobiont on dry twigs. Weak parasite as anamorph. Recently, the fungus is recorded as anamorph on dry twigs by the author in the Balkan Range (near Platchkovtsi village) and Thracian Lowland (Plovdiv).

Diaporthe oncostoma (Duby) Fuckel, Jahrb. Nassauischen Vereins Naturk. 23/24: 205 (1870) as Phomopsis oncostoma (Thüm.) Höhn., Sber. Akad. Wiss. Wien, Math.-Naturw. Kl., Abt. 1, 115: 681 (1906)

Anamorph. **Pycnidia** single, often subepidermal, scattered. α- **conidia** (7.2–) 9.6±1.0 (–12.1) × (2–) 3.11±0.3 (–4.5) μm, *n*=275, L/w (2–5), hyaline, elongate ellipsoid, guttulate. b- **conidia** 15.5–21 × 1.2–1.75 μm, hyaline, elongate, slightly curved at the edge.

Specimens examined: Dead twigs of *Robinia pseudoacacia* L. Black Sea Coast: Arkutino Reserve, 15.09.2011, coll. *D.Y. Stoykov* (SOMF 29360, SOMF 29403); Balkan Range: Sinite Skali Locality, 21.06.2012, coll. *D.Y. Stoykov* (SOMF 29413); Sofia region: Sofia, 06.05.2011, coll. *D.Y. Stoykov* (SOMF 29414).

Note. Weak parasite. Causative agent of bark necrosis and stem canker. Teleomorph is recorded on dead twigs (Stoykov 2012).

Erysiphe cichoracearum DC., in Lamarck & de Candolle, Fl. Franç. 2: 274 (1805)

Teleomorph: **Ascocarps** *ca* 150 μm in diam. **Appendages** 4.5–6.5 μm wide. **Asci** (45–) 51–61 × (16–) 25–33 μm. **Ascospores** (20–) 24–32 × (13–) 14.5–16 μm. Anamorph (*Oidium*): **Conidia** 22–35 (–40) × (12–) 15–18 μm.

Specimens examined: Leaves of: *Helianthus tuberosus* L. Sofia region: Sofia, 06.10.2011, coll. *D.Y. Stoykov* (29415); Sofia, near Pliska Hotel, 26.09.2011, coll. *D.Y. Stoykov* (SOMF 29416); *Solidago virgaurea* L. Sofia region: Sofia, Faculty of Biology, coll. *D.Y. Stoykov*, 28.10.2011 (SOMF 29337), 01.10.2011, coll. *D.Y. Stoykov* (SOMF 29417).

Note. Obligate parasite on leaves, petioles and stems.

Erysiphe pseudacaciae (P.D. Marchenko) U. Braun & S. Takam., Schlechtendalia 4: 12 (2000)

Ascocarps 80–85 μm in diam. **Peridial cells** 8–13.5 μm; appendages 5.5–7 μm wide. Asci 45–55 × 25–28(–30) μm. **Ascospores** 9–12 × 7–8 μm, ovoid.

Specimens examined: Leaves and twigs of *Robinia pseudoacacia* L. Black Sea Coast: near river Kamchiya, Longoz Hotel, 09.10.2009 (in stat. conid.), coll. *D.Y. Stoykov*; Mt Belasitsa, near Konguro Chalet, 25.09.2009, coll. *D.Y. Stoykov* (SOMF 27556).

Note. Obligate parasite on leaves and young twigs.

Massaria anomia (Fr. : Fr.) Petr., Ann. Mycol. 21: 114 (1923)

Ascopores (41–) 48.1±4.0 (–57.5) × (12.5–) 15.4±1.6 (–18) μm, *n*=50, L/w (2.75–3.7), uniseriate in the ascus.

Specimens examined: Dry twigs of *Robinia pseudoacacia* L. Vitosha region: Mt Plana, 08.05.1975, coll. & det. *V. Fakirova* (SOMF 13773); Rila Mts: above Rila Monastery, 19.10.1973, coll. & det. *V. Fakirova* (SOMF 13784); Thracian Lowland: Plovdiv distr., Popovitsa vill., 10.06.1977, coll. & det. *V. Fakirova* (SOMF 13794).

Note. Saprobiont on dead twigs.

Mycosphaerella polygoni-cuspidati Hara, Byotyugai-Zasshi 5: 617 (1918), as anamorph

Specimen examined: On dry leaves of *Falopia japonica* L. Sofia region: Sofia, near Arena Zapad Cinema, 11.07.2010, coll. *D.Y. Stoykov* (SOMF 27622).

Note. The teleomorph is saprobiont on dead leaves, while the anamorph is a parasite on living leaves. According to Djeddour & al. (2008), this fungus is hemibiotrophic pathogen, causative agent of serious damages and ubiquitous leaf spot in Japan, supposedly presented in several known morphotypes and/or pathotypes.

Puccinia xanthii Schwein., Schr. Naturf. Ges. Leipzig 1: 73 (1822)

Teliospores brownish, two-celled (32–) 41.3 ±8.3 (–56) × (12–) 14.6 ± 2.1 (–18) μm, *n*=50, L/w (2–3.6). **Pedicel** 14.5–33 × 5–9 μm.

Specimens examined: On living leaves of *Xanthium strumarium* L. Thracian Lowland: near Stara Zagora, 14.09.2011, coll. *D.Y. Stoykov* (SOMF 29420); *X. italicum* Moretti. Forebalkan: Gabrovo distr., Sennik vill., 20.10.1963, coll. & det. *C. Hinkova* (SOMF 10535).

Note. Strong obligate parasite. Plant pathogen, causing microcyclic rust on the *Xanthium* species (Morin & al. 1992). Considered as appropriate for biologic control in the field. Inoculations on the leaves of *P. xanthii*, made as experiments causing fungal attacks, have shortened the plant life cycle and have reduced the plant growth rate and productivity (Julien & al. 1979). Recently reported on *Xanthium italicum* in Hungary (Harcz & Kövics 2003).

Sawadaea bicornis (Wallr. : Fr.) Homma, Coll. Agric., Hokkaido Imp. Univ. 38: 371 (1937), studied here as Oidium.

White powdery coating formed on young leaves and petioles, visible during spring and earlier summer months. **Macroconidia** (17–) 23.85±2.3 (–30) × (12–) 14.05±0.9 (–16.5) µm, *n*=50, L/w (1.2–2.2).

Specimens examined: On leaves of *Acer negundo* L. Forebalkan: Teteven distr., Yablanitsa town, 09.08.2009, coll. *D.Y. Stoykov* (SOMF 27534); Golyama Zhelyazna vill., 07.06.2012, coll. *D.Y. Stoykov* (SOMF 29361); Balkan Range: Tryavna town, 18.06.2012, coll. *D.Y. Stoykov* (SOMF 24910); Sofia region: Sofia, 26.10.1980, coll. & det. *V. Fakirova* (SOMF 16255); Sofia, 04.06.2010, coll. *D.Y. Stoykov* (SOMF 27619, SOMF 27620); Thracian Lowland: Plovdiv, Avksentiy Velishki Str., 21 & 22.05.2012, coll. *D.Y. Stoykov* (SOMF 29407 & SOMF 29408).

Note. Obligate parasite on leaves. All specimens are recorded in conidial state.

Lucero & al. (2006) reported strong defoliation of *Acer negundo* trees during 2001–2002 in Argentina, caused by the anamorphic stage of *Sawadaea bicornis (*Wallr.) Miyabe powdery mildew, named *Oidium*. The fungus appeared as formations of chlorotic spots, covered with whitish powdery coating, which later necrotised and pierced the leaf tissue. They reported the size of conidia about 17–36 × 11–17 µm. *Sawadaea bicornis* in *Oidium* state is distributed in Europe, Africa, Asia, North & South America (after Lucero & al. 2006).

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