DIPLODIA AND *DOTHIORELLA* SPECIES (BOTRYOSPHAERIACEAE: ASCOMYCOTA) FROM UZBEKISTAN

Yusufjon Gafforov

Laboratory of Mycology
Institute of Botany
Academy of Sciences of the Republic of Uzbekistan
232 Bogishamol St., Tashkent 100053, UZBEKISTAN
yugafforov@yahoo.com

Davron Rakhimov

Center of Remote Sensing and GIS technologies
8 Xalqobod St.
Tashkent 100084, UZBEKISTAN

ABSTRACT

The first and really only significant data on Botryosphaeriaceae mycobiota from the arid and semi-arid region of Uzbekistan are presented. This study reports 27 species of *Diplodia*-like fungi (Botryosphaeriaceae) from the study area; nine species are newly reported for Uzbekistan. Most species of *Diplodia* and *Dothiorella* were found on host plants of the families Amaranthaceae, Asteraceae, Fabaceae, Lamiaceae, Rosaceae, and Salicaceae. An annotated list of *Diplodia*-like species is given, including their host plant species, notes on taxonomy, ecology, and geographical distributions. A geo-referenced distribution map is included.

Key Words: Central Asia, Uzbekistan, Dothideomycetes, host plants, new records

RESUMEN

Se presenta el primer y único dato significante de la micobiota de Botryosphaeriaceae de la región árida y semiárida de Uzbekistán. Este estudio aporta 27 especies de hongos semejantes a *Diplodia* (Botryosphaeriaceae) del área de estudio; nueve especies son citas nuevas para Uzbekistán. La mayoría de las especies de *Diplodia* y *Dothiorella* se encuentras en plantas huéspedes de las familias Amaranthaceae, Asteraceae, Fabaceae, Lamiaceae, Rosaceae, y Salicaceae. Se da una lista comentada de especies semejantes a *Diplodia*, incluyendo sus especies de planta huéspedes, notas de su taxonomía, ecología, y distribuciones geográficas. Se incluye un mapa de distribución georreferenciado.

INTRODUCTION

The Botryosphaeriaceae comprise one of largest groups of ascomycetous fungi (Crous et al. 2006; Liu et al. 2012: Slippers et al. 2013; Dissanayake et al. 2016) with more than 1000 species (Kirk et al. 2008). These fungi cause stem cankers and die-back disease of various plants worldwide (Slippers & Wingfield 2007). *Diplodia*-like fungi (*Botryosphaeriaceae*) reproduce both sexually and asexually and have dark-colored spores (Crous et al. 2006; Phillips et al. 2008). These fungi are known as endophytes, saprophytes, and are pathogens of mainly woody plants (Slippers & Wingfield 2007). Some species are known as serious disease agents of ecologically and economically important coniferous and deciduous woody plants including ornamental trees and shrubs (Waterman 1943; Brown-Rytlewski & McManus 2000; Alves et al. 2004). The occurrence of *Diplodia*-like fungi is particularly high in Central Asia due to the arid and semi-arid climate conditions of the region and where plant pathogenic fungi often represent the decisive factor in the existence of shelterbelts. However, little is known about the occurrence of these fungi in Central Asia. This region is one of the most diverse regions in the world with respect to both fauna and flora and has many relict and endangered species. There have also been a few studies on pycnidial fungi of flowering plants in different parts of Uzbekistan (Kirgizbaeva et al. 1987; Salieva & Gafforov 2001, 2002; Gafforov 2002, 2005, 2016, 2017), but there is still no comprehensive study or even a preliminary survey of the total number of these fungi and plant pathogenic fungi in general, for Central Asia. The Botryosphaeriaceae of Uzbekistan has had little interest and research attention. As a result, more research is needed on the taxonomic status and distribution of *Diplodia*-like fungal species and their impact on plants.

Therefore, the purpose of this study was to assess the diversity and distribution of the *Diplodia*-like species associated with flowering plants from the arid and semi-arid region of Uzbekistan.

MATERIALS AND METHODS

Study area.—Uzbekistan is located in the center of the Eurasian continent and its varying landscapes of high mountain ranges, wide steppes, deserts and riparian wetlands have resulted in a diversity of habitats (Fig. 1). Almost 85% of Uzbekistan's territory is occupied by deserts or semi-deserts, including the largest desert in Central Asia, the Qizilqum. Extensive Tien-Shan and Hissar-Alai mountain systems flank the deserts in the eastern and southeastern part of the country and occupy 15% of the territory. This area is characterized by diverse ecosystems, including vast plains, different kinds of deserts, mountain steppes, mountain forests and alpine meadows, riparian gallery forests in the desert river valleys, wetlands, and oases. The basic vegetation pattern consists of trees and shrubs alternating with steppe and meadow areas or bare rocks. Much of the forest area is dominated by saxaul (*Haloxylon* spp.) and other shrubs particularly in desert and semi-desert areas of Uzbekistan. Mountainous areas consist of relict deciduous and coniferous forests that contain juniper and walnut mixed with wild apple, apricot, plum, and other fruit and nut tree species. The climate is decidedly continental, arid and semi-arid with low annual precipitation between 100 and 200 mm, cloudless, hot, dry summers with sunshine, and cold winters (Klein Tank et al. 2006; Lioubimtseva 2009).

Field surveys and morphological studies.—Samples were collected from woody and herbaceous plants growing in arid and semi-arid areas of Uzbekistan. Samples were placed in paper bags, dried at room temperature and deposited in Tashkent Mycological Herbarium (TASM), Institute of Botany, Academy of Sciences of Uzbekistan, Tashkent. Morphological observations were made using slide stained preparations and a Motic BA410 light microscope in the Mycology Laboratory of the Institute of Botany. Moreover, numerous herbarium specimens of *Diplodia*-like fungi deposited in TASM were re-examined. The *Diplodia*-like specimens were identified using relevant literature (Sutton 1980; Merezhko 1980; Melnik 1997; Kirgizbaeva et al. 1997; DeWet et al. 2003; Crous et al. 2006; Phillips et al. 2008). Flowering plant species were identified from Skorcov 1972; Paxamova 1976; Pratov 1976; Fisyun 1976; Klyuekov and Pimenov 1981 and *Flora of Uzbekistan* (1953–1962). The taxonomic and nomenclatural concepts for *Diplodia*-like fungal species mostly follow Mycobank (2016) and Index Fungorum (2016). Host plant names follow The Plant List (2013).

Data compilation for GIS map.—Distribution maps of *Diplodia*-like species were produced using Google Earth georeferencing. Distribution was assessed from collections, specimens deposited in the TASM Herbarium. Species descriptions are from observations of fresh specimens from this study and relevant literature. Latitude, longitude, and altitude data were compiled. A WGS84 Geographic Coordinate System imported the data into ArcGIS 9.3 and converted to a distribution point map (Fig. 1).

RESULTS AND DISCUSSION

Taxonomy and morphology

Morphological characteristic of the *Diplodia*-like fungi (Fig. 2): pycnidia spherical, ellipsoid, depressed or flattened, with papillary stoma, immersed or semi-submersed in substrate/hosts. Pycnidia clustered or solitary, scattered, sometimes arranged in concentric rows, covered with epidermis, and then less protruding from cracks, subcutaneous to erumpent or superficial, partially erumpent when mature, brown to black. Conidiophores simple, hyaline, short slightly elongated, occasionally septate, rarely branched, cylindrical, arising from the cells lining the pycnidial cavity, thin. Conidia 1- or rarely 2-septate, initially hyaline, olive, brown to dark brown, thick-walled, oblong, cylindrical, fusiform, ellipsoid, ovoid, sometimes tapered, almost colorless. Young conidia hyaline and one-celled. Mature conidia symmetrical or sometime slight asymmetrical, constricted at the septum; smooth, striated or granulose.

The following section contains the list of the *Diplodia*-like fungi found in this study. New records are marked with an asterisk (*). *Diplodia*-like species are described morphologically (or a source with description is cited) with an emphasis on spore characteristics and fruiting bodies. Original citation, collection date, location, host plant, and elevation are provided. Material examined is included along with distribution and notes on the species.

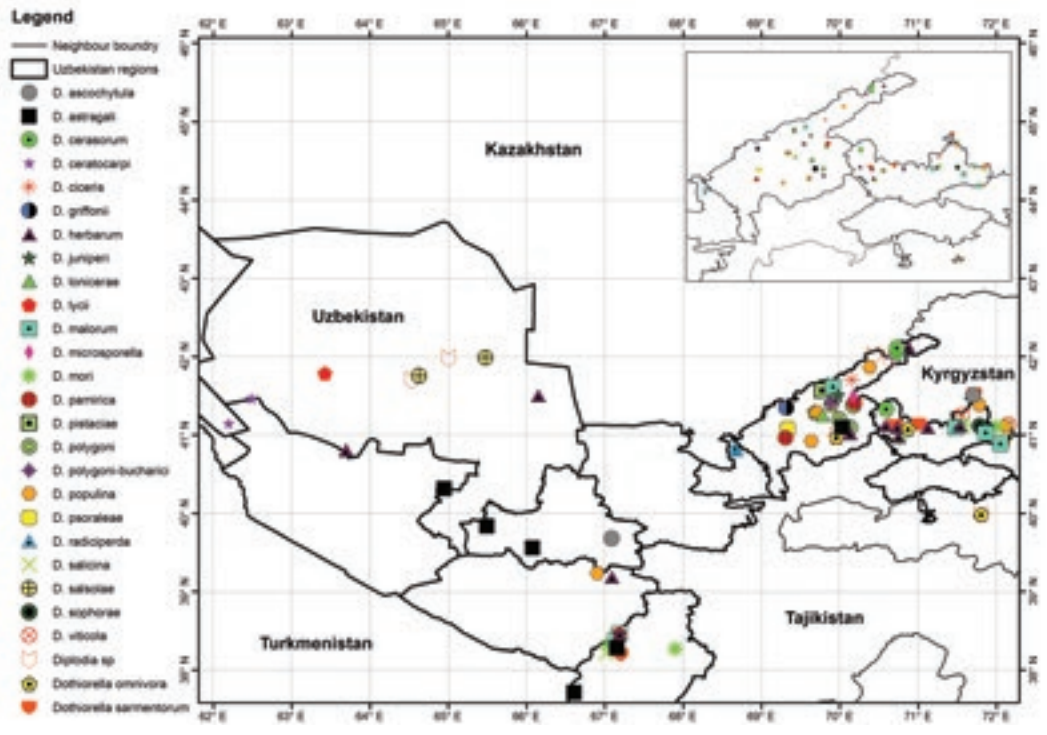

Fig. 1. Distribution map of *Diplodia*-like species in arid and semi-arid areas of Uzbekistan.

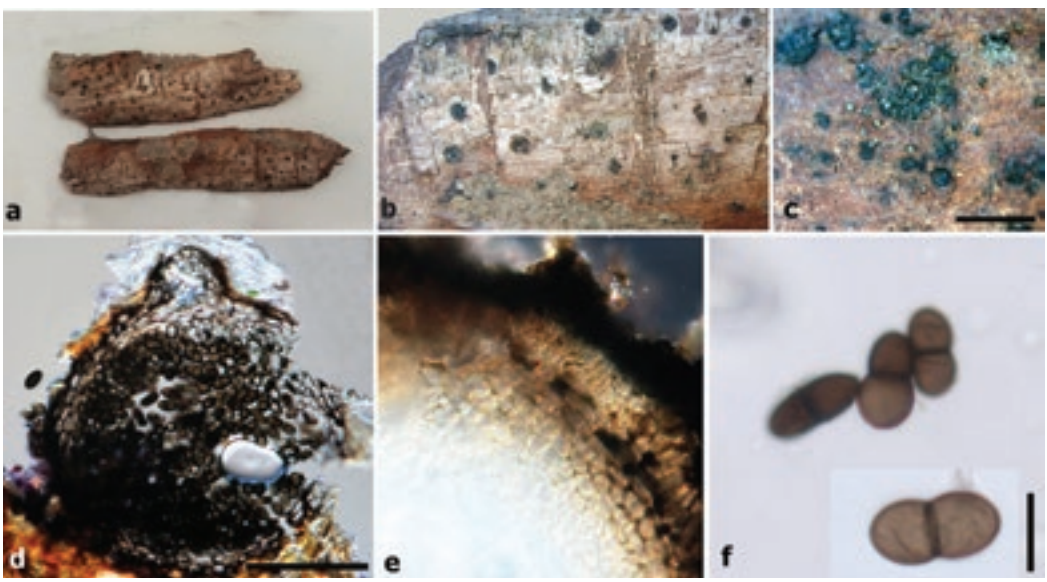

Fig. 2. **a.** Appearance on host substrate. **b–c.**, Conidiomata on the host surface. **d.** Vertical section through conidioma. **e.** Conidiomata cell wall. **f.** Mature dark brown conidia.

Diplodia ascochytula Sacc., Michelia 2(7):349. 1881. *Microdiplodia ascochytula* (Sacc.) Allesch., Rabenh. Krypt.-Fl., ed. 2 (Leipzig) 1(7):88. 1901[1903].

Description.—Pycnidia irregularly spherical, 125–220 × 120–200 µm in diam. (compared to 170–200 × 140–160 µm, as described in Jaczewski [1917]), with rounded stoma, surrounded by pigmented tissue, cloth crowded, dive, and then projecting, thick-walled, dense, and olive-brown. Conidia ellipsoid, fusiform, 12.6–16.8 × 4.5–5.5 µm (compared to 9–12 × 2.5–3.5 µm described by Jaczewski [1917]), light-olive, two-celled, constricted at the septum.

Material examined.—On dry branches of *Lonicera hispida* Pall. ex Schult. **UZBEKISTAN:** Namangan prov., Yangiqurgon district, floodplains of Nanay village, 22 Jul 2000; Samarqand prov., Jomboy district, river of Zarafshon, 20 Jul 1988 (Kirgizbaeva et al. 1997).

Distribution.—Kazakhstan, Uzbekistan.

Notes.—Referring the Uzbekistan specimens to this species is somewhat arbitrary, since isolates from this study differ from the type species in the larger sizes of their pycnidia and conidia. Phylogenetic analyses are needed to clarify species relationships.

Diplodia astragali Golovin., Trudy Sredneaz. Univ. 14(5):36. 1950.

Description.—Pycnidia spherical, 75–160 µm in diam. (compared to 185–344 × 137–283 µm described in Byzova et al. [1968]), initially immersed in the tissue, then cracks projecting from the papillary stoma, becoming thin-walled, dark brown to black. Conidia oval, straight, 9.1–10.4 × 3.9–5.0 µm, dark brown, two-celled, oval constricted at the septum.

Material examined.—On dead stems of *Elaeosticta alaica* (Lipsky) Kljuykov, Pimenov & V.N. Tikhom, *Astragalus villosissimus* Bunge, *A. sieversianus* Pall. **UZBEKISTAN:** Tashkent prov., Oxangoron district, Abyazsoy, Western Tien Shan Mts., 02 Oct 1954 (Panfilova & Gaponenko 1963); Samarqand prov., Qizilqum desert, SE Tosh-quduq well-draw, 13 Sep 1936 (Gaponenko 1965); Bukhara prov., Gijdivon district, 2 km far from NE, Shurkul, 14 Oct 1957, *TASM 5309*, Navoiy prov. Qizilqum desert, Qarnob chul, 12 Jun 1958, *TASM 3239, 3240*; *Surkhandaryo* prov.: Sherobod district, Vandob village, h–1238 m, Jul 1986; Kuhitog Mt., Machoylisoy, h-2280 m, 07 Jul 1984.

Distribution.—Kazakhstan, Turkmenistan, and Uzbekistan.

Notes.—Conidia from this study are slightly smaller and the shape is less globular-oblong compared to that descibed by Byzova et al. ([1968], 11.5–17.8 × 5.2–8 µm).

Diplodia cerasorum Fuckel, Bot. Zeitung 26:83, Fung. Rhen. no 1958. 1867.

Description.—Pycnidia grouped or solitary, dark, immersed, later breaking, blunt conical, dully conic, with a large papillate stoma, 400–500 × 300–350 µm in diam. Conidial tissue is well developed. Conidiophores thin, threadlike, hyaline towards the inner region, 7.5–9 × 3.3–4.5 µm. Conidia oblong to ovoid, 22.5–24 × 9.5–10 µm, brown to dark brown, 1-septate, sometimes slightly constricted at the septum.

Material examined.—On dry and dead branches of cherries (*Cerasus tianschanica* Pojark., *Prunus mahaleb* L., *P. cerasus* L.). **UZBEKISTAN:** Tashkent prov., Bustonliq on the rocky slopes, the gorges of the Chotqol Mt. range, 10 Jun 1953, Maydontol range in the Western Tien Shan Mts., 07 Jul 1953 (Panfilova & Gaponenko 1963), 15 Sep 1958, *TASM 5325*.

Distribution.—Kazakhstan, Uzbekistan.

Notes.—Frequent.

Diplodia ceratocarpi Golovin, Trudy Sredneaz. Univ. 14(5):36. 1950.

Description.—Byzova et al. (1968: 337).

Material examined.—On dead leaves of *Ceratocarpus arenarius* L. **UZBEKISTAN:** Bukhara prov., Qizilqum desert, 13 Sep 1936, 16 May 1956 (Gaponenko 1965).

Distribution.—Uzbekistan.

***Diplodia ciceris** Schwarzman, in Byzova et al., Cryptogamic Flora of Kazakhstan 5, Fungi Imperfecti (Deuteromyeetes) 2, Sphaeropsidales (Alma-Ata) 350. 1968.

Description.—Pycnidia ellipsoidal, irregularly spherical, lenticular, 300–500 × 120–504 µm in diam., with

long papillary stomata, 80–137.5 µm, 65–100 µm, with wide rounded stoma, 60 × 87.5 µm, scattered, crowded, dive, gibbose. Wall is thick, dense, with small irregularly rounded cells, dark brown, almost black. Conidia cylindrical, 8.8–13.2 × 4.4 µm, olive, two-celled, not constricted.

Material examined.—On dead stems of *Cicer flexuosum* Lipsky. **UZBEKISTAN:** Tashkent prov., grass steppe of Western Tien Shan Mts., the upper Oqsarsoy, among the rocks, 24 Jul 1949 collected by S.R. Schwarzman (Byzova et al. 1968).

Distribution.—Kazakhstan and Uzbekistan.

Notes.—The species differs from morphologically similar *Diplodia astragali* Golovin in having long papillary stoma. We did not check the type specimen from herbarium at Alma-ty (AA).

Diplodia griffonii Sacc. & Traverso, Sylloge Fungorum 20:1228. 1911.

Description.—Byzova et al. (1968: 347).

Material examined.—On dead stems and shoots of *Pyrus ussuriensis* Maxim. ex Rupr. **UZBEKISTAN:** Tashkent city, Botanical garden, Oct 1988 (Kamilov 1991).

Distribution.—Kazakhstan and Uzbekistan.

Notes.—We discovered fungal specimens of this species in TASM for re-examination. Byzova et al. (1968) reported the occurrence of *D. griffonii* on *Malus domestica* Borkh in Kazakhstan and Turkmenistan.

Diplodia herbarum (Corda) Lev., Ann. Nat. Bot. 5:292.1846.

Description.—Pycnidia solitary, ellipsoidal, spherical, 150–300 µm in diam. (compared to 200 µm diam. as described in Grove [1937]), with prominent, crowded, immersed pseudoparenchymatous wall, olive-brown to dark. Wall formed outside is made of dark colored cells within a colorless substrate, gradually turning into underdeveloped conidiogenous layer. Stomata lacking, sometimes pseudo stomata present, mature conidia are relased from the pycnidia through the crack. Conidiophores, 7–-15 µm, hyaline, 1-septate, straight or slightly crooked. Conidia ellipsoidal, oblong, 10.5–21.7 × 3.5–9 µm, brownish olive two-celled, (compared to those described by Saccardo [1880], 20–25 × 9–12 µm) constricted at the septum.

Material examined.—On dead and dry stems of various flowering plants (*Marrubium anisodon*, *Anabasis eriopoda*, *Spiraea hypericifolia*, *Galatella* sp., *Scaligeria* sp., *Artemisia* sp.). **UZBEKISTAN:** Tashkent prov., Bustonliq district, Maydontol and Oygain mts. (1800 m), 21 Jul 1955, *TASM 2989*; Oxangoron district, Angren, Jun 1954, *TASM 5326*; Bukhara prov., Qizilqum, Quljuktog Mt., 10 May 1956, the same place (650 m), 15 May 1956, Navoiy prov., Uchtepa village, 12 Jun 1956 (Gaponenko 1965); Namangan prov., Pop district, Chodak foothills, 06 May 2000; Dugob village, W slope of the Qurama Mt., 27 Sep 2001; Qandagon, E mountain, 17 Jul 2002; Chust district, Gova village, 27 Apr 2001; Kosonsoy district, Quqimboy village, 09 May 2000; Qashqadaryo prov., Kitob district, Qaynar village, 24 May 1996 (Nuraliev 1999); Surxondaryo prov., Boysun district, Kengdala, 21 May 2016, *YG-S14* (TASM).

Distribution.—Kazakhstan, Turkmenistan, Uzbekistan.

Notes.—This species might represent a species complex and molecular studies are necessary to resolve its position in *Diplodia*. The species has been reported from various plant species in the genera of *Aeluropus*, *Dactylis*, *Lilium*, *Atriplex*, *Thalictrum*, *Brassica*, *Gossypium*, *Ferula*, *Lappa*, *Galium*, *Lactuca*, *Marrubium*, *Anabasis*, *Spiraea*, and *Galatella* in Central Asia (Kirgizbaeva et al. 1997; Salieva 1989; Nuraliev 1999; Gafforov 2017). Frequent.

***Diplodia juniperi** West , Bull. Soc. Roy. Bot. Belg. 7. 1857.

Description.—Pycnidia scattered, solitary or aggregated rarely immersed in tissue, spherical, 500–600 µm in diam , dark-brown to black when mature, with elongated stoma, permeating the epidermis, with rounded sorus. Conidiogenous cells subulate, 3–5 × 2.5 µm. Conidia oblong to ovate, 15–21 × 7–10 µm, brown becoming almost black, 1-septate, unconstricted at septa.

Material examined.—On *Juniperus pseudosabina* Fisch. & C.A.Mey. **UZBEKISTAN:** Tashkent prov., Bustonliq district, Beldirsoy, Ugam-Chatkal State National Natural Park, Western Tien Shan Mts., 25 May 2011, *YG 008* (TASM).

Distribution.—Uzbekistan.

Notes.—New record for mycobiota of Uzbekistan.

Diplodia lonicerae Fuckel, Bot. Zeitung 26:82, Fung. Rhen. no 1951. 1867.

Description.—Conidiomata pycnidial, spherical, 900–1000 µm in diam. solitarily or aggregated, with elongated stoma, sometimes scattered, immersed in the host branch, later projecting with small papillary stoma, but clearly visible, with 25–30 µm porus, black. Conidiogenous thin-walled, thread-like, 10–15 × 1–1.5 µm. Conidia elongated, 20.5–32 × 8.8–10 µm, dark brown to black, 1-septate, sometimes slightly constricted at the septum.

Material examined.—on shoot of *Lonicera tianschanica* Pojark. **UZBEKISTAN:** Tashkent prov., Parkent district, Suqoq, Oltinbelsoy in the Western Tien Shan Mts., 10 Aug 1953, *TASM 5892*; Surkhandaryo prov., Boysun district, Boysun Mt., Machaylisoy, 10 Jun 1984 (Salieva 1989).

Distribution: Uzbekistan.

Notes.—The species is rare in Uzbekistan.

Diplodia lycii Fuckel, Fungi Rhenani Exsiccati Cent. XVI–XVIII 16–18:174, Fung. Rhen. no 1711. 1866.

Description.—Saccardo (1884: 367).

Material examined.—On *Lycium ruthenicum* Murray. **UZBEKISTAN:** Bukhara prov., Qizilqum desert, (Gaponenko 1965).

Distribution.—Uzbekistan.

Notes.—We did not find the species in TASM.

***Diplodia malorum** Fuckel, Fungi Rhenani Exsiccati Cent. XVI–XVIII 16–18:174, Fung. Rhen. no 1706. 1866.

Description.—Conidiomata pycnidial, spherical to oblong, 400 × 500 µm in diam., solitary or aggregated, immersed, partially erumpent when mature, dark brown becoming black. Double-layer walls, well-developed, the outer layer formed of 5–7 rows of dark brown, diathermic cells and inner wall formed of 3–5 rows of hyaline, pseudoparenchymatic cells. Conidiogenous cells hyaline, smooth, swollen at the base, 7.5–1 7 × 3–5 µm, proliferating at the same level to produce periclinal thickening, or proliferating percurrently, giving rise to 2–3 annelations. Conidia oblong to cylindrical with broadly rounded ends, 17–30 × 10–15 µm, thick-walled, with smooth outer surface and verruculose inner surface, hyaline, becoming dark brown with age, young conidia aseptate becoming 1-septate after the release from the pycnidium, constricted at the septum.

Material examined.—On the branches of *Malus domestica* Borkh., *M. niedzwetzkyana* Dieck ex Koehne. **UZBEKISTAN:** Namangan prov., Turaqurgon district, in the apple gardens of Kuymazor village, 14 Aug 2000; Norin district, near to Uchtepa village, 25 Jul 2000; Uychi district, Qizilrovod village, 19 Nov 2000; Tashkent prov., Bustonliq district, Xojikent village, Western Tien Shan Mts., 27 May 1992, *TASM 5339*; Surxondaryo prov., Boysun district, Machay, Qizil Naur village, 21 May 2016, *YG-S07* (TASM).

Distribution.—Uzbekistan.

Notes.—New record for Uzbekistan mycobiota. According to our observations, it is possible that the species is causing dying of shoots, twigs and branches of apples in northwestern and southern Uzbekistan.

***Diplodia mori** West., Bull. Soc. R. Bot. Belg. 2:244. 1864[1863].

Description.—Pycnidia in groups, rarely with papillary stoma, spherical, flattened-spherical, dark, 250–300 µm in diam., immersed, later extending from the epidermis. Conidiophores 1-septate, 8–11 × 1.5–2 µm, whitish to brown. Conidia oblong to ellipsoid or oblong to ovoid, 20–25 × 8–10 µm, dark brown, 2-septate, slightly constricted at septa.

Material examined.—On dead and dry branches of *Morus alba* L., *M. nigra* L. **UZBEKISTAN:** Namangan prov., Pop district, Chodaksoy, 06 May 2000; Kosonsoy district, Soyovul village, 09 May 2000; Uchqurgon district, near to Sirdaryo River, 27 Jun 2001; Surxandaryo prov., Denov district, Denov village, Apr 1984; Boysun district, Machay village, 17 May 2016, *YG-S22* (TASM).

Distribution.—Uzbekistan.

Notes.—New record for mycobiota of Uzbekistan. The species is widespread (especially dark-spored morphological forms) in arid regions of Uzbekistan and steppe zone of Ukraine. Frequent.

Diplodia microsporella Sacc., Syll. Fung. (Abellini) 3:357. 1884. *Microdiplodia microsporella* (Sacc.) Allesch., Rabenhorst's Kryptogamen-Flora, Pilze - Fungi Imperfecti 1(7):79. 1901.

Description.—Pycnidia immersed on host tissue, later extending from the epidermis, spherical or oblate spherical, black, with papillary stoma, 300–500 µm in diam , Walls small-celled, dark brown. Conidiogenous tissue is well developed, short, thin-walled. Conidiophores, cylindrical, hyaline. Conidia mostly oval-shaped, slightly stretched at the level of the septum, olive-brown, 12–16 × 5–7 µm.

Material examined.—On dry leaves of *Leonurus panzerioides* Popov. Tashkent prov., Bustonliq district, Maydontol Mt., 04 Jul 1955, N slope of ridge of Pulatxan, 10 Aug 1955, (Panfilova & Gaponenko 1963).

Distribution.—Uzbekistan.

Notes.—We did not find the species in TASM.

Diplodia pamirica Golovin, Trudy Sredneaz. Univ. 14(5):36. 1950. *Microdiplodia pamirica* (Golovin) Frolov, Koshkelova, Frolov & Dzhuraeva, Mycoflora of BadkItyz, Karabil and the southern part of the Murgab Oasis, (Ashkhabad). 139 (1970).

Description.—Pycnidia globular, with paraplectenchimatic walls, 100–220 µm in diam. (compared to 207–265 µmas described in Golovin [1950]), with rounded stoma up to 15 µm, surrounded by a pigmented tissue, scattered, immersed, brown or dark-brown. Conidia cylindrical, ellipsoidal, 7.7–5.4 × 4.4–6.6 µm (compared to 11.5–16.1 × 5.75–8.05 µm described in Golovin [1950]), 2-septate, slightly wasted and clouded.

Material examined.—On dying stems of *Artemisia* sp. **UZBEKISTAN:** Tashkent prov., Bustonliq district, Maydontol village, Tashkent W slope in the Western Tien Shan Mts., 04 Jul 1955, *TASM 5337*; Oxongoron district, Oxongoron reservoir, in the mountain, 05 Jun 1957 (Panfilova & Gaponenko 1963).

Distribution.—Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan.

Notes.—The species differs from the type species by its smaller conidia and pycnidia and conidia which are cylindrical in shape. Sporadic.

Diplodia polygoni Ruhland, Verh. Berliner Bot. Vereins 41:83. 1900.

Description.—Pycnidia ellipsoid, 400–650 × 450–600 µm in diam., brown and became dark-brown when older, with rounded stoma. Pycnidia with paraplectenchimatic walls, scattered, immersed on host tissue. Conidiophores hyaline. Conidia ellipsoidal, 14–17.5 × 5.5–6.5 µm, 2-septate, unconstricted at the septum.

Material examined.—On *Polygonum* sp. **UZBEKISTAN:** Tashkent prov., Bustonliq district, Maydontol range in Western Tien Shan Mts., 04 Jul 1955, *TASM 5317*, Oxongaron district, Chatkal range, W slope of Dukentsay, 04 Jul 1955, *TASM 5332*, Muzbel, NW slope, 27 Jul 1955, *TASM 5333*.

Distribution.—Kazakhstan, and Uzbekistan

Notes.—The species has larger pycnidia and conidia compared to that described in Baltic region (Byzova et al , 1968).

***Diplodia polygoni-bucharici** Schwarzman, Byzova et al., Cryptogamic Flora of Kazakhstan 5; Fungi Imperfecti (Deuteromyeetes); 2. Sphaeropsidales (Alma-Ata) 335. 1968.

Illustration.—Byzova et al. (1968: 335–336).

Description.—Pycnidia 280–450 × 260–400 µm in diam., ellipsoid, with rounded stoma, 50–55 µm, numerous, scattered, emergent. Pycnidia with paraplectenchimatic small-cell and pseudoparenchymatic walls, 6–8 µm, dark brown. Conidia ellipsoid, 4.4–7 × 3–3.3 µm, clouded-brown, 2-septate, unconstricted at the septum.

Material examined.—On dead stems of *Polygonum coriarium* Grig. **UZBEKISTAN:** Tashkent prov., the upper of Aqsoqotasoy among the stones, Western Tien Shan Mts., 24 Jun 1949 (Byzova et al. 1968).

Distribution: Kazakhstan, Uzbekistan.

Notes.—New record for mycobiota of Uzbekistan.

Diplodia populina Fuckel, Jahrb. Vereins Naturk. Herzogth. Nassau. 23–24:170. 1870.

Description.—Pycnidia separate or aggregated and confluent, immersed, later extending from the epidermal cracks, flattened-spherical to ovoid, outside black, inside yellowish, 300–350 µm in diam., with small papillary stoma, 20 µm thick. Conidiophores, 12–15 × 2–3 µm, hyaline. Conidia oblong-ovate, sometimes somewhat to obovate, 23–25 × 12–14 µm, brown to dark brown, young conidia light brown,1-septate.

Material examined.—On dying and dead twigs of *Populus nigra* L., *P. tremula* L., *P. talassica* Kom., *P. pruinosa* Schrenk. **UZBEKISTAN:** Namangan prov., Norin district, Uchtepa village, 14 May 2000; Chortoq district, Peshqurgon village, 27 Nov 2000, 29 Jun 2001; Turaqurgon district, Pop foothills, Kuymazor village, 30 Apr 2001; Uchqurgon district, Katta Fargona canal, 20 Nov 2000; Tashkent prov., Oxongoron district, in natural forests and artificial forest plantations of near to village, 04 Sep 1953, Pskom district, Pskem Mt., 08 Sep 1953; Parkent district, in village, 08 Oct 1954 (Panfilova & Gaponenko 1963); Kashkadarya prov., Kitob district, near to Mingchinor, 10 Jun 1995 (Nuraliev 1999).

Distribution.—Kazakhstan, Tajikistan, Turkmenistan, and Uzbekistan.

Notes.—This species is widespread on poplar trees from the arid regions of Uzbekistan.

Diplodia pistaciae Berl. & Bres., Ann. Soc. Alpinisti Tridentini 14:69. 1889.

Description.—Kirgizbaeva et al. (1997: 162).

Material examined.—On dead branches of pistachio tree (*Pistacia atlantica* Desf.). **UZBEKISTAN:** Tashkent prov., Gazalkent district, Gazalkent, Western Tien Shan Mts., 10 Oct 1980 (Panfilova & Gaponenko 1963).

Distribution.—Uzbekistan.

Notes.—The species is rare.

Diplodia psoraleae (Castagne) P. Karst. & Har., J. Bot., Paris 4:359. 1890. *Microdiplodia psoraleae* (Castagne) Allesch., Rabenh. Krypt.-Fl., ed. 2 (Leipzig) 1(7):93. 1901[1903].

Description.—Pycnidia scattered, immersed on host tissue, dark brown, with stoma. Conidiophores hyaline. Conidia oblong, 9.5–10 × 3.5–4.5 µm, 1-septate.

Material examined.—On *Cullen drupaceum* (Bunge) C.H. Stirt. **UZBEKISTAN:** Tashkent prov., Urtachirchiq district, state stud farm No68, 08 May 1954, *TASM 5318*.

Distribution.—Uzbekistan.

Notes.—The specimen (*TASM 5318*) was in too poor condition to make full description and we found only one specimen in TASM.

***Diplodia radiciperda** Thüm., Symb. Mycol. Austr. 10. 1877.

Description.—Conidiomata pycnidial, solitary, globose, light brown when young, then becoming dark brown, thin-walled, translucent, 400–650 µm in diam. Conidiophores, cylindrical, hyaline. Conidia ellipsoid to ovate, 17 × 10 µm, brown, 1-septate, slightly constricted at the septum.

Material examined.—On stems of *Malus* sp. **UZBEKISTAN:** Syrdaryo prov., Sirdaryo district, 08 Mar 1997, *TASM 5307*; Sirdaryo, 08 Jul 1997, *TASM 5308*.

Distribution.—Uzbekistan.

Notes.—New record for mycobiota of Uzbekistan.

***Diplodia salicina** Lév., Ann. Sci. Nat. Bot. 5:292. 1846.

Description.—Pycnidia aggregated, 400–500 µm in diam., dark brown to black, half immersed in the tissue, with elongated stoma easily seen on tissue, with porus 40–45 µm, wall consisting of three rows of dark brown cells and 2–3 rows of colorless cells with pseudoparenchymatous structure. Conidiogenous tissue is well developed, thin-walled. Conidiophores hyaline, 12–14 µm, cylindrical. Conidia ellipsoid, 22–24 × 10 µm, brown, 1-septate, some of them 2-septate, young conidia clouded and hyaline.

Material examined.—On dead branches of *Salix alba* L., *S. acutifolia* Willd. **UZBEKISTAN:** Namangan prov., Kosonsoy district, in floodplain of Soyovul village, 09 May 2000; Uchqurgon district, Katta Fargona canal, 01 Oct 2001. Surxondaryo prov., Boysun district, Darbant village, 8 May 2016, *YG-S02* (TASM).

Distribution.—Uzbekistan.

Notes.—New record for mycobiota of Uzbekistan. The species has smaller pycnidia and conidia compared to that described in Ukraine (Merezhko, 1980). Common in northeastern Uzbekistan province.

Diplodia salsolae Szembel, Comment. Inst. Astrachandefens. Pl. 3. 1924. *Microdiplodia salsolae* (Szembel) Frolov, in Koshkelova, Frolov & Dzhuraeva, Mycoflora BadkItyz, Karabil and the southern part of the Murgab Oasis, Ashkhabad 139. 1970.

Description.—Pycnidia solitary, surrounded by a pigmented tissue surface, spherical, 300–400 µm in diam., with a round stoma, thick-walled, carbonaceous, brittle, dark brown to black. Conidiophores hyaline, subcylindrical. Conidia ovoid to ellipsoid, 8–12.5 × 4–5 µm, olive-brown, 2-septate, unconstricted or slightly constricted at the septum.

Material examined.—on dead *Salsola arbuscula* Pall. **UZBEKISTAN:** Navoiy prov., Qizilqum, Tamdybulak, 21 Oct 1957, *TASM 2806*, NW of Yangiquduq draw-well, 15 Jun 1960 (Gaponenko 1965).

Distribution.—Kazakhstan, Kyrgyzstan, Turkmenistan, and Uzbekistan.

Notes.—The species has smaller pycnidia and conidia compared to that found in Kazakhstan (Byzova et al. 1968).

***Diplodia sophorae** Speg. & Sacc., Michelia 1(5):485. 1879.

Description.—Merezhko (1980: 113–114).

Material examined.—On *Sophora pachycarpa* C.A. Mey. **UZBEKISTAN:** Namangan prov., Namangan district, Paxtalikul, Childrin's sanatorium, 1925 (specimens in lab of Yachevskiy), (Zaprometov 1928).

Distribution.—Kyrgyzstan, Uzbekistan.

Notes.—In Kyrgyzstan, the species has been reported on *Styphnolobium japonicum* (L.) Schott (Masolova 1987). According to N.G. Zaprometov (1928), *D. sophorae* pycnidia measure 265–412 µm in diam. and conidia measure 16–25 × 8–10 µm in diam.

***Diplodia viticola** Desm., Ann. Sci. Nat. Bot. 10:311. 1838.

Description.—Pycnidia scattered, sometimes in linear rows, solitary or aggregated, initially on epidermis, later covered, spherical, rarely flattened-spherical, dark brown becoming black, 650–750 µm in diam., with conic stoma projecting from sorus measuring 40 µm. Conidiogenous cells hyaline, short, 10 µm, smooth, cylindrical cells not seen. Conidia mostly oblong to ovoid, sometimes oblong-oval, 15–20 × 7–12 µm, smoky-brown to dark brown, young conidia aseptate, becoming 1-septate, rarely 2-septate with age

Material examined.—on dying and dead branches of *Vitis vinifera* L. **UZBEKISTAN:** Namangan prov., Kosonsoy district, Qorasuv village in grape orchards, 28 Jun 2001; Uchqurgon district, 4 bulim, 01 Oct 2001.

Distribution.—Turkmenistan, Uzbekistan.

Notes.—New record for mycobiota of Uzbekistan. The species often occurs together with *Pilidiella diplodiella* (Speg.) Crous & Van Niekerk.

Diplodia zygophylli Kalymb., Trudy Bot. Inst. Akad. Nauk S.S.S.R., Ser. 2, Sporov. Rast.11:269. 1956.

Material examined.—On *Zygophyllum* sp. **UZBEKISTAN:** Bukhara region (Gaponenko 1965).

Notes.—According to the Mycobank and Index Fungorum, this species name is invalid. We did not find the species in TASM and therefore did not include it in the list of *Diplodia*-like species from Uzbekistan.

Diplodia sp.

Material examined.—On dry and dead stems and of *Spiraea hypericifolia* L., *Ammodendron conollyi* Boiss., *Convolvulus tragacanthoides* Turcz., *Artemisia* sp., *Punica granatum* L., *Mentha* sp., *Tamarix* sp. **UZBEKISTAN:** Namangan prov., Pop district, Sonsoloq village, Qiziltosh Mt., 06 Jul 2001; S slope of Irgaylisoy Mt., 07 Jul 2001; Navoiy prov., 6 km far from well-draw of Sukuti, 28 Oct 1957, *TASM 5324*, 9 km S from Adzherekty, 25 May 1957, *TASM 5181*; Fergana prov., Shohimardon, 10 Oct 1957, *TASM 5336*; Tashkent prov., Bustonliq district, Maydontol, 1954, *TASM 5337*, 30 Jun 1949, *TASM 5338*; Oxangoron district, village, 27 Jul 1997, *TASM 5340*; 05 Jun 1992, *TASM 2963*.

Notes.—The morphological identification of this fungus was not possible due to a lack of appropriate references.

Dothiorella omnivora Linaldeddu, Deidda, & Scanu, Eur. J. Pl. Pathol. 146:259–279. 2016. *Diplodia juglandis* (Fr.) Fr., Summa vegetabilium Scandinaviae 1:417. 1849.

Description.—Pycnidia mostly clustered, sometimes solitary, immersed in the tissue, spherical to pear-shaped, dark black, 260–600 µm in diam., thick-walled. Conidiophores hyaline, 1-septate, beaked, 6–10 × 1.5–2 µm. Conidia ellipsoid to ovoid, 13.6–17.6 × 8–10 µm, dark brown, 1-septate, occasionally slightly constricted at the septum.

Material examined.—On branches and shoots of *Juglans regia* L. **UZBEKISTAN:** Tashkent prov., Parkent district, Chotqol biosphere reserve, 13 Aug 1953, Okresnosti Parkent, 19 Jun 1954, Yongoqlisoy, mountain, 25 Sep 1954; Namangan prov., Pop district, Pardatursin village, 25 Nov 2000.

Distribution.—Tajikistan, Uzbekistan.

Note.—Species found in Namangan prov. differed in conidia size (17.6 × 8–10 µm) from those found in Tashkent prov. Phillips et al. (2008) and Linaldeddu et al. (2016), transferred this species to *Dothiorella*.

Dothiorella sarmentorum (Fr.) A.J.L. Phillips, J. Luque, & A. Alves, Mycologia 97:522. 2005. *Diplodia pruni* Fuckel, Symb. Myc. 169. 1870. *Diplodia rosae* West., Herb. Crypt. fasc. 25, No. 1227. 1859.

Description.—Phillips at al. (2005: 522).

Material examined.—on dead twigs and branches of *Prunus armeniaca* L., *P. persica* (L.) Batsch, *P. domestica* L., *P. dulcis* (Mill.) D.A. Webb and *Armeniaca sogdiana* Kudr., *Rosa canina* L., *R. ecae* Aitch., *R. moschata* Herrm., *R. beggeriana* Schrenk ex Fisch. & C.A. Mey, *Rosa* sp., and other wild roses. **UZBEKISTAN:** Tashkent prov., Oxangaron district, Oxangaron, Western Tien Shan Mts., 02 Oct 1954, *TASM 2816*; Tashkent city, Botanical garden, Oct 1988, (Kamilov 1991); Namangan prov., Chust district, Gavo Mt., 10 Jul 2001; Yangiqurgon district, Nanay village, Kuksaroy, 30 Jun 2001; Pop district, near to Indigansoy, 06 Jul 2001; Fergana prov., Fergana district, Shohimardonsoy, 04 Jul 1950, *TASM 5334, 5335*; Surxondaryo prov., Boysun district, Boysun village, 7 May 2016, *YG-S01* (TASM).

Distribution.—Tajikistan, Uzbekistan.

Notes.—In Uzbekistan, the species has been previously described as *Diplodia pruni* and *D. rosae* (Panfilova & Gaponenkon 1963; Kirgizbaeva et al. 1998; Gafforov 2002, 2005). Here, we treat the taxon as *Dothiorella sarmentorum* following Phillips at al. (2005). Our observations also indicate that *D. sarmentorum* on other Rosaceae and other host plant families is not very similar morphologically and can be quite different from its European counterpart. Clarifying its classification will require molecular studies that include specimens from semi-arid regions of Central Asia. This species is widespread and occurs as an anamorphic state on dead branches and stems of *Prunus* and *Rosa* taxa in Uzbekistan.

Diversity of *Diplodia*-like species occurring on various hosts in Uzbekistan

In total, 27 species of the *Diplodia*-like fungi were reported from Uzbekistan. The *Diplodia*-like species belonged to the genera *Diplodia* (25 species) and *Dothiorella* (2), both in the Botryosphaeriaceae. Among them, nine species (*D. ciceris*, *D. juniperi*, *D. malorum*, *D. mori*, *D. polygoni-bucharici*, *D. radiciperda*, *D. salicina*, *D. sophorae, D. viticola*) are newly reported for the Dothideomycetes mycota of Uzbekistan.

In this study, *Diplodia*-like species were found on 58 host plant species belonging to 19 families and 19 genera. They were most frequently found on plants belonging to Amaranthaceae, Asteraceae, Fabaceae, Rosaceae, and Lamiaceae. However, more collections and further taxonomic and phylogenetic studies will substantially increase our knowledge on the diversity and host associations of these fungi in Uzbekistan. The Diplodia-like fungi are widespread and occur on a variety of hosts, including *Anabasis eriopoda*, *Armeniaca sogdiana*, *Gallatela* sp., *Marrubium anisodon*, *Prunus armeniaca*, *P. persica*, *P. domestica*, *P. dulcis*, *Rosa canina*, *R. ecae*, *R. moschata*, *R. beggeriana,* and *Spiraea hypericifolia*.

Some species found in this study exhibit a pronounced saprotrophic life-style, e.g. *Diplodia*-like species (withering annual or biennial twigs, dead branches of apricot, peach, plum, almond and other wild roses), and *D. cerasorum* (on drying and death cherry branches). These fungi have a pervasive presence and may pose the threat to mountain and forest plant communities, and are especially important for orchards. We assume that

some species, e.g. *Dothiorella omnivora*, *Diplodia populina*, *D. malorum*, *D. salicina* can sometimes cause mass drying of living branches and even the death of host plants in adverse conditions. The remaining 2 species (*D. ascochytula*, *D. viticola*) develop as saprotrophs on dead branches without causing significant harm to plants.

In Uzbekistan, all *Diplodia*-like fungi retard growth and development of plants, decreasing the yield of biomass and their commercial value, which is consistent with the data obtained for other regions of Central Asia (Mosolova 1987; Gafforov 2016). *Diplodia astragali*, *D. pamirica*, *D. microsporella,* and *D. salsolae* are often found on the leaves of various plants, but do not cause significant harm to the hosts.

In general, the species composition of the *Diplodia*-like fungi in the Uzbekistan is similar to that of other arid countries of Central Asia, e.g. Kyrgyzstan, South Kazakhstan and Turkmenistan (Byzova et al. 1968; Koshkelova & Frolov 1973; Masolova 1987), but differs in the diversity of species typical of a pronounced arid climate (Gaponenko 1965; Koshkelova & Frolov 1973; Gafforov 2002, 2017).

Geo-referencing was conducted for the data from recently collected samples and herbarium specimen labels and imported into ArcGIS, and a distribution map of *Diplodia*-like species in the Uzbekistan was prepared (Fig. 1). The GIS distribution map showed that *Diplodia herbarum* was the most commonly collected species, found on various herbaceous and woody plants in deserts and mountain areas across the study side. Other most commonly found species included *Diplodia populina*, *D. salicina*, *D. malorum,* and *Dothiorella sarmentorum* distributed mainly in foothill and scrublands of Uzbekistan. *Diplodia ceratocarpi*, *D. lycii,* and *D. salsolae* were found only in the desert and arid areas, whereas, *Diplodia astragali* was found only in the desert area. *Diplodia ceciris*, *D. juniper*, *D. lonicerae*, *D. pistaciae*, *D. polygoni*, *D. polygoni-bucharici*, *D. radiciperda,* and *Dothiorella omnivora* were found only in the mountainous area of Uzbekistan. *Diplodia* sp. was found on different altitudes and vegetation types across the study area.

The diversity of *Diplodia*-like species in the Uzbekistan was high and included 27 species belonging to the Dothideomycetes. The most commonly found species were *D. cerasorum*, *D. herbarum*, *D. lonicerae*, *D. mori*, *D. populina*, *D. salicina, Dothiorella sarmentorum,* and *Dothiorella omnivora*.

The results of this study have shown that a great diversity of *Diplodia* and *Dothiorella* fungi occurs in arid and semi-arid regions of Uzbekistan. Twenty-seven species of the Botryosphaeriaceae were described and these belonged to the two previously mentioned genera. However, species were described following the morphological species concept which is not considered accurate to separate morphologically similar cryptic species of the Botryosphaeriaceae (Phillips et al. 2013). Therefore, phylogenetic analyses are necessary to confirm morphology-based identifications, and detect species new to science and/or new to Uzbekistan. Moreover, further sampling is needed to improve our knowledge on the diversity, ecology and impact of dark spored *Diplodi*a and *Dothiorella* species occurring on cultivated and wild trees in arid and semi-arid regions of Uzbekistan.

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