Hyphodontia (Hymenochaetales, Basidiomycota) and similar taxa from Central Asia

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***Hyphodontia* (Hymenochaetales, Basidiomycota) and similar taxa from Central Asia**

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Abstract

Wood-inhabiting fungi are noteworthy components of woody ecosystems which are responsible for the decomposition and turnover of wood nutrients. While the diversity and ecology of these fungi in the temperate forests has been relatively well explored, little is known on diversity of these fungi in the arid and semi-arid forest ecosystems. This is the first study on diversity, distribution and ecology of the fungal genus *Hyphodontia* s.l. in the five countries of Central Asia viz., Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Altogether 11 species are confirmed for the region, among which the following six species are reported for the first time from Central Asia: *Hyphodontia alutaria*, *H. pallidula*, *Kneiffiella alutacea*, *Lyomyces crustosus*, *L. erastii* and *L. sambuci*. In addition to morphological evidence, the identity of three species is confirmed with phylogenetic analysis based on ITS nuclear ribosomal DNA region. The spectra of known hosts for many of the studied species were expanded. An annotated species list and geo-referenced distribution maps are provided as well as notes on taxonomy, ecology, and local, regional and global distribution. An identification key to the species of *Hyphodontia* s.l. recorded in arid and semi-arid regions of Central Asia is also provided.

Key words: Taxonomy, ITS, wood-inhabiting basidiomycetes, global distribution, GIS, Central Asia, *Agaricomycetes*

42 Introduction

43 Wood-inhabiting fungi are noteworthy components of woody plant ecosystems and take an active part
44 in decomposition and turnover of wood nutrients. Corticioid fungi are one of the major groups of
45 wood-inhabiting basidiomycetes (Larsson 2007), although some of them are mycorrhizal.
46 Morphologically, this group has holobasidia and effused basidiomata, with a smooth, wrinkled, toothy,
47 or somewhat poroid hymenophore (Dai 2011, 2012). The majority of the corticioid species function as
48 white rot wood decomposers (Swift 1982). Current molecular systematic research confirms that
49 corticioid fungi are phylogenetically heterogeneous and distributed among all major clades within
50 Agaricomycetes (Hibbett et al. 2007; Larsson 2007).

51 The genus *Hyphodontia* (Fr.) J. Erikss. is one of the most species-rich genera of corticioid fungi.
52 The genus was first described by Eriksson in 1958 and belongs to the order Hymenochaetales, class
53 Agaricomycetes. Species in *Hyphodontia* s.l. have resupinate basidiomata with variable micro- and
54 macromorphology, usually distinguished by a toothy hymenophore; smooth or poroid hymenophores
55 are present in some species. The hyphal system is monomitic and hyphae generally have distinct to
56 somewhat thickened walls and small semicircular clamps, basidia subclavate to suburniform with
57 allantoid, ellipsoid to subglobose basidiospores that are thin-walled, usually with one or two guttules
58 (Eriksson and Ryvardeen 1976).

59 *Hyphodontia* s.l. species are wood-decaying saprobes, causing a white rot in deciduous and
60 coniferous woody plants and therefore participating in carbon recycling of forest ecosystems (Eriksson
61 and Ryvardeen 1976). *Hyphodontia* s.l. was monographed on a world scale by Langer (1994), who
62 provided descriptions and keys for the identification of the species. A global morphological key has
63 been recently updated by Yurchenko and Wu (2016) and Riebesehl and Langer (2017). Most
64 *Hyphodontia* s.l. species have been described from the Neotropics, Paleotropics and Holarctic Region
65 (Parmasto 1968; Eriksson and Ryvardeen 1976; Gilbertson 1980; Hjortstam 1983; Wu 1990, 2001,

2006; Langer 1994, 1998; Ginns 1998; Langer and Dai 1998; Greslebin and Rajchenberg 2000, 2003; Kotiranta and Saarenoksa 2000; Dai 2011; Bernicchia and Gorjón 2010; Lee and Langer 2012; Gorjón 2012; Riebesehl et al. 2015; Chen et al. 2016). Recently new species of *Hyphodontia* s.l. have been discovered from Asia and Réunion Island (Maekawa 1993, 1994, 2000; Xiong et al. 2009, 2010; Yurchenko and Wu 2013, 2014; Zhao et al. 2014; Riebesehl et al. 2015; Chen et al. 2016; Chen et al. 2017; Kan et al. 2017a; Kan et al. 2017b). Currently, 125 *Hyphodontia* s.l. species are recognized in the world (Riebesehl and Langer 2017; Chen et al. 2017; Kan et al. 2017a; Kan et al. 2017b). In Central Asia, four species have been reported from Kazakhstan, one species from Kyrgyzstan and one from Uzbekistan (Schwartzman 1964; Eljchibayev 1966; Kan et al. 2017a). However the knowledge of *Hyphodontia* species in Central Asia is very poor.

Based on morphological characters, Hjortstam and Ryvarden (2009) proposed splitting *Hyphodontia* s.l. into 13 separate genera. Recent molecular phylogenies (Larsson et al. 2006; Yurchenko and Wu 2014; Riebesehl and Langer 2017) inferred from ribosomal DNA sequence data demonstrated the polyphyletic nature of *Hyphodontia* s.l. Yurchenko and Wu (2014) distinguished twelve clades, but without sufficient support for the derivative genera. Riebesehl and Langer (2017) classified the species into seven genera: *Hastodontia* (Parmasto) Hjortstam & Ryvarden, *Hyphodontia* J. Erikss., *Kneiffiella* P. Karst., *Lagarobasidium* Jülich, *Lyomyces* P. Karst., *Palifer* Stalpers and P.K. Buchanan and *Xylodon* (Pers.) Gray. We are following the classification of Riebesehl and Langer (2017) in this paper.

The aim of this study is making an overview on the diversity and distribution of the Central Asian *Hyphodontia* s.l. species, reporting new records, discussing the accepted species from the region, as well as providing phylogenetic analyses of the species discussed. A checklist and a key to the species are provided, and the current knowledge of the genus in the five countries of Central Asia is discussed.

Materials and methods

91 *The study area*

92 In this article, Central Asia is regarded as the region covering Kazakhstan, Kyrgyzstan, Tajikistan,
93 Turkmenistan and Uzbekistan. According to the WWF Ecozones system, Central Asia is part of the
94 Palearctic ecozone (Olson et al. 2001). The region has varied geography, including high mountains of
95 Tien-Shan and Pamir-Alai, vast deserts of Kara-Kum (Black Sand), Kyzyl-Kum (Red Sand),
96 Taklamakan, and large and mostly treeless grassy steppes. The vast steppe areas of Central Asia,
97 together with the steppes of Eastern Europe, are considered a homogenous geographical zone known
98 as the Eurasian steppe. Much of the area consists of steep mountain ranges reaching 7,495 m in
99 elevation, largely covered by rock and devoid of extensive vegetation. Lowlands stretch from north to
100 south for more than 3,000 km, and there is a gradient from a mixed deciduous forests to forest-steppe
101 and steppe zones and finally to semi-arid and arid zones.

102 The largest biomes in Central Asia are temperate grasslands, savannas, and shrublands biome.
103 Central Asia also contains mountain grasslands and shrublands, deserts and xeric shrublands as well as
104 temperate coniferous forests biomes. Despite the mountainous nature of Central Asia, forests cover a
105 relatively small proportion of each country. Much of the forest area is dominated by small trees of the
106 genus *Haloxylon* Bunge ex E. Fenzl (Amaranthaceae) and other shrubs, particularly in desert and semi-
107 desert areas of Central Asia. In moist, mountainous areas the main species are juniper (*Juniperus* spp.),
108 Asian spruce (*Picea schrenkiana* Fisch. & C.A. Mey.), Siberian fir (*Abies sibirica* Ledeb.), poplar
109 (*Populus* spp.), willow (*Salix* spp.), walnut (*Juglans regia* L.), pistachio (*Pistacia vera* L.), apple
110 (*Malus sieversii* (Ledeb.) M.Roem., and *M. niedzwetzkyana* Dieck ex Koehne), almond (*Amygdalus*
111 *communis* L.), wild plum (*Prunus sogdiana* Vassilcz.), wild cherry (*Prunus ferganica* Lincz),
112 mountain ash (*Sorbus persica* Hedl.), wild pear (*Pyrus bucharica* Litv., and *P. korschinskyi* Litv.) and
113 other deciduous forest trees, fruit-bearing trees, and shrubs. Climate is decidedly continental, arid and
114 semi-arid with low annual precipitation, cloudless, hot, dry summers and moist, relatively warm

winters in the south and cold winters with severe frosts in the north (Klein Tank et al. 2006; Lioubimtseva 2009).

Collection and preservation of samples

This study was based on fresh samples collected during recent field surveys of wood-inhabiting basidiomycetes from Tashkent province in the north-eastern Uzbekistan. The authors collected *Hyphodontia*-like species in the Tashkent Botanical Garden (41°20'37.67" N, 69°18'57.83" E) in September of 2013 and Ugam-Chatkal State National Natural Park (41°55'31.12" N, 70°34'27.09" E) in October and November of 2011. The national park is the important nature park of Uzbekistan on the southern slopes of the western part of Tien Shan Mountains as conservation of plants, animals and fungi, revision of fungal herbarium specimens, and bibliographic references. The authors had a chance to study part of the valuable fungal collections made by Estonian mycologists in Central Asia, deposited at Mycological herbarium TAAM, Estonian University of Life Sciences, Tartu, Estonia. The recently collected samples and duplicate specimens of *Hyphodontia* s.l. species from TAAM are deposited at TASM (Tashkent Mycological herbarium), Institute of Botany and Zoology, Uzbek Academy of Science, Uzbekistan. We re-examined 30 *Hyphodontia* s.l. specimens from TAAM. Each specimen is mentioned in the text with herbarium number and collection date. Herbarium acronyms used in the paper are from Index Herbariorum (Thiers, continuously updated).

Morphological examination

For the observation of specimens, laboratory techniques described by Largent et al. (1977) were used. Microscopic sections of basidiomes were examined in 5% aqueous KOH plus 1% phloxine solutions, Melzer's reagent (Hawksworth et al. 1995; Kirk et al. 2008) for amyloid or dextrinoid reactions, and Cotton Blue in lactic acid (Hjortstam 1983) for cyanophily. Basidiome and hymenophoral morphology were observed and photographed with Leica M165 FC stereomicroscope.

Measurements were made digitally from slide stained preparations observed under a Leica DM6000 B microscope. Descriptive terminology for taxonomic characters was taken from Langer (1994) and Kirk et al. (2008). Common color names have been used according to Petersen (1996). The species names follow Riebesehl and Langer (2017); host tree names follow ThePlantList (2013).

Molecular work

Six taxa with positive results in polymerase chain reaction (PCR) were selected for molecular study, represented by specimens recently collected in Uzbekistan and Kazakhstan. Genomic DNA was extracted as described in Gafforov et al. (2014). The amplification by PCR of internal transcribed spacer (ITS) was performed using primers ITS1F/ITS4 or ITS1/ITS4 (White et al. 1990; Gardes and Bruns 1993). Sequencing was performed by Macrogen Inc., Seoul, Korea, utilizing ABI 3730 XL automated sequencers (Applied Biosystems) using primers ITS1/ITS4. The raw sequence data were aligned using MEGA7 (Kumar et al. 2016). The assembled sequences obtained in this study were deposited in NCBI GenBank. Each sequence was compared to the reference sequences in GenBank, using a BLAST search (<http://blast.ncbi.nlm.nih.gov/Blast.cgi>). Accordingly, some ITS sequences were downloaded from GenBank and incorporated with the newly generated ITS sequences in a dataset (Table 1). *Phellinus gabonensis* Decock & Yombiyeni (Yombiyeni et al. 2011), another member of Hymenochaetales, was chosen as outgroup (following Riebesehl and Langer 2017). The alignment was calculated with MAFFT version 7 (Kato and Standley 2013), using L-INS-i algorithm. The data matrix consisted of 64 sequences with ITS1, 5.8S gene and ITS2; six of them were generated in this study (Table 1).

Two different phylogenetic analyses were calculated. The Minimum Evolution phylogram was constructed in MEGA7 with default settings, using Tamura-Nei model, partial deletion for gaps and 1000 bootstrap (BS) replications. The Bayesian analysis was done with MrBayes 3.2.6 (Ronquist and

Huelsenbeck 2003), using default settings with 200,000 generations and one saved tree every 1000 generations. MEGA7 and FigTree 1.4.2 (Rambaut 2012) were used for processing the phylograms.

Data compilation for GIS Map

A point distribution map of *Hyphodontia* s.l. species (Fig 1) were produced using the ArcGIS 10.1 desktop software. GPS navigation device and Google Earth software were used for geo-referencing recently collected samples in study sites of *Hyphodontia* s.l. specimens based on herbarium data and relevant literature data. A WGS84 Geographic coordinate system was used as a reference datum. We used for geo-referencing GPS coordinates of *Hyphodontia* s.l. species in vegetation map of Central Asia used as the layer from Zhou et al. (2015). MODIS and Natural Earth database in the Central Asia map caption, e.g., Fig. 1. Study area. Land cover data was adapted from the 500 m Moderate Resolution Imaging Spectroradiometer (MODIS) land cover product (MCD12Q1). Data for roads, rivers, lake centerlines, and country boundaries were downloaded from the Natural Earth database (2017).

Results

Annotated list of *Hyphodontia* s.l. species from Central Asia

Information on *Hyphodontia* s.l. species such as collection date, location, host tree and elevation are provided in Fig. 1, Table 2. Species are listed alphabetically, and records new to Central Asia are marked with an asterisks.

****Hyphodontia alutaria*** (Burt) J. Erikss., Symb bot upsala 16 (1): 104, 1958.

Since *Hyphodontia alutaria* is morphologically quite similar to *H. zhixiangii* and no Central Asian specimens of *H. alutaria* was sequenced, we cannot exclude the possibility that the so-called *H. alutaria* in Central Asia is actually *H. zhixiangii*. At this time, we treat them as *H. alutaria* according

to the morphological concept of *H. alutaria* in a wide sense. This species usually widespread on coniferous trees such as *Abies*, *Cupressus*, *Juniperus*, *Picea*, *Pinus* and *Taxus*, however, Ginns and Lefebvre (1993) reported on *Betula*, *Populus*, angiosperm as host plants in North America. In Uzbekistan we found this species on a stem of deciduous tree, *Pterocarya pterocarpa* (Juglandaceae). Although *Xylodon flaviporus* (Berk. & M.A. Curtis ex Cooke) Ghobad-Nejhad and Hallenberg (2012) had been found on *Pterocarya fraxinifolia* from the Caucasian region, this report is the first for any *Hyphodontia* s.l. on *P. pterocarpa*. We also report the first record of *H. alutaria* on *Juniperus polycarpus* var. *seravschanica*, though it was long known to grow on *J. communis*. *Hyphodontia alutaria* was collected in dry and moist areas of foothills to mountains with altitude 700 – 1800 m, indicating that this species is well adapted to a continental environment with high temperature.

Specimens examined: TAJIKISTAN: Khatlon Prov., Hissar mountain range (alt. 1800 m) in the Western part of the Pamir-Alay Mountains, on the stem of *Juniperus polycarpus* var. *seravschanica*, 25 May 1978, I. Parmasto, TAAM 097283; UZBEKISTAN: Tashkent Prov., Botanical garden in Tashkent city, on twigs and stem of *Pterocarya pterocarpa* Kunth ex I. Iljinsk, 2 Sep 2013, Yu. Sh. Gafforov, YG-G37 (TASM).

Global distribution: ASIA: Central Asia: Tajikistan, Uzbekistan; East Asia: China (Dai 2011); South Asia: India (Kaur et al 2014); Armenia (Ghobad-Nejhad 2011), Iran (Ghobad-Nejhad and Hallenberg 2012); EUROPE: many countries (Bernicchia and Gorjón 2010); NORTH AMERICA: Canada, USA (Gilbertson 1980); SOUTH AMERICA: Argentina (Greslebin and Rajchenberg 2000), Colombia (Hjortstam and Ryvarden 2008), Uruguay (Hjortstam and Ryvarden 2007a), Venezuela (Hjortstam and Ryvarden 2005, 2007b); AUSTRALASIA: Australia, New Zealand (Cunningham 1963); SOUTH ATLANTIC OCEAN: St. Helena (Ryvarden 2015).

Hyphodontia arguta (Fr.) J. Erikss., Symb bot upsal 16 (1): 104, 1958.

213 In Central Asia, this species is very common, with a wide range of habitat and substrate, growing
214 from 1600 to 2900 m elevation and on diverse coniferous and deciduous wood plants in both xeric and
215 moist mountain forests. This is the first report of this species on dead wood of the *Crataegus*
216 *songarica*, *Malus sieversii* and *Sorbus tianschanica* – endemic trees of the Central Asian Mountains.
217 Our specimens have variable sizes of lagenocystidia. According to Schwartzman (1964) the basidia are
218 $10\text{--}15 \times 3.6\text{--}6 \mu\text{m}$, and basidiospores $5\text{--}6 \times 4\text{--}5 \mu\text{m}$. Here we report the species from the basidiomata
219 of *Phellinus pini*. Schwartzman (1964) also reported *H. arguta* in Kazakhstan as *Odontia lactea* (P.
220 Karst.) P. Karst, which is now regarded as a synonym of *H. arguta* (Index Fungorum 2017).

221 *Specimens examined*: KAZAKHSTAN: Northern Tien Shan Mountains, Trans-Ili Alatau mountain
222 (alt. 1600–1800 m), Medeo-Mohnaja sopka in Almaty province, on dried twigs and stump of *Sorbus*
223 *tianschanica* Rupr., 27 Aug 1963, A. Raitviir, TAAM 043480; KYRGYZSTAN: Jalal-Abad prov.,
224 Ozom Kasl, Terskey Ala-Too range in the Tien-Shan Mountains, on dead wood of *Picea schrenkiana*,
225 6 Jun 1971, B. Kullman, TAAM 065201: Chatkal Mountain, Sary-Chelek Nature Reserve in Western
226 Kyrgyzstan, on dried stems and dead stump of *Picea schrenkiana*, 4 Aug 1967, A. & T. Raitviir,
227 TAAM 044594; TAJIKISTAN: Pamir mountain range (Alt. 2700 m) in the northeast of Tajikistan, on
228 dead wood of *Juniperus communis* var. *saxatilis* Pall., 8 Jun 1978, I. Parmasto, TAAM 097334.

229 Records from Schwartzman (1964): KAZAKHSTAN: Dzungarian Alatau, Terekty-river valley,
230 Yablonevaya lesnaya dacha, 10 Jun 1944; Trans-Ili Alatau range, Maloe Almatinskoy ushelya, north
231 slope of Moxnatoy copki (Alt 1700 m), 20 Oct 1946; pass of Butakovskiy (Alt. 2900 m) in North Tien
232 Shan Mountains; Medeo, 10 Aug 1948; Saxroma 7 Aug 1948; river of Maloy Amatinka 17 Aug 1948;
233 river Batareyki, 9 Aug 1948; Oliniy klyuv 17 Sep 1957; Issiqskoy, Lake Issyq, 1 Aug 1962; river
234 Lepsy, Terekty, Djalanash 1934, 1944; Pitomnik agrolesxoza 14 Aug 1948; "Vorota" slope (Alt 2600
235 m), 18 Jul 1948; Talgar, Kurtuguy, 22 Sep 1961; Chilskoy ushelya, Chilskaya lesnaya dacha, ushelya
236 Burunskaya 11–13 Jul 1948; Almaty city 27 Jul 1962; East Kazakhstan province, 10 Sep 1943
237 (Schwartzman 1964).

238 *Global distribution:* AFRICA: Reunion Island (Riebesehl et al. 2015), South Africa (Hjortstam and
 239 Ryvar den 2007a); ASIA: Central Asia: Kazakhstan, Kyrgyzstan, Tajikistan; East Asia: China (Dai
 240 2011), Japan, Taiwan (Langer 1994); South Asia: India (Kaur et al. 2014); EUROPE: all countries
 241 (Bernicchia and Gorjón 2010); NORTH AMERICA: Mexico (Tapia et al. 2016), USA (Gilbertson
 242 1980); SOUTH AMERICA: Argentina (Greslebin and Rajchenberg 2000), Brazil (Hjortstam and
 243 Ryvar den 2009), Colombia (Hjortstam and Ryvar den 2008), Venezuela (Hjortstam and Ryvar den
 244 2005); AUSTRALASIA: Australia, New South Wales (Langer 1994).

245

246 ****Hyphodontia pallidula*** (Bres.) J. Erikss., Symb bot upsal 16 (1): 104, 1958.

247 *Hyphodontia pallidula* is morphologically close to *H. alutaria*, but differs in the smoother and more
 248 light-coloured basidiomata (Eriksson and Ryvar den 1976). *Hyphodontia pallidula* occurs on decaying
 249 coniferous wood of *Picea* forest in the Tien Shan Mountains of Kyrgyzstan. It can also be found on
 250 deciduous (*Alnus*, *Betula*, *Populus*) wood (Eriksson and Ryvar den 1976). The species occurs
 251 frequently in cold moist regions.

252 *Specimens examined:* KYRGYZSTAN: Issyk-Kul prov., Terskey Ala-Too (alt. 2100 m) range in
 253 Western Tien Shan Mountains, Tochen kochae, on dead wood of *Picea* sp. 10 Apr 1971, B. Kullman,
 254 K. Kalamees & A. Kollom, TAAM 009800.

255 *Global distribution:* AFRICA: South Africa (Hjortstam and Ryvar den 2007a); ASIA: Central Asia:
 256 Kyrgyzstan; East Asia: China (Dai 2011), Japan (Hjortstam and Ryvar den 2004), Taiwan (Wu 1990);
 257 South Asia: India (Kaur et al. 2014), Georgia (Ghobad-Nejhad and Hallenberg 2012); EUROPE: all
 258 countries (Bernicchia and Gorjón 2010); NORTH AMERICA: Canada, USA (Gilbertson 1980, Ginns
 259 1998); SOUTH AMERICA: Venezuela (Hjortstam and Ryvar den 2005, 2007b), SOUTH ATLANTIC
 260 OCEAN: St. Helena (Ryvar den 2015).

261

262 ***Hyphodontia zhixiangii*** L.W. Zhou & Yu. Sh. Gafforov, Phytotaxa, 299 (2): 273–279, 2017.

This species was recently described on a living tree of *Juniperus* from Uzbekistan and is morphologically very close to *Hyphodontia alutaria* and *H. arguta* (Kan et al. 2017a). The current study found that *H. zhixiangii* also grows on *Picea* in Kazakhstan. Because only several specimens of *H. zhixiangii* have been studied from both morphological and phylogenetic perspectives, certain specimens collected from Central Asia and previously labelled as *H. alutaria* and *H. arguta* might actually represent *H. zhixiangii*. Future studies are helpful to check this hypothesis and get comprehensive knowledge of its distribution.

Specimens examined: KAZAKHSTAN: Northern Tien Shan Mountains, Trans-Ili Alatau range, Dzhonischke, Karascha, on stump of *Picea schrenkiana*, 16 May 1976, A. Raitviir, TAAM 063975.

Records from Kan et al. (2017a): UZBEKISTAN: Jizzakh Region, Zaamin District, Zaamin National Park, on the base of living *Juniperus*, 9 Sep 2016, L. W. Zhou, LWZ 20160909-4 (holotype in IFP, isotype in TASM), on stump of *Juniperus*, 9 Sep 2016, L. W. Zhou, LWZ 20160909-8, LWZ 20160909-9. (IFP, TASM).

Global distribution: ASIA: Central Asia: Kazakhstan (in this study), Uzbekistan (Kan et al. 2017a)

****Kneiffiella alutacea*** (Fr.) Jülich & Stalpers, Verh K ned Akad Wet, tweede sect 74:134, 1980.

Among species of *Hyphodontia* s.l. with allantoid basidiospores and thin-walled, tubular cystidia, this is the only one with an odontoid hymenophore. However, there is great variation in the number and size of the thin-walled cystidia within species from different regions (Eriksson and Ryvarden 1976; Langer 1994). This is the first report of *K. alutacea* on *Picea schrenkiana*, from an area where the climate is generally moist, in mountain forest in the Northern Tien-Shan of Kazakhstan.

Specimens examined. KAZAKHSTAN: Almaty prov., Almatinka, Zailiysky Alatau Mountain range (elev. 2100 m) in Northern Tien-Shan Mountains, on dead wood of *Picea schrenkiana* Fisch. & C.A.Mey., 23 Aug 1963, A. Raitviir, TAAM 043393.

287 *Global distribution:* ASIA: Central Asia: Kazakhstan; East Asia: China (Dai 2011), Japan
288 (Hjortstam and Ryvarde n 2004); South Asia: India (Kaur et al 2014); EUROPE: all countries (Eriksson
289 and Ryvarde n 1976; Langer 1994); NORTH AMERICA: Canada, USA (Gilbertson 1980); SOUTH
290 AMERICA: Colombia (Hjortstam and Ryvarde n 2008); SOUTH ATLANTIC OCEAN: St. Helena
291 (Ryvarde n 2015).

292

293 ***Kneiffiella floccosa*** (Bourdot & Galzin) Jülich & Stalpers, Verh K ned Akad Wet, tweede sect 74:130,
294 1980.

295 This rare species is reported on *Picea schrenkiana* from only a single specimen collected in 1949 at
296 altitude 2286 m, in moist High Mountain coniferous forest of Trans-Ili Ala-Tau range in the Northern
297 Tien Shan Mountain.

298 Record from Schwartzman (1964): KAZAKHSTAN: Almaty Prov., Northern Tien Shan Mountains,
299 Trans-Ili Alatau mountain range (Alt. 2286 m), Lake Issyk, on dead wood of *Picea schrenkiana*, 25
300 Jun 1949.

301 *Global distribution:* ASIA: Central Asia: Kazakhstan; Eastern Asia: China (Dai 2011); EUROPE:
302 Austria, Estonia, France, Sweden (Langer 1994); NORTH AMERICA: Canada, USA (Langer 1994).

303

304 ****Lyomyces crustosus*** (Pers.) P. Karst., Revue mycol 3(9):23, 1881.

305 This common species has a wide distribution in the Northern Hemisphere and occurs both on
306 deciduous and coniferous wood. Our specimens were collected in the desert shrublands to the high
307 mountain forest, indicating that this species is well adapted to the arid and semi-arid environments of
308 the study area. This is the first time *L. crustosus* has been found on dead stump and twigs of *Crataegus*
309 *azarolus* var. *pontica* (K. Koch) K.I. Chr. and stump of *Fraxinus pennsylvanica*. We found many
310 crystal encrustations on all specimens from arid and semi-arid regions of Central Asia. Strong crystal

encrustations were previously reported (Langer 1994) in species growing in arid climates, mainly from *Lyomyces* species.

Specimens examined: KYRGYZSTAN: Jalal-Abad prov., Chatkal Mountain, Sary-Chelek Nature Reserve, on stump of *Crataegus azarolus* var. *pontica*, 04 Aug 1967, (TAAM 44593); TURKMENISTAN: Kara-Kola district, Chozly-Deke (alt. 1250 m), on unknown deciduous wood, 22 April 1971, (TAAM 54961); UZBEKISTAN: Tashkent Prov., Bustonliq district, Oqtosh ximprom oromgoxi (alt. 1350 m), Ugam range in the Western Tien Shan Mountains, on living tree of *Fraxinus pennsylvanica* Marshall., 03 Sep 2013, *Yu. Sh. Gafforov*, YG-G39 (TASM).

Global distribution: AFRICA: South Africa (Hjortstam and Ryvar den 2007a); ASIA: Central Asia: Kyrgyzstan, Turkmenistan, Uzbekistan; East Asia: China (Dai 2011), Japan (Maekawa 1994), Taiwan (Wu 1990); South Asia: India (Kaur et al. 2014); Armenia, Azerbaijan, Iran, Georgia (Ghobad-Nejhad 2011); EUROPE: many countries (Langer 1994); NORTH AMERICA: Mexico (Tapia et al. 2016), USA (Ginns 1998); SOUTH AMERICA: Brazil (Hjortstam and Ryvar den 2009), Colombia (Hjortstam and Ryvar den 2007a), Venezuela (Hjortstam and Ryvar den 2005, 2007b); AUSTRALASIA: Australia (Maekawa 1994).

****Lyomyces erastii* (Saaren. & Kotir.) Hjortstam & Ryvar den, Syn Fung 26:43, 2009. (Fig. 2)**

This species is similar to *L. sambuci* (Pers.) P. Karst. but differs in lacking thick-walled hyphae and differs also in basidiospore size and shape. We collected *L. erastii* in a warm climatic xeric mountain forest at altitude 1800 m.

Specimens examined: UZBEKISTAN: Tashkent prov., Ugam-Chatkal National Natural State Park, Xojikent village, Ugam range of Western Tien Shan Mountains, on deciduous wood, 2 Nov 2011, *Yu. Sh. Gafforov*, YG 022 (TASM).

Global distribution: ASIA: Russia (Kotiranta and Saarenoksa 2000), Central Asia: Uzbekistan; Iran (Ghobad-Nejhad and Hallenberg 2012); EUROPE: Finland (Kotiranta and Saarenoksa 2000), Ukraine (Ordynets et al. 2012).

Lyomyces pruni (Lasch) Riebesehl & E. Langer, Mycol Prog, 2017.

This species is widespread in continental areas from eastern Asia through Europe, as well as North and South America. It usually occurs in coniferous trees of the genera *Abies*, *Cupressus* and *Juniperus*, however species from the study site were reported on wood of deciduous *Fraxinus* (Schwartzman 1964). Morphologically *L. pruni* is close to the *L. crustosus*-group but it is distinguished by size, and spore of shape, also numerous subulate cystidiols in the hymenium.

Records from Schwartzman (1964): KAZAKHSTAN: Almaty Province, river Charyn in Northern Tien Shan Mountains, Charyn State National Natural Park, Ash forests, on dead wood of *Fraxinus* sp., 10 Mar 1943.

Global distribution: ASIA: Central Asia: Kazakhstan; East Asia: China (Dai 2011), Japan (Hjortstam and Ryvar den 2004), South Asia: India (Kaur et al. 2014); EUROPE: all countries (Langer 1994; Bernicchia and Gorjón 2010); NORTH AMERICA: Mexico (Tapia et al. 2016), USA (Ginns 1989); SOUTH AMERICA: Argentina (Greslebin and Rajchenberg 2000).

****Lyomyces sambuci*** (Pers.) P. Karst., Bidr Känn Finl Nat Folk 37:153, 1882.

This species is morphologically highly variable. It is widespread and common all over the world. We found variation in size and number of the cystidia, as well as in size and shape of basidia and basidiospores among specimens from the study area, perhaps indicating that *L. sambuci* is a species complex rather than a homogenous taxon even within this region. Distribution of *L. sambuci* is known from the moist forest and subalpine forest in the high mountains of the northern European countries, and it extends as far as the xeric and shrublands forest-steppe from Tajikistan, Turkmenistan and

Uzbekistan. Central Asian specimens are covered with many crystals, especially those from Turkmenistan. The presence of numerous crystals may minimize evaporation of water in the arid and semi-arid region. We report it for the first time on dead stem and stump of *Populus pruinosa*, *Philadelphus* sp. and *Acer turcomanicum* from Central Asia.

Specimens examined: TAJIKISTAN: Khatlon prov., Tigrovaya Balka Nature Reserve (alt. 2000 m), on stump of *Populus pruinosa* Schrenk, 31 March 1977, I. Parmasto, TAAM 096702; TURKMENISTAN: Ashgabat Prov., Kopet –Dag basin, District Glok-Tepe, Dushak mountain (alt. 2050 m), Geok-tepe District, on dead wood of *Juniperus pseudosabina* Fisch. & C.A. Mey., 28 Oct 1971, E. Parmasto, TAAM 055650; Kopet - Dag mountain range (alt. 1700 m), Ahal Prov., Baharly District, Arvaz, on dried stem of *Acer turcomanicum* Pojark., 18 October 1971, E. Parmasto, TAAM 055483; UZBEKISTAN: Botanical Garden in Tashkent city, on dead wood of *Philadelphus* sp., 20 April 1982, E. Parmasto, TAAM 104263; Botanical Garden in Tashkent city, on dead wood, 2 Sep 2013, Yu. Sh. Gafforov, YG-G2, YG-G8, YG-G20, YG-G31, YG-G33 (TASM); Tashkent Prov., Bustonliq District, Xojikent village, Ugam-Chatkal State National Natural Park, Ugam range of Western Tien Shan Mountains, on dead wood branch, 14 October 2011, Yu. Sh. Gafforov, YG 036 (TASM).

Global distribution: ASIA: Central Asia: Tajikistan, Turkmenistan, Uzbekistan; East Asia: China (Dai 2011), Taiwan (Wu 1990); South Asia: India (Kaur et al. 2014); EUROPE: all countries (Langer 1994; Bernicchia and Gorjón 2010); NORTH AMERICA: Mexico (Tapia et al. 2016), USA (Gilbertson 1980; Ginns 1998); SOUTH AMERICA: Argentina (Greslebin and Rajchenberg 2000, 2003); AUSTRALASIA: Australia, New Zealand (Maekawa 1994); SOUTH ATLANTIC OCEAN: St. Helena (Ryvarden 2015).

Xylodon asperus (Fr.) Hjortstam & Ryvarden, Syn Fung 26:34, 2009.

383 In Central Asia, *Xylodon asperus* is known on deciduous trees of *Populus talassica*, endemic to
384 Kazakhstan. This fungal species is distributed in temperate and tropical regions with cold and hot
385 seasonable climate. So far, it has been collected temperate continental mountain region between 1700–
386 2300 m alt.

387 Records from Schwartzman (1964): KAZAKHSTAN: Almaty prov., Northern Tien Shan mountain,
388 Trans-Ili Alatau range, Maloe Almatinskoy ushelya, Gorelnik u vodopada, 8 Aug 1948; Moxnatnoy
389 sopki, 16 Aug 1948, “Vorota”, 17 Aug 1948, Lake, 12 Jul 1956, Agroselxoz, 14 Aug 1948; Almaty
390 Prov., River Charyn, 10 Mar 1943.

391 *Global distribution:* ASIA: Central Asia: Kazakhstan; East Asia: China (Dai 2011), Japan
392 (Hjortstam and Ryvarde 2004); Armenia, Azerbaijan, Georgia, (Ghobad-Nejhad 2011); EUROPE:
393 Norway, Sweden, Germany, Austria (Langer 1994); NORTH AMERICA: Mexico (Tapia et al. 2016),
394 USA (Gilbertson 1980); SOUTH AMERICA: Colombia (Hjortstam and Ryvarde 2008), Venezuela
395 (Langer 1994).

396

397 ***Phylogenetic analysis***

398 The current dataset with 64 ITS sequences resulted in an alignment of 867 positions, including
399 introduced gaps; 426 positions were constant. The data matrix is subdivided into the parts ITS1, 5.8S
400 gene and ITS2 with the following positions: 1–385 for ITS1, 386–559 for 5.8S gene, 560–867 for
401 ITS2.

402 Minimum evolution (ME) as well as Bayesian method generated congruent topologies in main
403 lineages, and thus only the topology of ME analysis is presented with bootstrap (BS) values and
404 integrated posterior probabilities from the Bayesian analysis. Phylogenetic analyses confirmed our
405 morphological identifications of *Hyphodontia zhixiangii*, *Lyomyces crustosus*, *L. erastii* and *L.*
406 *sambuci* (Fig. 3).

407

Key to species of *Hyphodontia* s. l. in Central Asia

1. Cystidia emerging from subiculum..... 2
1. Cystidia emerging from subhymenium or hymenium 3
2. Cystidia thin-walled *K. alutacea*
2. Cystidia thick-walled *K. floccosa*
3. Septocystidia and/or lagenocystidia present 4
3. Septocystidia and lagenocystidia absent 7
4. Spores 2.5–3 μm wide..... *H. pallidula*
4. Spores min. 3 μm wide 5
5. Capitate/subcapitate cystidia or septocystidia basally
thick-walled..... 6
5. Capitate/subcapitate cystidia or septocystidia basally
thin-walled *H. arguta*
6. Spores 4.5–5 $\times$ 3–3.5 μm *H. alutaria*
6. Spores (4.3)4.6–5.5(6) $\times$ (3.2)3.3–4(4.3) μm *H. zhixiangii*
7. Cystidia fusiform with acute apex *L. crustosus*
7. Cystidia with round apex 8
8. Hymenium smooth..... 9
8. Hymenium spiny 10
9. Hyphae of subiculum thick-walled *L. sambuci*
9. Hyphae of subiculum thin-walled *L. erastii*
10. Hyphal ends of aculei tapering..... *L. pruni*
10. Hyphal ends of aculei capitate *X. asperus*

Re-identifications

We have studied also three specimens collected in Turkmenistan and Uzbekistan by Erast Parmasto and Ain Raitviir in 1971 and 1972 that were labelled as “*Hyphodontia* sp.”, (TAAM 127581) or “*Hyphodontia steccherinoides*” (TAAM 134536, 134542). The latter name has never been published, and we consider it as *ad interim* name of Erast Parmasto. Our microscopic investigation showed that all three specimens represent *Steccherinum ciliolatum* (Berk. & M.A. Curtis) Gilb. &

439 Budington. Three other specimens were named by the same collectors as "*Hyphodontia pruni*"
440 (TAAM 054973, 055024 and 054952). We re-identified these specimens as *Hyphodermella rosae*
441 (Bres.) Nakasone. All re-identifications were delivered to the TAAM herbarium via web-based
442 manager of biodiversity information PlutoF (Abarenkov et al. 2010, <https://plutof.ut.ee>).
443

444 **Geo-referencing data**

445 As a result of geo-referencing data from herbarium labels and literature information, and importing
446 this data to ArcGIS 10.1 desktop, a distribution GIS map of *Hyphodontia* s.l. species in Central Asia
447 was prepared (Fig. 1). *Hyphodontia arguta* was the most commonly collected species, found on
448 coniferous and deciduous trees in moist mountain of Kazakhstan, Kyrgyzstan and Tajikistan. The next
449 most abundant species was *Lyomyces sambuci*, distributed mainly in forest-steppe and xeric
450 shrublands of Tajikistan, Turkmenistan and Uzbekistan. *Lyomyces crustosus* (on *Crataegus azarolus*
451 var. *pontica*, *Fraxinus pennsylvanica*) and *L. pruni* (on *Fraxinus* sp.) occurred in the xeric mountains
452 deciduous forest. *Lyomyces erastii* is collected in the warm climatic xeric mountain forest of
453 Uzbekistan. *Xylodon asperus*, *Kneiffiella alutacea*, *K. floccosa*, *Hyphodontia alutaria* and *H. pallidula*
454 were found only in the coniferous and deciduous forest trees in the mountains areas of Kazakhstan,
455 Kyrgyzstan and Tajikistan. Most of the samples were collected from dead deciduous and coniferous
456 wood showing a white rot.
457

458 **Discussion**

459 This preliminary survey of the diversity of corticioid white-rot fungi of *Hyphodontia* s.l. in Central
460 Asia reveals previously unreported species, as well as known species growing on previously
461 unreported hosts. *Hyphodontia alutaria*, *Lyomyces crustosus*, *L. erastii* and *L. sambuci* are new for
462 Uzbekistan; *L. crustosus*, *L. sambuci* are new for Turkmenistan; *H. alutaria*, *H. arguta*, *L. sambuci* are

new for Tajikistan; *H. arguta* and *H. pallidula* are new for Kyrgyzstan; *H. zhixiangii* is new for Kazakhstan and *Kneiffiella alutacea* is reported as new record for Central Asia.

Our study of *Hyphodontia* s.l. diversity in Central Asia is a preliminary effort, but it suggests that much greater diversity of wood-rotting fungi than one might expect occur in this arid to semi-arid, largely treeless region. In a study examining a mere of 30 specimens from TAAM, and recently collected samples in Uzbekistan and from references, we report 11 species of *Hyphodontia* s.l., compared to only five reported previously (Schwartzman 1964; Eljchibayev 1966; Kan et al. 2017a). This study also expands the known hosts spectra for many of the *Hyphodontia* s.l. taxa studied. We expect that additional *Hyphodontia* s.l. species will be found in further mycological inventories (Kan et al. 2017a).

Increased sampling from other continents are needed to elucidate the taxonomy and diversity of these wide-ranging *Hyphodontia* s.l. species and other corticioid fungi from Central Asia. However, a more thorough examination of local specimens will also help to clarify the diversity. For example, *Lyomyces pruni* from Kazakhstan (Schwartzman 1964) examined here had basidiospores differing somewhat in size and shape compared to those growing further north. Either this extends the range of morphological variation in *L. pruni*, or it hints that more than one species is being called *L. pruni*. A more extensive study might find cryptic undescribed taxa in Central Asia when including more sequences for phylogenetic inference.

The incrustation with crystals on hyphae of *Lyomyces crustosus*, *L. erastii* and *L. sambuci* seems to be an adaption to their life-style on twigs and branches exposed to drought. Those species are very often found in areas with dry climatic conditions. This adaptation is to minimize water loss in the arid and semi-arid climate of Central Asia (Klein Tank et al. 2006).

Our phylogenetic study reveals our collections of three species (*L. erastii*, *L. crustosus* and *H. zhixiangii*) to be conspecific with representative of these species from other regions, thus confirming their identifications. Three sequences from our *L. sambuci* specimens YG 036, YG-G2 and TAAM

104263 clustered with high support with another *L. sambuci* sequence (TFC Mic 15133) from Spain. It is striking that a further sequence of *L. sambuci* with its origin in Taiwan (GEL3400) does not fit into this clade. But nevertheless this sequence is closely orientated to the *L. sambuci* cluster with our sequences. Eriksson and Ryvarden (1976) assumed on morphological basis that *L. sambuci* represents a species complex. The differences between the sequences from specimens from Taiwan and Spain/Uzbekistan support this theory. Therefore, Uzbekistan *L. sambuci* collections are conspecific with European specimens. Consequently, a further morphological study is needed to clarify if the Taiwanese material belongs to an independent species.

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724 **Fig. 1** Distribution map of *Hyphodontia* s.l. species in Central Asia

725 **Fig. 2** *Lyomyces erastii*, YG 022 (TASM)

726 **Fig. 3** Phylogenetic position of Central Asian species of *Hyphodontia* s.l. sequenced in this study. The topology
727 was inferred using the Minimum Evolution method on the basis of ITS dataset. Bootstrap values are shown
728 below the branches and Bayesian posterior probabilities above the branches. Names of specimens with
729 sequences obtained in this study are given in bold.

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Fig. 1 Distribution map of *Hyphodontia* s.l. species in Central Asia

249x189mm (300 x 300 DPI)

Fig. 2 *Lyomyces erastii*, YG 022 (TASM)

92x66mm (300 x 300 DPI)

Fig. 3 Phylogenetic position of Central Asian species of *Hyphodontia* s.l. sequenced in this study. The topology was inferred using the Minimum Evolution method on the basis of ITS dataset. Bootstrap values are shown below the branches and Bayesian posterior probabilities above the branches. Names of specimens with sequences obtained in this study are given in bold.

184x286mm (300 x 300 DPI)

Table 1. Specimens used for the phylogenetic analyses. Sequences generated in this study are given in bold.

Species	Specimen voucher	GenBank	Reference	Origin
		accession number		
		ITS		
<i>Hastodontia hastata</i> (Litsch.) Hjortstam & Ryvarden	KAS-GEL3124	DQ340311	unpublished	Sweden
<i>Hyphodontia alutaria</i> (Burt) J. Erikss.	UC2023078	KP814431	Rosenthal et al. 2017	USA
<i>H. arguta</i> (Fr.) J. Erikss.	FR-0219451	KR349243	Riebesehl et al. 2015	La Réunion
<i>H. borbonica</i> Riebesehl, E. Langer & Barniske	FR-0219441	KR349240	Riebesehl et al. 2015	La Réunion
<i>H. chinensis</i> C.C. Chen & Sheng H. Wu	Wu1307-42	KX857802	Chen et al. 2017	China
<i>H. nongravis</i> (Lloyd) Sheng H. Wu	GC1412-22	KX857801	Chen et al. 2017	Taiwan
<i>H. pallidula</i> (Bres.) J. Erikss.	KAS-GEL2097	DQ340317	unpublished	Germany
<i>H. reticulata</i> C.C. Chen & Sheng H. Wu	Wu1109-178	KX857805	Chen et al. 2017	Taiwan
<i>H. subdetritica</i> S.S. Rattan	FR-0261085	KY081793	Riebesehl & Langer 2017	La Réunion
<i>H. subtropica</i> C.C. Chen & Sheng H. Wu	Wu9806-105	KX857807	Chen et al. 2017	Vietnam
<i>H. zhixiangii</i> L.W. Zhou & Yu.Sh. Gafforov	TAAM 063975	MF382994	This study	Kazakhstan
<i>H. zhixiangii</i>	LWZ20160909-4	KY440396	Kan et al 2017a	Uzbekistan
<i>Kneiffiella abieticola</i> (Bourdote & Galzin) Jülich & Stalpers	KHL 12498 (GB)	DQ873601	Larsson et al. 2006	Sweden
<i>K. alutacea</i> (Fr.) Jülich & Stalpers	KAS-GEL2284	DQ340340	unpublished	Germany

<i>K. barba-jovis</i> (Bull.) P. Karst.	KHL 11730 (GB)	DQ873609	Larsson et al. 2006	Sweden
<i>K. cineracea</i> (Bourdot & Galzin) Jülich & Stalpers	KAS-GEL4958	DQ340336	unpublished	La Réunion
<i>K. decorticans</i> (Gresl. & Rajchenb.) Hjortstam & Ryvar den	SP415980	KY081795	Riebesehl & Langer 2017	Argentina
<i>K. efibulata</i> (J. Erikss. & Hjortstam) Jülich & Stalpers	GB-0151167	KY081796	Riebesehl & Langer 2017	Sweden
<i>K. floccosa</i> (Bourdot & Galzin) Jülich & Stalpers	UC2022902	KP814441	Rosenthal et al. 2017	USA
<i>K. palmae</i> Rick ex Hjortstam & Ryvar den	FR7	KP689185	Wang et al. 2016	China
<i>K. stereicola</i> (Bres.) Nakasone	Blackwell 2141	KY081797	Riebesehl & Langer 2017	USA
<i>K. subalutacea</i> (P. Karst.) Jülich & Stalpers	KAS-GEL2196	DQ340341	unpublished	Norway
<i>K. subefibulata</i> (Jia J. Chen & L.W. Zhou) Riebesehl & E. Langer	Dai 10803	KT989971	Chen et al. 2016	China
<i>K. subglobosa</i> (Sheng H. Wu) Hjortstam	Wu890805-2	KY081798	Riebesehl & Langer 2017	Taiwan
<i>Lagarobasidium calongei</i> M. Dueñas, Tellería, Melo, M.P. Martín	MA-Fungi 73256	NR119737	Dueñas et al. 2009	Azores Islands
<i>L. detriticum</i> (Bourdot & Galzin) Jülich	MA-Fungi 5758	FM876211	Dueñas et al. 2009	Spain
<i>Lyomyces crustosus</i> (Pers.) P. Karst.	YG-G39	MF382993	This study	Uzbekistan
<i>L. crustosus</i>	UC2022841	KP814310	Rosenthal et al. 2017	USA
<i>L. erastii</i> (Saaren. & Kotir.) Hjortstam & Ryvar den	YG 022	MF382992	This study	Uzbekistan

<i>L. erastii</i>	MA-Fungi 34336	JX857800	unpublished	Spain
<i>L. griseliniae</i> (G. Cunn.) Riebesehl & E. Langer	KHL 12971 (GB)	DQ873651	Larsson et al. 2006	Costa Rica
<i>L. juniperi</i> (Bourdot & Galzin) Riebesehl & E. Langer	FR-0261086	KY081799	Riebesehl & Langer 2017	La Réunion
<i>L. microfasciculatus</i> (Yurchenko & Sheng H. Wu) Riebesehl & E. Langer	TNM F24757	JN129976	Yurchenko & Wu 2014	Taiwan
<i>L. sambuci</i> (Pers.) P. Karst.	TAAM 104263	MF382989	This study	Uzbekistan
<i>L. sambuci</i>	YG-G2	MF382990	This study	Uzbekistan
<i>L. sambuci</i>	YG 036	MF382991	This study	Uzbekistan
<i>L. sambuci</i>	KAS-GEL3400	DQ340326	unpublished	Taiwan
<i>L. sambuci</i>	TFC Mic 15133	JX857734	unpublished	Spain
<i>L. vietnamensis</i> (Yurchenko & Sheng H. Wu) Riebesehl & E. Langer	TNM F9073	JX175044	Yurchenko & Wu 2014	Vietnam
<i>Palifer verecundus</i> (G. Cunn.) Stalpers & P.K. Buchanan	KHL 12261 (GB)	DQ873642	Larsson et al. 2006	USA
<i>Phellinus gabonensis</i> Decock & Yombiyeni	MUCL 52025	HM635715	Yombiyeni et al. 2011	Gabon
<i>Xylodon apacheriensis</i> (Gilb. & Canf.) Hjortstam & Ryvarden	Canfield 180	KY081800	Riebesehl & Langer 2017	USA
<i>X. asperus</i> (Fr.) Hjortstam & Ryvarden	UC2023169	KP814365	Rosenthal et al. 2017	USA

<i>X. astrocystidiatus</i> (Yurchenko & Sheng H. Wu) Riebesehl, Yurchenko & E. Langer	Wu 9211-71	JN129972	Yurchenko & Wu 2014	Taiwan
<i>X. borealis</i> (Kotir. & Saaren.) Hjortstam & Ryvar den	UC2022850	KP814307	Rosenthal et al. 2017	USA
<i>X. brevisetus</i> (P. Karst.) Hjortstam & Ryvar den	UC2023199	KP814485	Rosenthal et al. 2017	Canada
<i>X. dimiticus</i> (Jia J. Chen & L.W. Zhou) Riebesehl & E. Langer	Dai 15321	KT989969	Chen et al. 2016	China
<i>X. flaviporus</i> (Berk. & M.A. Curtis ex Cooke) Riebesehl & E. Langer	ICMP 13836	AF145585	Paulus et al. 2000	Taiwan
<i>X. hastifer</i> (Hjortstam & Ryvar den) Hjortstam & Ryvar den	Ryvar den 19767,	KY081801	Riebesehl & Langer 2017	Argentina
<i>X. heterocystidiatus</i> (H.X. Xiong, Y.C. Dai & Sheng H. Wu) Riebesehl, Yurchenko & E. Langer	Wu 9209-27	JX175045	Yurchenko & Wu 2014	Taiwan
<i>X. lenis</i> Hjortstam & Ryvar den	Wu890714-3	KY081802	Riebesehl & Langer 2017	Taiwan
<i>X. nespori</i> (Bres.) Hjortstam & Ryvar den	KUC20130712-14	KJ668518	Jang et al. 2016	South Korea
<i>X. niemelaei</i> (Sheng H. Wu) Hjortstam & Ryvar den	GC 1508-146	KX857798	Chen et al. 2017	Taiwan
<i>X. nothofagi</i> (G. Cunn.) Hjortstam & Ryvar den	PDD:91630	GQ411524	Fukami et al. 2010	New Zealand
<i>X. ovisporus</i> (Corner) Riebesehl & E. Langer	Wu0809-76	KX857803	Chen et al. 2017	China
<i>X. paradoxus</i> (Schrad.) Chevall.	FCUG 2425	AF145571	Paulus et al. 2000	Russia

<i>X. pseudotropicus</i> (C.L. Zhao, B.K. Cui & Y.C. Dai) Riebesehl, Yurchenko & E. Langer	Dai 10768	KF917543	Zhao et al. 2014	China
<i>X. quercinus</i> (Pers.) Gray	Otto Miettinen 15050,1 (H 6013352)	KT361632	Ariyawansa et al. 2015	Finland
<i>X. raduloides</i> (Pers.) Riebesehl & E. Langer	ICMP 13833	AF145580	Paulus et al. 2000	Australia
<i>X. ramicida</i> Spirin & Miettinen	Viacheslav Spirin 7664 (H)	KT361634	Ariyawansa et al. 2015	Russia
<i>X. rhizomorphus</i> (C.L. Zhao, B.K. Cui & Y.C. Dai) Riebesehl, Yurchenko & E. Langer	Dai 12354	KF917544	Zhao et al. 2014	China
<i>X. rimosissimus</i> (Peck) Hjortstam & Ryvarde	Ryberg 021031 (GB)	DQ873627	Larsson et al. 2006	Sweden
<i>X. spathulatus</i> (Schr.) Kuntze	KHL7085 (GB)	KY081804	Riebesehl & Langer 2017	Sweden
<i>X. stratosus</i> (Hjortstam & Ryvarde) Hjortstam & Ryvarde	LR9798	KY081805	Riebesehl & Langer 2017	Kenya

Table 2. Summary of distribution and provisional ecological information on the *Hyphodontia* s.l. species in Central Asia [KZ, Kazakhstan; KG, Kyrgyzstan; TJ, Tajikistan; TM, Turkmenistan; UZ, Uzbekistan].

Species	Elevation (m. a. s. l.)	Substrate/Host	Habitat and Ecology	Distribution	Vegetation zone/ Ecosystems
<i>Hyphodontia alutaria</i>	700 - 1800	<i>Juniperus polycarpus</i> var. <i>seravschanica</i> , <i>Pterocarya pterocarpa</i>	Coniferous and deciduous forest in foothills and Mountain area.	TJ, UZ	Boreal, mediterranean, temperate oceanic, temperate continental, warm-temperate desert, mixed-temperate
<i>H. arguta</i>	1700-2900	<i>Juniperus communis</i> var. <i>saxatilis</i> , <i>Picea schrenkiana</i> , <i>Sorbus tianschanica</i> , <i>Abies sibirica</i> , <i>Pinus sylvestris</i> , <i>Malus sieversii</i> , <i>Crataegus songarica</i> , <i>Phellinus pini</i>	Coniferous and deciduous wood plants in the xeric and moist mountains forest	KG, KZ, TJ	Boreal, mediterranean, temperate oceanic, temperate continental, cold-temperate, warm-temperate, tropical
<i>H. pallidula</i>	2100	<i>Picea</i> sp.	Coniferous forest in moist mountain area	KG	Cold-temperate, boreal, tropical
<i>H. zhixiangii</i>	1700-2000	<i>Juniperus</i> sp. and <i>Picea schrenkiana</i>	Coniferous forest in Mountain area	KZ, UZ	Boreal, temperate continental, cold-temperate, warm-temperate, tropical
<i>Kneiffiella alutacea</i>	2100	<i>Picea schrenkiana</i>	Coniferous forest in Mountain area	KZ	Boreal, boreo-nemoral, temperate oceanic, temperate continental, mediterranean, steppe –taiga, cold-temperate
<i>K. floccosa</i>	2286	<i>Picea schrenkiana</i>	Coniferous forest in Mountain moist area	KZ	Boreal, temperate continental, temperate oceanic
<i>Lyomyces crustosus</i>	1250 – 2100	<i>Crataegus azarolus</i> var. <i>pontica</i> , <i>Fraxinus pennsylvanica</i> , Unknown deciduous wood	Deserts shrublands and xeric mountain forest	KG, TM, UZ	Boreal, temperate continental, temperate oceanic, mediterranean, warm-temperate desert, mixed-temperate
<i>L. erastii</i>	1800	Unknown deciduous wood	Deciduous forest in mountain area	UZ	Boreal, warm-temperate desert and semi desert, mediterranean
<i>L. pruni</i>	750 – 2413	<i>Fraxinus</i> sp.	Deciduous xerophytic light forests in steppe/arid to mountain zone	KZ	Temperate continental, temperate oceanic, boreal, tropical, mediterranean, warm temperate desert
<i>L. sambuci</i>	1000 – 2500	Unknown died wood, tree branch, <i>Juniperus pseudosabina</i> , <i>Populus pruinosa</i> , <i>Philadelphus</i> sp., <i>Acer turcomanicum</i>	Xerophytic deciduous forest-steppe and moist coniferous forests in mountain area.	TJ, TM, UZ	Warm temperate desert, temperate oceanic, boreal, tropical
<i>Xylodon asperus</i>	1700 – 2300	<i>Populus talassica</i> , <i>P. tremula</i>	Deciduous forest wood in mountain area.	KZ	temperate continental, subtropical, boreal, forest steppe