

## First overview of *Laboulbeniomyces* (Ascomycota) of Ukraine with new records for the country

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The first overview of the *Laboulbeniomyces* of Ukraine is presented and includes 37 species belonging to 16 genera, 2 families (*Laboulbeniaceae* and *Herpomycetaceae*) and 2 orders (*Laboulbeniales* and *Herpomycetales*). Among them, *Amorphomyces italicus*, *Botryandromyces heteroceri*, *Dimorphomyces myrmedoniae*, *Distolomyces forficulae*, *Herpomyces stylopygae*, *H. ectobiae*, *Hesperomyces virescens*, *Laboulbenia egens*, *L. flagellata*, *L. hyalopoda*, *L. luxurians*, *L. thaxteri*, *L. uncinata*, *L. vulgaris*, *Monoicomycetes drusillae* and *M. labiatus* are newly reported for Ukraine. All genera above, except for *Laboulbenia*, are reported for the first time from Ukraine. New records for *Cantharomyces italicus*, *Laboulbenia cristata*, *L. pedicellata*, *L. rougetii*, *Misgomyces dyschirii* and *Rickia peyerimhoffii* are also mentioned.

**Key words:** *Laboulbeniales*, *Herpomycetales*, Blattodea, Dermaptera, Coleoptera, Diptera.

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První přehled ukrajinských zástupců třídy *Laboulbeniomyces* představuje 37 druhů z 16 rodů, 2 čeledí (*Laboulbeniaceae* a *Herpomycetaceae*) a 2 řádů (*Laboulbeniales* a *Herpomycetales*). Jako zcela nové pro Ukrajinu jsou uvedeny druhy *Amorphomyces italicus*, *Botryandromyces heteroceri*, *Dimorphomyces myrmedoniae*, *Distolomyces forficulae*, *Herpomyces stylopygae*, *H. ectobiae*, *Hesperomyces virescens*, *Laboulbenia egens*, *L. flagellata*, *L. hyalopoda*, *L. luxurians*, *L. thaxteri*, *L. uncinata*, *L. vulgaris*, *Monoicomycetes drusillae* a *M. labiatus*. Pro všechny uvedené rody s výjimkou rodu *Laboulbenia*, jakož i pro čeleď *Herpomycetaceae* a řád *Herpomycetales*, jde o první záznamy o jejich výskytu na ukrajinském území. Studie přináší i nové nálezy druhů *Cantharomyces italicus*, *Laboulbenia cristata*, *L. pedicellata*, *L. rougetii*, *Misgomyces dyschirii* a *Rickia peyerimhoffii*.

## INTRODUCTION

*Laboulbeniomyces* are a group of obligate ectoparasitic fungi (excluding some *Pyxidiophora* species) associated with arthropods (De Kesel et al. 2020). Three orders of the class, i.e. *Herpomycetales*, *Laboulbeniales* and *Pyxidiophorales*, include 2,395 species (Catalogue of Life on-line). Research of this fungal group continues with the cooperation of entomologists and mycologists (Haelewaters et al. 2021).

Unfortunately, *Laboulbeniomyces* are still poorly known fungi in Ukraine. Nevertheless, *Laboulbenia pitraeana* Sorokin was described by Kharkiv mycologist N.V. Sorokin (Sorokin 1871) from the Kharkiv Region 150 years ago and was the first report of these fungi in Ukraine. Later, this species was synonymised with *Stigmatomyces baeri* H. Karst. (Koval 1974). Twelve species were reported by Polish mycologists Siemaszko et Siemaszko (1928, 1932, 1934) from Podillia (Vinnytsa and Ternopil Regions) and the Carpathians (Ivano-Frankivsk and Lviv Regions), among which *Cantharomyces denigratus*, *Chitonomyces melanurus*, *C. paradoxus*, *Corethromyces cristatus*, *Helodiomyces elegans*, *Laboulbenia deltomeri* and *Rhachomyces pilosellus*. Later, only a few more taxa were reported from screening old entomological collections. *Laboulbenia lecoareri*, *L. oodiphila*, *L. patrata*, *L. stenolophi* and *Rickia peyerimhoffii* were found on an insect collected by M. Klapacz in 1924 and by S. Tenenbaum in 1931 and 1938 (Majewski 1994, 2008). *Laboulbenia olisthopi* is the oldest species found by T. Majewski (2008) in S. Stobiecki's insect collection from Ivano-Frankivsk Region dated 1886. During the previous century, Ukrainian mycologists did not proceed with the study of this group. In recent literature, we find a few records of *Laboulbeniales*, e.g. *Laboulbenia pedicellata* from Crimea (Haelewaters et al. 2019). Very recently, Rossi et Christian (2020) described a new species, *Stigmatomyces scaptodrosophilae*, found in the Mukachevo District of the Zakarpattia Region.

Until recently, there was no list of *Laboulbeniomyces* for Ukraine. Apart from 11 Ukrainian *Laboulbeniales* cited by Santamaria et Pedersen (2021), no exhaustive list of *Laboulbeniomyces* existed. Prior to this project and based on our literature review, 21 species of *Laboulbeniales* had been reported from Ukraine. The new records reported here were made by the first author, i.e. during a study of Coleoptera for promotion of the Ukrainian Biodiversity Information Network (Mishustin 2021). The present authors have taken the first steps to study these organisms in the country. In this paper, we present the first comprehensive overview of records of *Laboulbeniomyces* from Ukraine, including some illustrations and data on their hosts and locations.

## MATERIAL AND METHODS

The study area mainly includes the outskirts of two Ukrainian towns in the steppe zone (Kherson) and the Transcarpathian Plain (Uzhhorod). We studied private insect collections from different regions of Ukraine as well. Host insects were collected either by hand or by using pitfall traps. Insects were kept in Eppendorf tubes with ethanol (96%). Groups of tubes were labelled and stored in sealed polyethylene zip-lock bags 80 × 100 cm.

Specimens were examined with standard microscope techniques using Optica SZM-2 7X-45X Trino Stereo Zoom (Ponteranica, Italy) and MICROMED-2 (LOMO, St. Petersburg, Russia) microscopes. Both temporary and permanent slides were made, the latter following Huldén (1983) and De Kesel et al. (2020). Photographs were taken with a Levenhuk C510 NG camera (Levenhuk, Tampa, FL, USA). Photographs of all studied species are deposited in the authors' databases.

Species identification was carried out using the following keys and catalogues: Thaxter (1900, 1908), De Kesel et al. (2020), Santamaria et Pedersen (2021). All fungi were identified by the authors, whereas insect identifiers are mentioned in Specimens examined. Nomenclature of fungi follows Index Fungorum and insect names follow De Jong et al. (2014). Names of insect subgenera are written in parentheses.

All examined specimens are deposited in the herbarium of Kherson State University (KHER). Insects and mycological slides are kept together and marked 'i' for insect collections and 'L' for mycological slides. The acronym is followed by the number of insect specimens from one locality kept in the plastic bag, the number in square brackets is the total number of insect individuals. The number after the dash indicates the particular insect or insects used for preparation of the fungus slides, kept in a different plastic bag or Eppendorf's tube, followed by the number or numbers of mycological slide labels in square brackets. Fungus slides may not be prepared from all insects in a particular sample.

## RESULTS AND DISCUSSION

## LIST OF SPECIES

***Amorphomyces italicus* Speng.**

Fig. 1a

Reported from Asia (China, Indonesia), Europe (Italy, Poland, Slovenia, Spain), Africa (Algeria, Cameroon) and South America (Argentina, Ecuador) (Rossi et Christian 2020). It represents a species and genus new for Ukraine.

Host insects: Staphylinidae (Coleoptera).

**Specimens examined** on *Carpelimus* sp.: Kherson Region, Kherson District, village of Zelenivka, 46°42'29" N, 32°36'34" E, 8 September 2021, leg. R. Mishustin, det. A. Kovalov (insect) (KHER i00091[3]–1[L00113], 2[L00114], 3[L00127]).

***Botryandromyces heteroceri* (Maire) I.I. Tav. et T. Majewski**

Fig. 1b

Widespread in Europe and also reported from Algeria (type), Turkey and Thailand (Santamaria et Pedersen 2021). This is the first Ukrainian record for both genus and species.

Host insects: Heteroceridae (Coleoptera).

**Specimen examined** on *Heterocerus heydeni* Kuwert, 1890: Kherson Region, Kherson District, village of Zelenivka, 46°42'29" N, 32°36'34" E, 19 March 2022, leg. R. Mishustin, det. A. Sazhnev (insect) (KHER i00096[5]–1[L00119]).

***Cantharomyces italicus* Speng.**

Previously reported on *Dryops viennensis* from the Ternopil Region, Ukraine (Siemaszko et Siemaszko 1934).

Host insects: Dryopidae (Coleoptera).

**Specimen examined** on *Dryops auriculatus* Geoffroy, 1785: Kherson Region, Kherson District, village of Zelenivka, 46°42'28" N, 32°36'39" E, 26 May 2021, leg. et det. R. Mishustin (insect) (KHER i00032 [L00032]).

***Dimorphomyces myrmedoniae* Thaxt.**

Fig. 1c

Described from Guatemala (Thaxter 1900), but later reported from Europe – Belgium, Bulgaria, Denmark, Greece, Poland, Italy, Spain, Switzerland and UK (Rossi et al. 2018, Santamaria et Pedersen 2021). This is the first record of this species and genus in Ukraine.

Host insects: Staphylinidae (Coleoptera).

**Specimen examined** on *Tachyusa constricta* Erichson, 1837: Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 8 May 2021, leg. R. Mishustin, det. R. Kovalev (insect) (KHER i00066 [L00082] together with *Monoicomyces labiatus*).

***Distolomyces forficulae* (T. Majewski) I.I. Tav.**

Figs. 1d, e

Previously reported from Belgium (De Kesel et Gerstmans 2012, De Kesel et al. 2020), Denmark (Santamaria et Pedersen 2021), Italy (Santamaria et Rossi 1999), Portugal (Santamaria et Rossi 1999), Poland (Majewski 1994, 2008) and Spain (Santamaria 1989). Records of both the genus and species are the first for Ukraine.

Host insects: Forficulidae (Dermaptera).

**Specimens examined** on *Forficula auricularia* Linnaeus, 1758: Kherson Region, Kherson, 46°38'13" N, 32°33'25" E, 16 April 2021, leg. et det. R. Mishustin (insect) (KHER i00031[2]–1[L00031]). – Mykolaiv Region, Bratskiy District, village of Lisove, inside rotten part of *Quercus robur* trunk (302 cm in circumference, age 65 years), 48°1'34" N, 31°39'14" E, 10 April 2021, leg. A. Khodosovtsev, det. R. Mishustin (insect) (KHER i00030 [L00030]).

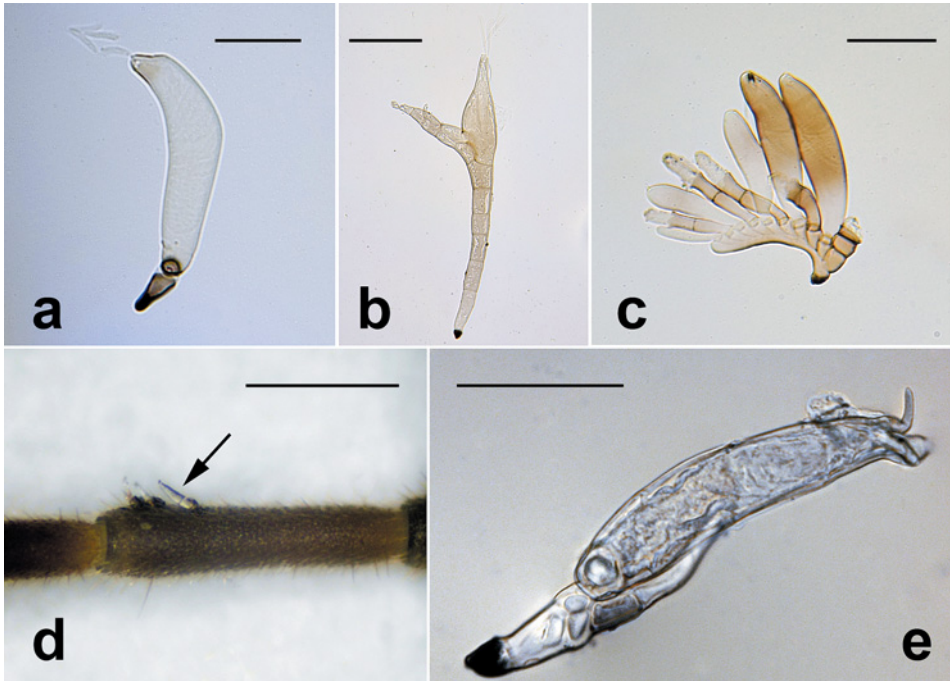
***Herpomyces ectobiae* Thaxt.**

Fig. 2c

Known from Europe, Africa, Asia, North and South America (Pfliegler et al. 2018). The European reports are from Belgium (Santamaria 2003, De Kesel et al. 2020), France (Santamaria 2003), Hungary (Santamaria et al. 1991), Poland and Spain (Santamaria 2003). This is a widespread invasive fungus on *Blattella germanica*, probably originating from Asia (Pfliegler et al. 2018). Both genus and species represent the first records for Ukraine.

Host insects: Blattellidae (Blattodea).

**Specimens examined** on *Blattella germanica* Linnaeus, 1767: Autonomous Republic of Crimea, Yalta, 44°30'45" N, 34°10'18" E, 6 August 2021, leg. O. Ramazanov, det. R. Mishustin (insect) (KHER i00014). – Kherson Region, Kherson, 46°38'37" N, 32°36'46" E, 6 April 2021, leg. et det. R. Mishustin (insect) (KHER i00011 [L00013]; i00012[4]–1[L00014]). – Odesa Region, Odesa, 46°28'4" N, 30°44'27" E, 6 May 2021, leg. et det. R. Mishustin (insect) (KHER i00013).



**Fig. 1.** a – *Amorphomyces italicus* (KHER L00114, scale bar = 25 µm); b – *Botryandromyces heteroceri* (KHER L00119, scale bar = 50 µm); c – *Dimorphomyces myrmedoniae* (KHER L00082, scale bar = 50 µm); d – *Distolomyces forficulae* on antenna of nymph (KHER i00031–I, scale bar = 0.5 mm); e – *Distolomyces forficulae* from imago (KHER L00030, scale bar = 50 µm). Photos by R. Mishustin (a, b, c, d), A. Khodosovtsev and R. Mishustin (e).

***Herpomyces stylopygae* Spig.**

Fig. 2b

A specialised parasite on *Blatta orientalis* which has possibly originated in southeast Europe between the Black Sea and the Caspian Sea (Pfliegler et al. 2018). To date, *H. stylopygae* has been reported on this host from Europe, Africa, North and South America, and Asia. We present the first records for Ukraine.

Host insects: Blattidae (Blattodea).

**Specimens examined** on *Blatta orientalis* Linnaeus, 1758: Kherson Region, Kherson, Khersonska fortetsya park, 46°38'32" N, 32°37'17" E, 14 April 2021, leg. et det. R. Mishustin (insect) (KHER i00015 [L00015]). – Odesa Region, Odesa, 46°25'42" N, 30°43'36" E, 6 August 2021, leg. Ye. Kalashnik, det. R. Mishustin (insect) (KHER i00016).

***Hesperomyces virescens* Thaxt.**

Fig. 2a

Associated with ladybirds and reported from all continents except Antarctica and Australia (Haelewaters et al. 2014, 2016). This is the first record of this species and genus in Ukraine.

Host insects: Coccinellidae (Coleoptera).

**Specimens examined** on *Harmonia axyridis* Pallas, 1773: Autonomous Republic of Crimea, Yalta, 44°30'40" N, 34°10'23" E, 6 August 2021, leg. O. Ramazanov, det. R. Mishustin (insect) (KHER i00029 [L00029]). – Cherkasy Region, Chygyryn District, village of Melnyky, Hotel Malva, 49°8'12" N, 32°17'52" E, 2 April 2021, leg. et det. R. Mishustin (insect) (KHER i00026 [L00026]). – Kherson Region, Kherson District, village of Antonivka, 46°40'25" N, 32°45'32" E, 13 April 2021, leg. et det. R. Mishustin (insect) (KHER i00027 [L00027]). – Zakarpattia Region, Uzhhorod, 48°36'59" N, 22°15'38" E, 11 May 2021, leg. et det. R. Mishustin (insect) (KHER i00028 [L00028]).

### ***Laboulbenia cristata* Thaxt.**

Collected in the Ternopil Region on *Paederus rubrothoracicus* Goeze, 1777 (Siemaszko et Siemaszko 1932). These are the first records for the steppe zone of Ukraine and the Zakarpattia Region.

Host insects: Staphylinidae (Coleoptera).

**Specimens examined** on *Paederidus ruficollis* Fabricius, 1777: Zakarpattia Region, Uzhhorod, 48°37'12" N, 22°15'35" E, 11 May 2021, leg. R. Mishustin, det. A. Kovalev (insect) (KHER i00024[10]–1[L00024]).

— on *Paederus balcanicus* C. Koch, 1938: Kherson Region, Kherson District, village of Zelenivka, 46°43'27" N, 32°39'57" E, 22 May 2021, leg. R. Mishustin, det. A. Kovalev (insect) (KHER i00104).

— on *Paederus baudii* Fairmaire, 1859 (= *Paederus schoenherri* Czwalina, 1889): Zakarpattia Region, Uzhhorod, 48°37'12" N, 22°15'35" E, 11 May 2021, leg. R. Mishustin, det. A. Kovalev (insect) (KHER i00025[6]–1[L00025]).

— on *Paederus limnophilus* Erichson, 1840: Zakarpattia Region, Uzhhorod, 48°37'12" N, 22°15'35" E, 11 May 2021, leg. R. Mishustin, det. A. Kovalev (insect) (KHER i00023[18]–1[L00023]).

### ***Laboulbenia egens* Speg.**

Fig. 2d

Distributed in Asia, Africa, Europe and North America (Santamaria et Pedersen 2021). This is the first record of the species in Ukraine.

Host insects: Carabidae (Coleoptera).

**Specimens examined** on *Tachys (Paratachys) bistriatus* Duftschmid, 1812: Kherson Region, Kherson District, village of Antonivka, 46°40'30" N, 32°46'51" E, 13 May 2021, leg. R. Mishustin, det. R. Panin (insect) (KHER i00080[3]–1[L00102]).

— on *Tachyura diabrachys* Kolenati, 1845: Zakarpattia Region, Uzhhorod, 48°36'37" N, 22°15'29" E, 11 May 2021, leg. R. Mishustin, det. R. Panin (insect) (KHER i00050[3]–1[L00059]); *ibid.*, 3 July 2021, leg. R. Mishustin (KHER i00070[7]–1 [L00090]).

### ***Laboulbenia flagellata* Peyr. s. lat.**

Fig. 3b

One of the most widespread species of *Laboulbenia*, known from all continents except Antarctica (Haelewaters et al. 2019). These are records new for Ukraine.

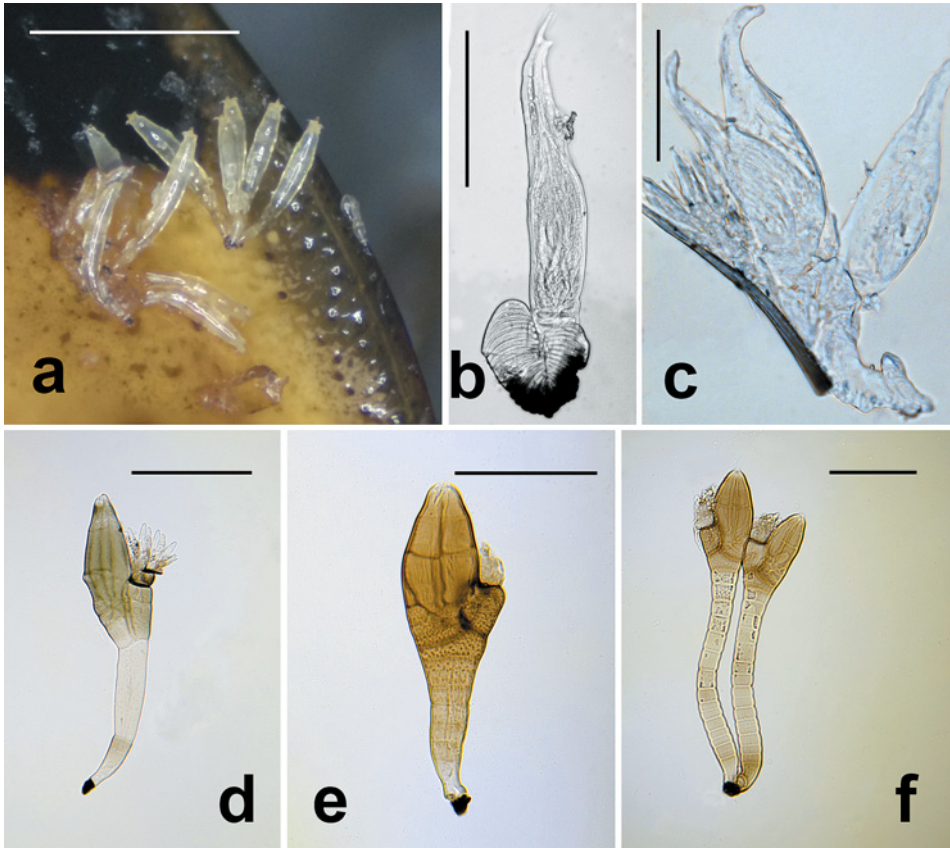
Host insects: Carabidae (Coleoptera).

**Specimens examined** on *Agonum (Olisares) emarginatum* Gyllenhal, 1827 (= *A. afrum* Duftschmid, 1812): Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 11 May 2021, leg. R. Mishustin, det. R. Panin (insect) (KHER i00040[4]–1[L00044], 2[L00045]).

— on *Agonum (Europhilus) piceum* Linnaeus, 1758: Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 8 June 2021, leg. et det. R. Mishustin (KHER i00071 [L00091]).

— on *Harpalus distinguendus* Duftschmid, 1812: Zakarpattia Region, Uzhhorod, 48°36'37" N, 22°15'35" E, 11 May 2021, leg. R. Mishustin, det. A. Kovalev (insect) (KHER i00072 [L00092]).

— on *Limodromus assimilis* Pontoppidan, 1763: Cherkasy Region, Chygyryn District, Kholodny Yar National Nature Park, 49°9'25" N, 32°15'15" E, 2 April 2021, leg. R. Mishustin, det. R. Panin (insect) (KHER i00018 [L00017]).



**Fig. 2.** **a** – *Hesperomyces virescens* (KHER i00026, scale bar = 0.5 mm); **b** – *Herpomyces stylopygae* (KHER L00015, scale bar = 100 µm, in water); **c** – *Herpomyces ectobiae* (KHER L00012, scale bar = 100 µm, in water); **d** – *Laboulbenia egens* (KHER L00090, scale bar = 50 µm); **e, f** – *Misgomyces dyschirii* (KHER L00125, scale bars = 50 µm). Photos by R. Mishustin (a, d, e, f), A. Khodosovtsev and R. Mishustin (b, c).

— on *Oxyypselaphus obscurus* Herbst, 1784: Kherson Region, Kherson, left bank of Dnipro river, 46°39'25" N, 32°41'15" E, 12 April 2021, leg. A. Khodosovtsev, det. R. Panin (insect) (KHER i00019 [L00018]).

**Notes.** *Laboulbenia flagellata* seems to be a species complex requiring comprehensive revision. This species differs from *L. rougetii* by its light outer appendages vs. dark outer appendages in *L. rougetii*.

***Laboulbenia hyalopoda* De Kesel**

Fig. 3a

Reported from Belgium (De Kesel et al. 2020) and Latvia (De Kesel et De Kesel 2006), but also from Denmark, Sweden and the UK (Santamaria et Pedersen 2021). The species represents the first record for Ukraine.

Host insects: Carabidae (Coleoptera).

**Specimen examined** on *Paradromius linearis* Olivier, 1795: Kherson Region, Kherson District, village of Antonivka, 46°40'25" N, 32°45'27" E, 25 May 2021, leg. R. Mishustin, det. R. Panin (insect) (KHER i00106 [L00190]).

Notes. The species is characterised by its slender hyaline receptacles and almost completely hyaline foot.

### ***Laboulbenia luxurians* Peyr.**

Widespread in Europe, also with a few records in Africa and South America reported on *Bembidion*, usually on members of subgenus *Notaphus* (e.g. Santamaria et Pedersen 2021). It is reported from Ukraine for the first time.

Host insects: Carabidae (Coleoptera).

**Specimen examined** on *Bembidion (Eupetodromus) dentellum* Thunberg, 1787: Zakarpattia Region, Uzhhorod, 48°36'37" N, 22°15'35" E, 11 May 2021, leg. R. Mishustin, det. R. Kovalev (insect) (KHER i00045 [L00052 together with *L. vulgaris*]).

### ***Laboulbenia pedicellata* Thaxt.**

Previously reported from the Autonomous Republic of Crimea on *Bembidion* sp. (Haelewaters et al. 2019). These are the first records for the steppe zone of Ukraine and the Zakarpattia Region.

Host insects: Carabidae (Coleoptera).

**Specimens examined** on *Bembidion articulatum* Panzer, 1796: Zakarpattia Region, Uzhhorod, 48°36'37" N, 22°17'12" E, 13 May 2021, leg. et det. R. Mishustin (insect) (KHER i00075 [L00095]).

— on *Bembidion* cf. *tetracolum* Fassati, 1944: Zakarpattia Region, Uzhhorod, 48°36'37" N, 22°15'35" E, 11 May 2021, leg. R. Mishustin, det. R. Panin (insect) (KHER i00033[40]–1[L00034 together with *L. vulgaris*]).

— on *Bembidion varium* Olivier, 1795: Kherson Region, Kherson, left bank of Veryovchina river, 46°41'46" N, 32°36'35" E, 24 April 2021, leg. R. Mishustin, det. R. Panin (insect) (KHER i00022 [L00022]). – Kherson District, village of Zelenivka, 46°42'29" N, 32°36'34" E, 20 August 2021, leg. et det. R. Mishustin (insect) (KHER i00099 [L00122]).

### ***Laboulbenia rougetii* Mont. et C.P. Robin**

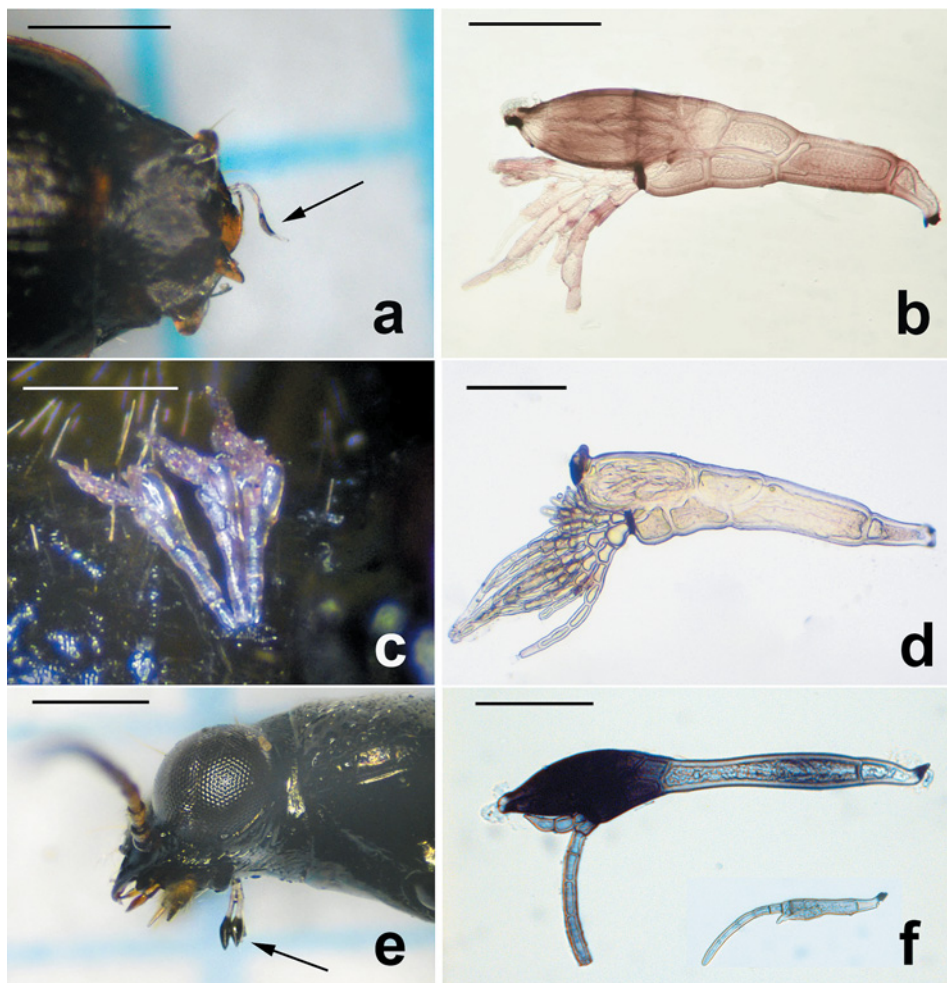
Widespread in Europe, Caucasus and South-East Asia (Santamaria et Pedersen 2021, Kong et al. 2020). In Ukraine, it was reported on *Brachinus crepitans* from the Ivano-Frankivsk Region (Siemaszko et Siemaszko 1928, Majewski 2008).

Host insects: all on Carabidae (Coleoptera).

**Specimens examined** on *Anchomenus dorsalis* Pontoppidan, 1763: Kherson Region, Kherson, Khersonska fortetsya park, 46°39'52" N, 32°37'45" E, 23 March 2021, leg. R. Mishustin, det. R. Panin (insect) (KHER i00003[6]–1[L00003]). – Zakarpattia Region, Uzhhorod, 48°36'37" N, 22°15'29" E, 25 May 2021, leg. et det. R. Mishustin (insect) (KHER i00005 [L00005]).

— on *Brachinus crepitans* Linnaeus, 1758: Autonomous Republic of Crimea, Sudak District, village of Krasnokamyanka, 44°55'15" N, 35°5'40" E, 22 July 2010, leg. G. Demidov, det. R. Mishustin (insect) (KHER i00010[5]–1[L00009]). – Odesa Region, Kodymsky District, village of Oleksandrivka, 48°0'7" N, 29°12'46" E, 17 May 2011, leg. G. Demidov, det. R. Mishustin (insect) (KHER i00008[2]–1[L00008]); the same locality and authors, 14 June 2015 (KHER i00009[5]).





**Fig. 3.** **a** – *Laboulbenia hyalopoda* (KHER i00106, scale bar = 0.5 mm); **b** – *Laboulbenia flagellata* (KHER L00017, scale bar = 100 µm, in water); **c** – *Laboulbenia uncinata* (KHER i00017, scale bar = 250 µm); **d** – *Laboulbenia uncinata* (KHER L00016, scale bar = 100 µm, in water); **e** – *Laboulbenia thaxteri* (KHER i00020–1, scale bar = 0.5 mm), **f** – *Laboulbenia thaxteri* (KHER L00019, scale bar = 100 µm, in water). Photos by R. Mishustin.

— on *Brachinus explodens* Duftschmid, 1812: Kherson Region, Kherson, Miskiy park, 46°38'29" N, 32°37'12" E, 19 March 2021, leg. et det. R. Mishustin (insect) (KHER i00001 [L00001]). – Kherson District, village of Zelenivka, 46°42'29" N, 32°36'39" E, 21 March 2021, leg. et det. R. Mishustin (insect) (KHER i00004 [L0004]). – village of Antonivka, 46°40'29" N, 32°46'24" E, 25 April 2021, leg. et det. R. Mishustin (insect) (KHER i00002 [L00002]). – Skadovsk District, Yagorlytskiy Kut peninsula, 46°19'3" N, 31°50'49" E, 14 May 2014, leg. L. Demidova, det. R. Mishustin (insect) (KHER i00006 [L00006]).

— on *Brachinus psophia* Audinet-Serville, 1821: Kherson Region, Kherson District, village of Zelenivka, 46°43'27" N, 32°39'57" E, 29 April 2021, leg. et det. R. Mishustin (insect) (KHER i00007[4]–1[L00007]).

— on *Chlaenius spoliatus* P. Rossi, 1792: Kherson Region, Kherson District, village of Zelenivka, 46°42'51" N, 32°37'47" E, 14 May 2021, leg. R. Mishustin, det. A. Kovalev et R. Mishustin (insect) (KHER i00011[2]–1[L00010, L00011, L00013], 2[L00012]).

Note. This species differs from *L. flagellata* by the strongly darkened outer side of the base of the outer appendage (De Kesel et al. 2020) and by its hosts (*Brachinus* spp.).

***Laboulbenia stenolophi*** Spig. (sub *L. acupalpi* Spig.)

Collected in Ukraine on *Acupalpus teutonius* Schrank, 1781 from the Ternopil Region (Majewski 2008). This is a record new for the steppe zone.

Host insects: Carabidae (Coleoptera).

**Specimen examined** on *Acupalpus elegans* Dejean, 1829: Kherson Region, Kherson District, village of Zelenivka, 46°43'27" N, 32°39'56" E, 11 February 2022, leg. R. Mishustin, det. A. Kovalev et R. Mishustin (insect) (KHER i00063 [L00078]).

***Laboulbenia thaxteri*** Cépède et F. Picard

Figs. 3e, f

Known from Europe and North Africa (Santamaria et Pedersen 2021). These are the first records of this species for Ukraine.

Host insects: Carabidae (Coleoptera).

**Specimens examined** on *Asaphidion flavipes* Linnaeus, 1760: Kherson Region, Kherson District, village of Antonivka, 46°40'26" N, 32°46'34" E, 25 April 2021, leg. R. Mishustin, det. R. Panin (KHER i00020[4]–1[L00019]). – Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 11 May 2021, leg. et det. R. Mishustin (KHER i00021[22]–1[L00020, L00021]).

Notes. The species is characterised by an inner appendage which never exceeds the perithecium and is composed of a basal cell with a single antheridium (De Kesel et al. 2020).

***Laboulbenia uncinata*** Thaxt.

Figs. 3c, d

Collected from France, Hungary, Poland, Romania, Russia, Spain, Switzerland and the USA (Santamaria et al. 2020). This is the first report from Ukraine.

Host insects: Carabidae (Coleoptera).

**Specimens examined** on *Harpalus distinguendus* Duftschmid, 1812: Kherson Region, Kherson, Khersonska fortetsya park, 46°38'29" N, 32°37'12" E, 2 April 2021, leg. R. Mishustin, det. R. Panin (KHER i00017 [L00016]). – Kherson District, village of Zelenivka, 46°42'30" N, 32°36'31" E, 19 June 2021, leg. R. Mishustin, det. R. Panin (KHER i00107 [L00131]).

Notes. The species is characterised by a strongly bevelled perithecial ostiole which is deflected from the appendages.

***Laboulbenia vulgaris*** Peyr. s. lat.

Widespread taxon and probably a species complex of parasites on Carabidae genera *Bembidion* and rarely on *Trechus* (Santamaria et Pedersen 2021). These are the first records from Ukraine.

Host insects: Carabidae (Coleoptera).

**Specimens examined** on *Bembidion dentellum* Thunberg, 1787: Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 11 May 2021, leg. R. Mishustin (KHER i00045 [L00052 together with *L. luxurians*]).

— on *Bembidion lampros* Herbst, 1784: Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 11 May 2021, leg. R. Mishustin (KHER i00036[10]–1[L00039]).

— on *Bembidion modestum* Fabricius, 1801: Zakarpattia Region, Uzhhorod, 48°36'59" N, 22°15'22" E, 8 May 2021, leg. R. Mishustin (KHER i00053[2]–1[L00062], 2[L00063]).

— on *Bembidion punctulatum* Drapiez, 1820: Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 11 May 2021, leg. R. Mishustin, det. R. Panin (insect) (KHER i00035[12]–1[L00037], 2[L00038]).

— on *Bembidion semipunctatum* Donovan, 1806: Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 11 May 2021, leg. R. Mishustin, det. A. Kovalev et R. Mishustin (KHER i00046[2]–1[L00053]).

— on *Bembidion cf. tetracolum* Say, 1825: Zakarpattia Region, Uzhhorod, 48°36'37" N, 22°15'35" E, 11 May 2021, leg. R. Mishustin, det. R. Panin et A. Kovalev (insect) (KHER i00033[40]–1[L00033], 2[L00034 together with *L. pedicellata*]).

— on *Bembidion varium* Olivier, 1795: Kherson Region, Kherson District, village of Zelenivka, 46°42'29" N, 32°36'34" E, 20 August 2021, leg. et det. R. Mishustin (insect) (KHER i00103 [L00129]).

— on *Bembidion (Peryphus) sp.*: Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 11 May 2021, leg. et det. R. Mishustin (insect) (KHER i00044[2]–1[L00051]).

***Misgomyces dyschirii* Thaxt.**

Fig. 2e, f

In Ukraine, this fungus was found in the Odesa Region on *Dyschirius substriatus* ssp. *priscus* Duftschmid, 1812 (Huldén 1985). This is the second record from Ukraine.

Host insects: Carabidae (Coleoptera).

**Specimens examined** on *Dyschirius sp.*: Kherson Region, Kherson District, village of Zelenivka, 46°42'29" N, 32°36'34" E, 20 August 2021, leg. et det. R. Mishustin (KHER i00101[5]–1[L00125], 2[L00126]).

***Monoicomyces drusillae* Santam.**

Recently, this species was described from Spain (Santamaria et al. 2020) and later reported from a single collection in Denmark (Santamaria et Pedersen 2021). Genus and species represent the first records for Ukraine.

Host insects: Staphylinidae (Coleoptera).

**Specimens examined** on *Drusilla canaliculata* Fabricius, 1787: Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 11 May 2021, leg. et det. R. Mishustin (KHER i00047 [L00054]); *ibid.*, 48°36'59" N, 22°15'22" E, 8 May 2021, leg. et det. R. Mishustin (KHER i00059[4]–1[L00070, L00071]).

***Monoicomyces labiatus* T. Majewski**

Rare species known from a few localities in Poland (Majewski 1984), Spain and the USA (Santamaria 1996). This is the first record from Ukraine.

Host insects: Staphylinidae (Coleoptera).

**Specimen examined** on *Tachyusa constricta* Erichson, 1837: Zakarpattia Region, Uzhhorod, 48°37'11" N, 22°15'34" E, 8 May 2021, leg. R. Mishustin, det. A. Kovalev et R. Mishustin (insect) (KHER i00066 [L00082 together with *Dimorphomyces myrmedoniae*]).

***Rickia peyerimhoffii* Maire**

Reported from Ukraine in the Ternopil Region on *Scaphisoma agaricinum* (Majewski 2008). This is the first record from the Zakarpattia Region.

Host insects: Staphylinidae (Coleoptera).

**Specimen examined** on *Scaphisoma* cf. *agaricinum* Linneus, 1758: Zakarpattia Region, Uzhhorod, 48°37'5" N, 22°15'20" E, 8 June 2021, leg. R. Mishustin, det. A. Kovalev (KHER i00061[3]– 1[L00075]).

SUMMARY

The first synopsis of the *Laboulbeniomyces* of Ukraine is given in Tab. 1. The total list consists of 37 species of 16 genera, 2 families (*Laboulbeniaceae* and *Herpomycetaceae*) and 2 orders (*Laboulbeniales* and *Herpomycetales*). It includes a total of 57 species, 36 genera, 11 families and 4 orders of arthropod hosts (Blattodea, Dermaptera, Coleoptera and Diptera).

Sixteen species, *Amorphomyces italicus*, *Botryandromyces heteroceri*, *Dimorphomyces myrmedoniae*, *Distolomyces forficulae*, *Herpomycetes stylopygae*, *H. ectobiae*, *Hesperomyces virescens*, *Laboulbenia egens*, *L. flagellata*, *L. hyalopoda*, *L. luxurians*, *L. thaxteri*, *L. uncinata*, *L. vulgaris*, *Monoicomycetes drusillae* and *M. labiatus* are reported from Ukraine for the first time. Seven genera, *Amorphomyces*, *Botryandromyces*, *Dimorphomyces*, *Distolomyces*, *Herpomycetes*, *Hesperomyces* and *Monoicomycetes*, the family *Herpomycetaceae* and the order *Herpomycetales* are also reported for the first time.

One species, *Chitonomyces melanurus* Peyr., was reported from Ukraine by Huldén (1983) with reference to Koval (1974), but the record of this fungus was attributed to the Central Chernozem Region (Russia) in this handbook. Therefore, this species was not included in our synopsis. Eleven species have not yet been confirmed by recent collections. *Laboulbenia pterostichi* was reported by Siemaszko et Siemaszko (1928), but this species does not occur in Europe (Rossi et Weir 1997, Santamaria et Pedersen 2021). Considering the host, *Harpalus tardus*, this *Laboulbenia* could belong to another species, namely *L. coneglianensis*, *L. ophoni* or *L. flagellata*. The Ukrainian material cannot be examined since the collection by J. Siemaszko and W. Siemaszko was lost during World War II (Majewski 1994), therefore this fungus is indicated as *Laboulbenia* sp. in our synopsis.

Considering that the neighbouring country Poland has 215 species (Santamaria et Pedersen 2021), our synopsis probably represents about 15% of the total expected diversity of *Laboulbeniomyces* in Ukraine. Moreover, since Ukraine has more habitats than Poland, especially different types of steppe, semi-deserts and the Crimean sub-tropic, we can probably expect a higher species diversity than in many other European countries. Our results are a first step towards a modern study of the *Laboulbeniomyces* of Ukraine.

**Tab. 1.** Synopsis of *Laboulbeniomyces* reported from Ukraine.

For fungal species documented in this study as well as reported in former literature, hosts marked by asterisk were reported only in the literature.

Species	Host	Region	Reference
<i>Amorphomyces italicus</i>	<i>Carpelimus</i> sp. (Coleoptera, Staphylinidae)	Kherson Region (Zelenivka)	this paper
<i>Botryandromyces heteroceri</i>	<i>Heterocerus heydeni</i> (Coleoptera, Heteroceridae)	Kherson Region (Zelenivka)	this paper
<i>Cantharomyces denigratus</i>	<i>Dryops viennensis</i> (Coleoptera, Dryopidae)	Ternopil Region (Kolodribka)	Siemaszko et Siemaszko 1934
<i>Cantharomyces italicus</i>	<i>Dryops auriculatus</i> * <i>Dryops viennensis</i> (Coleoptera, Dryopidae)	Ternopil Region (Kolodribka) Kherson Region (Zelenivka)	Siemaszko et Siemaszko 1934 this paper
<i>Chitonomyces melanurus</i>	<i>Laccophilus hyalinus</i> (Coleoptera, Dytiscidae)	Ternopil Region (Dobrivlany)	Siemaszko et Siemaszko 1934
<i>Chitonomyces paradoxus</i>	<i>Laccophilus hyalinus</i> (Coleoptera, Dytiscidae)	Ternopil Region (Dobrivlany)	Siemaszko et Siemaszko 1934
<i>Corethromyces cristatus</i> (= <i>Rhadinomyces cristatus</i> )	<i>Lathrobium fulvipenne</i> var. <i>letzneri</i> <i>Lathrobium castaneipenne</i> (Coleoptera, Staphylinidae)	Ternopil Region (Zaleszczyki)	Siemaszko et Siemaszko 1932
<i>Dimorphomyces myrmedoniae</i>	<i>Tachyusa constricta</i> (Coleoptera, Staphylinidae)	Zakarpattia Region (Uzhhorod)	this paper
<i>Distolomyces forficulae</i>	<i>Forficula auricularia</i> (Dermaptera, Forficulidae)	Kherson Region (Kherson) Mykolaiv Region (Lisove)	this paper
<i>Helodiomyces elegans</i>	<i>Dryops luridus</i> (Coleoptera, Dryopidae)	Ternopil Region (Dobrivlany)	Siemaszko et Siemaszko 1934
<i>Herpomyces ectobiae</i>	<i>Blattella germanica</i> (Blattodea, Blattellidae)	AR Crimea (Yalta) Kherson Region (Kherson)	this paper
<i>Herpomyces stylopygae</i>	<i>Blatta orientalis</i> (Blattodea, Blattidae)	Kherson Region (Kherson) Odesa Region (Odesa)	this paper
<i>Hesperomyces virescens</i>	<i>Harmonia axyridis</i> (Coleoptera, Coccinellidae)	AR Crimea (Yalta) Cherkasy Region (Melnyky) Kherson Region (Antonivka) Zakarpattia Region (Uzhhorod)	this paper
<i>Laboulbenia cristata</i>	<i>Paederus balcanicus</i> <i>Paederus limnophilus</i> * <i>Paederus rubrothoracicus</i> <i>Paederidus ruficollis</i> <i>Paederus baudii</i> (Coleoptera, Staphylinidae)	Ternopil Region (Zaleszczyki) Kherson Region (Zelenivka) Zakarpattia Region (Uzhhorod)	Siemaszko et Siemaszko 1932 this paper
<i>Laboulbenia deltomeri</i> (as <i>Laboulbenia nebriae</i> )	<i>Deltomerus carpathicus</i> (Coleoptera, Carabidae)	Ivano-Frankivsk Region (Chornohora)	Siemaszko et Siemaszko 1928, 1932
<i>Laboulbenia egens</i>	<i>Tachyura diabrachys</i> <i>Tachys (Paratachys) bistratus</i> (Coleoptera, Carabidae)	Kherson Region (Antonivka) Zakarpattia Region (Uzhhorod)	this paper

Species	Host	Region	Reference
<i>Laboulbenia flagellata</i>	<i>Agonum (Olisares) emarginatum</i> <i>Agonum (Europhilus) piceum</i> <i>Harpalus distinguendus</i> <i>Limodromus assimilis</i> <i>Oxypselaphus obscurus</i> (Coleoptera, Carabidae)	Cherkasy Region (Kholodny Yar) Kherson Region (Kherson) Zakarpattia Region (Uzhhorod)	this paper
<i>Laboulbenia hyalopoda</i>	<i>Paradromius linearis</i> (Coleoptera, Carabidae)	Kherson Region (Antonivka)	this paper
<i>Laboulbenia lecoareri</i>	<i>Trechoblemus micros</i> (Coleoptera, Carabidae)	Ivano-Frankivsk Region (Chornohora, Deliatyn) Lviv Region (Drogobych)	Majewski 2008
<i>Laboulbenia luxurians</i>	<i>Bembidion (Eupetodromus) dentellum</i> (Coleoptera, Carabidae)	Zakarpattia Region (Uzhhorod)	this paper
<i>Laboulbenia olisthopi</i>	<i>Olisthopus sturmii</i> (Coleoptera, Carabidae)	Ivano-Frankivsk Region (Sniatyn)	Majewski 2008
<i>Laboulbenia oodiphila</i>	<i>Oodes helopioides</i> (Coleoptera, Carabidae)	Ternopil Region (Dobrivlany, Melnytza-Podilska, Zvenygorod)	Majewski 1994
<i>Laboulbenia patrata</i>	<i>Zorochochrous minimus</i> (Coleoptera, Elateridae)	Vinnytsa Region (Zozulyntsi) Ternopil Region (Zaleszczyki, Zeleny Gay)	Siemaszko et Siemaszko 1934 Majewski 2008
<i>Laboulbenia pedicellata</i>	<i>Bembidion articulatum</i> <i>Bembidion varium</i> <i>Bembidion</i> cf. <i>tetracolum</i> * <i>Bembidion</i> sp. (Coleoptera, Carabidae)	AR Crimea (Eupatoria) Zakarpattia Region (Uzhhorod) Kherson Region (Kherson, Zelenivka)	Haelewaters et al. 2019 this paper
<i>Laboulbenia rougetii</i>	<i>Anchomenus dorsalis</i> <i>Brachinus crepitans</i> <i>Brachinus explodens</i> <i>Brachinus psophia</i> <i>Chlaenius spoliatus</i> (Coleoptera, Carabidae)	AR Crimea (Krasnokamyanka) Ivano-Frankivsk Region (Bovshiv) Kherson Region (Antonivka, Kherson, Yagorlytskyi Kut, Zelenivka) Odesa Region (Oleksandrivka) Zakarpattia Region (Uzhhorod)	Siemaszko et Siemaszko 1928 Majewski 2008 this paper
<i>Laboulbenia stenolophi</i>	<i>Acupalpus elegans</i> * <i>Acupalpus teutonius</i> (Coleoptera, Carabidae)	Kherson Region (Zelenivka) Ternopil Region (Zvenygorod)	Majewski 2008 this paper
<i>Laboulbenia thaxteri</i>	<i>Asaphidion flavipes</i> (Coleoptera, Carabidae)	Kherson Region (Antonivka) Zakarpattia Region (Uzhhorod)	this paper
<i>Laboulbenia uncinata</i>	<i>Harpalus distinguendus</i> (Coleoptera, Carabidae)	Kherson Region (Kherson, Zelenivka)	this paper
<i>Laboulbenia vulgaris</i>	<i>Bembidion dentellum</i> <i>Bembidion lampros</i> <i>Bembidion modestum</i> <i>Bembidion punctulatum</i> <i>Bembidion semipunctatum</i> <i>Bembidion</i> cf. <i>tetracolum</i> <i>Bembidion varium</i> <i>Bembidion (Peryphus)</i> sp. (Coleoptera, Carabidae)	Kherson Region (Zelenivka) Zakarpattia Region (Uzhhorod)	this paper

Species	Host	Region	Reference
<i>Laboulbenia</i> sp. (as <i>L. pterostichi</i> )	<i>Harpalus tardus</i> (Coleoptera, Carabidae)	Vinnitsa Region (Derebchin)	Siemaszko et Siemaszko 1928
<i>Misgomyces dyschirii</i>	* <i>Dyschirius substriatus</i> ssp. <i>priscus</i> <i>Dyschirius</i> sp. (Coleoptera, Carabidae)	Kherson Region (Zelenivka) Odesa Region (Odesa)	Huldén 1985 this paper
<i>Monoicomyces drusillae</i>	<i>Drusilla canaliculata</i> (Coleoptera, Staphylinidae)	Zakarpattia Region (Uzhhorod)	this paper
<i>Monoicomyces labiatus</i>	<i>Tachyusa constricta</i> (Coleoptera, Staphylinidae)	Zakarpattia Region (Uzhhorod)	this paper
<i>Rhachomyces pilosellus</i>	<i>Lathrobium castaneipenne</i> <i>Lathrobium elongatus</i> (Coleoptera, Staphylinidae)	Ternopil Region (Chervonograd, Zaleszczyki)	Siemaszko et Siemaszko 1932
<i>Rickia peyerinhaffii</i>	<i>Scaphisoma</i> cf. <i>agaricinum</i> (Coleoptera, Staphylinidae)	Ternopil Region (Derevivka) Zakarpattia Region (Uzhhorod)	Majewski 2008 this paper
<i>Stigmatomyces baeri</i> (= <i>Laboulbenia</i> <i>pitraeana</i> , <i>Stigmatomyces muscae</i> )	<i>Musca domestica</i> (Diptera, Muscidae)	Kharkiv Region (Kharkiv) Cherkasy Region (Smila)	Sorokin 1871 Wize 1929
<i>Stigmatomyces</i> <i>scaptodrosophilae</i>	<i>Scaptodrosophila deflexa</i> (Diptera, Drosophilidae)	Zakarpattia Region (Karpaty)	Rossi et Christian 2020

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