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Diversity of myxomycete on Konya-Beyşehir highway route

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Konya-Beyşehir karayolu güzergahındaki miksomiset çeşitliliği

Abstract: In this study, it was aimed to determine myxomycetes growing on materials collected from forests on Konya-Beyşehir (Turkey) highway route between 2019-2020. 253 materials such as log and stump materials, forest debris and bark of living tree were collected during the fieldworks in the region. The moist chamber technique was applied to the collected materials. As a result, 80 myxomycete specimens were developed and 21 myxomycete taxa belonging to 8 families were identified. The most common species is *Perichaena depressa* Lib. and was detected on 17 different substrates. In addition, the localities of the species (station number, substrate, collection date, collection number), and photographs of the species identified from the region are also given.

Key words: Biodiversity, Konya, myxomycete

Özet: Bu çalışmada, 2019-2020 yılları arasında Konya-Beyşehir (Türkiye) karayolu güzergâhındaki ormanlardan toplanan materyaller üzerinde gelişen miksomisetlerin tespit edilmesi amaçlanmıştır. Bölgeye düzenlenen arazi çalışmalarında kesilmiş ve devrilmiş ağaç kütüğü materyalleri, orman döküntü katı ve canlı ağaç kabuğu gibi 253 adet materyal toplanmıştır. Toplanan materyallere nem odası tekniği uygulanmıştır. Arazi ve laboratuvar çalışmaları sonucunda 80 miksomiset örneği gelişmiş ve 8 familyaya ait 21 miksomiset taksonu tespit edilmiştir. En yaygın tür *Perichaena depressa* Lib. olup 17 farklı substratta tespit edilmiştir. Ayrıca türlerin lokaliteleri (istasyon numarası, substrat, toplama tarihi, toplama numarası), ve bölgeden tespit edilen türlerin fotoğrafları da verilmiştir.

Anahtar Kelimeler: Biyoçeşitlilik, Konya, miksomiset

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1. Introduction

Myxomycetes (slime moulds), also known as Mycetozoa or Myxogastria, are ameboid protists that have been considered as a special group of fungi for many years. They are called as “cıvık mantarlar” in our country (Türkiye) (Sesli et al., 2020).

Though some of them have fructifications, large enough to be seen by naked eye, most of them are quite small and they can be best observed with a hand lens or a microscope (Stephenson and Stempen, 2000). For most of its life, a myxomycete exists as a thin, free-living mass of protoplasm (Stephenson and Stempen, 2000). In their slimiest state, they creep through the forest growing in size and consuming food (Niblett, 2017). Plasmodia usually inhabit environments, such as soil, dead wood, and various plant litter and debris, which are moist and support bacteria and other decay microorganisms (Stephenson and Landolt, 1996; Clark and Haskins, 2015). After a period of feeding and growth, the plasmodium moves out of its normal habitat and into a drier, more exposed location. Here it gives rise to one or more fruiting bodies (Stephenson and Stempen, 2000).

Classification of myxomycetes was made first according to their microscopic characters (Rostafiński, 1873) and then according to the type of plasmodia and the morphogenesis of fruiting bodies (Martin et al., 1983; Lado and Eliasson, 2017). Therefore, myxomycetes have been studied in the kingdoms of plants, animals and protists by different taxonomists over time (Ing, 1999). In addition, myxomycetes are typically found in the same habitats as fungi, they were treated as taxa within the Kingdom *Fungi* (Class *Myxomycetes*) (Everhart and Keller, 2008). Baldauf and Doolittle (1997) conducted a phylogenetic analysis of highly conserved, elongation factor 1-alpha (EF-1α) gene sequences and showed that myxomycetes are not fungi. Physiology, morphology, life history, and genetic analysis support the classification of myxomycetes in the Kingdom *Protoctista* along with other eukaryotic microorganisms (Spiegel et al., 2004). With the increasing availability of genetic information, traditional myxomycete taxonomy is being increasingly challenged, and new hypotheses continue to emerge (Walker and Stephenson, 2016). Recently, Cavalier-Smith (2013), using Zoological Nomenclature, proposed a new classification of the myxomycetes based on evolutionary and phylogenetic evidence. Since this classification has not yet been consolidated (Lado and Eliasson, 2017), the classification used by researchers such as Martin and Alexopoulos (1969) and Nannenga-Bremekamp (1991) in their main works is generally used.

Myxomycetes have long attracted the attention of biologists, and always surprised them. Almost 1000 species (Lado, 2005-2022) have been detected worldwide, and 301 species have been identified in Turkey (Baba, 2021; Baba and Sevindik, 2021; Baba et al., 2021). Though Myxomycetes of the Beyşehir district have been studied (Yağız et al., 2002), any myxomycete record in our study area have been given. A part of this study was presented as a poster presentation at EMC19. The study aims to determine the myxomycetes and species richness along the Konya-Beyşehir road.

2. Material and Method

The study area consists of a region of 80 km along Konya-Beyşehir highway route up to the Beyşehir district border within Konya province in Central Anatolian Region (Fig. 1). The coordinates of the localities are given in the table (Table 1).

Although Beyşehir district is located within the boundaries of Konya province and is takes place in the Central Anatolian Region, it mostly reflects the Mediterranean climate characteristics in terms of precipitation, and continental climate characteristics in terms of temperature conditions. As for the general climatic feature, it belongs to the main Mediterranean climate floor (Kaya and Şimşek, 2014).

Since the study area consisted of forested areas on the highway with a width of 500 m from the road, no sampling was made from the mountainous areas and interior parts of the region. *Cedrus libani* A. Rich, *Pinus nigra* J.F.Arnold, and the members of *Juniperus* L., *Pyrus* L., *Morus* L., *Ulmus* L., *Juglans* L., *Platanus* L., *Quercus* L., *Salix* L. and *Populus* L. are common around Altınapa dam lake (Yıldıztugay et al., 2006). In Urban Forests (Kent Ormanı), the dominant species is *P. nigra*. In addition, there are approximately 180 perennial woody and herbaceous plant species, including *Quercus*, *Juniperus*, *Acacia* Martius, *Populus*, *Crataegus* Tourn. ex L. (Anonymus, 2022). *Salix* and *Populus* trees are also common along the streamsides and orchards.

The study materials were collected during field studies conducted between 2019-2020. In the field, samples from rotten bark and wood, bark of living trees, leaves, needles and pine cones and dungs were collected. For each of the material, which may have spores or plasmodium on them, a collection number was given and placed in a palstic bag or small cardboard box.

Moisture chamber technique was applied to collected the materials (Gilbert and Martin, 1933), and were examined under a stereomicroscope pediodically (every day) and sporocarp developments were recorded. The developing samples were glued together with their substrates to cardboard boxes measuring 4 × 4.5 × 11.5 cm and to the central part of the suitably cut cardboard boxes.

Figure 1. Map of the study area (adopted from Google Earth)

With the aid of a stereomicroscope, features such as the type of sporocarp, colour, dimensions, stalk lengths, calcified structure of peridium (if present), type of peridium opening were determined. Microscopic features such as the spore size, colours under the microscope light, spore ornaments, ornaments of the capillitial threads, their dimensions, presence of columella, calyculus, stalk structure, peridium features, whether the capillitial system is calcified or not were determined under a light microscope. Identification of specimens wer performed using the major works such as Martin and Alexopoulos (1969), Stephenson and Stempen (2000), Neubert et al. (1993; 1995; 2000), Nannenga-Bremekamp (1991) and Poulain et al. (2011).

The names, authors and synonyms of taxa were checked from the online nomenclature information system prepared by Carlos Lado (Lado, 2005-2022). The classification sytem used by Poulain et al. (2011) was followed. In addition, some required information related to the nomenclature of myxomycetes was checked from the website www.mycobank.org, which provides regularly updated data. During identification, digital photographs of both the sporocarp structures and microscopic structures of the samples were also taken.

Table 2. The coordinates of the sample collection sites

Localities	Date	Coordinates
B1 (Altınapa Dam)	01.05.2019 11.06.2020	37°53′06″N 32°18′36″E
B2	11.06.2020	37°52′58″N 32°16′07″E
B3	11.06.2020	37°48′12″N 31°48′36″E
B4	11.06.2020	37°46′07″N 31°47′63″E
B5	11.06.2020	37°52′49″N 31°56′56″E
B6	11.06.2020	37°52′51″N 31°59′51″E
B7 (Konya Urban forest)	01.05.2019 11.06.2020 12.07.2020	37°53′47″N 32°13′53″E

The samples are kept in the Fungarium of the Selçuk University Mushroom Application and Research Centre.

3. Results

Protozoa R. Owen

Myxomycota Whittaker

Myxomycetes G. Winter

Echinosteliales G.W. Martin

Echinosteliaceae Rostaf. ex Cooke

3.1. *Echinostelium minutum* de Bary (Fig. 2a)

Location: B1, on debris barks, 01.05.2019, RB32; B7, on bark of living *Juniperus* sp., 01.05.2019, RB42; B1, near the stream, on debris bark of *Populus* sp., 11.06.2020, RB68; B3, on dried reed, 11.06.2020, RB109; B5, on log branch *Acacia* sp. Martius, 11.06.2020, RB144; B7, on debris twig, 12.07.2020, RB192.

Liceales E. Jahn

Cribrariaceae Corda

3.2. *Cribraria cancellata* (Batsch) Nann.-Bremek. (Fig. 2b)

Location: B7, on stump bark, 12.07.2020, RB192.

3.3. *Cribraria violacea* Rex (Fig. 2c)

Location: B5, on stump wood of *Populus* sp., 11.06.2020, RB140.

Liceaceae Chevall.

3.4. *Licea denudescens* H. W. Keller & T. E. Brooks (Fig. 2d)

Location: B1, on log wood, 11.06.2020, RB66; B1, on bark of living *Populus* sp., 11.06.2020, RB79; B3, on debris bark of *Salix* sp., 11.06.2020, RB110.

Physarales T. Macbr.

Badhamiaceae Locq.

3.5. *Badhamia macrocarpa* (Ces.) Rostaf. (Fig. 2e)

Location: B1, on branch of living tree, 01.05.2019, RB3; B7, on bark of living tree, 01.05.2019, RB38; B7, on debris bark of *Juniperus* sp., 01.05.2019, RB43; B1, on bark of *Salix* sp. log, 11.06.2020, RB72.

3.6. *Badhamia panicea* (Fr.) Rostaf. (Fig. 2f)

Location: B7, on branch of living tree, 01.05.2019, RB53.

Didymiaceae Rostaf. ex Cooke

3.7. *Didymium annulisporum* H. W. Keller& Schokn. (Fig. 2g)

Location: B1, on debris wood, 01.05.2019, RB12; on bark of living *Crataegus* sp. L., 01.05.2020, RB13; B1, on debris bark of *Populus* sp., 11.06.2020, RB70; B4, on debris twig bark of *Populus* sp., 11.06.2020, RB115; B5, on bark of living *Populus* sp., 11.06.2020, RB134; B7, on bark of living tree, 12.07.2020, RB207.

Physaraceae Chevall.

3.8. *Physarum cinereum* (Batsch) Pers. (Fig. 2h)

Location: B7, on bark of living tree, 11.06.2020, RB162.

3.9. *Physarum didermoides* (Pers) Rostaf. (Fig. 2i)

Location: B1, on debris bark, 01.05.2019, RB29; B7, on bark of living tree, 01.05.2019, RB38; B1, near stream, on debris bark of *Populus* sp., 11.06.2020, RB68; B2, on debris twig *Pinus nigra*, 11.06.2020, RB90; B3, on debris twig *Salix* sp., 11.06.2020, RB106; B4, on bark of living *Populus* sp., 11.06.2020, RB114; B4, on bark of living *Populus* sp., 11.06.2020, RB118; B4, on debris bark of *P. nigra*, 11.06.2020, RB126; B5, on bark of living *Populus* sp., 11.06.2020, RB134; B7, on bark of living tree, 11.06.2020, RB162; B7, on debris twig, 12.07.2020, RB173; on debris cone, 12.07.2020, RB225; on log wood, 12.07.2020, RB250.

3.10. *Physarum notabile* T. Macbr. (Fig. 2j)

Location: B1, on bark of living *P. nigra*, 11.06.2020, RB86; B4, on debris bark of *Populus* sp., 11.06.2020, RB118.

Stemonitidales T. Macbr.

Stemonitidaceae Fr.

3.11. *Comatricha nigra* (Pers. ex J. F. Gmel.) J. Schröt. (Fig. 2k)

Location: B7, on debris twig, 12.07.2020, RB184; B7, on bark of living tree, 12.07.2020, RB241.

3.12. *Macbrideola cornea* (G. Lister & Cran) Alexop. (Fig. 2l)

Location: B7, on bark of living of *Juniperus* sp., 01.05.2019, RB42; on debris bark of *Juniperus* sp., 01.05.2019, RB43.

3.13. *Paradiacheopsis fimbriata* (G. Lister & Cran) Hertel ex Nann.-Bremek. (Fig. 2m)

Location: B7, on bark of living *Juniperus* sp., 01.05.2019, RB42.

Trichiales T. Macbr.

Arcyriaceae Rostaf. ex Cokee

3.14. *Arcyria cinerea* (Bull.) Pers. (Fig. 2n)

Location: B7, on log wood, 01.05.2019, RB40; B5, on log wood of *Populus* sp., 11.06.2020, RB140; B7, on log wood, 12.07.2020, RB250.

3.15. *Arcyria pomiformis* (Leers) Rostaf. (Fig. 2o)

Location: B7, on debris wood, 12.07.2020, RB185; RB190; RB196; B7, on debris cone, 12.07.2020, RB198.

Trichiaceae Chevall.

3.16. *Arcyodes incarnata* (Alb. & Schwein.) O. F. Cook (Fig. 2p)

Location: B1, on debris bark of *Salix* sp., 11.06.2020, RB73.

3.17. *Perichaena chrysosperma* (Curr.) Lister (Fig. 2r)

Location: B7, on debris wood, 01.05.2019, RB36; on stump wood, 01.05.2019, RB40.

3.18. *Perichaena depressa* Lib. (Fig. 2s)

Location: B1, on stump wood, 01.05.2019, RB23; on debris bark, 01.05.2019, RB29; on stump wood, 01.05.2019, RB31; on stump bark of *Populus* sp., 01.05.2019, RB33; B7, on debris wood, 01.05.2019, RB36;

B1, on debris bark of *Populus* sp., 11.06.2020, RB65; B1, near the stream, on debris wood of *Populus* sp., 11.06.2020, RB67; B1, on debris twig bark of *Populus* sp., 11.06.2020, RB70; B1, on debris bark of *Salix* sp., 11.06.2020, RB73; B1, on debris bark of *Populus* sp., 11.06.2020, RB85; B3, on bark of living *Populus* sp., 11.06.2020, RB112; B4, on debris bark of *Populus* sp., 11.06.2020, RB118; B5, on bark of living *Populus* sp., 11.06.2020, RB134; B5, on log twig of *Acacia* sp., 11.06.2020, RB144; B6, on root bark of *Acacia* sp., 11.06.2020, RB149; B7, on debris twig, 12.07.2020, RB242; on bark of dead tree, 12.07.2020, RB247.

3.19. *Perichena quadrata* T. Macbr. (Fig. 2t)

Location: B1, on debris bark of *Populus* sp., 11.06.2020, RB83.

3.20. *Perichaena vermicularis* (Schwein.) Rostaf. (Fig. 2u)

Location: B7, on bark of living tree, 01.05.2019, RB38; on bark of living *Juniperus occidentalis* Hooker, 01.05.2019, RB41; on bark of living of *Juniperus* sp., 01.05.2019, RB42; B1, on log bark of *Populus* sp., 11.06.2020, RB69; B4, on bark of *Populus* sp., 11.06.2020, RB118; B6, on twig of living *J. communis* L., 11.06.2020, RB146; B6, on root bark of *Acacia* sp., 11.06.2020, RB149.

3.21. *Trichia lutescens* (Lister) Lister (Fig. 2v)

Location: B6, on twig of living *J. communis*, 11.06.2020, RB146; B7, on twig of living *J. communis*, 11.06.2020, RB160.

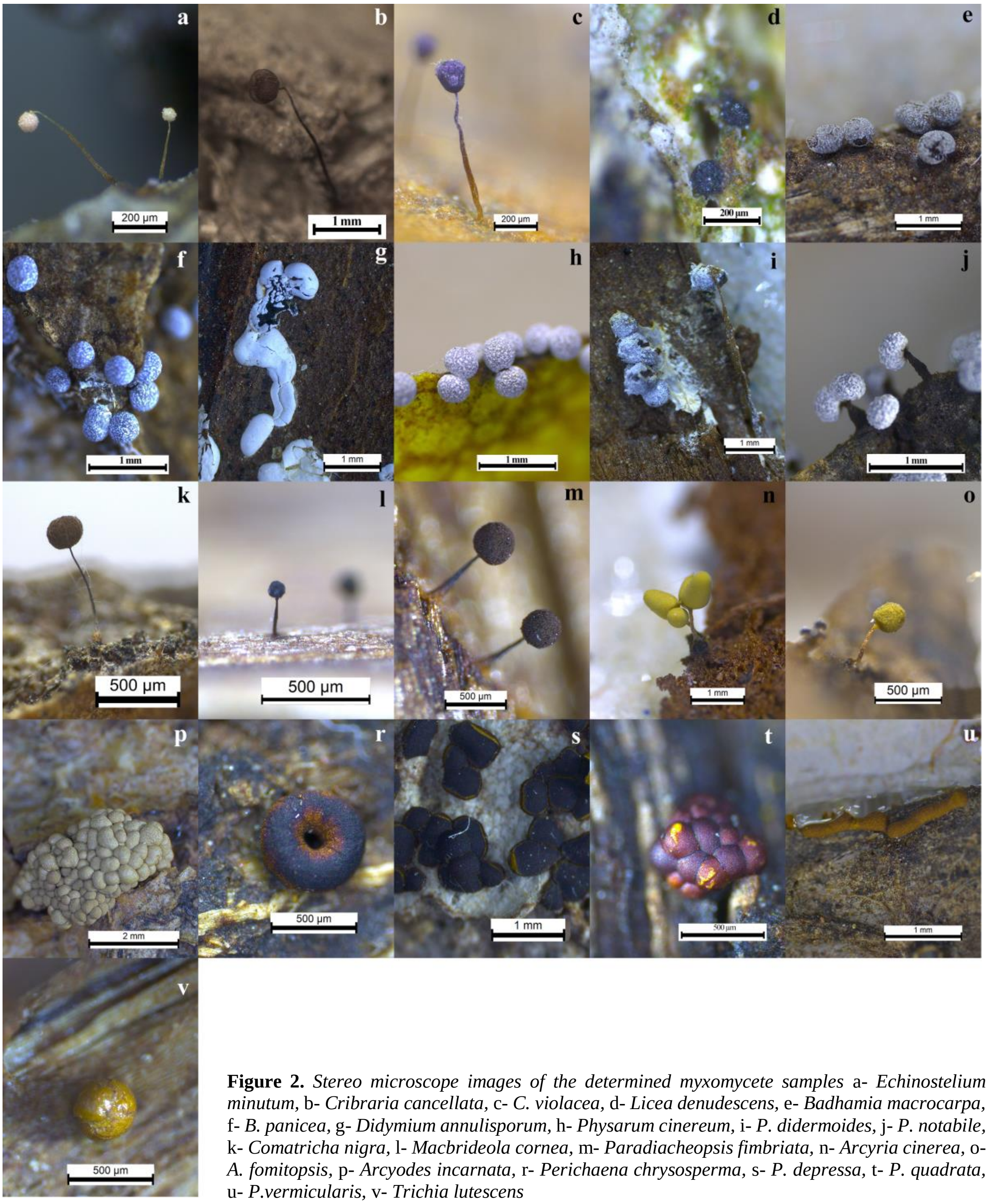

Figure 2. *Stereo microscope images of the determined myxomycete samples* a- *Echinostelium minutum*, b- *Cribraria cancellata*, c- *C. violacea*, d- *Licea denudescens*, e- *Badhamia macrocarpa*, f- *B. panicea*, g- *Didymium annulisporum*, h- *Physarum cinereum*, i- *P. didermoides*, j- *P. notabile*, k- *Comatricha nigra*, l- *Macbrideola cornea*, m- *Paradiacheopsis fimbriata*, n- *Arcyria cinerea*, o- *A. fomitopsis*, p- *Arcyodes incarnata*, r- *Perichaena chrysosperma*, s- *P. depressa*, t- *P. quadrata*, u- *P.vermicularis*, v- *Trichia lutescens*

4. Discussions

As a result of the field and laboratory studies, a total of 80 myxomycetes specimens were developed and of 21 myxomycete taxa were identified. No mature sporocarp was found in its natural environment. All specimens were developed using the moist chamber technique. Most specimens remained in the plasmodium stage, and the development of some myxomycete samples were prevented by invertebrate larvae.

The distribution of 21 determined species to the orders, is as follows: *Trichiales* 8 (38.1%), *Physarales* 6 (28.57%), *Liceales* 3 (14.29%), *Stemonitidales* 3 (14.29%) and *Echinosteliales* 1 (4.76%) (Fig. 3).

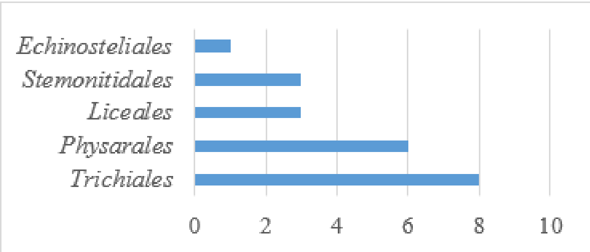

Figure 3. Order wise distribution of the determined taxa

Trichiales seems to be the most crowded order in the region. The order was represented with two families *Arcyriaceae* 2 (9.5%) and *Trichiaceae* 6 (28.57%) in the region. Within *Arcyriaceae, A. cinerea* was detected on two different substrates, and was detected on four different substrates. Within the family *Trichiaceae*, *Perichaena* is the most crowded genus with 4 species, among which *P. depressa* was the most abundant species which were detected on 17 different substrates.

Members of the order *Physarales* were distributed to two families, *Didymiaceae* and *Physaraceae*. In the region *Didymiaceae* was represented with only one (4.76%) species while *Physaraceae* was represented with 5 (23.81%) species. *Physarum didermoides* was found to be the second abundant taxon in research area and detected on 13 different substrates.

Twenty seven (33.75%) of the determined species were detected on debris bark, 20 (25%) on bark of living tree, 8 (10%) on log bark, 2 (2.5%) on root bark, 8 on log wood (10%), 7 (8.75%) on debris twigs, 2 (2.5%) on branches of living tree, 3 (3.75%) on cones, 2 (2.5%) on debris wood, and 1 (1.25%) on dried reeds (Fig. 4). As total, 71.25% of the samples were detected on bark and 12.5% on wood.

As it is the general case, 71.25% of the samples were corticolous myxomycetes detected on the bark. The bark of the branches and trunks of trees (Ing, 1994) are suitable substrates for myxomycetes (Snell and Keller, 2003; Liu et al., 2015; Policina and dela Cruz, 2020). The water holding capacity of the bark, the general shape of the tree, the surface texture of the bark, and the epiphytic cover of algae, moss, liverwort and lichens (Everhart and Keller, 2008, Stephenson and Stephen, 2000) facilitate colonization by more species (Keller and Braun, 1999).

When compared the results of this study show similarities and also some differences with those conducted in close environs and in Turkey (Ergül and Dülger, 2002; Ergül et al., 2005; Yağız and Afyon, 2005; Oran et al., 2006; Eroğlu and Kaşık, 2013a,b; Ocak and Konuk, 2018; Touray and Ergül, 2019).

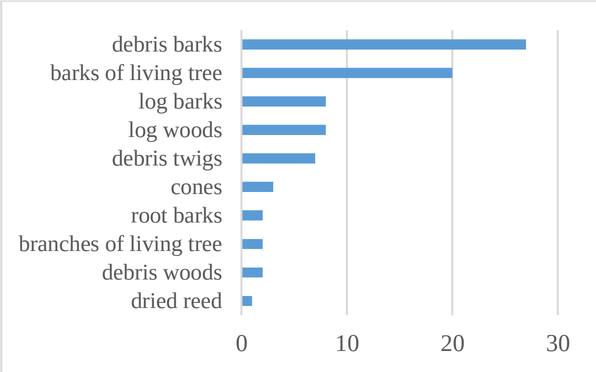

Figure 4. Substrate wise distribution of the determined taxa

Echinostelium minutum, the most common corticolous myxomycete species (Snell and Keller, 2003; Everhart and Keller, 2008), was determined for the first time on *Juniperus* and *Populus* spp. in Turkey while *Cribraria violacea* was also determined by Eroğlu and Kaşık (2013a) on *Populus* sp., and on rotten wood. Existance of this species on on *Acacia* sp. was also reported by Oran et al. (2006).

Occurrence of *Physarum didermoides* on three barks was reported by many researchers (Demirel and Kaşık, 2012; Eroğlu and Kaşık, 2013a), *P. notabile* (Ergül and Dülger, 2002; Ergül et al., 2005; Eroğlu and Kaşık, 2013b; Ocak and Konuk, 2018; Touray and Ergül, 2019).

Members of *Macbrideola* (Stephenson and Stephen, 2000) and *Paradiacheopsis* (Ing, 1994) species are common on tree bark. As it is the case in many studies *M. cornea* (Härkönen and Uotila, 1983; Härkönen, 1987; Ergül et al., 2005; Ocak and Hasenekoğlu, 2005; Yağız and Afyon, 2005; Oran et al., 2006; Yağız and Afyon, 2007; Baba, 2012; 2015; Oskay and Tüzün, 2015; Baba, 2017; Baba et al., 2018; Ocak and Konuk, 2018; Touray and Ergül, 2019; Baba et al., 2020; Baba and Sevindik, 2020) and *P. fimbriata* (Härkönen and Uotila, 1983; Härkönen, 1987; Baba and Tamer, 2008; Baba et al., 2012) were determined on the barks of *Juniperus* sp.

Perichaena depressa, which was detected on *Populus* and *Salix* spp., had the same substratec in Eroğlu and Kaşık (2013a). Additionally, we determined it on *Acacia* sp. as well.

Unlike other studies (Gücin and Öner, 1986; Demirel et al., 2006; Baba and Tamer, 2008; Baba et al., 2013; Baba and Zümre, 2015; Çağlar et al., 2016; Baba and Doğan, 2018; Zümre et al., 2019)., *Trichia lutescens* was detected on *Juniperus* sp.

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contributions

The authors contributed equally.

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