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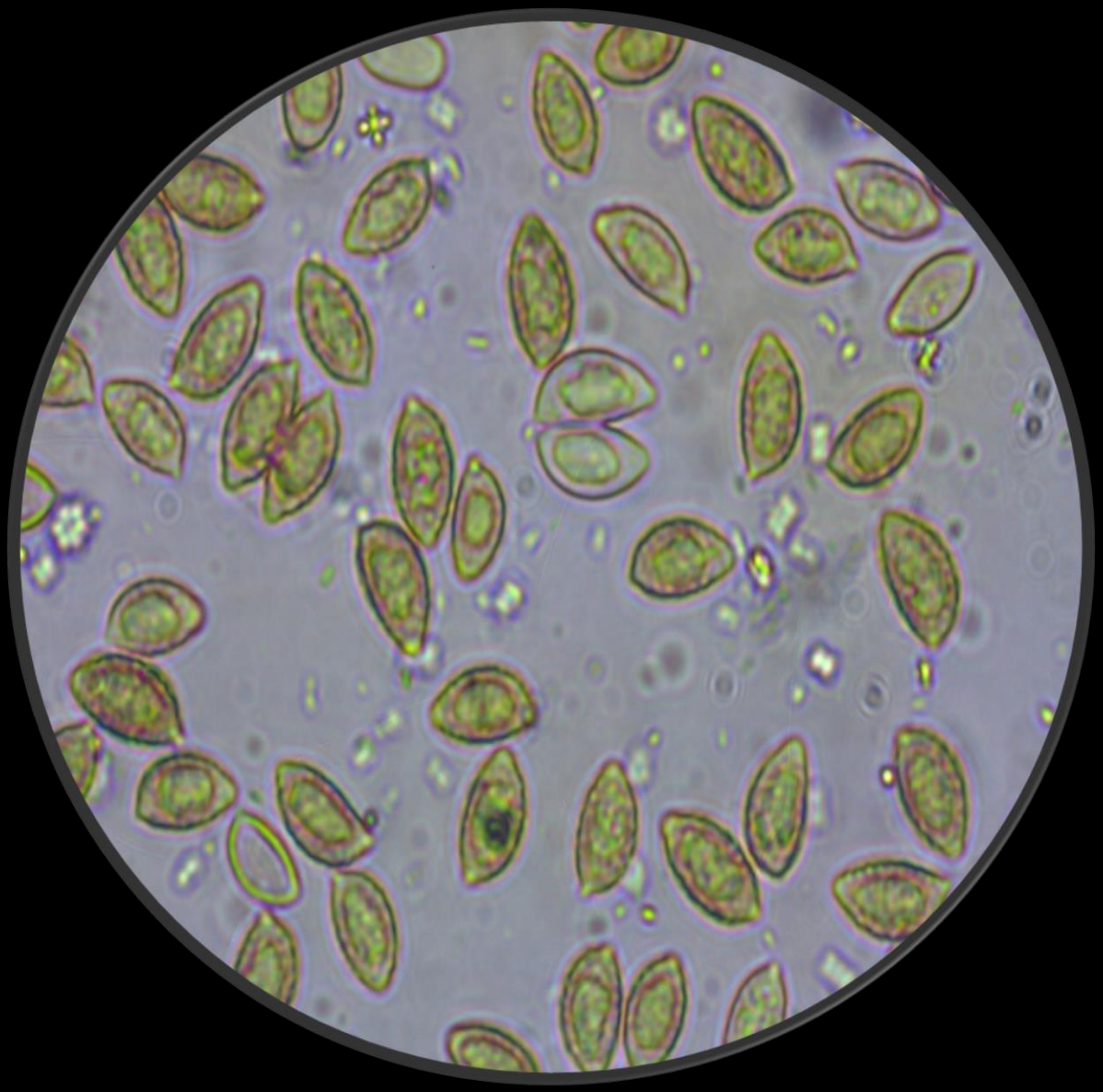

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Uygulama ve Araştırma Merkezi
KONYA-TÜRKİYE

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Bu sayımızda yer alan eserler hakkında aşağıda isimleri yazılı hakemlerimize yaptıkları değerlendirmeler için teşekkür ederiz.

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İÇİNDEKİLER/ CONSTENS

ARAŞTIRMA MAKALELERİ / RESEARCH ARTICLES

Bu makaleye şu şekilde atıf yapılır: Çelik, Z. &Alma, M.H. (2023). Ağrı Merkez/Hamur İlçesinde Belirlenen Makromantarlar, *Mantar Dergisi* 14(1) 1-9.

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Ağrı Merkez/Hamur İlçesinde Belirlenen Makromantarlar

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Öz: Bu çalışma, 2018-2019 yılları arasında Ağrı ili Merkez ve Hamur ilçesi sınırları içerisinde yer alan bölgede doğal olarak yetişen ve toplanan makromantar örnekleri üzerinde yapılmıştır. Arazi ve laboratuvar çalışmaları sonucu teşhisleri yapılan mantar örneklerinin *Pezizomycetes* ve *Agaricomycetes* sınıflarına ait 5 takım ve 20 familya içerisinde dağılım gösteren toplam 57 makromantar taksonu olduğu tespit edilmiştir. Bunların 31'i yenen, 20'si yenmeyen ve 6 tanesi ise zehirli özelliktedir. Bu çalışma ile ülkemiz mikobiyotasının belirlenmesine katkı sağlanması yanısıra mantarların yörede etnomikolojik amaçlı olarak yararlanma durumlarının belirlenmesi amaçlanmıştır.

Anahtar kelimeler: *Basidiomycota, Ascomycota*, Ağrı Merkez/Hamur, Makromantar

Macrofungi Determined in Ağrı Central/Hamur District

Abstract: This study was carried out on macrofungus specimens naturally grown and collected in the region located within the borders of central and Hamur district of Ağrı province between 2018-2019. It has been determined that the mushroom samples identified as a result of field and laboratory studies have a total of 57 macrofungi taxa, which are distributed in 5 orders and 20 families belonging to the *Pezizomycetes* and *Agaricomycetes* classes. Of these, 31 are edible, 20 are inedible, and 6 are poisonous. In this study, it was aimed to contribute to the determination of our country's mycobiota, as well as to determine the ethnomicological use of fungi in the region.

Key words: *Basidiomycota, Ascomycota*, Agri Central/Hamur, Macrofungus

Giriş

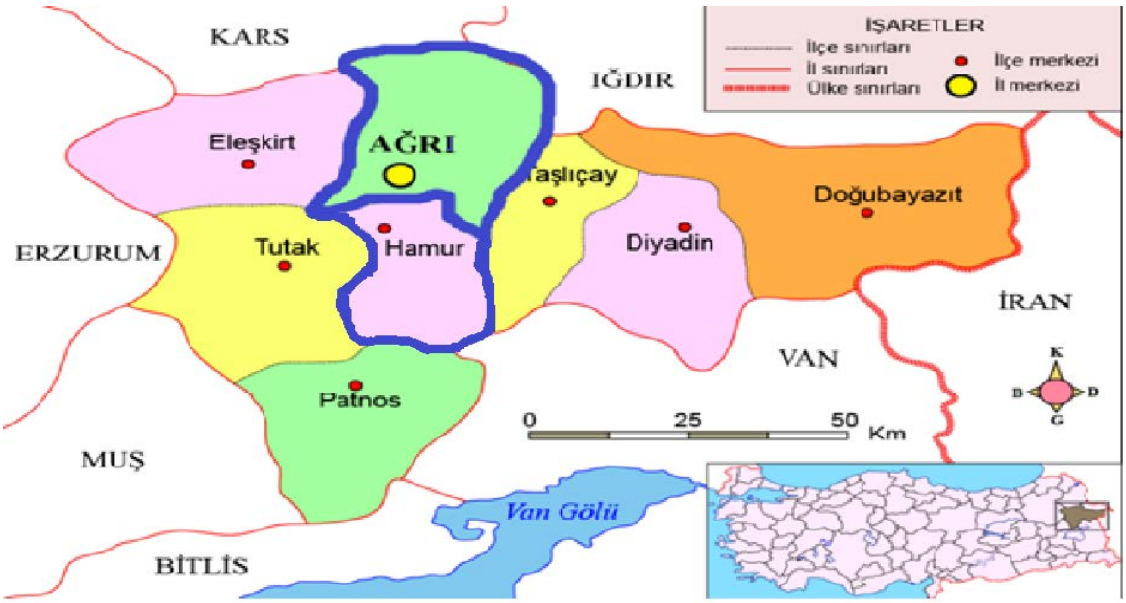
Genel anlamda mantarlar, ökaryotik, eşeyli ve eşeysiz çoğalabilen, spor üreten, hif diye bilinen tipik olarak hücre duvarıyla kuşatılmış dallanan ve ipliksel somatik yapıya sahip, saprofitik, parazitik veya simbiyotik bir yaşam sürdüren, hücre çeperi kitinden oluşan, absorbsiyonla beslenen, klorofilsiz organizmalar olarak tanımlanırlar. Makromantarlar Fungi âleminin, *Ascomycota* ve *Basidiomycota* bölümlerine ait, gözle görülüp elle tutulan, saplı ve sapsız, şapkalı veya top şekil başta olmak üzere farklı ve birçok çeşitli şekillerde üreme yapıları olan canlılardır. Mantarlar, ekolojik olarak büyük öneme sahip canlılardır. Ayrıca, çürükçül olanlar besinlerini bitkisel atıklar, cansız ağaç parçaları ve hayvan gübresi gibi ölü organik maddelerden temin ederek doğadaki besin maddelerinin ve azot, fosfor, potasyum, demir, gibi organik yapıdaki elementlerin geri dönüşümünde önemli katkıları bulunmaktadır (Chang and Miles, 2004; Vargas and Zardoya, 2014; Chang and Wasser, 2018).

Ülkemiz sınırları içerisinde yetişen makromantarlarla ilgili yapılmış olan çalışmalar Sesli ve ark.,(2020) ve Solak ve ark., (2015) tarafından liste halinde sunulmuştur. Genel anlamda bu çalışmalarda belirtildiği üzere ülkemizde konu ile ilgili yapılan ilk çalışma 1915'te başlamış olup 2015 yılına kadar toplam olarak 2422 makromantar taksonu belirlenmiştir. Ayrıca verilen listede yapılan çalışmalardan sonra (Sesli ve ark.,2020; Akçay ve ark., 2022) sonucunda verilmiş olan bu sayı artmaktadır. Bu çalışmada, Ağrı Merkez ve Hamur ilçesi sınırları içerisinde doğal olarak yetişen makromantarlar tespit edilerek, Doğu Anadolu Bölgesi ve ülkemiz mikobiyotasının zenginleştirilmesine katkı sağlanması ve bunula birlikte belirlenen bu mantarların habitatları, mevsimsel dağılımları ve yörede etnomikolojik amaçlı olarak yararlanma durumlarının belirlenmesi amaçlanmıştır.

Materyal ve Metot

Mevcut çalışmanın materyalini oluşturan makromantar örnekleri 2018-2019 yılları arasında Ağrı ili

Merkez ve Hamur ilçesi sınırları içerisinde yer alan bölgede doğal olarak yetişen ve toplanan örnekler üzerinde yapılmıştır. Bununla birlikte mantar örneklerinin yetişmelerinin uygun olduğu bilinen ilkbahar ve sonbahar aylarında toplanmıştır. Çalışma alanında toplanan makromantar örneklerinin morfolojik ve etnomikolojik özellikleri not edilerek örneklerin teşhisinde veri olarak kullanılmıştır. Aynı zamanda araziden laboratuvara taşınan mantarın belirlenmiş olan mikolojik teknikler ve teşhis anahtarı uygulanması sonucunda fungaryum materyalleri haline getirilmiştir. Yapılmış arazi ve laboratuvar çalışmaları sonrasında elde edilen veriler (Buczacki, 1989; Bresinsky and Besl, 1990; Phillips, 1981; Moser, 1983; Breitenbach and Kranzlin, 1986, 1991, 1995; 2000; Jordan, 1995; Ellis and Ellis, 1990; Kränzlin, 2005; Dähncke, 2004; Jordan, 2004) ilgili literatürle karşılaştırılarak mantar örneklerinin teşhisleri yapılmış olup kayıtları yapılan örnekler Iğdır Üniversitesi Ziraat Fakültesinde saklanmaktadır.



Şekil 1. Araştırma alanının haritası (Kocaman ve ark., 2011).

Şekil 2. Araştırma alanından görünüm.

Bulgular

İlgili çalışma sonucunda, 2018-2019 yılları arasında Ağrı ili Merkez ve Hamur ilçesi sınırları içerisinde yer alan bölgede doğal olarak yetişen makromantarların tespit edilmesi amacı ile yapılmıştır. Belirlenen taksonlar; habitat, substrat, toplama yeri, ilçe, köy, coğrafi konum, yükseklik, toplama tarihi, şahsi fungaryum numarası ve yenilebilirlik durumları (örn.: Ağaç altı ve kalıntısı üzeri, merkez, dere kenarı, kütük üzeri, çayırlık alan, gübre üzeri,05º 79'620"K, 43º 86'959"D, 1730 m, 05.04.2018, ÇELİK. 32), kendilerine ait fungaryum numaraları ile birlikte verilmiştir. Teşhis edilen örneklerin *Pezizomycetes* ve *Agaricomycetes* sınıflarına ait olup 5 ordo ve 20 familya olarak dağılım gösteren 57 makromantar taksonu olduğu tespit edilmiştir. Ayrıca bunların 31'i yenen, 20'si yenmeyen ve 6 tanesi ise zehirli olan makromantar tespit edilmiştir. Buna ek olarak teşhisi yapılan mantar örneklerinin türleri Sesli ve ark., (2020) ve http://indexfungorum.org., http://www.mycobank.org. veri tabanları baz alınarak sistematik sıraya dizilmiştir.

Ascomycota

Pezizales

Helvellaceae Fr.

1- *Paxina queletii* Bres, **Papaztası;** Kavak (*Populus* sp.) ağaçları altında, Hamur-Ceylanlı, 05º 79'622"K, 43º 82'956"D, 1723 m, 05.04.2018, ÇELİK. 12. Yenir.

2- *Helvella leucopus* Pers., **Top semermantarı;** Kavak (*Populus* sp.) ağaçları altı, Hamur-Ceylanlı, 05º 79'612"K, 43º 82'950"D, 1720 m, 05.04.2018, ÇELİK. 18. Yenir.

Morchellaceae Rchb.

3- *Morchella elata* Fr., Siyah göbek; Kavak (*Populus* sp.) ağaçları altı, Hamur, 05º 89'613"K, 43º 74'876"D, 1773 m, 05.04.2018, ÇELİK. 14. Yenir.

4- *Morchella esculenta*(L.) Pers., **Kuzugöbeği;** Kavak (*Populus* sp.) ağaçlar altı, Merkez Yukarı yol düzü, 05º 93'433"K, 44º 10'421"D, 1733 m, 01.05.2018, ÇELİK. 13. Yenir.

Pezizaceae Dumort.

5- *Peziza vesiculosa* Bull., **Yiğitçanak;** Hayvan gübresi üzerinde, Merkez Yukarı yol düzü, 05º 97'533"K, 44º 10'471"D, 2180 m, 20.05.2018, ÇELİK. 15. Yenmez.

Basıdıomycota

Agaricales

Agaricaceae Chevall.

6- *Agaricus arvensis* Schaeff., **Atmantarı;** Çayırlık alanda ve Kavak (*Populus* sp.) ağaçları altı, Merkez Yukarı yol düzü, 05º 93'567"K, 44º 10'578"D, 1880 m, 20.05.2018-12.06.2018, ÇELİK. 9. Yenir.

7- *Agaricus bisporus* (J.E. Lange) Imbach,

Kültür mantarı; Çayırlık, Hamur ve Merkez Yukarı yol düzü, 05º 97'533"K, 44º 10'471"D, 2180 m, 20.05.2018-15.10.2018, ÇELİK. 34, 44. Yenir.

8- *Agaricus campestris* L., İçi kızıl; Çayırlık alan, Merkez Yukarı yol düzü, 05º 96'093"K, 43º 71'091"D, 2172 m, 20.05.2018, ÇELİK. 36. Yenir.

9-*Agaricus xanthodermus* Genev., **Ağulu kızıl;** Çayırlık, Hamur-Ceylanlı ve Merkez Yukarı yol düzü, 05º 96'062"K, 43º 69'913"D, 1960 m, 20.05.2018, ÇELİK. 7. Zehirli.

10- *Bovista plumbea* Pers., **Puf mantarı;** Çayırlık alan, Hamur-Ceylanlı, 05º 77'910"K, 43º 86'298"D, 1970 m, 05.04.2018, ÇELİK. 6. Yenir.

11- *Bovistella utriformis* (Bull.) Demoulin & Rebriev, **Yan poslak;** Genellikle dağlık alanda, güneşli yüksek meralarda, çayırlıklarda, otlaklarda kumlu topraklarda, kısa bodur ağaçların bulunduğu alanda; Hamur-Ceylanlı, 05º 77'910"K, 43º 86'298"D, 1995 m, 30.05.2018, ÇELİK. 50. Yenir.

12- *Lycoperdon perlatum* Pers. **Fıssakuri;** Kumlu toprak ve Çayırlık alanda; Hamur-Ceylanlı, 05º 75'934"K, 43º 86'278"D, 1985 m, 30.05.2018, 05º 67'678"K, 43º 84'256"D, 1895 m, 12.10.2018,ÇELİK. 11, 17. Yenir.

13- *Coprinus comatus* (O.F. Müll.) Pers., **Söbelen;** Çayırlık alanda, Söğüt (*Salix* sp.), ağaçları altı, Hamur-Ceylanlı ve Merkez Yukarı yol düzü, 05º 95'869"K, 43º 70'105"D, 2160 m, 20.05.2018, ÇELİK. 10, 19. Yenir.

14- *Lepiota erminea* (Fr.) P. Kumm., **Süt pullu;** Kavak (*Populus* sp.) ağaçlar altı, çayırlık alanda, Hamur-Özdirek ve Merkez, 05º 95'869"K, 43º 70'105"D, 2160 m, 20.05.2018, 16.10.2018, ÇELİK. 43, 51. Yenir.

15- *Leucoagaricus leucothites*(Vittad.) Wasser, **Ak etlice;** Çayırlık alan ve Kavak (*Populus* sp.) ağaçlar altı, Hamur-Özdirek, 05º 85'829"K, 43º 76'225"D, 2120 m, 16.10.2018, ÇELİK. 42. Yenmez.

Bolbitiaceae Singer

16-*Panaeolus papilionaceus* (Bull.)Quél., **Süslü tersçanı;** Hayvan gübresi üzeri, çayırlıklarda Hamur-Özdirek, Merkez Yukarı yol düzü, 05º 55'679"K, 43º 72'303"D, 2060 m, 20.05.2018, 24.10.2018, ÇELİK. 16, 31. Yenmez.

17- *Conocybe apala* (Fr.) Arnolds, **Ak yalınetek;** Çayırlık, Hamur-Özdirek, Merkez Yukarı yol düzü, 05º 58'676"K, 43º 71'345"D, 2043 m, 24.10.2018, ÇELİK. 21. Yenmez.

18- *Conocybe semiglobata* Kühner & Watling, **Kör yalınetek;** Çayırlık, park ve bahçelerde, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 56'587"K, 43º 71'323"D, 1978 m, 24.05.2018, ÇELİK, 22.Yenmez.

19- *Conocybe subovalis* Kühner & Watling

Piç yalınetek; Çayırlık, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 56'587"K, 43º 71'323"D, 1975 m, 24.05.2018, ÇELİK, 37. Yenmez.

Cortinariaceae R. Heim ex Pouzar

20- *Cortinarius purpurascens* Fr., **Ekli örümcekmantarı;** Kavak (*Populus* sp.), ağaçları altı ve asidik topraklarda, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 56'587"K, 43º 71'323"D, 1775 m, 01.05.2018, ÇELİK, 38. Yenir.

21- *Hebeloma mesophaeum* (Pers.) Quél., **Ala turpkokan;** Kavak (*Populus* sp.) ağaçları altı, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 56'587"K, 43º

71'323"D, 1775 m, 01.05.2018, 24.10.2018, ÇELİK, 2,23. Yenmez.

Entolomataceae Kotl. & Pouzar

22- *Entoloma sericeoides* (J.E. Lange) Noordel., **Seri kıvrıkbaş;** Kavak (*Populus* sp.) ve Söğüt (*Salix* sp.), ağaçları altı, Merkez Yukarı yol düzü, 05º 56'587"K, 43º 71'323"D, 1732 m, 01.05.2018, ÇELİK, 24. Zehirli.

Inocybaceae Jülich

23- *Inocybe flocculosa* Sacc, **Aykümbet;** Kavak (*Populus* sp.) ve konifer ağaçları altı, Hamur-Özdilek, Merkez Yukarı yol düzü, 05º 55'477"K, 43º 70'463"D, 1898 m, 05.05.2018, 24.10.2018, ÇELİK, 1,39. Zehirli.

24-*Inocyb flocculosa* Sacc, **Aykümbet;** Kavak (*Populus* sp.), ağaçları altı, kalkerli topraklar, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 56'467"K, 43º 71'453"D, 1798 m, 24.10.2018, ÇELİK, 2,23. Zehirli.

25- *Pseudosperma rimosum* (Bull.) Matheny & Esteve-Rav., **Uysalkümbet;** Konifer ve Kavak (*Populus* sp.), ağaçları altı, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 55'679"K, 43º 72'303"D, 2060 m, 20.05.2018, 24.10.2018, ÇELİK, 3, 33. Zehirli.

Pleurotaceae Kühner

26- *Pleurotus eryngii* (DC.) Quél., **Çakşır mantarı;** Heliz (Çakşır) bitkisi üzeri, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 79'620"K, 43º 86'959"D, 2163 m, 05.04.2018, 20.05.2018, ÇELİK, 8. Yenir.

27- *Pleurotus ostreatus* (Jacq.) P. Kumm., **İstiridye mantarı;** Kavak (*Populus* sp.) ve Söğüt (*Salix* sp.) kütüğü üzeri, Hamur, Merkez Yukarı yol düzü, 05º 79'612"K, 43º 86'933"D, 2154 m, 20.05.2018, ÇELİK, 5. Yenir.

Pluteaceae Kotl. & Pouzar

28- *Pluteus romellii* (Britzelm.) Sacc**., El çıtkırdı;** Kavak (*Populus* sp.) ve Söğüt *(Salix* sp.), kütüğü üzeri, Hamur, Merkez Yukarı yol düzü, 05º 79'612"K, 43º 86'933"D, 2154 m, 05.04.2018, 20.05.2018, ÇELİK, 40. Yenir.

29-*Pluteus salicinus* (Pers.) P. Kumm. **Söğüt çıtkırdı;**

Odun kalıntısı üzeri, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 79'412"K, 43º 86'833"D, 2154 m, 30.05.2018, 20.10.2018, ÇELİK, 41. Yenir.

30-*Volvopluteus gloiocephalus* (DC.) Vizzini, Contu & Justo, **Kakilvik;** Söğüt *(Salix* sp.) ve Kavak (*Populus* sp.) altı, Hamur, Merkez Yukarı yol düzü, 05º 80'612"K, 43º 83'953"D, 2178 m, 20.05.2018, ÇELİK, 45. Yenir.

Psathyrellaceae Vilgalys, Moncalvo & Redhead

31-*Coprinellus disseminatus* (Pers.) J.E. Lange, **Minikmürekkep;** Söğüt (*Salix* sp.) kütüğü üzeri, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 79'620"K, 43º 86'959"D, 2063 m, 05.10.2018, ÇELİK, 4, 20. Yenir.

32- *Coprinellus impatiens* (Fr.) J.E. Lange, **Cammürekkebi;** Söğüt *(Salix* sp.) kütüğü üzeri, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 79'620"K, 43º 86'959"D, 2063 m, 05.06.2018, ÇELİK, 26. Yenmez.

33- *Coprinellus micaceus* (Bull.) Vilgalys, Hopple & Jacq. Johnson, **Pullumürekkep;** Kavak (*Populus* sp.) ve Söğüt (*Salix* sp.) kütüğü üzeri, Merkez Yukarı yol düzü, 05º 79'531"K, 44º 84'659"D, 2073 m, 05.05.2018, ÇELİK, 28. Yenmez.

34-*Coprinopsis nivea* (Pers.) Redhead, Vilgalys & Moncalvo, **Ak döbelen;** Hayvan gübresi üzeri, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 79'640"K, 43º 86'859"D, 2163 m, 05.06.2018, ÇELİK, 47. Yenmez.

35-*Coprinopsis atramentaria* (Bull.) Redhead, Vilgalys & Moncalvo, **Kütük döbeleni;** Kavak (*Populus* sp.) kütüğü üzeri, Merkez Yukarı yol düzü, 05º 79'531"K, 44º 84'659"D, 2073 m, 05.10.2018, ÇELİK, 48. Zehirli.

36-*Parasola plicatilis* (Curtis) Redhead, Vilgalys & Hopple, **Açık sevelen;** Çayırlık, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 80'660"K, 43º 85'759"D, 2103 m, 05.04.2018, 20.05.2018, ÇELİK, 29. Yenmez.

37-*Psathyrella candolleana* (Fr.) Maire, **Güzel pulcuklu;** Söğüt *(Salix* sp.), ağaçları altı, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 55'584"K, 43º 71'433"D, 1995 m, 24.05.2018; 06.10.2018, ÇELİK, 30, 35. Yenmez.

38- *Psathyrella lutensis* (Romagn.) Bon, **Üç pulcuklu;** Kavak (*Populus* sp.) ve Söğüt (*Salix* sp.), ağaçları altı, Hamur, 05º 56'687"K, 43º 71'523"D, 1992 m, 20.05.2018, ÇELİK, 32. Yenmez.

39- *Psathyrella prona* (Fr.) Gillet, **Yel pulcuklu;** Çayırlık alan, Hamur özdirek köyü, 05º 56'867"K, 43º 71'323"D, 2175 m, 06.05.2018, 10.10. 2018, ÇELİK, 27, 66. Yenmez.

40-*Psathyrella spadiceogrisea* (Schäeff.) Maire, **Yol pulcuklu;** Ağaç kalıntıları üzeri, Merkez Yukarı yol düzü, 05º 55'654"K, 43º 71'476"D, 1895 m, 26.05.2018; 13.10. 2018, ÇELİK, 30, 35. Yenmez.

Strophariaceae Singer & A.H. Sm.

41- *Agrocybe dura* (Bolton) Singer, **Yaz meteliği;** Çayırlık alanlarda, Hamur, 05º 56'664"K, 43º 72'523"D, 2085 m, 06-08.05.2018, ÇELİK, 57. Yenir.

42-*Agrocybe pediades* (Fr.) Fayod, **Kollu metelik;** Çayırlık alanlarda, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 55'474"K, 43º 71'513"D, 2195 m, 24.05.2018; 06.10.2018, ÇELİK, 52, 60. Yenir.

43- *Agrocybe paludosa* (J.E. Lange) Kühner & Romagn. ex Bon, **Yaş metelik;** Çayırlık alanda, Hamur, Merkez Yukarı yol düzü, 05º 55'474"K, 43º 71'513"D, 2165 m, 22.05.2018, ÇELİK, 53. Yenmez.

44- *Agrocybe praecox* (Pers.) Fayod, **Bahar meteliği;** Kavak (*Populus* sp.), ağaçları altı, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 55'574"K, 43º 71'534"D, 2095 m, 06.05-10.2018, ÇELİK, 55. Yenir.

45-*Pholiota aurivella* (Batsch) P. Kumm., **Sarı pulbaş;** Söğüt *(Salix* sp.), ağacı üzeri, Merkez Yukarı yol düzü, 05º 55'632"K, 43º 71'513"D, 2095 m, 06.10.2018, ÇELİK, 54. Yenmez.

46-*Pholiota gummosa* (Lasch) Singer, **Yapışkan pulbaş;** Kavak (*Populus* sp.), ağaçları altı, Hamur-Ceylanlı, 05º 55'474"K, 43º 71'513"D, 1995 m, 16.10.2018, ÇELİK, 65. Yenmez.

Hymenogastraceae Vittad.

47-*Psilocybe coronilla* (Bull.) Noordel., **Kefgarik;** Çayırlık, Hamur-Ceylanlı, 05º 55'674"K, 43º 71'713"D, 2165 m, 06.05.2018, ÇELİK, 67. Yenir. Yenir.

Tubariaceae Vizzini

48- *Tubaria furfuracea* (Pers.) Gillet, **Fırfırlı tubarya;** Söğüt *(Salix* sp.), ağacı üzeri, Merkez Yukarı yol düzü, 05º 55'867"K, 43º 71'583"D, 2105 m, 22.05.2018, ÇELİK, 62. Yenmez.

Marasmiaceae Roze ex Kühner

49- *Marasmius oreades* (Bolton) Fr. **Mıhbaşı;** Çayırlık alan ve Kavak (*Populus* sp.), ağaçları altı, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 55'387"K, 43º 71'513"D, 2155 m, 06-22.05.2018, ÇELİK, 61, 56. Yenir.

Tricholomataceae R. Heim ex Pouzar

50- *Lepista irina* (Fr.) H.E. Bigelow, **Süslü cincile;** Kavak (*Populus* sp.), ağaçlar altında, Hamur-Ceylanlı, Merkez Yukarı yol düzü, 05º 55'387"K, 43º 71'513"D, 2130 m, 22.05.2018, ÇELİK, 63. Yenir.

51- *Lepista personata* (Fr.) Cooke, **Diken mantarı;** Kavak (*Populus* sp.), ağaçlar altında, Hamur-özdirek, Merkez Yukarı yol düzü, 05º 55'387"K, 43º 71'513"D, 2155 m, 06-22.05.2018, ÇELİK, 58, 70. Yenir.

52-*Tricholoma populinum* J.E. Lange, **Kavakkarakız;** Kavak (*Populus* sp.), ağaçları altı, Hamur ve Merkez Yukarı yol düzü, 05º 55'457"K, 43º 71'554"D, 1978 m, 24.10.2018, ÇELİK, 59, 69. Yenir.

Boletales

Paxillaceae Lotsy

53- *Paxillus involutus* (Batsch) Fr.,**Pax mantarı;** Kavak (*Populus* sp.), ağaçlar altı, Hamur-Ceylanlı, 05º 55'387"K, 43º 71'513"D, 2145 m, 06-16.05.2018, ÇELİK, 68. Zehirli.

Hymenochaetales

Hymenochaetaceae Donk

54- *Phellinus igniarius* (L.) Quél., **Kara toynak;** Huş *(Betula* sp.), ağaç gövdesi üzeri, Hamur ve Merkez Yukarı yol düzü, 05º 55'457"K, 43º 71'554"D, 2078 m, 24.05.2018, ÇELİK, 73, 79. Yenmez.

Polyporales

Polyporaceae Fr. ex Corda

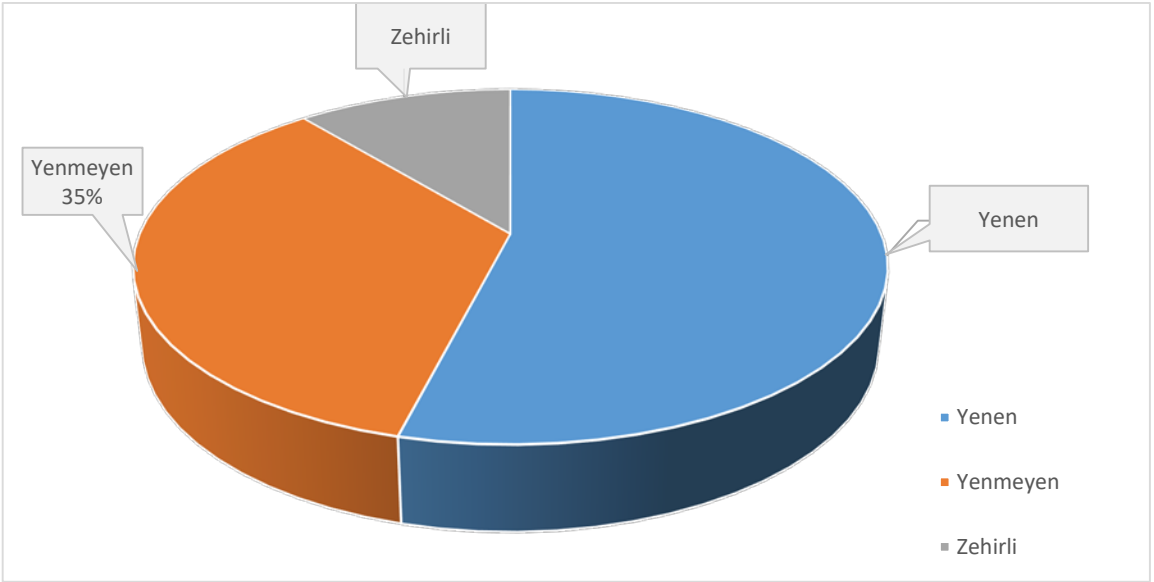
55-*Fomes fomentarius* (L.) Fr., **Kavmantarı;** Söğüt (*Salix* sp.), ağacı üzeri, Hamur-Özdirek köyü, 05º 55'776"K, 43º 71'654"D, 1988 m, 24.10.2018, ÇELİK, 74, 76. Yenmez.

56- *Lentinus tigrinus* (Bull.) Fr., **Kaplanmatarı;** Söğüt (*Salix* sp.), kütüğü üzeri, Hamur-ceylanlı ve Merkez Yukarı yol düzü, 05º 55'457"K, 43º 71'554"D, 2089 m, 22.05.2018, ÇELİK, 87, 96. Yenir.

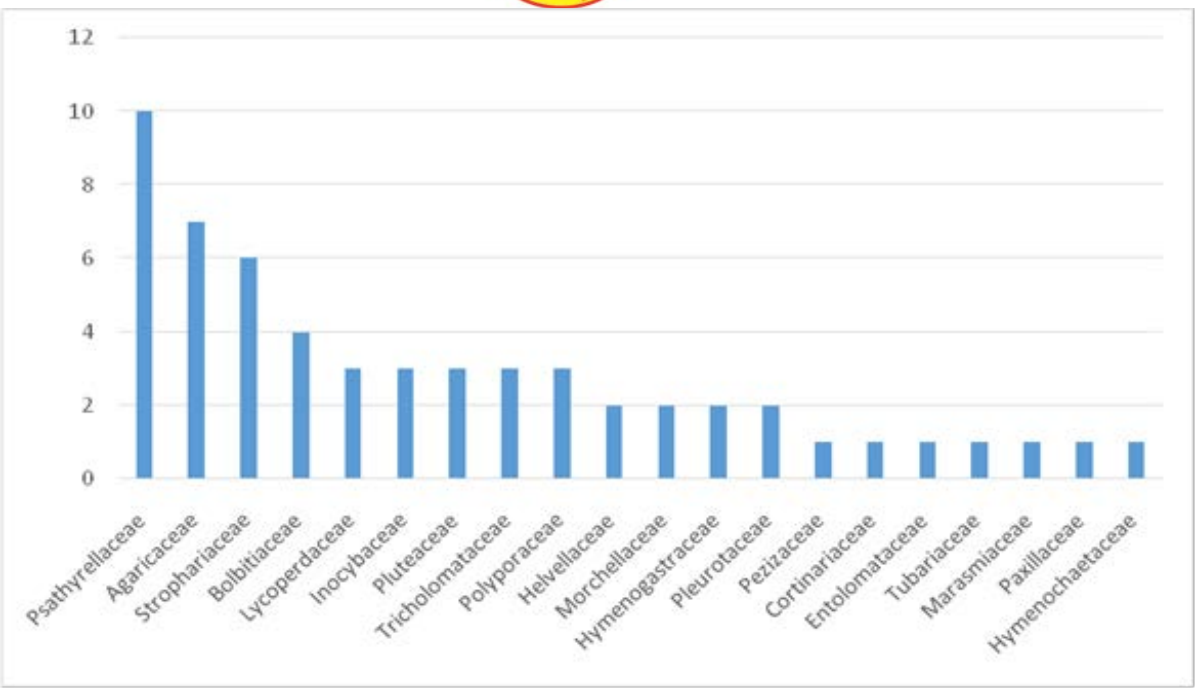
57- *Polyporus squamosus* (Huds.) Fr., **Görkemli;** Söğüt (*Salix* sp.), kütüğü üzeri, Hamur-ceylanlı-özdirek köyü ve Merkez Yukarı yol düzü, 05º 55'487"K, 43º 71'384"D, 2119 m, 04-24.10.2018, ÇELİK, 85, 93. Yenir.

Tartışma

Bu çalışma sonunda, Ağrı ili Merkez ve Hamur ilçesi sınırları içerisinde yer alan bölgede 2018-2019 yılları arasında doğal olarak yetişen *Pezizomycetes* ve *Agaricomycetes* sınıflarına ait olan 20 familya'ya ait toplam 57 makromantar taksonu tespit edilmiştir. Bu mantar örneklerinde 31 yenen, 20 yenmeyen, 6 zehirli özelliktedir (Şekil 3). Yenen türler toplam türlerin %54, yenmeyenler %35, zehirli türler ise %11'ni oluşturmaktadır. Ayrıca bölge genelinde tanınan ve besin olarak tüketilen mantar takson sayısı oldukça azdır. Bunun en önemli sebebi yerel halkının çoğunluğunun tüm mantarların zehirli olduğunu düşündüğü öngörülmektedir.



Şekil 3. Yörede tespit edilen makromantarların yenilebilirlik durumuna göre dağılımı.

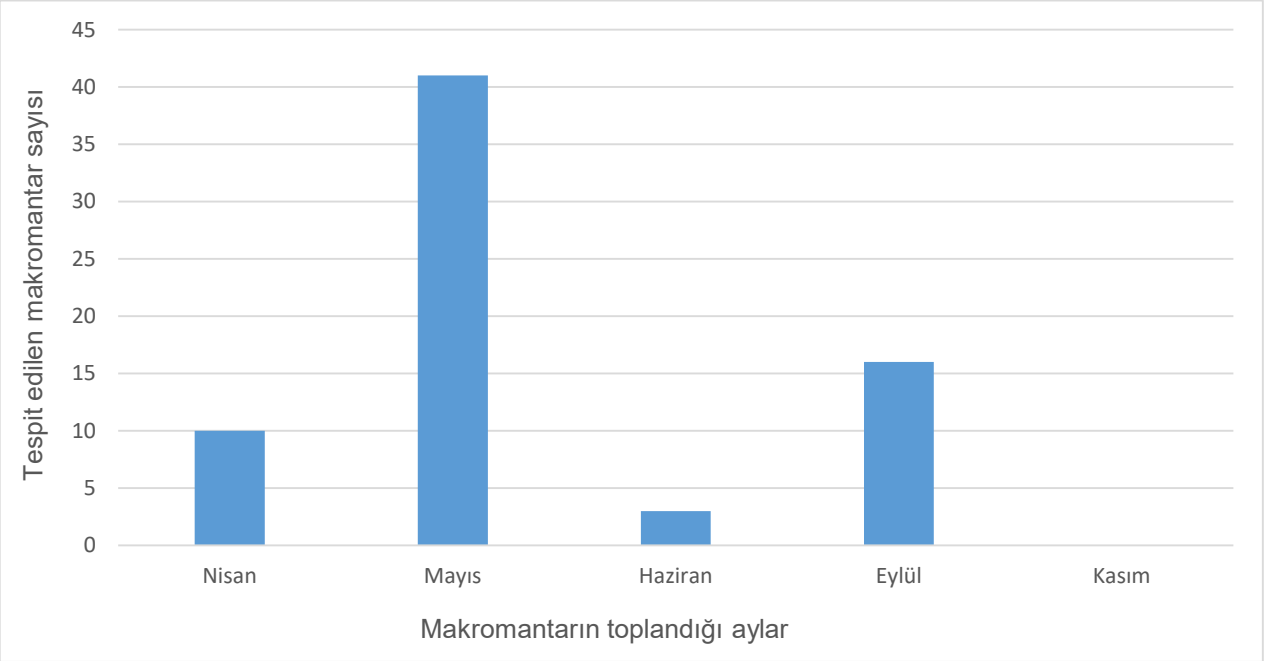


Şekil 4. Tespit edilen makrofungus taksonlarının familyalara göre dağılımı.

Tablo 1. Bazı yenen türlerin yöresel isimleri

Yenen Türler	Yenen Türlerin Yöresel İsimleri	Türlerin Kullanım Amaçları
Agaricus bisporus	Çayır mantarı (Demirel ve Koçak, 2016)	Yemeklik olarak kullanılmaktadır.
Agrocybe dura	Çayır mantarı (Demirel ve ark., 2017)	Yemeklik olarak kullanılmaktadır.
Lycoperdon perlatum	Fıssakuri (Demirel ve ark., 2017)	Halk arasında yara üzerine sürülerek kullanılmaktadır.
Pleurotos ostreatus	Ağaç mantarı (Çağlı ve Öztürk, 2020)	Yemeklik olarak kullanılmaktadır.
Pleurotos eryngii	Çakşır mantarı (Demirel ve Koçak, 2016)	Yemeklik olarak kullanılmaktadır.

Çalışma bölgesinde en fazla makromantar örneği Mayıs ve Eylül aylarında toplandığı tespit edilmiştir. Bunun sebebi ilkbahar yağışların ve sıcaklığın mantar yetişmesi için uygun olmasından kaynaklanmaktadır. Haziran ayında daha az örnek toplandığı tespit edilmiştir. Temmuz, Ağustos ve Kasım aylarında ise ekolojik faktörler makromantarların yayılışına ve yetişmesine uygun olmadığından; ayrıca Aralık, Ocak, Şubat ve Mart aylarında ise düşük sıcaklık ve toprağın karla kaplı olmasından dolayı herhangi bir örnek toplanamamıştır (Şekil 5).



Şekil 5. Araştırma yöresinde toplanan makromantarların aylara göre dağılımı.

Tablo 2. Araştırma yöresine yakın bölgelerde yapılmış olan çalışmalarla benzerlik durumu

Aştırma Yöresi	Tespit edilen toplam makromantar sayısı	Ortak takson sayısı	Benzerlik oranı (%)
Ağrı (Demirel ve ark., 2003)	**47**	**27**	**57.44**
Malazgirt (Muş) (Akçay ve ark., 2012)	**50**	**24**	**48**
Karz Dağı (Bitlis-Tatvan) (Sadullahoğlu, 2013)	**79**	**28**	**35.44**
Zilan Vadisi (Van-Erciş) (Koçak, 2014)	**98**	**51**	**52.04**
Van (Demirel ve ark., 2015)	**122**	**41**	**33.60**
Kağızman (Kars) (Uzun ve ark., 2020)	**86**	**41**	**47.67**
Muradiye (Van) (Çağlı ve Öztürk, 2020)	**86**	**26**	**30.23**

Aynı zamanda, Tablo 1'de görüldüğü üzere çalışmada teşhis edilen makromantarların çalışma alanına yakın olan bölgelerde yapılmış benzer çalışmalarda; Malazgirt (Muş) (Akçay ve ark., 2012); Karz Dağı (Bitlis-Tatvan) (Sadullahoğlu, 2013); Zilan Vadisi (Van-Erciş) (Koçak, 2014); Van (Demirel ve ark., 2015) ve Kağızman (Kars) (Uzun ve ark., 2020) ile karşılaştırılmıştır. Bununla birlikte, Malazgirt (Muş) %48; Bitlis-Tatvan %35.44; Van-Erciş %52.04; Van %33.60 ve Kağızman (Kars) %47.67 gibi benzerlik oranlarının olduğu görülmektedir. Mevcut sonuçlara göre bu benzerlik ve farklılıkların olması belirtilmiş olan çalışma alanlarının sahip oldukları kendilerine ait bitki örtüsü ve iklim özelliklerinden kaynaklandığı düşünülmektedir. İlgili araştırma bölgemizde yaygın makromantar taksonu *Psathyrellaceae* familyasına ait olan türlerin olduğu belirlenmiştir. Ayrıca bu çalışma ile tespit edilen türler, ülkemizde Türkiye makromantarları olarak kaydedilmiştir.

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Ecological Factors Influencing the Occurrence of *Armillaria mellea* (Basidiomycota, Agaricales, Physalacriaceae) in Yuvacik Dam Watershed in Kocaeli, Türkiye

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Abstract: The occurrence of *Armillaria mellea* (Vahl) P. Kumm. and the ecological characteristics of this fungus were studied in Kocaeli, Yuvacik dam basin mixed-broad leaved forests**.** During the surveys, we analyzed the sporocarps (fruiting bodies) of *A. mellea* growing up on woody plants in plots selected by cluster sampling in the Yuvacik dam watershed dominated by broad-leaved forests. The Runs test results showed that randomness rules complied in the selection of the plots, and there was no tendency ($p= 0.109 > 0.05$, $z= -1.603$). The presence/absence of *A. mellea* and environmental variables were tested with Chi-square analysis, and the temperature differed among these environmental variables. To the dendrogram, *A. mellea* was mainly seen in the south of the study area and preferred western aspects. It is understood that this macrofungus prefers the south of the study area because of the altitude. Our data showed that sporocarps of *A. mellea* generally occurred in the western aspect, at temperatures of 15–20°C, >80% humidity and 800–1000 m altitude. Our logistic regression analysis model ($z=-9.508+0.307\times temperature+0.081\times humidity$) showed that if the temperature and humidity change by 1 unit in the region, sporocarp formation is affected by 36% and 8.4%, respectively.

Key words: *Armillaria mellea,* Sporocarp, Chi-square analysis, Logistic regression, Temperature, Humidity, Altitude

Yuvacık Barajı Havzasında (Kocaeli, Türkiye) *Armillaria mellea* (Basidiomycota, Agaricales, Physalacriaceae)'nın Oluşumunu Etkileyen Ekolojik Faktörler

Öz: Kocaeli, Yuvacık baraj havzası karışık-geniş yapraklı ormanlarında *Armillaria mellea* (Vahl) P. Kumm.'nın oluşumu ve bu mantarın ekolojik özellikleri incelenmiştir. Araştırmalar sırasında, geniş yapraklı ormanların hâkim olduğu Yuvacık baraj havzasında küme örneklemesi ile seçilen parsellerde odunsu bitkiler üzerinde yetişen *A. mellea* sporokarpları (fruktifikasyon organları) analiz edilmiştir. Runs testi sonuçları, parsellerin seçiminde rastgelelik kurallarına uyulduğunu ve herhangi bir eğilimin olmadığını göstermektedir ($p= 0.109 > 0.05$, $z= -1.603$). *A. mellea*'nın varlığı/yokluğu ve çevresel değişkenler Ki-kare analizi ile test edilmiş ve sıcaklık bu çevresel değişkenler arasında farklılık göstermiştir. Dendrograma göre *A. mellea* daha çok çalışma alanının güneyinde görülmekte ve batı bakıyı tercih etmektedir. Bu makrofungusun çalışma alanın güneyini tercih etmesinin sebebinin ise yükseklik olduğu anlaşılmaktadır.

Verilerimiz, *A. mellea* sporokarplarının genel olarak batı bakıda, 15-20°C, >80 % nemde ve 800-1000 m yüksekliklerde bulunduğunu göstermektedir. Elde ettiğimiz lojistik regresyon analizi modeli (z=-9.508+0.307×temperature+0.081×humidity), bölgede sıcaklık ve nem 1 birim değişirse sporokarp oluşumunun sırasıyla %36 ve %8.4 oranında etkilendiğini göstermektedir.

Anahtar kelimeler: *Armillaria mellea*, Sporokarp, Ki – kare analizi, Lojistik regresyon, Sıcaklık, Nem, Yükseklik

Introduction

The genus *Armillaria* (Basidiomycota, Agaricales, Physalacriaceae) are natural components of the mycoflora in many forests worldwide. They occur worldwide in boreal, temperate, and tropical forests, and through diverse parasitic activities, they influence many host species. The genus *Armillaria* is, therefore, significantly considered in the ecology and management of many natural forests (Kile et al., 1991). It also has a long and controversial taxonomic history. This discussion goes back to the Danish botanist Martin Vahl's description of *Agaricus melleus* (syn: *Armillaria mellea*) in 1787. Many taxonomic revisions have subsequently been published addressing the controversial genus name. *Armillaria* Fr. Staude is now the broadly accepted generic name with *Armillaria mellea* (Vahl) P. Kumm. (honey mushroom) (Balmantarı) representing the type of the genera. (Volk & Burdsall, 1995; Watling et al., 1982; Coetzee et al., 2018, Sesli et al., 2020). *A. mellea* was recognized as a mixture of at least 10 different "biological species" in the late 1970s (Hagle, 2010; Lushaj et al., 2010) and *A. mellea* sensu stricto is described as a pathogen in broadleaf and conifers (Kile et al., 1991; Guillaumin et al., 1993; Lushaj, 2008).

Among the seven species of *Armillaria* spread in Europe, six species are wood decay fungi with wide distribution and of great ecological and economical importance (Kile et al., 1991; Guillaumin et al., 1993; Lushaj, 2008). In the Balkan countries, seven species have been reported from Albania (Lushaj, 2008), six species from Slovenia and the Czech Republic (Munda, 1997; Jankovský, 2003), and five from Greece and Serbia (Tsopelas, 1999; Lushaj et al., 2010). There have been identified eleven species in Türkiye; *A. borealis* Marxm. & Korhonen (Kuzey balmantarı), *A. bulbosa* (Romagn.) Kile & Watling, *A. cepistipes* Velen.(Narin balmantarı), *A. gallica* Marxm. & Romagn.(Şiş balmantarı), *A. mellea*, *A. obscura* (Schaeff.) Herink (Top balmantarı) *A. ostoyae* (Romagn.) Herink (Külahlı balmantarı), *A. socialis* (DC.) Fayod (Yığın balmantarı), *A. solidipes* Peck, *Desarmillaria ectypa* (Fr.) R.A. Koch & Aime (Sivri balmantarı), and *D. tabescens* (Scop.) R.A. Koch & Aime (Sesli and Denchev, 2014, Sesli et al., 2020, Solak and Türkoğlu, 2022). *A. mellea* has been recorded on deciduous species such as *Quercus*, *Fagus*, *Castanea*, *Carpinus*, *Populus*, *Salix*, *Corylus*, and *Juglans* and coniferous species such as *Pinus*, *Abies*, and *Cedrus* in Türkiye (Selik, 1973; Sümer, 1977; Doğan and Öztürk, 2006; Türkekul, 2008).

In the life cycle of *Armillaria* species, basidiospores germinate on the woody substrate, and formed mycelium colonizes this wood tissue. Healthy trees are infected either by root contacts with infected woody tissue or by rhizomorphs growing out from the infected centre. *Armillaria* invades the root system and the lower stem of the infected trees, killing the cambium and causing heart rot. Sporocarps develop on dead/moribund wood tissue and release basidiospores into the environment (Heinzelmann et al., 2019). *Armillaria* overwinters as a mycelium or rhizomorph on the stems or roots of infected or dead trees. *Armillaria* overwinters as a mycelium or rhizomorph on the stems or roots of infected or dead trees. Rhizomorphs are black, branched, and filamentous structures that develop from spores and supply nutrient and air transmission (Selik, 1986; Baumgartner et al., Hagle, 2010; 2011;).

Most species of *Armillaria* are considered to be facultative necrotrophs that have parasitic and saprophytic phases. First, *Armillaria* colonizes the cambium of living roots (parasitic phase). Then, the fungus kills the cambium, causing a necrotic lesion beneath the root bark. Lastly, the fungus feeds on the dead tissue (saprophytic phase). This saprophytic capability makes *Armillaria* root disease so difficult to prevent (Baumgartner et al., 2011). Relatively few studies have focused on the distribution of the species, physical space factors, or stand type characteristics of the forest (Bruhn et al., 2000). *A. mellea* was associated with high pathogenicity in deciduous and coniferous except for pines in alkaline soils in England and observed that it grows rhizomorphs under soil over short distances (Rishbeth, 1982). Termorshuizen and Arnolds (1994) pointed out that host preferences of *Armillaria* species may be affected by soil type and their virulence may be related to tree vitality affected by soil type. It was detected on broad-leaved hosts growing on clay and loess soils in The Netherlands. It was recognized as a dominant parasite on broadleaved forests and fruit trees, especially in warm regions in the Czech Republic (Jankovský, 2003). This species was identified in deciduous and coniferous forests below 1100 m altitude in Greece (Tsopelas, 1999). *A. mellea* was determined on oaks between 700–1050 m altitude in Serbia (Keča et al., 2009), while on a few broadleaved and conifers species,

below 1200 m in Albania (Lushaj et al., 2010). It was a species with low frequency in Poland (Łakomy, 2006) and the Ukrainian Carpathians (Tsykun et al., 2012).

Macrofungi studies in Turkey focused on its biodiversity rather than the ecological characteristics of fungi. There are a few papers based on this framework in our research area (Akata et al. 2018; Doğan et al., 2021). Yuvacik dam watershed, is located east of the Marmara region and in the transition zones of the three phytogeographic regions. The study area consists predominantly of pure and mixed broadleaved trees and mixed stands of deciduous and coniferous trees. *A. mellea*, which may attack deciduous and coniferous species, has been identified in previous studies in the research area. The present study aims to find out the ecological characteristics of *A. mellea* in the Yuvacik dam watershed area. We compared the presence/absence status of *A. mellea* to various environmental parameters in the sampled plots and analysed them with logistic regression.

Material and Metod

Study Area

Yuvacik dam watershed is located in the east of the Marmara region and the south of the Izmit district of Kocaeli province. It is coordinated at 40°32" N and 29° 58" E and covers 25.759 ha (Fig. 1 (Google Earth, 2022)). The Yuvacık Dam is fed by three main streams, numerous creeks and the Hüseyinli pond, which is used for irrigation. The average altitude of the area varies from 170-1300 m (Beşkardeş, 2012; Efe et al., 2013).

The study area is in the transition zones of the three different phytogeographic regions including the Euro–Siberian (Sub–Euxine, underside section), the Mediterranean (the Aegean, underside section), and Irano–Turanian (the side of the inner Anatolia). In the watershed, the predominant forest tree species are *Fagus sylvatica* subsp. *orientalis* Lipsky, *Quercus* species, *Carpinus betulus* L., *Pinus nigra* Aiton, *P. sylvestris* L. and *Abies nordmanniana* subsp. *equi-trojani* (Asch. & Sint. ex Boiss.) Coode & Cullen). In addition, some other species are also found, such as *Castanea sativa* Mill., *Corylus avellana* L., *Alnus glutinosa* (L.) Gaertn., *Populus tremula* L., and *Juglans regia* L. in the area. Forests are made up of pure stands as well as mixed stands of these particular species (Beşkardeş, 2012; Efe et al., 2013). To the Thornthwaite methodology, the annual average precipitation and temperature are 1038.7 mm and 9.5 °C, respectively. The study area has a climate model that reflects similar oceanic climate parameters such as humidity, mild temperature and no water shortage (Zengin et al., 2005). The prevailing soil type is eutric cambisol and orthic luvisol in the FAO system (FAO 2022).

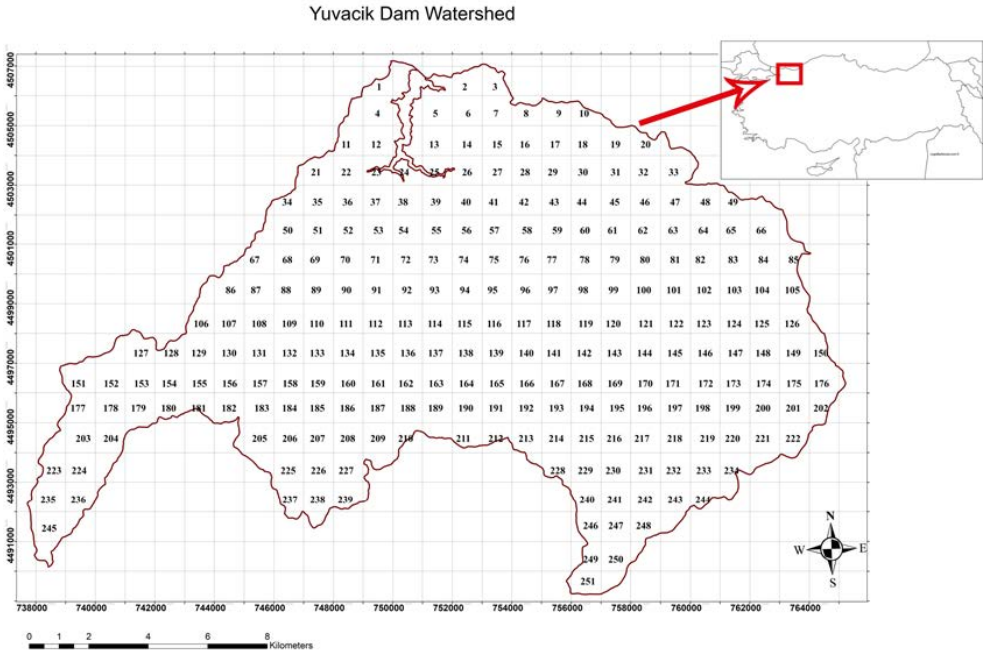

Figure 1. Location of Yuvacik dam watershed in the Marmara Region

The cluster sampling method was used in the Yuvacik dam watershed, spread over a 25759 hectar wide geographical area. The study area was divided into plots of 1 km² (grids) and 251 plots were obtained. 30 of 251 plots which correspond to approximately 12% of the study area were selected by simple random sampling (Fig 2). In our research, the transect method used 4 parallel transect sections running across plots of 1 km², 200 m apart as sampling patterns.

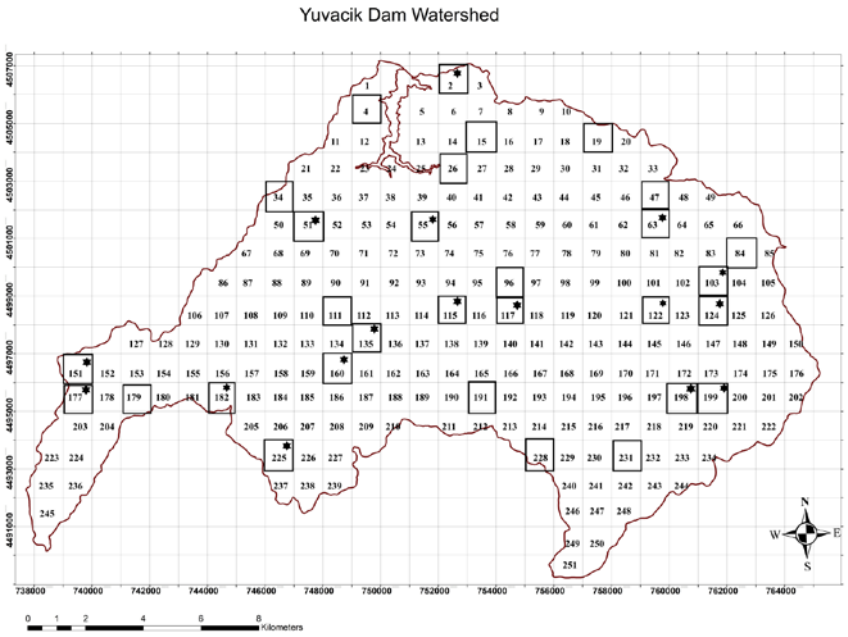

Figure 2**.** 30 sampled plots in the Yuvacik dam watershed (*where *Armillaria mellea* occurs)

Fungal Survey

Field surveys were systematically conducted during the vegetation season for symptomatic hosts and *A. mellea* sporocarps. Fallen and living trees, shrubs and stumps were examined in four parallel transects, each 1 km in length. Whenever sporocarps were encountered on a plot, at least one individual mushroom was collected from genets representing each morphology type. The photographs were taken in their habitat. During the field studies, environmental variables of the sampled plots such as stand type, age class, tree species, crown closure, aspect, altitude, temperature, and air humidity were noted (Table 1). Microscopic characteristics of sporocarps specimens were examined using a Bresser light microscope. The measurements of at least 25 spores per specimen were taken. Identification was made from the relevant literature (Breitenbach and Kränzlin, 1991). Collected specimens turned into fungarium specimens and preserved in the cabinets by İZT-391 (3828) numbering at Poplar and Fast-Growing Forest Trees Research Institute, Kocaeli.

Statistical analysis

The Runs Test was performed to control whether the field study was on randomly selected plots. Chi-square analysis was used to determine whether there was a relationship among environmental variables in plots where *A. mellea* was observed. Hierarchical cluster analysis was performed considering ecological similarities and differences among plots. Besides, a dendrogram was created to show the similarity of the plots according to the environmental variables. In this paper, to find out the correlation between a set of independent variables such as temperature (°C), humidity (%), altitude (m), age class, and crown closure and the binary dependent variable with two possible values (presence=1/absence=0) logistic regression analysis was performed (Küçüker et al., 2010).

$$P(Y) = \frac{e^z}{1+e^z} \rightarrow P(Y) = \frac{1}{1+e^{-z}}$$

z is a linear combination of independent variables.

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

β_0, β_1, β_2,...+ β_n are regression coefficients. The calculation of the regression coefficients is as follows:

$$\ln\left(\frac{P(Y)}{Q(Y)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

$$\frac{P(Y)}{Q(Y)} = e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots\cdots\cdots + \beta_n X_n} = e^{\beta_n X_n}$$

$$Q(Y) = 1 - P(Y)$$

The odds of an event occurring are calculated as the ratio of the probability of the property being present compared to the probability of it being absent. Odds= (P(Y))/(1-P(Y)) Which means, the Exp (β) value of each parameter is considered as the odds ratio. Exp (β_i) values indicate to what extent the dependent variable Y is more likely to be observed with the effect of the variable X_i (Akalp, 2016).

Table 1. Sampling plots, hosts and environmental variables of *Armillaria mellea*

Plot No	Pre/Abs (1/0)	Coordinates	Altitude (m)	Slope (°)	Temperature (°C)	Humidity (%)	Aspect*	Host**	Colonization Site	Age Class***	Crown Closure****
2	1	36T/4506955-754968	537	31	13	81	NE	OK	Collar	BC	2
4	0	35T/4505440-749692	341	46	9	79	N	-	-	BC	2
15	0	35T/4504656-753915	612	24	8	84	S	-	-	BC	2
19	0	36T/4504596-757176	789	26	10	78	SW	-	-	BC	2
26	0	35T/4503521-752445	187	17	5	68	SE	-	-	BC	2
34	0	35T/4502608-746524	645	10	6	81	SW	-	-	BC	2
47	0	36T/4502324-759452	1012	23	6	77	SW	-	-	BC	2
51	1	35T/4501076-747851	459	26	12	77	N	OK	Collar	BC	2
55	1	36T/4501924-751604	587	10	8	74	NE	OK	Collar	BC	2
63	1	36T/4501672-759596	898	29	6	78	SW	OK	Stump	BC	2
84	0	36T/4500908-762885	1167	19	7	85	W	-	-	BC	2
96	0	36T/4499536-754539	1119	9	7	75	SW	-	-	CD	3
103	1	36T/4499040-761978	632	19	8	79	NW	OK	Stump	BC	2
111	0	35T/4498488-748296	592	44	15	86	SW	-	-	BC	2
115	1	35T/4498827-752720	886	25	17	83	W	BE	Stump	CD	3
117	1	36T/4498396-754532	1120	10	18	86	NW	BE	Collar	CD	3
122	1	36T/4498164-759912	1261	15	17	77	SE	OK	Stump	BC	2
124	1	36T/4498496-761687	743	29	11	77	NE	BE	Stump	BC	3
135	1	35T/4497228-749676	1061	27	16	82	SW	BE	Stump	CD	3
151	1	35T/4496392-739216	1041	28	20	72	SE	BE	Stump	CD	3
160	1	35T/4496768-748156	843	26	16	81	W	BE	Stump	CD	3
177	1	35T/4495642-739516	903	16	17	78	SW	HBM	Stump	CD	3
179	0	35T/4495080-741356	842	27	15	67	W	-	-	BC	2
182	1	35T/4495496-744556	987	7	17	62	NE	HBM	Stump	CD	2
191	0	35T/4495584-753917	1186	7	14	55	E	-	-	CD	3
198	1	36T/4495726-760196	991	15	23	76	SE	OK	Stump	BC	2
199	1	36T/4495612-761875	900	23	15	81	E	OK	Stump	BC	2
225	1	35T/4493436-746768	1042	19	15	57	NW	OK	Stump	BC	2
228	0	36T/4493800-755480	975	18	12	60	SE	-	-	BC	2
231	0	36T/4493560-758760	850	8	16	56	SW	-	-	BC	2

*N: North, S: South, W: West, E: East, SW: Southwest, NW: Northwest, SE: Southeast
**OK: Oak, HBM: Hornbeam, BE: Beech
***a (0 – 8 cm), b (9 – 20 cm), c (21 – 36 cm), d (36 - 52 cm) Diameter at Breast Height (Age class)
****1 (11 – 4 %), 2 (41 – 70%), 3 (71 – 100%) Crown closure

To investigate whether environmental factors affect the presence of sporocarps of *A. mellea* in the plots, we analysed all variables together and removed the least expressive independent variable stepwise with Binary Logistic and Backward LR method on IBM SPSS Statistics 21 (IBM CR, 2012).

Results

According to the Runs test, there was no relationship between the presence of *A. mellea* and the selection order of the plots (p= 0.109 > 0.05, z= -1.603). Our results showed that randomness rules complied in the selection of the plots, and there was no tendency. *A. mellea* was detected in 17 of the 30 plots. This count represents 56% of the study area. All of the sporocarps of *A. mellea* were found on deciduous trees and particularly on stumps. 71% of plots, where *A. mellea* sporocarps occur were at an altitude of >800 m. Our determinations showed that they grew up mostly in the western aspect, "bc" age class and "2" crown closure. In addition, its sporocarps occurred in a high frequency at a temperature of 15–20 °C and >80 humidity (Table 1; Fig 3).

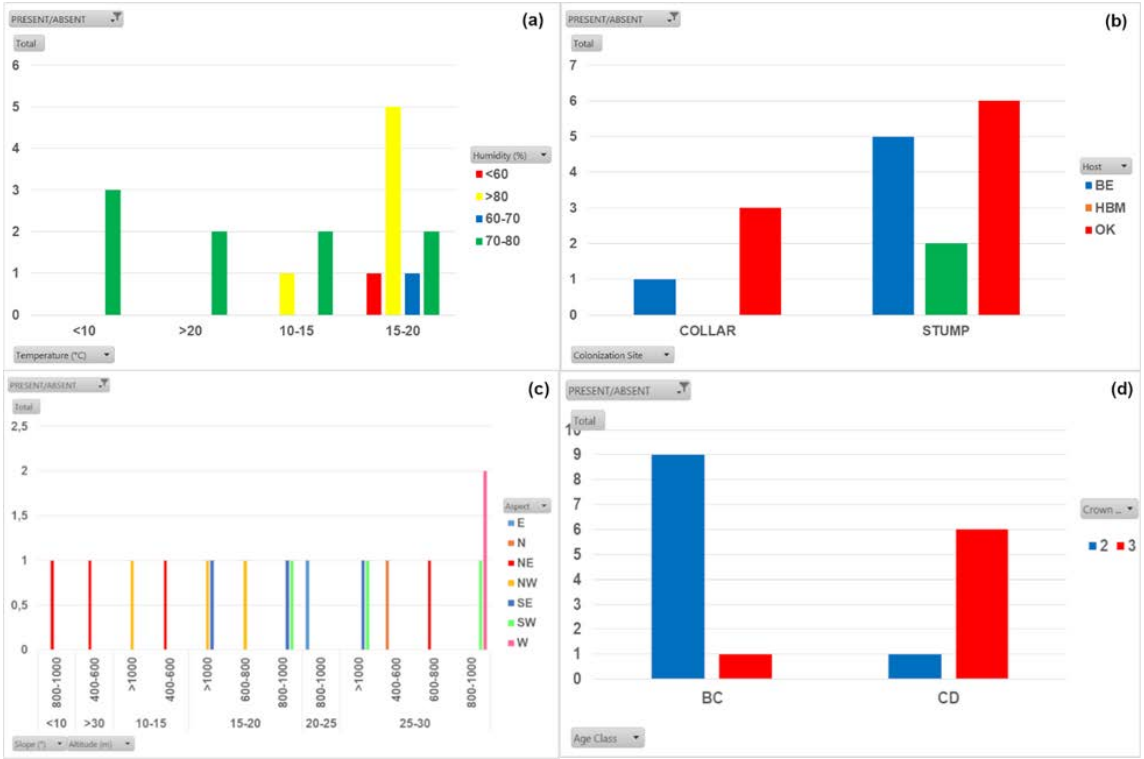

Figure 3. The effect of environmental variables on the occurrence of *Armillaria mellea* (a)Temperature–humidity, (b)colonization site-–host preference, (c)altitude–slope–aspect, (d)age class–crown closure

The presence/absence of *A. mellea* and environmental variables were tested with Chi-square analysis, and the results are given in Table 2. The temperature was different among these environmental variables, except for the host and colonization area. In addition, the graphical representations of these environmental variables were given in Figure 4. Environmental similarities and differences among plots where *A. mellea* was present and absence was determined by Hierarchical clustering analysis. In addition, a dendrogram showing the similarities of the plots was created for environmental variable groups in Figure 5.

The dendrogram consisted of 3 clusters including in order of 9, 12 and 9 plots from top to bottom and *A. mellea* was found on 6, 7, and 4 plots, respectively. To the dendrogram, *A. mellea* was mainly seen in the south of the study area and preferred western aspects. It is understood that this macrofungus prefers the south of the study area because of the altitude. In addition, *A. mellea* needed optimum conditions in terms of temperature and humidity; in other words, the probability of its occurrence decreases at high humidity and low temperature, as well as at low humidity and high temperature.

Table 2. Chi-square analysis of environmental variables, effect on the occurrence of *Armillaria mellea*.

Environmental Variables	**df**	**X^2**	***p*-Value**	**Cramer's V**	**Effect Size**
Slope (°)	5	4.830	0.348>0.05 NS	0.401	Relatively Strong
Altitude (m)	4	4.457	0.437>0.05 NS	0.385	Moderate
Temperature (°C)	1	5.954	0.015<0.05 *	0.454	Relatively Strong
Humidity (%)	3	3.180	0.365>0.05 NS	0.326	Moderate
Aspect	7	8.824	0.366>0.05 NS	0.542	Relatively Strong
Age Class	1	2.334	0.127>0.05 NS	0.279	Moderate
Crown Closure	1	2.334	0.127>0.05 NS	0.279	Moderate
Host	4	10.168	0.038<0.05 *	0.550	Relatively Strong
Colonization Site	3	22.961	0.000<0.001 ***	0.875	Very Strong

NS: Non-significant, *correlation is significant at the 0.05 level

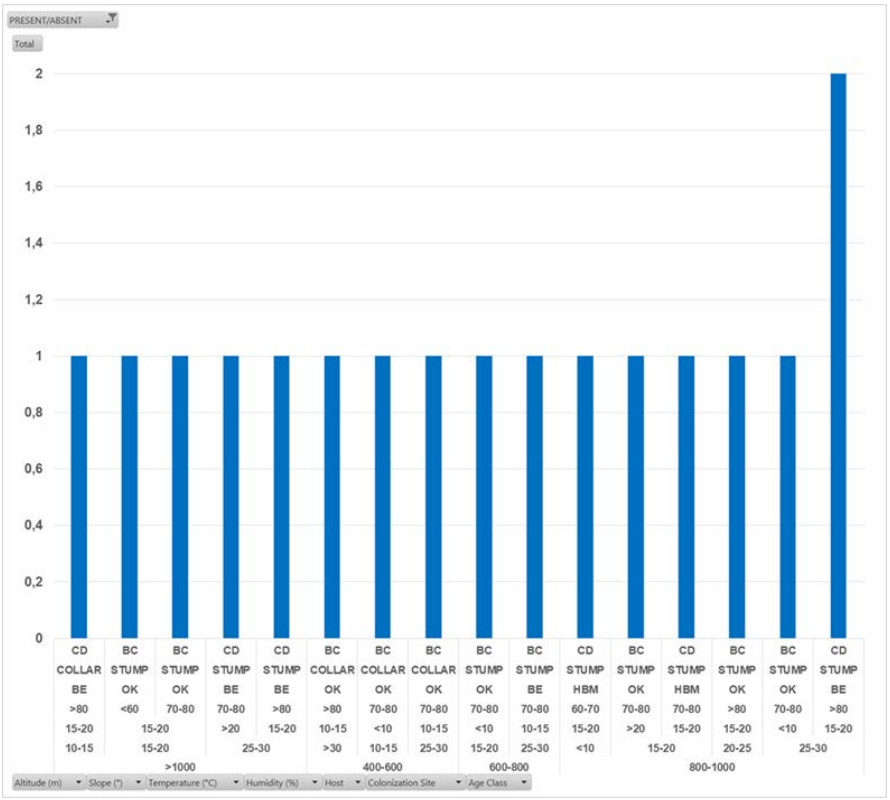

Figure 4. The relationship between environmental variables and *Armillaria mellea* in Yuvacik dam watershed.
OK: Oak, HBM: Hornbeam, BE: Beech, a (0–8 cm), b (9–20 cm), c (21–36 cm), d (36-52 cm) Diameter at Breast Height (Age class); 1 (11–4 %), 2 (41–70%), 3 (71–100%) Crown closure

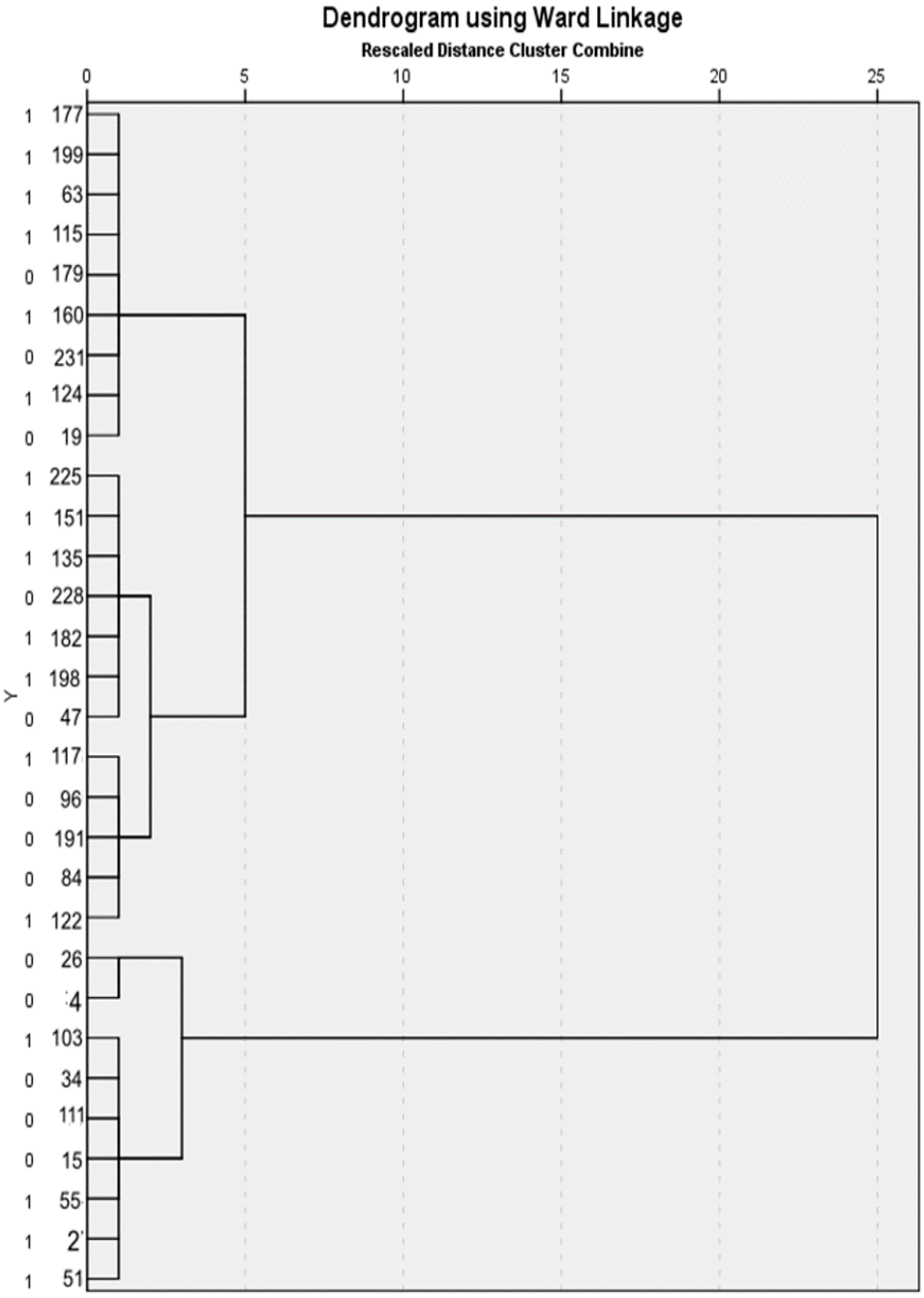

Figure 5. The clustering of the plots according to the presence/absence of *Armillaria mellea* for environmental variable groups in the study area.

It was investigated whether there is an effect of temperature (°C), humidity (%), altitude (meters), age class and crown closure on the presence of sporocarps of *A. mellea* in the plots. To create a new model using the Binary Logistic and Backward LR method, the age class, crown closure and altitude variables were removed from the model at the last step (Step 5). In terms of significance levels, positive advantages and Exp (B) values, the temperature (°C) and humidity (%) variables remained in the model, and the following statistically significant model was created.

$$z = -9.508 + 0.307 \times \text{temperature} + 0.081 \times \text{humidity}$$

In step 5 of Table 3, we found that the temperature affects the occurrence of sporocarps of *A. mellea* 1,36 times (36%). In other words, when the temperature is altered by 1 unit, sporocarps' probability of occurrence is affected by 36% (e^0.307). Furthermore, the humidity alteration affects

the presence of sporocarps of *A. mellea* by 8.4% (e^0.081). In the new model, when the ratio of the relevant independent variables is included in the model, the probability ratio of the dependent variables (P(Y)) is obtained. If P(Y) is >0.5, we estimate that *A. mellea* is found in the area.

Table 3. Logistic regression analysis and estimated logit coefficients, the effects of the environmental variables on the occurrence of *Armillaria mellea* sporocarps.

Variables in the Equation							
Steps- Variable		Estimated Logit Coefficient	Standard Error	Wald	df	Significance Level	Exp(B)/Odds Ratio
Step 1[a]	altitude	-.001	.002	.352	1	.553	.999
	slope	-.084	.071	1.388	1	.239	.919
	temperature	.382	.164	5.413	1	.020	1.465
	humidity	.121	.069	3.060	1	.080	1.128
	age class	.830	1.980	.176	1	.675	2.294
	crown closure	-1.153	1.725	.447	1	.504	.316
	constant	-10.140	6.273	2.613	1	.106	.000
Step 2[a]	altitude	-.002	.002	.411	1	.521	.998
	slope	-.072	.064	1.295	1	.255	.930
	temperature	.358	.149	5.765	1	.016	1.430
	humidity	.116	.067	3.037	1	.081	1.124
	crown closure	-.646	1.220	.280	1	.597	.524
	constant	-9.459	5.804	2.656	1	.103	.000
Step 3[a]	altitude	-.001	.002	.243	1	.622	.999
	slope	-.073	.063	1.318	1	.251	.930
	temperature	.366	.146	6.320	1	.012	1.442
	humidity	.120	.066	3.331	1	.068	1.127
	constant	-10.635	5.429	3.837	1	.050	.000
Step 4[a]	slope	-.060	.058	1.076	1	.300	.942
	temperature	.344	.138	6.192	1	.013	1.410
	humidity	.119	.066	3.264	1	.071	1.127
	constant	-11.478	5.285	4.716	1	.030	.000
Step 5[a]	temperature	.307	.121	6.429	1	.011	1.360
	humidity	.081	.051	2.511	1	.113	1.084
	Constant	-9.508	4.570	4.329	1	.037	.000
a. Variable(s) entered on step 1: altitude. slope. temperature. humidity. age. crown.							

Discussions

To chi-square results, the presence of *A. mellea* is independent of the slope, altitude, humidity and aspect, age class and crown closure variables, but it is dependent on temperature, host and colony location variables. *A. mellea* was specified mostly at an altitude of >800 m while it was not seen above 1200 m in the present study. This finding is consistent with previous studies conducted in Europe (Guillaumin et al., 1993; Tsopelas, 1999; Keča et al., 2009; Lushaj et al., 2010; Mesanza et al., 2017).

In this survey, all of the sporocarps were found on broad-leaved trees. It was recorded on deciduous trees by previous studies in the Netherlands, Greece, Czech Republic, Serbia, Albania, and Spain (Termorshuizen and Arnolds, 1994; Tsopelas, 1999; Jankovský, 2003; Keča et al., 2009; Lushaj et al., 2010; Mesanza et al., 2017).

In our study, sporocarps were mostly found on the root collars of living trees of oak and beech, and stumps in the western aspect. Mesanza et al. (2017) observed *Armillaria* species mostly in the western aspect of Spain. Also, they mainly found sporocarps on the root collars of dead and living trees and stumps. Our determinations showed that *A. mellea* grew up in the "bc" age class and "2" crown closure. Dálya et al. (2019) evaluated the presence and distribution of root rot fungi in the Vallombrosa (Italy) forest after severe storm damage. They noted that *A. mellea* grew between 20–60, according to the age classes of forest stands. Our findings are similar to the study results of Dálya et al. (2019).

A. mellea is widely spread in the presence of an Atlantic climate as in England, part of France and the Mediterranean climate in Italy, Portugal and Spain (Guillaumin et al., 1993). In our study, we found out that the optimum temperature was 15–20 °C and humidity >80 humidity (%) for the growth of the sporocarps of the species. Guillaumin et al., (1993) reported that *A. mellea* is a thermophilic species of Atlantico-Mediterranean distribution. Keča (2005) reported that the fastest growth was at 22 °C in his study of mycelium development on five *Armillaria* species, including *A. mellea*. Hasegawa et al., (2011) showed that *A. mellea* was thermophilic according to Kira's warmth index (WI) and indicated a very similar thermal preference between Europe and Japan.

In addition, the dendrogram showing the similarities of the plots was created for environmental variable groups by hierarchical clustering analysis. We also provided the knowledge that the occurrence of *A. mellea* decreased both at high humidity and low temperature or low humidity and high temperature. In other words, the sporocarps of *A. mellea* prefer optimum conditions of temperature and humidity.

The results of logistic regression analysis revealed that temperature affects the growth of the sporocarps of *A. mellea* by 36%. When the temperature varies by 1 degree, the growth of the sporocarps is affected 1.36 times. This rate is 8.4% for humidity. This logistic regression equation can be used to predict *Armillaria'*s prevalence in this study area.

Armillaria has not been reported as a major epidemic or disease agent for the study area so far. However, there are significant losses in the world, especially in terms of oak species. It is required to observe *A. mellea*, which can be a substantial threat to deciduous and coniferous species. Our results show that the sporocarps of *A. mellea* grow on stumps by 80%. This detection indicates that the species is currently saprophytic in the area and reveals that treatment of stumps should be attentive to avoid an epidemic caused by *A. mellea* in the future.

A. mellea is the most virulent species of broad-leaved forests and has caused significant economic losses in western Europe. However, *Armillaria* species are thought to be beneficial for the carbon cycle in natural ecosystems as a saprophytic, especially white–rot. It is also used in the food and pharmaceutical industry. It is a requirement to realize regular surveys in the field for a species that is considered to have such different effects. There is little knowledge of *Armillaria'*s diversity, distribution, pathogenicity, pandemic, and virulence in the forest of Türkiye. The species diversity of the *Armillaria* complex should be investigated and supported by molecular methods. It is required to give importance to the pathogenicity, virulence, and pandemic risk analysis studies of *Armillaria* species in Türkiye forests. Since the incidence of *A. mellea* is higher in the “bc” age class and “2” crown closures in the study area, it is revealed that more attention should be paid to sites with this feature in terms of epidemics in forestry studies. In addition, our findings support that this fungus commonly affects younger individuals. Studies on assessment as a non–wood forest product (in the food and pharmaceutical industry) maybe provide significant knowledge of the environmental requirements of these species.

Author contributions

Sabiha Acer coordinated the research, planned and carried out the identifications and discussed the results. Ersel Yilmaz developed the theory and analytical methods, conducted the field experiment, and run the data analysis. Ayhan Karakaya supervised the work, designed and conducted the field experiment, and discussed the results. All authors helped in writing, read, and approved the final manuscript.

Conflicts of interest

The authors declare no competing interests.

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Domestication of Wild Edible Mushrooms in Eastern Africa: A Review of Research Advances and Future Prospects

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Abstract: Mushroom farming is an emerging industry in Africa with great potential to improve livelihoods. However, the industry is still dominated by a few exotic varieties faced with challenges of regional adaptability. Also, information concerning their domestication status, challenges and future prospects is scattered and unclear. The purpose of this paper was to review and detail the diversity of mushrooms occurring in Eastern Africa (EA), reveal the wild edible/medicinal species (WEMs) that have already been domesticated, their domestication status, the nutritional composition status of the edible species and availability of their germplasm (mother cultures). To achieve this, a detailed review of published research articles, books and reports from EA was conducted. Data was collected from articles focusing on the diversity of WEMs, nutritional composition analysis and domestication methods and status. From the review, 306 WEMs are shown to have desirable characteristics for utilization as food /medicine, with Tanzania documenting the highest number (147) followed by Malawi (90). Among these, 82 species are edible ectomycorrhizal species with great potential to support the mushroom industry if sustainably harvested and managed. The rest are saprophytic fungi species. Only 14 species among the saprobe group have been tissue cultured, tested for spawn production and cultivation. 51 species have been analyzed for nutritional composition. However, none of these have been commercially introduced to cultivation and the availability of their germplasm for research and propagation purpose is uncertain. The result from this study clearly shows research on the domestication of WEMS in Africa is still in its infancy stages.

Key words: Cultivation, Distribution, Species, Substrates, Symbiosis

Doğu Afrika'da Yenilebilir Yabani Mantarların Kültüre Alınması: Araştırmadaki İlerlemeler ve Gelecekteki Beklentiler Üzerine Bir İnceleme

Öz: Mantar yetiştiriciliği, geçim kaynaklarını iyileştirme konusunda büyük potansiyele sahip, Afrika'da gelişmekte olan bir endüstridir. Bununla birlikte, sektöre hala bölgesel uyum sağlamada zorluklarla karşı karşıya kalan birkaç egzotik tür hakimdir. Ayrıca, mantarların kültüre alma durumları, karşılaştıkları zorluklar ve gelecek beklentileri ile ilgili bilgiler dağınık ve belirsizdir. Bu makalenin amacı, Doğu Afrika'da bulunan mantarların çeşitliliğini incelemek ve detaylandırmak, halihazırda kültüre alınmış olan yabani yenilebilir/tıbbi mantar türlerinin (WEM'ler), kültüre alma durumlarını, yenilebilir türlerin beslenme kompozisyon durumunu ve anaç kültürlerinin (germplazmlarının) mevcudiyetini ortaya çıkarmaktır. Bunu başarmak için, yayınlanan araştırma makaleleri, kitaplar ve Doğu Afrika raporlarının ayrıntılı bir incelemesi yapılmıştır. Veriler, yabani yenilebilir/tıbbi türlerin çeşitliliğine, besin bileşimi analizine ve kültüre alma yöntemlerine ve statüsüne odaklanan makalelerden toplanmıştır. Araştırmada 306 yabani yenilebilir/tıbbi türün gıda/ilaç olarak kullanım için arzu edilen özelliklere sahip olduğu gösterilmiştir, en yüksek sayıyı ortaya koyan Tanzanya (147) ve onu Malavi (90) takip etmektedir. Bunların arasında 82 tür, sürdürülebilir bir şekilde hasat edilir ve yönetilirse mantar endüstrisini destekleme potansiyeli yüksek, yenilebilir ektomikorizal türlerdir. Geri kalanı saprofitik mantar türleridir. Saprofitik grubundan sadece 14 türün doku kültürü yapılmış ve tohumluk misel üretimi ve yetiştirme için test edilmiştir. 51 tür besin bileşimi açısından analiz edilmiştir. Bununla birlikte,

bunların hiçbiri ticari olarak kültüre alınmaya çalışılmamıştır ve anaç kültürlerin araştırılması ve çoğaltılması amacıyla mevcut durum belirsizdir. Bu çalışmadan elde edilen sonuç, Afrika'da yabani yenilebilir/tıbbi türlerin kültüre alınmasına ilişkin araştırmaların henüz başlangıç aşamasında olduğunu açıkça göstermektedir.

Anahtar kelimeler: Kültür mantarcılığı, Dağılım, Türler, Substratlar, Simbiyoz

Introduction

Wild edible mushrooms are valuable non-wood forest resources, cherished by many communities in the world (Boa, 2004; Dejene et al., 2017a; Degreef et al., 2016; Degreef et al., 2020; Ngom et al., 2022). In Africa, wild mushroom gathering and hunting is a common practice mostly among the rural populace, especially during the rainy season (Dejene et al., 2017b; Kashiki et al., 2021; Ngom et al., 2022), which is suitable fructification of fungi. They are the source of food, health promoting properties and economic value (Boa, 2004; Dejene et al., 2017a; Sande, 2019; Niazi and Ghafoor, 2021). Ethnomycological knowledge obtained from different parts of the world reveals the use of mushrooms in various ways including in traditional medicine (Atri and Chadha, 2018). In Tanzania for example, the wild mushroom collection is a socio-economic activity among the Hehe and Benna communities. It is estimated that the collectors earn approximately US $500 to 1000 for 750 - 1500 kg of mushrooms per season (Atri and Chadha, 2018). In other regions of Africa, wild edible mushrooms are collected to serve various nutritional needs, especially protein which in most cases is lacking or it is expensive (Atri and Chadha, 2018). Among the most cherished mushrooms in Africa are *Termitomycetes* which are preferred due to their unique taste, flavor and texture (Degreef et al., 2020). Despite the role mushrooms play to improve livelihoods and the well being of many communities in Africa, there is increasing unsustainable harvesting which raises concerns about their depletion from the wild which will consequently increase food insecurity among local communities in the near future (Waiganjo et al., 2008; Dejene et al., 2017a; Degreef et al., 2020). To protect the planet and its biodiversity while reducing food insecurity and maintaining peace and human prosperity in line with the 2015 Sustainable Development Goals (SDGs), local mushroom cultivation and expansion of the mushroom industry have been proposed as a viable way of sustaining mushroom supply and protecting WEMs in nature (Niazi and Ghafoor, 2021).

Mushroom cultivation has increased tremendously in many parts of the world. It is carried out in more than 100 countries with a growth rate of 6-7% annual production (Niazi and Ghafoor, 2021). China leads with over 80% in the production of edible and medicinal mushrooms. The mushroom industry is the second largest in China and has created over 25 million job opportunities (Willis, 2018). However, mushroom cultivation is low in Africa and the region contributes less than 1% of the annual worldwide production of mushrooms (Adejumo and Awosanya, 2005; Onyango et al., 2011; Dejene et al., 2017a). This is majorly attributed to over-reliance on wild harvesting and low uptake of mushroom cultivation when compared to the cultivation of other food crops such as maize and beans. Partly, it is dependent on imported exotic mushroom mother cultures which tend to be expensive and sometimes difficult to access making mushroom farming expensive and unattractive. In East Africa, only cultivated mushrooms of exotic origin (*Agaricus, Pleurotus, Lentinula* and *Ganoderma* sp) cultured from imported mother cultures (Musieba et al., 2012) dominates the mushroom industry. These imported strains are associated with low yields and susceptibility to pests and diseases, the assumption being that the species lack regional adaptability (Otieno et al., 2015). Over the past years, there has been increased interest to exploit and domesticate wild edible and medicinal saprophytic mushrooms with desirable characteristics such as good regional adaptability, ability to grow on readily available substrates, low susceptibility to pests and diseases and good flavor for sustainable nutritional source in Eastern Africa (EA) (Mdachi et al., 2004; Magingo et al., 2004; Oriyo et al., 2004; Mshadete and Cuff, 2008; Mwita et al., 2010; Musieba et al., 2012; Juma et al., 2015; Wendiro, Wacoo and Wise, 2019).

Eastern Africa is a tropical region with 10 countries (Tanzania, Kenya, Uganda, Rwanda, Burundi, South Sudan, Djibouti, Eritrea, Ethiopia, and Somalia). The region is known for its unique forested ecosystems hosting valuable mycodiversity (Pegler and Rayner, 1969; Pegler, 1977; Boa, 2004). Although research on the diversity and taxonomy of mushroom resources in this

region is increasing tremendously with new species being reported (Boa, 2004; Tibuhwa, 2011; Njuguini et al., 2018; Nteziryayo et al., 2019; Muchane et al., 2021;Ngom et al., 2022) information concerning domestication of these wild edible varieties is still scanty. Unlike many parts of the world where more than 100 species have been domesticated and 60% commercialized (Chang and Miles, 2004; Dejene et al., 2017a; Willis, 2018) in EA available information points only to the successful cultivation trials, but reports of adopted species by farmers for cultivation is lacking (Magingo et al., 2004, Mshadete and Cuff, 2008, Musieba et al., 2012, Juma et al., 2015). Additionally, the diversity of WEMs in EA is also poorly investigated. The potential of WEMs contribution to the mushroom industry remains less known and explored, with information concerning their domestication status, challenges and future prospects still scattered and not clear. There is still no clear distinction between edible and medical mushrooms.

Domestication of WEMs in EA provides a great opportunity of producing mushroom strains adapted to EA environmental and climate conditions as well as strains less susceptible to diseases. Since most of these WEMs are adapted to high temperatures and humid conditions, their production can be faster compared to exotic strains from temperate regions (Musieba et al., 2012). Optimization and simulation of growth conditions to match that of natural habitats is also possible since habitats and growth conditions of domesticated strains are known and accessible. Such information will enable spawn producers and mushroom farmers to use only strains ideal for conditions in the growing facility and use of right substrate. Domestication of WEMs will also increase the production of traditionally preferred and high-nutritional indigenous mushrooms. This will increase levels of mushroom farming adoption and production. This will also minimize losses, increase value for money, and lower the cost of production thus expanding the mushroom industry in EA. Although many of the common edible species have therapeutic properties and are used for medical purposes, information regarding their unique medicinal properties is also required for proper characterization.

The purpose of this paper is to review and detail the diversity of WEMs with special reference to EA, it's potential in the mushroom industry, domestication status, the nutritional value in comparison to introduced exotic species and availability of their germ-plasm (mother cultures).

Material and Metod

Literature was obtained through Internet-based scientific literature search engines (ISI web of Science, Research gate and Google scholar) and Libraries. Research materials that fulfilled the following criteria were selected; research materials and articles in eight selected countries focusing on the diversity of WEMs, nutritional composition analysis, articles detailing domestication, experimental methods and status. Data collected included; wild edible mushroom species (WEMs), nutrient content of WEMs, domesticated mushroom species, status of domestication (tissue culture, spawn or cultivated). Methods & materials used during domestication, and the yield of cultivated mushrooms was considered. Data were extracted from the results section and appendices with the list of WEMs, tables of means, graphs, and figures. Graphs and tables were used to summarize WEMs species in different countries.

Results

Diversity of edible (medicinal) mushrooms

This study has revealed a diverse community of wild edible mushroom (WEMs) species in East Africa with a total of 306 species of WEMs distributed within the division *Basidiomycota* (82 genera within 39 families) and *Ascomycota* (4 genera within 2 Phylum) (Table 1).

Table 1: list of wild edible / Medicinal mushrooms in East Africa Region

Species	Habitat association	Country	Reference
***Afloboletus luteolus* (Heinem.) Pegler & T.W.K. Young**	**Ectomycorrhizal**	**Tanzania, Burundi, Malawi**	**Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016**
***Afroboletus costatisporus* (Beeli) Watling.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004**
***Afrocantharellus fistulosus* Tibuhwa & Buyck**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
***Afrocantharellus splendens* Buyck**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**

Afrocantharellus symoensii **(Heinemann) Tibuhwa**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Agaricus campestris **(L. ex Fr.)**	**Saprobe**	**Tanzania, Kenya, Somalia, Malawi , Ethiopia**	**Pegler, 1977; Rammeloo and Wallyne, 1993; Boa, 2004; Mdachi *et al*., 2004; Tibuhwa, 2011; Woldegiorgis, 2015;Dejene *et al*., 2017a; Dejene *et al*., 2017b ; Njugini *et al*., 2018**
Agaricus campestroides **(Heinem & Gooss. -Font**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017b**
Agaricus amboensis **(Fayod) Sacc.**	**Saprobe**	**Somalia, Uganda**	**Boa, 2004**
Agaricus arvensis **Schaeff.**	**Saprobe**	**Ethiopia ,Tanzania, Uganda**	**Harkonen *et al*., 2003; Degreef *et al*., 2016; Dejene *et al*., 2017a; Dejene *et al*., 2017b; Ngom *et al*., 2022**
Agaricus augustus **Fr.**	**Saprobe**	**Kenya, Tanzania**	**Pegler, 1977; Tibuhwa, 2011; Njuguini *et al*., 2018**
Agaricus bimbaumii **(Corda)Singer**	**Saprobe**	**Tanzania**	**Tibuhwa, 2013**
Agaricus bingensis **Heinem.**	**Saprobe**	**Malawi, Uganda**	**Rammeloo and Wallyne 1993; Boa, 2004**
Agaricus bisporus **(Lange) Imbach**	**Saprobe**	**Tanzania, Ethiopia, Kenya, Malawi**	**Rammeloo and Wallyne, 1993; Tibuhwa, 2011; Tibuhwa, 2013; Woldegiorgis, 2015**
Agaricus croceolutescens **(Heinemann & Gooss.-Font)**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Agaricus placomyces **Perk.**	**Saprobe**	**Tanzania**	**Tibuhwa 2013**
Agaricus silvaticus **Schaeff.**	**Saprobe**	**Kenya**	**Pegler, 1977; Njuguini *et al*., 2018**
Agaricus **sp. L.: Fr. Emend. Karst**	**Saprobe**	**Tanzania, Uganda, Malawi**	**Nakalembe *et al*., 2009**
Agaricus subedulis **Heinem.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a.**
Agaricus sylvicola **(Vitt.) Lév.**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Agaricus volvatulus **Heinem. & Gooss.**	**Saprobe**	**Kenya**	**Tibuhwa 2011; Njuguini *et al*., 2018**
Agrocybe pediades **(Fr.) Fayod**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Amanita aff. calopus **(Beeli)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Amanita aurea **(Beeli) E.J. Gilbert**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003**
Amanita bingensis **(Beeli) Heinem.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Amanita cf. robusta **(Beeli)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne 1993**
Amanita flammeola **(Pegler & Piearce)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa 2004**
Amanita fulva **(Schaeff) Fr.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Amanita goossensiae **(Beeli)**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Amanita hemibapha **(Berk. & Br.)**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne 1993**
Amanita loosii **Beeli**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016**
Amanita mafingensis **Härk. & Saarim.**	**Ectomycorrhizal**	**Burundi**	**Harkonen *et al*., 2003; Tibuhwa, 2013; Degreef *et al*., 2016**

Amanita masasiensis **Hark. & Saarim.**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003;Tibuhwa, 2013**
Amanita **Pers.**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995; Dejene *et al*., 2017a**
Amanita pudica **(Beeli) Walleyn**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Amanita rhodophylla **(Beeli)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Amanita robusta **(Beeli)**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004**
Amanita rubescens **(Pers.: Fr.)**	**Ectomycorrhizal**	**Burundi, Malawi**	**Rammeloo and Wallyne, 1993; Buyck and Nzigidahera, 1995; Boa, 2004; Degreef *et al*., 2016**
Amanita tanzanica **Hark. Saarim.**	**Ectomycorrhizal**	**Tanzania, Burundi**	**Harkonen *et al*., 2003; Tibuhwa, 2013; Degreef *et al*., 2016**
Amanita vaginata **(Bull.: Fr)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Amanita verna **(Bull.) Lam.**	**Ectomycorrhizal**	**Burundi**	**Nteziryayo, *et al*,. 2019**
Amanita zambiana **(Pegler & Pierce)**	**Ectomycorrhizal**	**Kenya, Malawi, Burundi**	**Rammeloo and Wallyne, 1993; Boa, 2004; Wandati *et al*., 2013; Nteziryayo *et al*., 2019**
Amylosporus **IJ-2014**	**Saprobe**	**Tanzania**	**Hussein *et al*., 2016**
Armillaria borealis **Marxmüller & Korhonen**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Armillaria cepistipes **Velen.**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Armillaria heimii **Pegler**	**Saprobe**	**Tanzania, Rwanda, Ethiopia**	**Tibuhwa, 2013; Degreef *et al*., 2016; Dejene *et al*., 2017a**
Armillaria lutea **Gillet**	**Saprobe**		**Degreef *et al*., 2016**
Armillaria mellea **(Vahl) P. Kumm.**	**Saprobe**	**Kenya, Tanzania, Uganda**	**Pegler, 1977; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Njuguini *et al*., 2018**
Armillaria ostoyae **(Romagn.) Herink**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Armillaria tabescens **(Scop.) Emel**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Auricularia auricula - judae **(Bull.: Fr.) Wettst.**	**Saprobe**	**Kenya, Malawi, Rwanda, Uganda**	**Rammeloo and Wallyne, 1993; Boa, 2004; Onyango *et al*., 2012; Degreef *et al*., 2016; Hussein *et al*., 2016; Njuguini *et al*., 2018**
Auricularia **Bull.ex Juss**	**Saprobe**	**Ethiopia; Kenya**	**Wandati *et al*., 2014; Dejene *et al*., 2017; Njuguini *et al*., 2018**
Auricularia cornea **Ehrenb.**	**Saprobe**	**Tanzania, Burundi, Rwanda**	**Tibuhwa *et al*., 2013; Degreef *et al*., 2016**
Auricularia delicata **(Mont. ex Fr.) Henn.**	**Saprobe**	**Kenya , Tanzania,Uganda Malawi**	**Rammeloo and Wallyne,1993; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2011; Tibuhwa, 2013; Degreef *et al*., 2016; Njuguini *et al*., 2018; Ngom , *et al*., 2022**
Auricularia fuscosuccinea **(Mont.) Henn.**	**Saprobe**	**Tanzania**	**Boa, 2004**
Auricularia polytrica **(Mont.) Sacc.**	**Saprobe**	**Tanzania, Kenya**	**Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2011; Hussein *et al*., 2016; Njuguini *et al*., 2018;**
Bolbitius vitellinus **(Pers.:Fr.)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993**
Boletus clavipes **(Perk) Pilat & Dermek**	**Ectomycorrhizal**	**Tanzania**	**Mdachi *et al*., 2004**
Boletus loosii **Heinem.**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Boletus pallidissimus **Watling**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Boletus pruinatus/ xerocomellus	**Ectomycorrhizal**	**Tanzania**	**Mdachi *et al*., 2004**

pruinatus **Fr.& Hok Sutara**			
Boletus spectabilissimus **Watling**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Tibuhwa, 2013**
Buntarantara Buntarantara	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2009**
Bunyabikandaigo	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2003**
Calvatia rubroflava **(Cragin) Lloyd**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Calvatia urtiliformis **(Bull.:Pers)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993**
Cantharellus rufopunctatus **(Beeli) Heinem.**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**
Cantharellus **Adans. ex Fr**	**Ectomycorrhizal**	**Malawi, Tanzania**	**Harkonen *et al*., 2003; Boa, 2004; Mdachi *et al*., 2004; Tibuhwa, 2013; Gateri *et al*., 2014;**
Cantharellus cibarius **Fr.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Cantharellus cibarius var. defibulatus **Heinem.**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**
Cantharellus congolensis **Beeli**	**Ectomycorrhizal**	**Burundi, Tanzania, Malwi**	**Rammeloo and Wallyne, 1993; Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016**
Cantharellus cyanescens **Buyck.**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995; Boa, 2004**
Cantharellus cyanoxanthus **R. Heim ex Heinem.**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Buyck and Nzigidahera, 1995; Tibuhwa, 2013; Degreef *et al*., 2016**
Cantharellus defibulatus **(Heinem.) Eyssart. & Buyck**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Cantharellus densifolius **Heinem.**	**Ectomycorrhizal**	**Burundi , Tanzania , Malawi**	**Rammeloo and Wallyne, 1993; Buyck and Nzigidahera 1995; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016**
Cantharellus floridula **(Pegler) Heinem.**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2004; Tibuhwa, 2013**
Cantharellus **Fr. var. *latifolius*** **Heinem.**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995**
Cantharellus isabellinus **Heinem.**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013**
Cantharellus longisporus **Heinem.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Cantharellus luteopunctatus **(Beeli) Heinem.**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Cantharellus miomboensis **Buyck & V. Hofst.**	**Ectomycorrhizal**		**Degreef *et al*., 2016**
Cantharellus parvisporus **(Eyssart. & Buyck)**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Cantharellus platyphyllus **Heinem. var. cyanescens (Buyck) Eyssart. & Buyck**	**Ectomycorrhizal**	**Tanzania, Burundi**	**Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016**
Cantharellus pseudocibarius **Henn.**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**

Cantharellus rhodophyllus **Heinem.**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Cantharellus ruber **Heinem.**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016**
Cantharellus rufopunctatus **(Beeli) Heneim.**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Buyck and Nzigidahera, 1995; Tibuhwa, 2013**
Cantharellus splendens **Buyck**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995; Degreef *et al*., 2016**
Cantharellus subincarnatus **Eyssart. & Buyck**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Cantharellus symoensii **Heinem.**	**Ectomycorrhizal**	**Burundi , Tanzania**	**Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016**
Cantharellus tenuis **Heinem.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Cantharellus tomentosus **Eyssart. & Buyck**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Clavaria albiramea **(Corner) Buyck & Duhem**	**Saprobe**	**Malawi**	**Boa, 2004**
Clavatia rubroflava **(Cragin) Lloyd**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Clavulina wisoli **R.H. Petersen**	**Saprobe**	**Tanzania**	**Harkonen *et al*., 2003**
Collybia aurea **(Beeli) Pegler**	**Saprobe**	**Burundi, Rwanda**	**Buyck and Nzigidahera 1995; Degreef *et al*., 2016**
Collybia confluens **(Pers) Kumm.**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Collybia dryophila **(Bull.) Kumm.**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Coprinellus domesticus **(Bolton)Vilgalys, Hopple & Jacq. Johnson**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Coprinellus niveus **Fr.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Coprinus cf. molestus **Bouriquet**	**Saprobe**	**Burundi**	**Buyck and Nzigidahera, 1995**
Coprinus cinereus **(Schaeff.)**	**Saprobe**	**Tanzania**	**Harkonen *et al*. 2003; Boa, 2004, Mshandete and Cuff 2007 and 2008, Raymond *et al*., 2012**
Coprinus comatus **(O.F Murill.) Pers**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Tibuhwa, 2013**
Coprinus disseminatus **(Pers.)J. E Lange**	**Saprobe**	**Tanzania, Malawi, Uganda , Kenya**	**Pegler, 1977; Boa, 2004; Tibuhwa, 2013; Njuguini *et al*. 2018**
Coprinus micaceus **(Bull.) Fr.**	**Saprobe**	**Kenya , Tanzania**	**Pegler 1977; Njuguini *et al*., 2018**
Coprinus **sp Pers.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Coprinus pseudoplicatilis **Voglina**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**

Coprinus sterquilinus **(Fries) Fries**	**Saprobe**	**Kenya**	**Boa, 2004**
Coprinopsis nivea **(Pers.) Redhead, Vilgalays & Moncalvo**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017**
Cotylidia aurantiaca **(Pat.) A.L. Welden**	**Saprobe**	**Burundi , Rwanda**	**Degreef *et al*., 2016**
Craterellus **Pers.**	**Ectomycorrhizal**	**Ethiopia**	**Dejene *et al*., 2017a**
Cymatoderma dendriticum **(Pers) D.A Raid**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Cystodermella elegans **(Beeli) Harmaja**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Dacryopinax spathularia **(Schwein.) G.W. Martin**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Entoloma argypus **P. Karst**	**Saprobe**	**Tanzania**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Favolus brasiliensis **(Fr) Fr.**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993**
Ganoderma applanatum **(Pers.) Pat.**	**Saprobe**	**Ethiopia, Uganda**	**Dejene *et al*., 2017b; Ngom *et al*., 2022**
Ganoderma lucidum **(Curtis) P. Karst**	**Saprobe**	**Tanzania**	**Mdachi *et al*., 2004**
Ganoderma **sp P. Karst sp**	**Saprophytic**	**Kenya**	**Njuguini *et al*., 2018**
Gyroporus castaneus **(Bull Quel.**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993**
Hygrophoropsis aurantiaca **(Wurfen) Maire**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Hymenagaricus **sp Heinem.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Hypholoma fasciculare **(Huds: Fr.) P.Kumm.**	**Saprobe**	**Burundi**	**Nteziryayo *et al*., 2019**
Hypholoma subviride **(Berk. & M.A. Curtis) Dennis**	**Saprobe**		**Boa, 2004; Degreef *et al*., 2016**
Inonotus **P.Karst.**	**Saprobe**	**Tanzania**	**Mdachi *et al*., 2004**
Joga kadzonzo	**Ectomycorrhizal**	**Kenya**	**Wandati *et al*., 2013**
Joga muhama	**Ectomycorrhizal**	**Kenya**	**Wandati *et al*., 2013**
Kuehneromyces mutabilis **Schaeff. Singer & A.H.Sm**	**Saprobe**	**Tanzania**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Lactarius aff. gymnocarpus **R. Heim ex Singer**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995**
Lactarius deliciosus **(L.ex Fr.) Gray**	**Ectomycorrhizal**	**Malawi, Tanzania , Burundi**	**Rammeloo and Wallyne, 1993; Harkonen *et al*., 2003; Tibuhwa, 2013**
Lactarius edulis **(Verbeken & Buyck)**	**Ectomycorrhizal**	**Burundi , Tanzania**	**Buyck and Nzigidahera, 1995**
Lactarius gymnocarpoides **Verbeken**	**Ectomycorrhizal**	**Tanzania, Malawi**	**Harkonen *et al*., 2003; Boa, 2004**

***Lactarius* Pers.**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Boa, 2004; Mdachi *et al*. 2004; Tibuhwa, 2013**
***Lactarius inversus* (Gooss.-Font &r. Heim.) Verbeken**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995**
***Lactarius kabansus* Pegler & Piearce**	**Ectomycorrhizal**	**Burundi , Tanzania**	**Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016; Nteziryayo *et al*., 2019**
***Lactarius luteolus* Peck.**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
***Lactarius medusae* Verbeken**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Tibuhwa, 2013**
***Lactarius pelliculatus* (Beeli) Buyck.**	**Ectomycorrhizal**	**Tanzania**	**Boa, 2004**
***Lactarius phlebophyllus* Heim.**	**Ectomycorrhizal**	**Tanzania**	**Boa, 2004**
***Lactarius piperatus* L. Roussel**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004**
***Lactarius pumilus* Verbeken**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Tibuhwa, 2013**
***Lactarius rubroviolascens* R. Heim.**	**Ectomycorrhizal**	**Tanzania**	**Boa, 2004**
***Lactarius tanzanicus* Karhula & Verbeken**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
***Lactarius vellereus* (Fr.) Fr.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004**
***Lactarius volemoides* Kurhula**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Tibuhwa, 2013**
***Lactifluus densifolius* Verbeken & Karhula**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
***Lactifluus edulis* (Verbeken & Buyck) Buyck**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
***Lactifluus gymnocarpoides* (Verbeken) Verbeken**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
***Lactifluus kigomaensis* sp. nov. De Crop & Verbeken**	**Ectomycorrhizal**	**Tanzania**	**Decrop *et al*., 2012**
***Lactifluus longisporus* (Verbeken) Verbeken**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
***Lactifluus luteopus* Verbeken**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
***Laetioporus* Murr. (IJ- 2014)**	**Saprobe**	**Tanzania**	**Juma *et al*., 2016**
***Laetioporus sulphureus* (Bull.) Murill**	**Saprobe**	**Burundi , Ethiopia, Tanzania**	**Boa, 2004;Tibuhwa, 2011; Woldegiorgis *et al*., 2015; Dejene *et al*. 2017a; Nteziryayo *et al*., 2019**
***Langermannia gigantea* (Batsch) Rostk.**	**Saprobe**	**Burundi**	**Boa, 2004**
***Lentinus cladopus* (Lev.)**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004; Degreef *et al.,* 2016**
***Lentinus edodes* (Berk.) Pegler**	**Saprobe**	**Ethiopia**	**Woldegiorgis, 2015**
***Lentinus* Fr.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017**
***Lentinus prolifer* (Pat. & Har.) Pegler**	**Saprobe**	**Uganda**	**Boa, 2004**

Lentinus sajor caju **(Fr.; Fr.)**	**Saprobe**	**Tanzania**	**Boa, 2004; Rammeloo and Wallyne, 1993; Hussein *et al*., 2015; Degreef *et al*., 2016**
Lentinus squarrosulus **Mont.**	**Saprobe**	**Tanzania**	**Rammeloo and Wallyne, 1993, Boa, 2004; Hussein, *et al*., 2015, Nteziryayo *et al*. 2019**
Lenzite elegance **(Spreng.) Pat.**	**Saprobe**	**Tanzania**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Lepista cafrorum **(Kalchbr. & Mc Owan)**	**Saprobe**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Lepista nuda **(Bull.) Cooke**	**Saprobe**	**Burundi**	**Boa, 2004**
Lepista sordida **(Schumach.) Singer**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Leucoagaricus holosericeus **(Gillet) M.M Moser**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Leucoagaricus leucothites **(Vittad.) Wasser**	**Saprobe**	**Tanzania**	**Boa, 2004; Dejene *et al*., 2017a**
Leucoagaricus rhodocephalus **(Berk.) Pegler**	**Saprobe**	**Tanzania**	**Boa, 2004**
Leucoagaricus rubrotinctus **(Peck.) Singer**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Leucocoprinus birnbaumii **(Corda) Singer**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Leucocoprinus cepistipes **(Sowerby) Pats.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Inocybe **(Fr.)Fr.**	**Saprobe**	**Malawi**	**Boa, 2004**
Lycoperdon **sp Pers.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Lycoperdon perlatum **Pers.**	**Saprobe**	**Burundi**	**Boa, 2004**
Macrocybe Lobayensis **(R. Heim) Pegler & Lodge**	**Saprobe**	**Malawi**	**Boa, 2004**
Macrolepiota aberderense **Mbaluto**	**Saprobe**	**Kenya**	**Mbaluto, 2015**
Macrolepiota dolichaula **(Berk. & Br.) Pegler & Rayner**	**Saprobe**	**Malawi, Kenya, Tanzania, Uganda , Ethiopia**	**Pegler, 1977; Rammeloo and Wallyne, 1993; Harkonen *et al*. 2003; Boa, 2004; Njuguini *et al*. 2018; Nteziryayo *et al*. 2019; Ngom *et al*., 2022**
Macrolepiota mastoidea **(Fr.) Singer**	**Saprobe**	**Kenya**	**Pegler, 1977**
Macrolepiota procera **(Scop.) Singer**	**Saprobe**	**Kenya, Tanzania , Ethiopia , Malawi, Uganda**	**Pegler, 1977; Rammeloo and Wallyne, 1993; Boa, 2004; Tibuhwa *et al*., 2011; Tibuhwa, 2013; Hussein et al., 2015; Dejene *et al*., 2017b; Njuguini *et al*., 2018; Ngom *et al*., 2022**
Macrolepiota rhacodes **(Vittad.) Singer**	**Saprobe**	**Burundi**	**Boa, 2004**
Macrolepiota **Singer**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a; Njuguini *et al*., 2018**
Malombo	**Saprobe**	**Kenya**	**Wandati *et al*., 2013**
Marasmiellus inoderma **(Berk.) Singer**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Marasmius arborescens **(Henn.) Beeli**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**

Marasmius bekolacongoli **Beeli**	**Saprobe**	**Burundi, Rwanda**	**Degreef *et al*., 2016**
Marasmius oreades **(Bolton) Fr.**	**Saprobe**	**Burundi**	**Boa, 2004**
Micropsalliota brunneosperma **(Singer) Pegler**	**Saprobe**	**Malawi**	**Boa, 2004**
Morchella elata **Fr.**	**Saprobe**	**Burundi**	**Boa, 2004**
Morchella esculenta **Fr.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2016**
Mycoamaranthus congolensis **(Dissing & M. Lange) Castellano & Walleyn**	**Ectomycorrhizal**		**Degreef *et al*., 2016**
Pholiota nameko **(T.Ito) S. Ito & S. Imai**	**Saprobe**	**Ethiopia**	**Gizaw, 2017**
Obulando	**Saprobe**	**Kenya**	**Wandati *et al* ., 2013**
Obumpokompoko	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2009.**
Obutoosa	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2009**
Olando	**Saprobe**	**Kenya**	**Wandati *et al*., 2014**
Oudemansiella tanzanica **nom. prov. Magingo**	**Saprobe**	**Tanzania**	**Magingo *et al*., 2004**
Panus conchatus **(Bull.) Fr.**	**Saprobe**	**Tanzania**	**Hussein *et al*., 2015**
Parmelia sulcata **Taylor**	**Saprobe**	**Burundi**	**Boa, 2004**
Paxillus brunneotomentosus **Heinem. & Rammeloo**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Perenniporia mundula **(Wakef) Ryvarden**	**Saprobe**	**Malawi**	**Boa, 2004**
Phlebopus colossus **(R.Heim) Singer**	**Saprobe**	**Burundi, Malawi**	**Boa, 2004; Degreef *et al*., 2016**
Pholiota **sp (Fr.) P Kumm.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Plebopus sudanicus **(Har. & Pat.)**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Pleurocybella porrigens **(Pers.) Singer**	**Saprobe**	**Burundi**	**Boa, 2004**
Pleurotus (HK-37)	**Saprobe**	**Tanzania**	**Raymond *et al*., 2013**
Pleurotus **(Jack. Ex. (Fr.) P. Kumm.**	**Saprobe**	**Uganda, Kenya,**	**Nakalembe *et al*., 2009; Gateri *et al*., 2014**
Pleurotus aff. cystidiosus **O.K. Mill.**	**Saprobe**	**Burundi**	**Buyck and Nzigidahera, 1995**
Pleurotus citrinopileatus **Singer**	**Saprobe**	**Kenya**	**Musieba *et al*., 2011; Musieba *et al*., 2012; Okoth 2013; Nteziryayo *et al*., 2019**
Pleurotus contrarius **Sacc.**	**Saprobe**	**Tanzania**	**Pegler, 1977**
Pleurotus cystidiosus **O.K. Mill.**	**Saprobe**	**Burundi, Rwanda, Tanzania**	**Huseein *et al*., 2016; Degreef *et al*., 2016**
Pleurotus djamor **(Rumph. ex Fr.) Boedijn**	**Saprobe**	**Tanzania, Kenya, Uganda, Rwanda**	**Boa, 2004; Harkonen *et al*., 2003; Tibuhwa, 2013; Nakalembe *et al*., 2015; Degreef *et al*., 2016; Njuguini *et al*., 2018;**

Pleurotus eryngii **(D C.) Quel.**	**Saprobe**	**Tanzania**	**Tibuhwa, 2011and 2013**
Pleurotus flabellatus **Sacc.**	**Saprobe**	**Tanzania, Kenya , Rwanda**	**Pegler, 1977; Mshandete and Cuff, 2008; Degreef *et al*., 2016**
Pleurotus florida **(Mont.).0 (Singer**	**Saprobe**	**Kenya**	**Wandati *et al*., 2014**
Pleurotus lignatilis **(Pers. Ex Fr.) Kummer**	**Saprobe**	**Uganda**	**Pegler, 1977**
Pleurotus limpidus **(Fr.) Sacc.**	**Saprobe**	**Tanzania**	**Pegler, 1977**
Pleurotus luteoalbus **Beeli**	**Saprobe**	**Kenya**	**Pegler, 1977**
Pleurotus opuntiae **(Durieu & Lev.) Sacc.**	**Saprobe**	**Kenya**	**Pegler, 1977**
Pleurotus ostreatus **(Jacq. ex Fr.) Kumm.**	**Saprobe**	**Burundi, Ethiopia, Tanzania , Uganda**	**Pegler, 1977; Woldegiorgis, 2015; Ngom *et al*., 2022**
Pleurotus sajor- caju **(Fr.) Sing.**	**Saprobe**	**Tanzania**	**Harkonen *et al*., 2003; Mdachi *et al*. 2004; Tibuhwa, 2011; Tibuhwa, 2013**
Pleurotus sapidus **(Quel.)**	**Saprobe**	**Kenya**	**Musieba, 2013; Otieno *et al*., 2015**
Pleurotus tuber-regium **(Rump. Ex Fr.) Singer**	**Saprobe**	**Burundi, Malawi, Tanzania**	**Rammeloo and Wallyne 1993; Boa, 2004; Harkonen *et al*., 2003; Tibuhwa, 2011 and 2013; Degreef *et al*., 2016**
Pluteus umborosus **(Pers.) P. Kumm.**	**Saprobe**	**Tanzania**	**Hussein *et al*., 2016**
Polyozellus multiplex **(Underw.) Murill**	**Saprobe**	**Burundi**	**Boa, 2004**
Polyporales **Gaum.**	**Saprobe**	**Tanzania**	**Hussein *et al*., 2016**
Polyporus **P.Micheli ex Adans**	**Saprobe**	**Uganda, Tanzania, Ethiopia,**	**Nakalembe *et al*., 2015; Harkonen *et al*., 2003; Tibuhwa 2013., Dejene *et al*. 2017b;**
Polyporus brasiliensis **Speg.**	**Saprobe**	**Malawi**	**Boa, 2004**
Polyporus cinnabarinus **(Jacq.) Fr.**	**Saprobe**	**Burundi**	**Nteziryayo *et al*., 2019**
Polyporus moluccensis **(Mont.) Ryvaden**	**Saprobe**	**Malawi, Tanzania**	**Boa 2004**
Polyporus tenuiculus **(P. Beauv.) Fr.**	**Saprobe**	**Kenya , Rwanda, Tanzania,Uganda,**	**Nakalembe *et al*., 2009; Tibuhwa, 2013; Hussein *et al*., 2016; Njuguini *et al*., 2018; Ngom *et al*., 2022**
Psathyrella atroumbonata **Pegler**	**Saprobe**	**Rwanda, Malawi,**	**Boa 2004; Rammeloo and Wallyne, 1993; Degreef *et al*., 2016**
Psathyrella candolleana **(Fr.) Maire**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993**
Psathyrella tuberculata **(Path.) A.H. Sm.**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Ptychoverpa bohemica **(Krombh) J. Schrot.**	**Saprobe**	**Burundi**	**Boa, 2004**
Pulveroboletus aberrans **(Heinemann &Goos.-Font)**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne,1993**
Pulveroboletus **Spec.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993**
Pycoporus sanguineus **(L.;Fr.)**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993**

Rubinoboletus balloui **(Peck) Heinem. & Rammeloo**	**Ectomycorrhizal**		**Degreef *et al*., 2016**
Rubinoboletus luteopurpureus **(Beeli) Hein. & Rammeloo**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Russula **Pers.**	**Ectomycorrhizal**	**Ethiopia**	**Gateri *et al*., 2014; Dejene, *et al*.2017**
Russula afronigricans **Buyck**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004**
Russula alboflоccosa **Buyck.**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et* al., 2003**
Russula atropurpurea **(Krombh.) Britelm.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne 1993**
Russula congoana **Pat.**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Degreef, *et al*., 2016**
Russula cyanoxantha **(Schaeff.) Fr.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne 1993**
Russula delica **Fr.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne 1993**
Russula hiemisilvae **Buyck**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Harkonen *et al*., 2003; Mdachi *et al*., 2003; Boa, 2004; Degreef, *et al*., 2016**
Russula liberiensis **Singer**	**Ectomycorrhizal**	**Tanzania**	**Boa, 2004**
Russula ochroleuca **(Pers.)Fr.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Russula phaeocephala **Buyck**	**Ectomycorrhizal**	**Burundi , Tanzania**	**Buyck and Nzigidahera 1995; Boa, 2004; Degreef *et al*., 2016**
Russula rosea **Pers.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Russula roseoviolacea **Buyck**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Russula schizoderma **Pat**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa 2004**
Russula sejuncta **Buyck**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Russula sublaevis **(Buyck) Buyck**	**Ectomycorrhizal**	**Tanzania**	**Boa, 2004**
Russula tanzaniae **Buyck.**	**Ectomycorrhizal**	**Tanzania**	**Boa, 2004**
Russula xerampelina **(Schaeff.) Fr.**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**
Rusulla cellulata **Buyck**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Buyck and Nzigidahera 1995, Harkonen *et al*., 2003, Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016**
Rusulla ciliata **Buyck**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Tibuhwa 2013**
Rusulla compressa **Buyck**	**Ectomycorrhizal**	**Tanzania, Kenya**	**Harkonen *et al*., 2003; Boa, 2004:; Tibuhwa, 2013; Wandati *et al*., 2013**
Schizophyllum commune **Fr.**	**Saprobe**	**Malawi, Kenya , Tanzania, Ethiopia, Burundi**	**Pegler, 1977; Rammeloo and Wallyne 1993; Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016; Dejene *et al*., 2017a; Muchane *et al.,* 2021**
Sparassis crispa **(Wulfen)Fr.**	**Saprobe**	**Burundi**	**Boa, 2004**
Stereopsis hiscens **(Berk. & Rav.) D. A Reid**	**Saprobe**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne 1993**
Stropharia rugusoannulata **Farlow ex Murill**	**Saprobe**	**Kenya**	**Njuguini *et al*., 2018**

Suillus cavipes **(Opat.) A.H.Sm. & Thiers**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**
Suillus granulatus **(L.) Roussel**	**Ectomycorrhizal**	**Tanzania , Kenya, Malawi**	**Rammeloo & Wallyne 1993, Harkonen *et al*., 2003; Boa 2004; Tibuhwa 2013, Degreef *et al*., 2016, Njuguini et al., 2018; Muchane *et al.,* 2021**
Suillus luteus **(L.) Roussel**	**Ectomycorrhizal**	**Burundi , Ethiopia , Tazania , Kenya , Malawi**	**Buyck and Nzigidahera, 1995; Mdachi *et al*., 2003; Boa, 2004; Degreef *et al*., 2016; Dejene *et al*., 2017a; Njuguini *et al*., 2018**
Termitomyces **(Beeli) R. Heim**	**Termitophilic**	**Burundi**	**Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Nakalembe *et al*., 2009; Gateri *et al*., 2014; Wandati, 2014; Woldegiorgis *et al*., 2015**
Termitomyces **(Oruka-stipe)**	**Termitophilic**	**Kenya**	**Wandati *et al.,* 2014**
Termitomyces aurantiacus **(Heim)**	**Termitophilic**	**Uganda, Tanzania, Ethiopia, Kenya, Malawi**	**Rammeloo and Wallyne, 1993; Buyck, 1995; Harkonen *et al*., 2003; Boa, 2004; Nakalembe *et al*., 2009; Tibuhwa, 2012 ; Tibuhwa, 2013; Dejene *et al*. 2017; Woldegiorgis *et al*., 2015**
Termitomyces clypeatus **Heim**	**Termitophilic**	**Kenya, Uganda, Tanzania, Ethiopia, Malawi**	**Pegler, 1977; Rammeloo and Wallyne 1993; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2011, Tibuhwa, 2012; Tibuhwa, 2013; Nakalembe and Kabasa, 2009; Ashagriel *et al*., 2014; Woldegiorgis *et al*., 2015; Dejene *et al*., 2017b; Ngom *et al*., 2022**
Termitomyces eurhizus **(Berk.) Heim**	**Termitophilic**	**Kenya, Ethiopia, Tanzania, Uganda, Malawi**	**Pegler, 1977; Harkonen *et al*., 2003; Boa, 2004; Nakalembe *et al*., 2009, Dejene *et al*., 2017b**
Termitomyces globulus **R. Heim & Gooss.- Font**	**Termitophilic**	**Kenya, Uganda**	**Pegler, 1977; Nakalembe *et al*., 2009**
Termitomyces le-testui **(Pat.) Heim**	**Termitophilic**	**Tanzania, Burundi, Ethiopia, Kenya, Uganda 2004**	**Pegler, 1977;Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2012; Ashagriel *et al*., 2014; Woldegiorgis *et al*., 2015; Degreef *et al*., 2016; Dejene *et al*., 2017a**
Termitomyces mammiformis **R. Heim**	**Termitophilic**	**Burundi, Tanzania**	**Pegler, 1977, Tibuhwa, 2012; Tibuhwa, 2013, Degreef *et al*., 2016**
Termitomyces microcarpus **(Berk. & Broome) R. Heim**	**Termitophilic**	**Tanzania, Ethiopia, Uganda, Kenya, Burundi, Rwanda; Uganda**	**Pegler, 1977;Rammeloo and Wallyne 1993; Harkonen., *et al*., 2003; Boa 2004; Nakalembe and Kabasa 2009; Olila *et al*., 2007; Tibuhwa, 2012; Tibuhwa, 2013; Woldegiorgis *et al*., 2015; Degreef *et al*., 2016 ; Dejene *et al*., 2017a ; Muchane *et al*., 2021; Ngom *et al*., 2022**
Termitomyces robustus **(Beeli) R. Heim**	**Termitophilic**	**Burundi, Rwanda, Tanzania, Ethiopia, Uganda, Malawi**	**Pegler 1977; Rammeloo and Wallyne 1993; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016; Dejene *et al*., 2017a; Ngom *et al*., 2022**
Termitomyces saggitiformis **(Kalchbr. & Cooke) D. A Reid**	**Termitophilic**	**Tanzania**	**Tibuhwa, 2012; Tibuhwa, 2013**
Termitomyces singidensis **Saarim & Hark.**	**Termitophilic**	**Tanzania**	**Harkonen *et al*., 2003; Boa, 2004;Tibuhwa, 2013**
Termitomyces **sp (Joga utuwe)**	**Termitophilic**	**Kenya**	**Wandati *et al*., 2013**
Termitomyces **sp (Mariondonik)**	**Termitophilic**	**Kenya**	**Wandati *et al*., 2013**
Termitomyces striatus **(Beeli) R. Heim**	**Termitophilic**	**Malawi, Burundi, Tanzania, Kenya, Uganda**	**Pegler, 1977; Rammeloo and Wallyne, 1993; Buyck and Nzigidahera, 1995 ; Boa, 2004; Tibuhwa 2013;Degreef *et al*., 2016**
Termitomyces titanicus **Pegler & Piearce**	**Termitophilic**	**Burundi, Malawi**	**Boa, 2004; Tibuhwa, 2012; Degreef *et al*., 2016**
Termitomyces tylerianus **Otieno**	**Termitophilic**	**Uganda, Tanzania, Kenya**	**Pegler, 1977; Rammello and Wallyne, 1993; Harkonen *et al.,* 2003; Nakalembe *et al*., 2009 ; Tibuhwa, 2013; Degreef *et al*., 2016**
Termitomyces umkowaani **(Cooke & Massee) D.A Reid**	**Termitophilic**	**Tanzania**	**Tibuhwa, 2011; 2012 & 2013; Muchane *et al*., 2021**

Termitomycetes eurhizus **(Berk) Heim**	**Termitophilic**	**Tanzania**	**Tibuhwa, 2012**
Termitomycetes letestui **(Pat.) R. Heim**	**Termitophilic**	**Ethiopia, Tanzania**	**Boa, 2004; Tibuhwa, 2013; Kabede, 2017**
Termitomycetes rabuori **Otieno**	**Termitophilic**	**Kenya**	**Pegler, 1977**
Termitomycetes schimperi **(Pat.) R. Heim**	**Termitophilic**	**Burundi, Rwanda, Tanzania, Ethiopia, Malawi**	**Rammeloo and Wallyne, 1993; Pegler, 1977; Boa, 2004; Kabede, 2017; Dejene *et al*., 2017a; Degreef *et al*., 2016**
Trametes polyzona **Pers.**	**Saprobe**	**Burundi**	**Nteziryayo *et al*., 2019**
Trametes suaveolens **(L.) Fries**	**Saprobe**	**Burundi**	**Boa, 2004**
Tremella fuciformis **Berk.**	**Saprobe**	**Tanzania, Uganda**	**Tibuhwa, 2013; Ngom *et al*., 2022**
Tricholoma caligatum **(Viv.) Ricken**	**Saprobe**	**Burundi**	**Boa, 2004**
Tricholoma lobayense **Heim**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993**
Tricholoma magnivelare **(Peck) Redhead**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**
Tricholoma spectabilis **Peerally & Sutra**	**Saprobe**	**Burundi**	**Buyck *et al*., 1995**
Trogia infundibuliformis **Trogia; Fr.**	**Saprobe**	**Malawi**	**Boa, 2004**
Tubosaeta brunneosetosa **(Sing.) E. Horak**	**Saprobe**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Tylopilus niger **(Heinem. & Gooss.-Font.) Wolfe**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Vascellum **F. Smarda**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Vasellum pratense **(Pers.) Kreisel**	**Saprobe**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne 1993**
Volvariella bobycina **(Scheaeff.) Singer**	**Saprobe**	**Malawi, Tanzania**	**Boa, 2004; Pegler, 1977; Rammeloo and Wallyne, 1993**
Volvariella speciosa **(Fr.: Fr.) Sing.**	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2009**
Volvariella volvaceae **(Bull.;Fr.)Sing.**	**Saprobe**	**Tanzania, Malawi, Kenya, Uganda**	**Pegler,1977, Rammeloo and Wallyne, 1993, Mshandete and Cuff, 2008, Harkonen *et al*., 2003, Boa, 2004, Tibuhwa *et al*., 2011, Tibuhwa, 2013**
Xerocomus pallidosporus **Heinem.**	**Saprobe**	**Malawi**	**Boa, 2004**
Xerocomus soyeri **Heinem.**	**Saprobe**	**Malawi**	**Boa, 2004, Rammeloo and Wallyne, 1993**
Xerocomus subspinulosus **Heinem.**	**Saprobe**	**Burundi**	**Buyck *et al*., 1995, Degreef *et al*., 2016**
Xerula radicata **(Relhan: Fr.) Dorfelt**	**Saprobe**	**Malawi**	**Boa, 2004**

Distribution of the wild edible Mushrooms in different Phyla and families

In the division *Ascomycota*, the macrofungi species belonged to the class *Lecanormycetes* represented by 1 species *Parmelia sulcatan*Taylor from the *Parmeliaceae* family and class *Pezizomycetes* represented by 3 species (*Morchella elata* Fr. , *Morchella esculenta* Fr. and *Ptychoverpa bohemica* (Krombh) J. Schrot.) from

Morchellaceae family. In the division *Basidiomycota*, the macrofungi species belonged to the class *Agaricomycetes* represented by species from *Agaricales* (47%), Russulales (16%), Polyporales (10%), *Cantharellales* (10%) and *Boletales* (8%). Species from other orders (*Auriculariales*, *Dacrymycetales*, *Hymenochaetales*, Incertae sedis, *Stereopsidales*, *Thelephorales*, and *Tremellales*) had less than 2% presentation.

Overall, the *Russulaceae* family had the highest number of species (51 species), followed by *Agaricaceae* (41 species), *Cantharellaceae* (30 species), *Lyophyllaceae* (26 species), *Polyporaceae* (21 species), *Amanitaceae* (20 species), *Pleurotaceae* (20 species), *Boletaceae* (18 species) and *Tricholomataceae* (11 species). The other families had less than 10 species (Figure 1). One species from order *Polyporales* was only identified up to order level while 9 species were described by their local names.

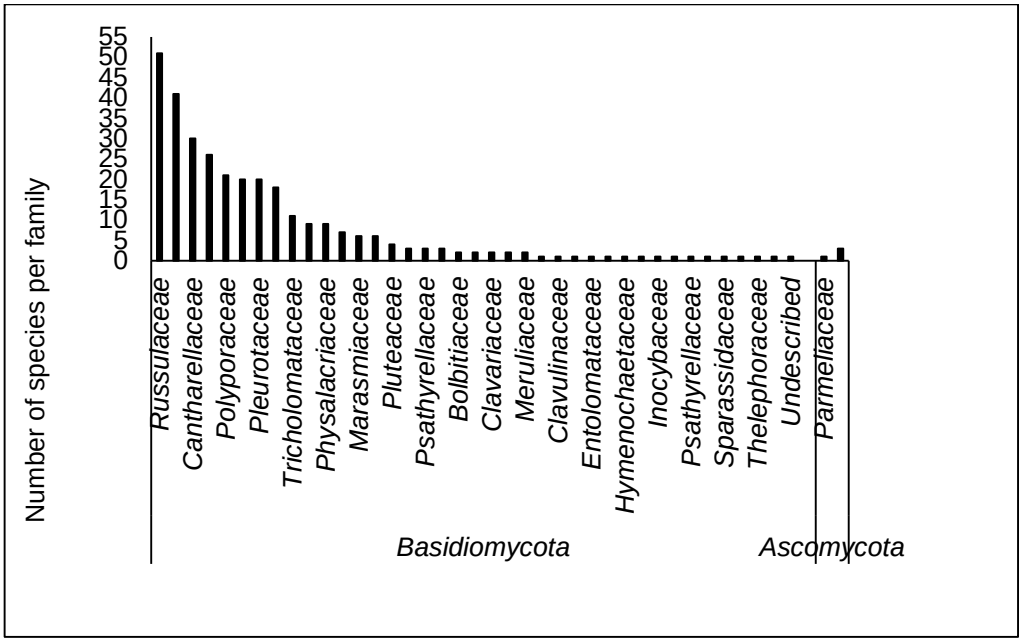

Figure 1: Distribution of WEMS into phyla and families

Distribution of Wild Edible Mushrooms in East African Countries

The WEMs occurred in all 8 East African countries namely Burundi, Kenya, Ethiopia, Somalia, Rwanda, Tanzania, Uganda and Malawi. Tanzania (143 species), Malawi (90 species) and Burundi (89) had the highest number while Somalia had the least with only 2 species (*Agaricus campestris* (L. ex Fr.), *Agaricus amboensis* (Fayod) Sacc.) from *Agaricaceae* family (Figure 2). The number of WEM species in other countries declined in order, Kenya (53 species), Ethiopia (46 species) Rwanda (28) and Uganda (28 species). WEMs communities in Tanzania, Malawi, and Burundi were dominated by ectomycorrhiza species while in other countries, the highest proportion of WEMs communities comprised saprophytic macrofungi species (Table 2).

Table 2: Wild edible / medicinal mushrooms species in East African countries

	Countries								
Families	Kenya	Uganda	Tanzania	Burundi	Rwanda	Malawi	Ethiopia	Somalia	Total
Agaricaceae	11	5	13	3	3	12	16	2	65
Amanitaceae	1	–	4	8		13	–	–	26
Auriculariaceae	4		4	1	2	2	1	–	14
Bolbitaceae	–	–	–	–	–	1	–	–	1
Boletaceae	–	–	5	4	1	7		–	17
Boletinellaceae	–	–		1		2		–	3
Bondarzewiaceae	–	–	1	–	–	–	–	–	1

Cantharellaceae	–	–	21	15		6	1	–	43
Clavuriaceae	–	–	–	–	–	1	–	–	1
Clavulinaceae	–	–	1	–	–	–	–	–	1
Dacrymycetaceae	–	–	–	–	1	–	–	–	1
Entolomataceae	–	–	1	–	–	–	–	–	1
Fomitopsidaceae	–	–	1	1	–	–	1	–	3
Ganodermataceae	1	–	1	–	–	–	1	–	3
Gyroporaceae	–	–	–	–	–	1	–	–	1
Hygrophoropsidiaceae	–	–	–	–	–	–	1	–	1
Hymenochaetaceae	–	–	1	–	–	–	–	–	1
Inocybaceae	–	–	–	–	–	1	–	–	1
Lyophyllaceae	12	10	15	9	3	7	10	–	66
Marasmiaceae	–	–	–	3	3	–		–	6
Meruliaceae	–	–	–	–	–	1		–	1
Morchellaceae	–	–	–	2	–	–	1	–	3
Parmeliaceae	–	–	–	1	–	–	–	–	1
Paxillaceae	–	–	–	1	–	–	–	–	1
Physalacriaceae	1	1	3	–	6	2	1	–	14
Pleurotaceae	9	3	10	4	3	1	1	–	31
Pluteaceae	1	2	2	–	–	2		–	7
Polyporaceae	2	3	8	3	1	7	3	–	27
Psathyrellaceae	–	–	–	–	1	2	3	–	6
Repetobasidiaceae	–	–	–	1	1	–	–	–	2
Russullaceae	1		32	19	–	12	1	–	65
Schizophyllaceae	1	–	1	1	–	1	1	–	5
Sparassidaceae	–	–	–	1	–	–	–	–	1
Stereopsidaceae	–	–	–	–	–	–	1	–	1
Strophariaceae	1	–	1	2	1		2	–	7
Suillaceae	2	–	2	2	–	2	1	–	9
Therephoraceae	–	–	–	1	–	–	–	–	1
Tremellaceae	–	–	1	–	–	–	–	–	1
Tricholomataceae	–	–	–	5	2	6		–	13
unidentified	4	4	–	–	–	–	–	–	9
Total	51	28	128	88	28	89	46	2	

Groups of Wild mushrooms in East Africa and substrate utilization

(a) Saprophytic WEMs

In East Africa, saprophytic WEMs diversity comprised 147 species (46% of total) within the division *Basidiomycota* (51 genera within 26 families) and *Ascomycota* (3 genera within 2 families) (Fig. 2). WEMs in *Ascomycota* belonged to the *Parmeliaceae* family (*Parmelia sulcate* Taylor) and *Morchellaceae* family (*Morchella elata* Fr., *Morchella esculenta* Fr. *Basidiomycota* division, *Agaricaceae* family (40 species) had the highest number of species, followed by *Polyporaceae* (21 species), *Pleurotaceae* (20 species), *Physalacriaceae* (9 species), *Tricholomataceae* (7

species), *Auriculariaceae* (7 species), *Marasmiaceae* (6 species), *Strophariaceae* (6 species) and *Psathyrellaceae* (4 species) families. The other families had less than 4 species (Fig. 2).

(b) Ectomycorrhizal WEMs

In Eastern Africa, ectomycorrhizal WEMs comprised 131 species (41% of the total) within the division *Basidiomycota* (23 genera within 12 families) (Fig. 4). *Russulaceae* family (51 species) had the highest number of species, followed by *Cantharellaceae* (30 species), *Amanitaceae* (19 species), *Boletaceae* (18 species) and *Suillaceae* (3 species). The other families had less than 2 species (Fig. 4). The highest documented ectomycorrhizal species belongs to the genus *Cantharellus* and *Russula* sp (26 species), followed by *Amanita* (20 species) and *Lactarius* (16 species) respectively (Table 1, Fig. 2).

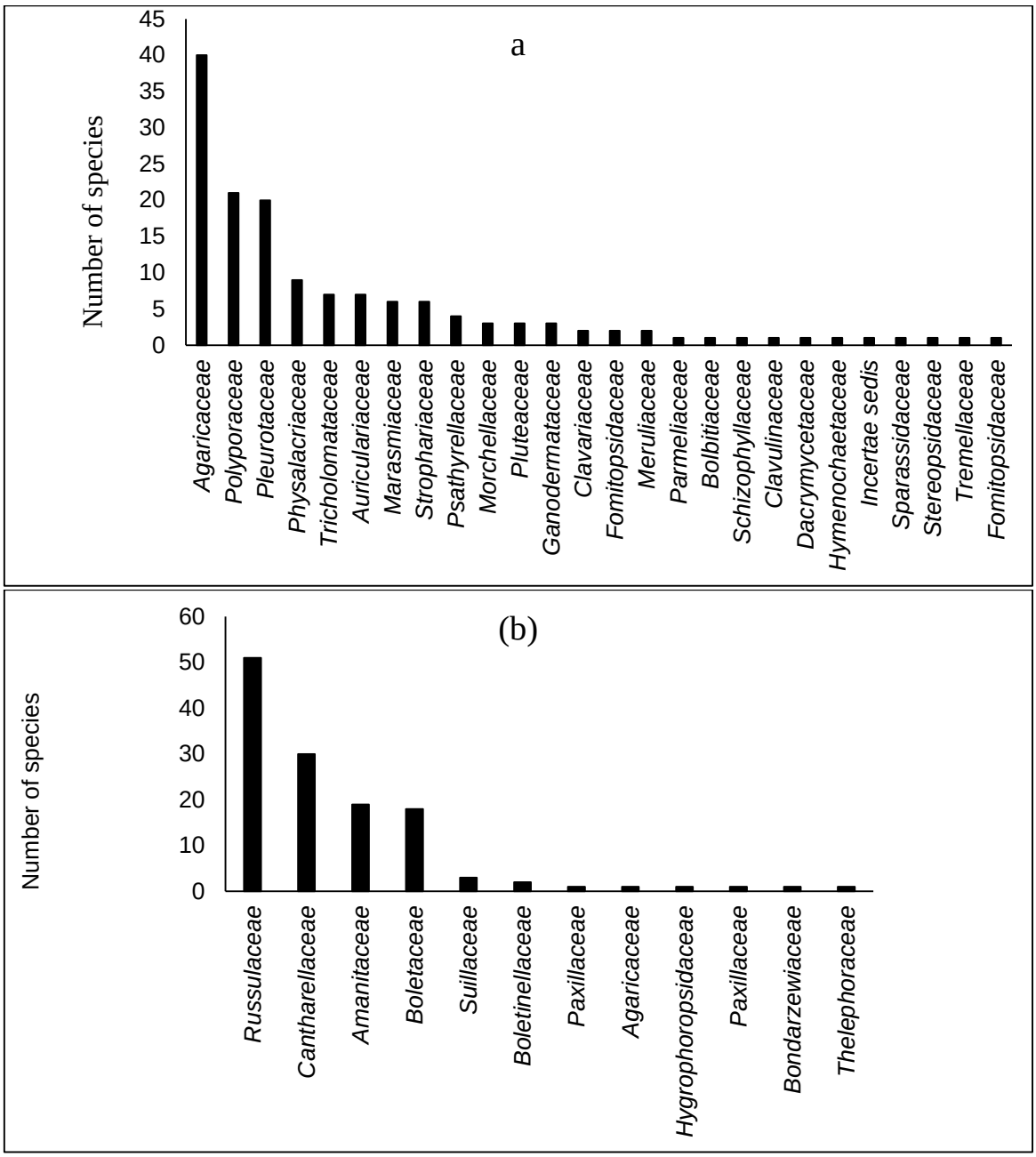

Figure 2: Number of Saprobe(a) and Ectomycorrhizal (b) wild edible mushroom species per family in Eastern Africa

(c) Termitophillic WEMs mushrooms

In East Africa, termitophillic species documented are 25 species (7.8% of the total). The species were reported in all the countries of East Africa with the exception of Somalia (Table 1).

Domestication Status of WEMs in East Africa

Domestication of wild edible mushrooms is gaining popularity in the East African region. Domestication is the process of bringing WEMs into cultivations. There are about 2000 WEMs in the world, but only around 30 species are in cultivation. In East Africa 14 saprophytic species (Amylosporus IJ-2014, *Coprinus cinereus* (Schaeff.) Gray, *Lentinus sajor caju* (Fr.; Fr.), *Lentinus squarrosus* Mont., *Hypholoma fasciculare* (Huds: Fr.) P.Kumm., *Nameko pholiota* (T.Ito) S. Ito & S. Imai, *Oudemansiella tanzanica* Magingo, *Pleurotus citrinopileatus* Singer, *Pleurotus flabellatus* Sacc., *Polyporales* sp Gaum., *Polyporus cinnabarinus*, Trametes polyzona Pers., Volvariella volvacea (Bull.;Fr.)Sing.) have been tissue cultured, and tested for spawn production and mushroom production under different growth conditions (Table 3). However, the cultivation of WEMs in this region is still in its early stages with only 24 species under experimental trials (Table 3).

The species *Auricularia polytrica* (Mont.) Sacc., *Laetioporus* sp Murr., *Polyporus tenuiculus* (P. Beauv.) Fr., *Pleurotus cystidiosus* O.K. Mill. and *Termitomyces* sp (Beeli) R. Heim. are still at spawn and tissue culture stages (Table 3). Auricularia auricula (Bull.: Fr.) did not fruit despite successful growth in spawn run and pinning stages (Table 3).

Process of cultivating wild edible mushrooms in East Africa

(a) Tissue culture and mycelia colonization rates of WEMs

The pure mycelial culture was established from fourteen mushroom species (Table 3). The main culture media used were Potato Dextrose Agar (PDA) and Malt Extract Agar (Malt) (Table 3). However, to culture *Pluteus umbrosus* (Pers.) P. Kumm., *Hypholoma fasciculare* (Huds: Fr.) P. Kumm., *Trametes polyzona* Pers., *Pleurotus citrinopileatus* Singer and *Lentinus squarrosus* Mont. AVOINE media was used (Table 3). SDYA media was also used for obtaining *Pholiota Nameko* mycelial culture (Table 3). The species were incubated upside down at 25-30 oC depending on the species' temperature requirements for 4 up to 48 days (Table 3). Pure cultures were subcultured for one to three months and cultures were stored at 4 °C to – 30 °C and some in liquid nitrogen at 196 °C..

Table 3: Domestication status of edible and medicinal Mushrooms in Eastern Africa

Species	Tissue culture			Spawn production		Mushroom cultivation					References
	Media	Incubation	Substrate	Incubation	Incubation	Substrate	Spawn	Pinning	Fruiting	Yield	
				Temperature							
		Period			period		run				
		--days-		° C	---days---		----------days----------			-g/kg-	
Coprinus cinereus	PDA	4	a	−	10	g	7 (12)	9 (15)	11 (17)	238	Mshandete and Cuff, 2008; Raymond *et al.,* 2013
Volvariella volvacea	PDA	5	a	−	12	g	9	11	13	114	Mshandete and Cuff, 2008
Pleurotus flabellatus	PDA	6	a	−	13	g	12	14	17	371	Mshandete and Cuff, 2008
Oudemansiella tanzanica	MALT	7	b	−	21	i, h, g	18 (19)	20 (21)	19 (22)	−	Magingo *et al* , 2004
Auricularia auricula	MALT	5 (7)	a, b	−	12	j, h, l, j	8 (14)	13 (23)	20 (35)	96-(266)	Onyango *et al* 2011
Pleurotus citrinopileatus	PDA, AVOINE	7 (10)	a, c	25	−	h, i, k, m, n, o, p, q, v, x	8 (21)	13 (28)	-	28.3 (397.7)	Nteziryayo et al., 2019
Pleurotus sp.2 (HK-37)	MALT	5 (7)	−	28	−	g	12 (14)	18 (43)	20 (46)	119.2	Raymond *et al* 2013)

Pleurotus cystidiosus	PDA	27	a	–	–	–	–	–	–	–	Juma *et a*l., 2015
Pleurotus djamor	PDA	–	–	–	–	–	–	–	–	123 (238)	Nakalembe *et al*., 2015
Polyporales sp.	PDA	48	a	25	–	t	67		105	23.29	Juma *et al*., 2015
Polyporus tenuiculus	PDA	20	a	–	–	–	–	–	–	–	Juma *et al*., 2015
Laetioporus sp. IJ-2014	PDA	24	a	–	–	–	–	–	–	–	Juma *et al*., 2015
Lentinus squarrosus	AVOINE	–	a	25	–	u	25(27)	–	–	212.6	Nteziryayo *et al*., 2019
Amylospora sp. IJ-2014	PDA	23	a	25	–	t	31	–	43	15.5	Juma *et al*., 2015
Auricularia polytrica	PDA	27	a	–	–	–	–	–	–	–	Juma *et al*., 2015
Nameko pholiota	PDA, MALT & SDYA	18(28)	a,b,c ,d,e, f	–	–	–	60	–	–	55 (797)	Gizaw, 2015
Termitomyces microcarpus	PDA	10	b	–	3 (31)	i, u	–	–	–	–	Olila *et al*., 2007
Lentinus saju caju	PDA & MALT	4	a	25	10	n, v	24 (28)	49 (52)	1 (2)	52	Hussein *et al*., 2015
Panus conchatus	PDA & MALT	4	a	–	17	n, v	–	–	–	–	Hussein *et al*., 2016
Pluteus umbrosus	AVOINE	7	a	25	17	n, v	–	–	–	–	Hussein *et al*., 2016
Hypholoma fasciculare	AVOINE	–	a	25	–	u	24(26)	–	–	153.5	Nteziryayo *et al*., 2020
Trametes polyzona	AVOINE	–	a	25	–	u	28(30)	–	–	208.7	Nteziryayo *et al*., 2020
**Pleurotus ostreatus*	MEA	–	a	–	14	v, j, w, x, y	15(20)	20(29)	22(31)	803 (2170)	Tekeste *et a*l., 2020
**Agaricus subrefescens*	–	–	f2	–	–	z	14(21)	7(29)	22(31)	684 (1428)	Thongklang *et al*., 2014

Key: Spawn substrate included (a) Sorghum grains, (b) Millet grains and (c) Wheat grains (d) Barley grain (e) rice (f) shredded maize (f2) Rye grain. Cultivation substrate included (g) Sisal waste (h) Rice straw, (i) Saw dust, (j) Sugarcane bagasse (k) Wheat straw, (l) Grass straw, (m) Maize cobs, (n) Banana leaves, (o) Ground nut, (p) Soya bean, (q) Coffee husk, (r) Coconut waste (s) Bean straw (t) Dried sugarcane tops (u) Cotton waste (v) Barley straw (w), Sasame stalks (x), Teff straw (y) Commercial compost. The values in parenthesis are maximum number of days taken or yield produced. The words in asterisks are for species commonly cultivated in the world.

(a) Spawn preparation

Spawn preparation started by obtaining good quality grains. Sorghum was the most used grain in spawn production in the EA region (Table 4). The grains were first soaked in water overnight followed by boiling for 10-20 min. Excess water was drained and 1-2% calcium carbonate (agricultural lime) was added and mixed thoroughly with the grains (Table 4). The grains were allowed to drain off excess water through a sieve or by spreading on a clean plastic sheet to air dry. Once drained, the grains were filled into 330-750 ml bottles up to ¾ of the jar, which are closed with lids and autoclaved for I hour at 121oC to kill the contaminants (Table 4). The bottles were allowed to cool and then inoculated aseptically with 2 pieces of 1cm culture of mushroom mycelia. The inoculated bottles were fitted with lids which were then shaken thoroughly by hand to spread the mycelia. The bottles were incubated at 25-28oC with caps loosely fitted in a well ventilated incubator for10 days- 21 days depending on the species (Table 3).

(a) Substrate preparation requirements and growth conditions for wild edible mushrooms

Different types of agricultural and industrial waste have proved potential in the cultivation of fourteen species of domesticated mushrooms in the EA region (Table 4). This is evident by the ability of the species to colonize the substrates and form fruitbodies. The preparation of substrates in this study employed two methods of substrate preparation which were compost and non-compost methods. The compost preparation method was used to cultivate *Coprinus cinereus* (Schaeff.), *Pleurotus flabellatus* (Sacc.) and *Volvariella volvaceae* (Bull.;Fr.) Sing. on sisal waste and manure. The outdoor compositing outdoor method took 21 days. For the non-composited substrates, the materials are first soaked in water in the ratio of 1:2 (substrate: water) overnight for 4 days (Table 4). Prepared substrates were

subjected to sterilization and pasteurization at 100-121oC for 1-6 hours and pasteurization at 70oC for two hours. The sterilized bags are allowed to cool to prevent the mycelium from heat destruction. Thereafter, 1-6% (three-six teaspoonfuls) of spawn were inoculated into each bag of the substrate (Table 4). The bags were transferred to the incubation room with temperatures between 23-30°C and humidity ranging between 69-81%. The mycelial colonization progress was monitored daily until the bags were fully colonized (Table 4). Contaminated bags were removed once spotted and taken outside the incubation room for disposal. Once fully colonized the bags were transferred to the fruiting room with lower temperatures 18-30ºC and humidity 50-95% (Table 4).

Table 4: Mycelial run requirements for Wild Edible Mushrooms in East Africa (EA)

Species	**Culture**	**Media treatment**		**Incubation**		**Culture preservation**	**References**
	Source	**Reagent**	**Antibiotic**	**Temperature (^{0}C)**	**Days**		
Oudemansiella tanzanica	Tissue	-	-	25	7	-	Magingo *et al*., 2004
Pleurotus HK-37	Pure culture	Distilled water, 70% Ethanol	-	-	8	-	Raymond *et al*., 2013
Coprinus cinereus	Tissue	3% hydrogen peroxide, 70% ethanol	250mg/l ampicillin	28	4	Malt at 4 ºC	Mshadete and Cuff, 2008
Pleurotus flabellatus	Tissue	-	250mg/l ampicillin	28	6	Malt at 4 ºC	Mshadete and Cuff, 2008
Volvariella volvaceae	Tissue	-	250mg/l ampicillin	28	5	Malt at 30 ºC	Mshadete and Cuff, 2008
Lentinus saju caju	Tissue	Distilled water, 70% ethanol, MEA	-	28	4	MEA at 4 ºC & liquid nitrogen	Hussein *et al*., 2016
Lentinus squarrosus	Tissue	Distilled water, 70% Ethanol	1 capsule chloramphenical	25		-	Nteziryayo *et al*., 2019
Amylospora sp IJ -2014	Tissue	PDA		25	-	-	Juma *et al* ., 2015
Nameko pholiota	Pure culture	-	0.025g chloramphenicol/250	25	30	-	Gizaw, 2015
Hypholoma fasciculare	Tissue	Distilled water, 70% ethanol	-	25		AVOINE at 4 ºC (monthly subculturing)	Nteziryayo *et al*., 2019
Trametes polyzona	Tissue	Distilled water, 70% ethanol	-	25		-	Nteziryayo *et al*., 2019
Pleurotus citrinopileatus	Tissue	Distilled water, & 70% ethanol	-	25		-	Musieba *et al*., 2012; Musieba *et al*., 2013, Nteziryayo *et al* ,2019
Auricularia auricula	-	-	-	-	-	-	Onyango *et al*., 2011

From the study, 47 edible species were analyzed for nutritional and medicinal benefits. Among the most commonly utilized species are the *Termitomycetes*, *Pleurotus* and *Ganoderma* species. Species belonging to *Termitomycetes* were the most (21%) analyzed in this study followed by *Pleurotus* species (12%) (Table 5)

Table 5: Nutritional status of wild edible mushrooms of East Africa

Species	Proximate Analysis	Mineral Content	Vitamins	Amino Acids	Anti-oxidants	Reference
Afrocantharellus splendens	-	-	-		+	Tibuhwa *et al*., 2014
Agaricus bisporus	+	+	+	+	+	Wandati *et al*., 2013
Agaricus campestris	-	+	-	-	+	Woldegiorgis *et al*., 2015
Agaricus sp	-	-	-	+	-	Mdachi *et al*., 2004
Amanita zambiana	+	+	-	-	+	Wandati *et al*., 2013
Auricularia judae	-	-	-		+	Hussein *et al*., 2015
Boletus clavipes	-	-	-	+	-	Mdachi *et al*., 2004
Boletus pruinatus	-	-	-	+	-	Mdachi *et al*., 2004
Cantharellus Rufopunctatus	-	-	-		+	Tibuhwa et al., 2014
Cantharellus	-	-	-	+	-	Mdachi *et al*., 2004
Ganoderma lucidum	-	-	-	+	-	Mdachi *et al*., 2004
Inonotus sp	-	-	-	+	-	Mdachi *et al*., 2004
Joga kadzonzo	+	+	-	-	+	Wandati, 2014
Joga muhama	+	+	-	-	+	Wandati, 2014
Lactarius sp	-	-	-	+	-	Mdachi *et al*., 2004
Lentinus edodes	-	+	-		+	Woldegiorgis *et al*., 2015
Lentinus sajor caju 1	-	-	-		+	Hussein *et al*., 2015
Lentinus sajor caju 2	-	-	-	-	+	Hussein *et al*., 2015
Lentinus squarrosulus	-	-	-	-	+	Hussein *et al*., 2015
Lentinus sulpureus	-	+	-	-	+	Woldegiorgis *et al*., 2015
Macrolepiota procera	-	-	-	-	+	Hussein *et al*., 2015
Malombo	+	+	-	-	+	Wandati *et* al., 2013
Auricularia sp	+	+	-	-	+	Wandati *et al*., 2013
Obulando	+	+	-	-	+	Wandati *et al*., 2013
Oando	+	+	+	+	+	Wandati *et al*., 2013
Panus cochatus	-	-	-	-	+	Hussein *et al*., 2015
Pleurotus caju	-	-	-	+	-	Woldegiorgis *et al*., 2015
Pleurotus florida	-	+	+	+	+	Wandati *et al*., 2013

Pleurotus ostreatus	-	-	-		+	Woldegiorgis *et al*., 2015
Pleurous tenuiculus	-	-	-		+	Hussein *et al*., 2015
Polyporus tenuiculus	+	+	+	+	-	Nakalembe, 2013;Nakalembe *et al*., 2015
Russula hiemisilvae	-	-	-	+	-	Woldegiorgis, *et al.*, 2015
Rusulla compressa	+	+			+	Wandati, 2014
Suillus sp	-	-	-	+	-	Woldegiorgis *et al*., 2015
Termitomyces (oruka-stipe)	+	+	+	+	+	Wandati *et al*., 2013
Termitomyces aurantiacus	-	+	-	-	+	Woldegiorgis *et al*., 2015
Termitomyces clypeatus	-	+	-	-	+	Woldegiorgis *et al*., 2015
Termitomyces eurhizus	+	-	-	+	-	Nakalembe *et al*., 2013
Termitomyces globulus	+	-	-	+	-	Nakalembe *et al*., 2013
Termitomyces letestui	-	+	-	-	+	Woldegiorgis *et al*., 2015
Termitomyces microcarpus	-	+	+	-	+	Woldegiorgis *et al.*, 2015; Nakalembe *et al*., 2015
Termitomyces tyleranus	-	+	+	-	-	Nakalembe *et al*., 2015
Termitomyces sp	-	+	-	-	-	Woldegiorgis *et al*., 2015
Termitomyces sp	+	+	+	+	+	Wandati *et al*., 2013
Termitomyces sp *(joga utuwe)*	+	+	-	-	+	Wandati *et al*., 2013
Termitomyces sp *(mariondonik)*	+	+	-	-	+	Wandati *et al*., 2013
Volvariella speciosa	-	+	+	-	-	Nakalembe *et al*., 2015

Key: analyzed (+), Not analyzed (-)

Discussions

The numbers of WEMs observed in this review corresponds to the number of identified and described wild edible mushroom species (300 species) reported in sub-Saharan Africa (Soro et al., 2019). This is a high number considering we have about 2000-2166 edible mushroom species which have been reported from all over the world (Rai et al., 2005; Nakalembe et al., 2015; Li et al., 2021). From the results, EA is endowed with a wide range of WEMs whose benefits can be applied to support mushroom industry as well as tree restoration programs, especially with tree species growing in association with ectomycorrhizal fungi.

There are over six thousand (6000) ECM fungi species mainly in division *Basidiomycota* and into lesser extent in division *Ascomycota* (Smith and Read, 2008). ECM fungi are characterized by presence of a fungal mantle that envelops host roots and a hartig net that surrounds root epidermal. In addition, the ECM fungi form soil-borne mycelia network important in uptake and translocation of nutrients and water to host tree species as well as movement of nutrients between individual tree hosts (Simard and Durall, 2004). These ECM fungi develop a dense mycelia network of about 200 m in a gram of dry soil. This mycelia network in soil is very important in the formation of soil aggregates, which in return facilitate carbon sequestrations in soil (Walland, 2006). ECM macrofungi are also the most expensive macrofungi, with a total market of billions of US dollars. The highly traded ECM species include *Tuber melanosporum*, *Tuber magnatum* (white truffle), *Tricholoma matsutake*, *Boletus edulis*, *Cantharellus* cibarius and *Amanita caesarea*. The majority of these species were from Miombo woodland and associated with Brachystegia, Julbernardia, Isoberlinia and Uapaca tree species known to symbiotically associate with ectomycorrhizal mushrooms species (Degreef et al., 2020). Miombo woodland makes up approximately 10% of the ecosystem in Kenya, Tanzania, Uganda and Burundi extending to DRC Congo, Malawi, Zimbabwe, Angola, Zambia and Mozambique explaining the high number of ectomycorrhiza mushroom species found in Tanzania, Burundi and Malawi (Degreef et al., 2020). The Ectomycorrhiza mushrooms form part of the most appreciated wild edible mushrooms (Kamalebo and De Kesel, 2020). All chanterelles are edible most and appreciated owing to large quantities harvested during the rainy seasons and the long shelf life. Apart from local consumption, the sale of the produce takes place in the markets and along the roads in many African countries (Degreef et al., 2016). Besides, *Amanita* comprises highly toxic species such as *Amanita phalloides* and *Amanita muscaria*, it's a genus with valuable members such as *Amanita losii* which has been proposed as the most productive (Degreef et al., 2020). The high number of *Russula* species could be attributed to its associations with different tree hosts. Other ectomycorrhiza species were documented in exotic plantation forests such as *Pinus*, *Cypress* and *Eucalyptus*. A few are from *Acacia* species plantations.

Ectomycorrhiza mushrooms are valuable WEMs widely collected for food and are also an important income source, generating US 70 per month for families during the rainy season (Degreef et al., 2020). Despite the key role of Miombo mushrooms in communities, the species are threatened by the practice of felling host trees that form symbiotic relationships with mushrooms to create farmlands and fuel sources (Degreef et al., 2020). As well, ectomycorrhizal mushrooms cannot be cultivated, due to their symbiotic nature with specific tree species. Thus, sustainable harvesting remains the most appropriate strategy for the conservation of beneficial mushrooms and their habitat. The other alternative is to cultivate ectomycorrhizal seedlings which have been inoculated with specific fungus for continued mushroom supply when conditions are conducive for fructification. It is important to note that native fungi fail to form symbiotic relationships with exotic tree species and therefore the right fungus should be identified for appropriate indigenous tree species (Ducousso et al., 2012). Therefore, sustainable land management practices and cheap fuel alternatives have been proposed to secure and sustain ectomycorrhiza mushrooms (Degreef, et al., 2020).

Termitomyces is a paleotropical genus of agarics growing in association with termites and their nests. The species belong to *Lyophyllaceae* (division *Basidiomycota*) with 30-40 species estimated globally (Kirk et al., 2008). Although species in this genus are saprobic, decomposing plant-derived material (e.g., wood, dry grass, and leaf litter) organic matter, the species are completely dependent on termites to survive. They are the most preferred species that form a favorite delicacy for most African and Asian communities. Their good flavor, taste and texture make them acceptable among these communities (Sathiya et al., 2020). Out of 27 that have been documented in Africa and Southeast Asia, 23 species are edible and 3 species are medicinal. *Termitomyces* mushrooms live in a mutualistic obligate relationship with termites, also found in Miombo woodland, although widely distributed in montane areas (Harkonen et al., 2003). Unlike many saprophytic mushrooms, termitomycetes species are difficult to cultivate artificially due to the complexity of the symbiotic relationship that exists between the termites and the mushroom forming fungi (Hsieh and Ju, 2018). However, attempts to culture mycelia on artificial media have been fruitful. In order to maintain sustainable utilization of *termitomycetes* in their natural habitats, efforts are needed to limit the destruction of ecosystems that are known to harbor the species in East Africa. Even as

communities harvest the species for home consumption, surplus can be sold to buy other types of foods and for improved livelihoods. Communities that shy off from consuming wild mushrooms should also be educated on which species are edible and sustainable methods of harvesting.

Cultivation of WEMs in this region is however still in its early stages with only 24 species under experimental trials. This is in comparison with 100 under artificial cultivation and 60 % of the species at commercial level in China (Willis, 2018). Of this, about 20 species are currently being cultivated at an industrial level (Gizaw, 2015). The advantage of cultivating mushrooms is the diversification of livelihoods and strengthening the resilience of farmers, the crop has a short cycle that takes only 2 months. Mushrooms are grown at a very low cost since cultivation is mostly done indoors with low requirements for water compared to other crops (FAO, 2017). Cultivation of wild edible mushrooms is also an environmentally friendly technological process of recycling organic waste (Girmay et al., 2016; Hussein et al., 2016). Since small-scale cultivation of over 20 species is undertaken across China, the model used can be used for technology transfer to researchers and farmers in East African countries and Africa at large. The demand for mushrooms is also growing in East Africa (Kenya, Tanzania, Burundi, DR Congo, Uganda) though partly met despite importation and wild gathering efforts (Degreef et al., 2016).

Domestication of WEMs in the region is an enormous opportunity to expand the mushroom industry since most WEMs have regional adaptability, grow rapidly at higher temperatures (>25°C) and their growth conditions can easily be replicated using locally available agricultural and industrial waste (Table 3). Types of agricultural and industrial wastes include wheat straw, rice straw, beans and barley, leaves of various trees, maize stalks, millets, cotton husks and banana leaves (Table 3) (Magingo et al., 2004)

The attempt to domesticate species would also offer year round valuable protein sources and broadening of income avenues for families in East Africa. However, none of these species have been commercially introduced into cultivation and the availability of their mother cultures (germplasm) for research and propagation purpose is uncertain. Despite the limited effort to successfully cultivate these species in East Africa, the attempts made elsewhere have been successful (Thawthong, et al., 2014; Rizal et al., 2015; Bandara et al., 2020). Thus, further studies are required in the region to determine optimal conditions (temperature, humidity, pH, aeration, suitable substrates) for each species in order to successfully grow them invitro.

The process of domesticating WEMs begins with the identification and selection of edible mushroom species whose cultivation potential is known. The cultivability of a species is established by determining if species in the same genus are cultivatable. The edibility of wild mushrooms is best obtained through local knowledge from herbalists, local collectors, and local communities. The knowledge can also be combined with scientific information (Thawthong et al., 2014). The choice of the best substrate for any mushroom species is also a very important step in the successful cultivation of mushrooms. Thus, the process is followed by selection of suitable artificial media and agricultural or industrial substrates. The process of cultivating mushrooms addresses the problem of agricultural and industrial waste by converting it into rich protein food sources (Mshandete and Cuff, 2008, Raymond, et al., 2013, Degreef, et al., 2020). Culturing the species on artificial culture helps to obtain pure mycelia of a specific strain to be cultivated (Mshandete and Cuff, 2008). The step is followed by choice of spawn with high quality viability which is the ability of the mycelia to produce fruiting bodies under different treatments of substrates, suitable conditions such as pH, temperatures and humidity (Thawthong, et al., 2014). Two methods are used in substrate preparation which mainly varies with species requirements. The two main methods are composting and non-composting. During the compost preparation, the substrate is made into piles that are turned after every three days from the 5th day of substrate preparation to the 21st day. According to Mshandete and Cuff (2008), the compositing method during substrate preparation manipulates the natural succession of microorganisms which involves preparing compost using agricultural or industrial wastes, organic and inorganic manures, and calcium sulfate (gypsum). The non-composting method involves soaking the substrate overnight to soften it. The aim of soaking is to moisten the substrate which is followed by draining off excess water by spreading it on a surface that allows excess water to drain off (Nteziryayo et al., 2019). To ensure that the right moisture is retained, a palm squeeze test is done to ensure that water does not drip between the fingers (Hussein et al., 2016). Pasteurization of the substrate is meant to kill the microorganisms that would

compete with mushroom mycelium and hinder production. In some instances, supplements are added to the substrates as a nitrogen source such as chicken manure, cow dung, or rice bran at a rate of 1 to 30% depending on the type of supplement used. The aim is to increase mushroom yield and overall production (Mshadete, 2013).

Among the species analyzed for nutritional composition, *Ganoderma lucidum* is known for immunity enhancement, especially among HIV & AIDS patients, *Volvariella volvaceae* for lowering high blood pressure, and *Schizophyllume commune* for fighting cancer (Chandrawanshi et al., 2017). Attempts to domesticate the species in EA have only been made for *Volvariella volvaceae* which was successful. Medicinal mushrooms owe their potential to the secondary metabolites they produce which enhance their immunomodulation, antibacterial, antifungal, antioxidant, antidiabetic, anticancer, antiallergic, anticholesterolemic, cardiovascular protector, antiparasitic, antiviral, hepatoprotective and detoxification effects (Valverde et al., 2015).

Species belonging to *Termitomycetes* were the most (21%) analyzed in this study followed by Pleurotus species (12%) (Table 5). This is probably because Termitomycetes mushrooms are the most consumed edible mushrooms due to their good taste and flavor and ease of availability during the rainy seasons. Pleurotus mushrooms grow easily on dead logs immediately after an adequate rainy season and its also the 2nd most cultivated species in the world making it a species of interest to researchers. The composition of edible mushrooms meaty taste and immunity enhancement properties make them acceptable as nutritional sources worldwide (Teklit, 2015). Also, the protein content in wild edible mushrooms is almost equal to that of milk (Lister, 2015) which makes them a good alternative to expensive and unavailable meat, especially among rural poor populations (Musieba et al, 2012) Additionally, wild mushrooms comprise carbohydrates, vitamins, minerals, antioxidants, phytochemicals and fiber essential for human health (Lister, 2015, Juma et al., 2016, Bandara et al., 2017). The valuable vitamins which are also lacking in most food sources such as Vit D, E, B1, ,B2 and B12 form part of the nutritional composition of most mushrooms (Valverde et al., 2015). Vitamin D in mushrooms is the only non-animal source and thus an important diet, especially, for vegetarians. As a result, mushrooms are gaining popularity recently promising to be potential functional food and medicines that would prevent and treat diseases such as diabetes, cancer and malnutrition (Zhang et al., 2012). It's worth noting that some of the medicinal mushrooms documented in East Africa are cultivatable such as Ganoderma lucidum, a means through which communities can exploit to generate income.

Conclusion

There is a high diversity of cultivatable wild edible saprophytic mushrooms in Eastern

- Africa with the potential to expand the mushroom industry.
- The yield of wild edible mushrooms is almost comparable to that of exotic species though domestication of the species is still in infancy stages.
- The East Africa region is endowed with many agricultural and industrial wastes suitable for the cultivation of most saprophytic mushrooms in the region.
- Efforts made to analyze Wild edible mushrooms in the region are an indication of the growing interest to explore natural resources for improved health and nutrition.
- Availability of the WEMs mother cultures (germ-plasm) for research and propagation is uncertain.

Recommendation

- Further research is needed for more detailed information on diversity, domestication, nutrient content analysis of cultivatable wild mushrooms and their suitable growth requirements for the best yields.
- More research is required to determine nutritional and phytochemical composition of over 80% wild edible/ medicinal mushrooms in East Africa region.
- Regional gene bank is needed for storage and conservation of wild mushrooms germplasm.

Author Contributions

All authors have equal contribution.

Conflict of Interest

The authors declare no conflict of interest.

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Hebeloma limbatum: Türkiye Mikotası İçin Yeni Bir Kayıt

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Öz: *Hebeloma limbatum* Beker, Vesterh. & U. Eberh. (Hymenogastraceae)'a ait meyvemsiler Türkiye'den ilk kez toplanmış ve burada arazi resimleri ve kısa bir tartışma ile birlikte sunulmuştur. Koleksiyonun teşhisi araziden elde edilen veriler ve mikroskobik inceleme sonuçlarına göre yapılmıştır. Yeni kayıt nispeten küçük, yapışkan, turuncumsu kahverengi veya beyazımsı şapka; krem rengi veya açık kahverengi lameller; beyazımsı sap; badem veya limon şeklinde, süslü, soluk sarı, 10–14 × 5–7.5 µm boyutlarında bazidiyosporlar; çomak veya şişe biçiminde, bazen başlıklı ve 30–100 × 5–14 µm büyüklüğünde sistityumlar ile teşhis edilir.

Anahtar kelimeler: Etli mantar, *Hebeloma*, Trabzon, Türkiye, Yeni kayıt

Hebeloma limbatum: A New Record For the Turkish Mycota

Abstract: Fruit bodies belonging to *Hebeloma limbatum* Beker, Vesterh. & U. Eberh. (Hymenogastraceae) were collected for the first time from Turkey and presented herein with field photos and a short discussion. The identification of the collection was made according to the data obtained from the field and the results of microscopic examination. The new record is identified with relatively small, sticky, orangey brown or whitish pileus; cream-colored or light brown lamellae; whitish stipe; almond- or lemon-shaped, ornamented, pale yellow, 10–14 × 5–7.5 µm sized basidiospores; club- or bottle-shaped, sometimes capped, and 30–100 × 5–14 µm sized cystidia.

Key words: Fleshy fungi, *Hebeloma*, Trabzon, Türkiye, New record

Giriş

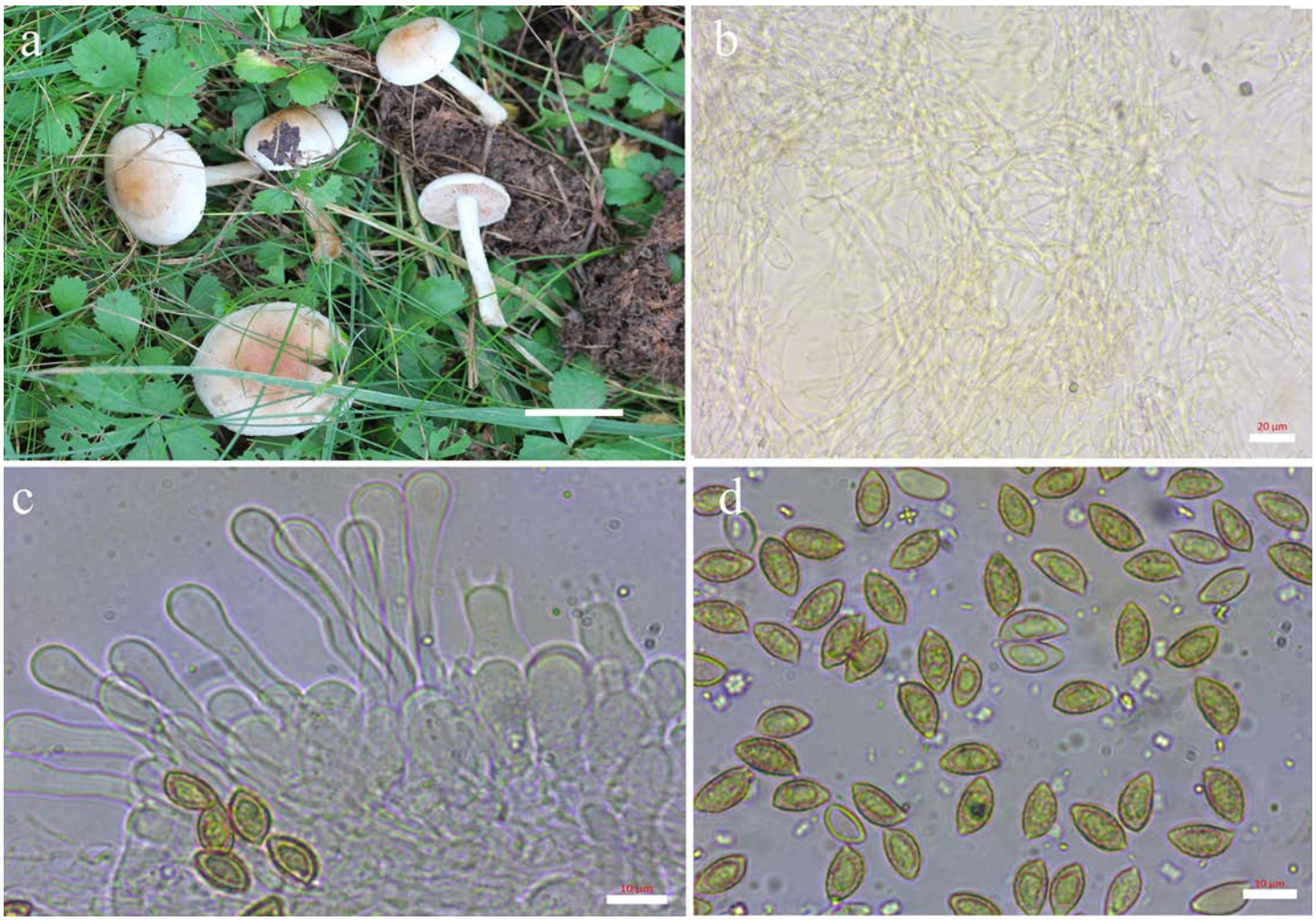
Hebeloma (Fr.) P. Kumm. cinsi mantarlar genellikle keskin ve bazen kötü ve itici kokuları, öbekler halinde toprakta veya çürümekte olan ağaçlar üzerinde yayılış göstermeleri ile arazide; ilginç ve çok sayıdaki sistityumları, badem veya limon biçiminde, bol ve genellikle süslü bazidiyosporları ile laboratuvarda kolaylıkla yakın cinslerden ayırt edilirler. Ancak cins içerisindeki birçok tür birbirine yakın özelliklere sahip olduğundan teşhis edilmeleri kolay değildir. Bir bölümü zehirli olup genellikle beslenme amaçlı kullanılmazlar. Mevcut çalışmadan önce Doğu Karadeniz bölümünde uzun süreli arazi çalışmalarında genellikle sonbaharda, ladin-kayın ormanlarında, çürümekte olan döküntüler ve ağaçlar üzerinde, çimenlerde ve diğer tip arazilerde *Hebeloma leucosarx* P.D. Orton, *H. populinum* Romagn., *H. laterinum* (Batsch) Vesterh., *H. radicosum* (Bull. : Fr.) Ricken (Sesli ve Baydar, 1996), *Hebeloma* aff. *aestivale* Vesterh. (Sesli ve ark., 2015), *H. sacchariolens* Quél. (Akata ve Sesli, 2017) ve *H. avellaneum* Kauffman (Sesli ve ark., 2018) türleri tespit edilmiştir. Literatür araştırmalarına göre bu cins günümüzde Türkiye'de yaklaşık 40 civarında türle (Sesli ve ark., 2020) ve dünyada ise yaklaşık 690 kayıtla temsil edilmektedir (Kirk ve ark., 2008). Elbette bu sayının tamamı farklı tür olmayabilir. Diğer öbekler üzerinde olduğu gibi *Hebeloma* konusunda da Türkiye'de ve dünyada yapılacak yeni çalışmalar araştırıcıları beklemektedir.

Mevcut çalışmanın amacı Türkiye için yeni olan *Hebeloma limbatum* türünün morfolojik özelliklerini tanıtmaktır.

Materyal ve Metot

Araştırmanın materyali olan meyvemsiler (Şekil 1) 16.11.2018 tarihinde Karadeniz Teknik Üniversitesi park alanında saptanmış, fotoğrafları çekilmiş, önemli morfolojik özellikleri not edilmiş, standart yöntemlerle toplanarak laboratuvara getirilmiş, kurutulup etiketlenerek

fungaryum dolabına yerleştirilmiştir. Bazidiyosporların görüntülenebilmesi için şapkadan bir parça kesilerek 2 dakika %5'lik amonyak çözeltisi içerisinde tutulmuş, daha sonra bir pens yardımı ile lam üzerine alınmış ve sporlar lam üzerine dökülünceye kadar aralıklı basınç uygulanmıştır. Bazidiyum, sistityum ve şapka derisinin hifal yapısını görüntülemek için keskin jiletle binoküler mikroskop altında çok sayıda ince kesitler alınmış, %5'lik amonyak çözeltisi ile işlemden sonra Axio Imager A2 araştırma mikroskobu altında inceleme yapılmıştır. İnceleme sırasında hücresel yapıların en ve boy ölçümleri yapılmış ve fotoğrafları çekilmiştir. Boyutların doğru olarak belirlenebilmesi için şapka derisi hücrelerinden, bazidiyumlardan ve de sistityumlardan 25'er ölçüm yapılmıştır. Teşhisler elde edilen verilerin ilgili literatür ile karşılaştırılması sonucunda yapılmıştır (Eberhardt, 2016). Koleksiyon materyali Trabzon Üniversitesi Fatih Eğitim Fakültesi'ndeki kişisel fungaryumda saklanmaktadır.



Şekil 1. *Hebeloma limbatum*: a- meyvemsiler, b- şapka derisi kesiti, c-sistityumlar, bazidiyumlar ve bazidiyoller, d-bazidiyosporlar (ölçek çubukları: a: 30 mm, b: 20 µm, c ve d: 10 µm)

Bulgular

Hymenogastraceae / Papazküregiller

Hebeloma limbatum Beker, Vesterh. & U. Eberh. [Şu eserde: Beker, Eberhardt, Vesterholt & Schütz, Fungal Biology 120(1): 83 (2016)] / Dönekturpkokan

Şapka dışbükey veya yayvan, 25–60 mm, merkeze doğru bej rengi, sarımsı veya turuncumsu kahverengi, bal rengi, koyu pembemsi kahverengi, soluk krem rengi, kenara doğru beyazımsı; kenarı dişli veya yivli, uzun süre içeriye doğru kıvrık, yüzeyi düz ve yapışkandır. Lameller sapa çentikli olarak bağlı veya genişliği ölçüsünde birleşik, krem, bej veya soluk kahverengi renkte, geniş, kenarları damlacıklı ve kahverengi beneklidir. Dokusu dayanıklı, acı, turp kokulu, beyazımsı veya açık kahverengidir. Sap silindirik veya çomak biçiminde ve tabanda hafif soğansı, dolu, kırılgan, 15–80 × 4–15 mm; yüzeyi beyaz tozsu yapılarla kaplı, pullu veya lifli ve tabanda soluk kahverengimsidir. Bazidiyumlar çomak biçiminde, 4 sporlu, kancalı ve 20–40 × 5–15 µm'dir. Bazidiyosporlar badem veya limon şeklinde, süslü, açık sarı ve 10–14 × 5–7.5 µm'dir. Sistityumlar çomak, ıspatula veya şişe şeklinde, bazen başlıklı ve 30–100 × 5–15 µm'dir. Şapka derisi hifleri jelatinli, şeffaf, 2–9 µm,

kancalı ve düzensiz yerleşimlidir. Yapısı jelatinli üst tabaka ile kısa silindirik ve sarımsı hücrelerden oluşmuş alt tabakadan meydana gelmiştir. Yenmez.

İncelenen örnekler: Türkiye, Trabzon, Karadeniz Teknik Üniversitesi yerleşkesi, 40°59'38.67"K / 39°46'16.72"D, hem geniş ve hem de iğne yapraklıların bulunduğu park alanında, otlar ve döküntüler arasında, çimenlik alanda, öbekler halinde, 16.11.2018, E. Sesli 4023.

Tartışma

Yeni kaydın bağlı olduğu *Hebeloma* cinsinde bazidiyokarplar *Tricholoma* veya *Collybia* tipinde, yüzeyleri yapışkan, tarçın rengi, soluk kahverengimsi, toprak veya kil rengi, beyazımsı ve kokuları genellikle iticidir. Bazı türlerin lamelleri damlacıklar oluşturur. Sapları üzerinde tozsu, pulsu veya tanecikli miselyum bulunur. İçeriği bazı türlerde turp kokusunu andırır, bazıları tatsız, bazıları acı ve bir kısmının kokusu pek belli değildir. *Hebeloma limbatum* ilk olarak İtalya'dan toplanarak tanımlanmış olup (Eberhardt ve ark., 2016) yeni koleksiyon 25–60 mm, merkeze doğru sarımsı, turuncumsu veya pembemsi kahverengi, kenarlarda bej rengi, soluk krem rengi veya beyazımsı şapka; krem veya bej rengi, soluk kahverengi ve damlacıklı lameller; badem veya limon şeklinde ve 10–14 × 5–7.5 µm bazidiyosporlar; çomak veya şişe şeklinde ve 30–100 × 5–15 µm sistityumlar ile teşhis edilir. Dış görünüş olarak benzer bir tür, *H. leucosarx*, benzer büyüklüğe ve renk tonuna sahip olmakla birlikte daha küçük bazidiyosporlara ve sistityumlara sahiptir. Ayrıca bu türde sistityumlar şişe şeklinde olmayıp her zaman çomak biçimindedir. Ayrıca bu tür söğüt ve huş altında yetişir. Bir diğer tür, *H. longicaudum* (Pers.: Fr.) Kumm. biraz daha küçük şapkaya, benzer renklere, daha uzun (60–110 mm) sapa, daha küçük (10–13 × 5–7 µm) bazidiyosporlara, bazıları dallanmış, silindir biçiminde sistityumlara sahip olmasıyle yeni kayıttan farklılık gösterir. Şapka rengi ve sap yapısı ile yakın gözüken bir diğer tür, *H. sinapizans* (Paul.: Fr.) Gill. iki kat büyük (50–120 mm) şapkalı, soluk kırmızımsı veya bej renkli, ayrık lamelli ve daha küçük (35–70 × 7–12 µm) sistityumludur. *Hebeloma velutipes* Bruchet huş veya fındık altında yetişir, küt tepe çıkıntılıdır, bazidiyosporlarının kenar kısımları dalgalıdır. *Hebeloma senescens* (Batsch) Berk. & Mr. daha az benzerlik gösterir, genellikle iğne yapraklılar altında yetişir, yüzeyi krem rengi, soluk kırmızımsı veya benzeri renklerdedir, daha küçük bazidiyosporlar (8.5–11.5 × 5–7 µm) üretir. Ayrıca bu türün silindirik sistityumları kıvrımlıdır. Söğüt ile mikorizal yaşayan *H. pusillum* Lge. daha küçük (10–30 mm), konik veya çan şeklinde ve belirgin tepe çıkıntılı şapkaya; pembemsi tonlu beyaz lamellere; badem şeklinde fakat daha küçük (9–12.5 × 5–6.5 µm) bazidiyosporlara sahiptir. *Hebeloma crustuliniforme* (Bull.: Fr.) Quel. konik veya çan şeklinde, tipik tepe çıkıntılı, soluk turuncumsu, beyazımsı şapkaya; çentikli ve krem rengi lamellere; eliptik veya badem biçiminde ve biraz daha küçük bazidiyosporlara sahiptir. Laden altında, iğne yapraklı veya yaprak döken ağaç ormanlarında yayılış gösteren *H. cavipes* Huijsman yakın büyüklükte olmakla birlikte, krem rengi veya soluk sarımsı şapkası, sapa tüm genişliği ile bağlı lamelleri ve daha küçük sistityumları ile *H. limbatumdan* farklılık gösterir. *Hebeloma candidipes* Bruchet genellikle ladin altında yayılış gösterir, daha küçük, kırmızımsı veya gri kahverengi şapkaya; beyazımsı veya bej kahvesi ve sapa genişliği ölçüsünde bağlı lamellere; daha küçük bazidiyosporlara ve sistityumlara sahiptir. *Hebeloma bruchetii* Bon aynı büyüklükte bazidiyokarplara sahip olmakla birlikte söğüt altında yetişir, bazidiyosporları (8–10 × 5–7 µm) ve sistityumları (40–60 × 8–11 µm) çok daha küçüktür (Breitenbach ve Kränzlin, 2000; Knudsen ve Vesterholt, 2008; Eberhardt ve ark., 2016).

Yazar Katkıları

Tüm yazarlar eşit katkıya sahiptir.

Çıkar Çatışması

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