

Mycorrhizal mushrooms associated with tree species in Shaki district of Azerbaijan

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Abstract: Based on the latest taxonomic and nomenclature changes totally 59 mushroom taxa (55 species, three forms, one variations) belonging to 27 genera, 13 families and seven orders from the phyla Ascomycota (Pezizales) and Basidiomycota (Agaricales, Boletales, Cantharellales, Gomphales, Russulales, Thelephorales) were registered in Shaki district of Azerbaijan. *Boletus*, *Lactarius* and *Russula* are dominant genera by their species number in the study area. Occurrence of mycorrhizal mushrooms according to the altitude, seasonality and taxonomic structure was analysed. *Amanita crocea* (Quél) Singer, *Lactarius citriolens* Pouzar and *L. pyrogalus* (Bull.) Fr. represent new records for Azerbaijan.

Key words: elevation, fungus, plant, seasonality, specialisation, species

INTRODUCTION

A mycorrhiza is an association between plant and fungus. The term “mycorrhiza” was first introduced by A.B. Frank in 1885 [Koide, Mosse, 2004]. Mycorrhizal fungi are an important component of ecosystems and about 50.000 fungi were recorded to form such kind of associations with 250.000 terrestrial plants. The well known mycorrhiza types are arbuscular mycorrhiza (AM) formed by Glomeromycota with 74% of all plant species, and the ectomycorrhiza (EM) formed by many Ascomycetes and Basidiomycetes. There are also orchid mycorrhizas formed between Basidiomycetes and orchid plants, and ericoid mycorrhizas formed between mainly Ascomycetes and some Basidiomycetes in association with plants of the family Ericaceae [Van der Heijden et al., 2015]. Unlike for AMs, large mycelial strands of

EM fungi may increase water flow by bridging the gap between the soil and the root.

There are many claims that mycorrhizal plants are more resistant to diseases caused by pathogenic fungi and bacteria than nonmycorrhizal ones. EM ensures the transfer of carbon, nitrogen and phosphate nutrients from soil to plant and from plant to plant, creating common mycorrhizal network. This association has impact on photosynthesis productivity, so this factor is higher in mycorrhizal plants in comparison with nonmycorrhizal ones. According to these facts mycorrhizal fungi play crucial role in ecosystem services, such as transport, store, release and cycle of nutrients [Eom et al., 2000; Koide, Mosse, 2004]. Notably, plants can survive and even grow in the absence of AM fungi, but AM fungi are obligate symbionts or obligate biotrophs. Development of highly ramified arbuscules within reprogrammed cortical cells of roots allows efficient exchange of nutrients between symbionts [Kamel et al., 2017].

The present study encompasses report of 59 mycorrhizal fungi in Shaki district, their taxonomic composition and host specialization. We also provide extensive information about altitudinal and seasonal occurrence of mycorrhizal fungi. Three new records of these mushrooms in Azerbaijan were also reported

MATERIAL AND METHODS

Extensive sampling was conducted during period of fruit body formation in 2016-2019s from the various places of Shaki district. The altitude range of mushroom collecting points covers 670-2100 m above sea level (a. s. l.). Collected specimens were air dried and deposited in the Mycological herbarium of the Institute of Botany, ANAS (BAK). The fungi were collected in following sites: Khan Yaylaghi (1900-2200 m a. s. l.); Mustafabey oak-beech, chestnut-beech forest (820-930 m a. s. l.); Markhal resort complex (960-1000 m a. s. l.); Naringala pine forest (1100 ± 50-70 m a. s. l.); surroundings of Shaki Khans' Palace (750 ± 50-70 m a. s. l.); in vicinity of Kungut village (740 m a. s. l.) (Fig. 1).

Specimens at first were examined visually using magnifying lens. Macromorphology (shape, size, and

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Figure 1. Sites of mushroom collected in Shaki district: A. Naringala pine forest; B: Markhal resort complex; C. Mustafabey oak-beech, chestnut-beech forest; D. KhanYaylaghi; E. Yukhari-bash historical reserve; F. in vicinity of Kungut village.

features of fruit body, peculiarities of flesh including taste, smell and colour, as well as its change after damage, presence of milky juice (lactate), etc.) was observed [Prance, Fechner, 2017]. Micromorphological features were investigated with help of the light microscope (Vert. A1, Carl Zeiss, Axion Imager, Göttingen, Germany) using sterile water for mounting of preparates. Those were dyed with Congo red for better visibility of details of microscopic structures (basidia, cystidia, spores, etc.) of mushrooms [Prance, Fechner, 2017]. Minimum 20 measurements of each type of structure were taken. Both the size and shape of basidiospores were considered and the results are estimated as the average. Identification was carried out with help of the available literature [Pilát, 1969; Dermek, Pilát, 1974; Zerova et al., 1979; Wasser, 1980; Determ..., 1985; Arora, 1986; Dudka, Wasser, 1987; Breitenbach, Kränzlin, 1995; Bondartseva, 1998; Grunert, Grunert, 2002; Ladurne, Simonini, 2003; Muñoz, 2005; Šutara, 2008; Hills, 2009; Heluta, Akulov, 2012; Funga Nodrica, 2012; Klofac, 2013; Boddy et al., 2013; Richard et al., 2015; Prance, Fechner, 2017; Heluta et al., 2019]. Nomenclature and taxonomy corresponds to Index Fungorum Partnership and MycoBank Database.

RESULTS AND DISCUSSION

In total 59 taxa (55 species, three forms and one variation) of mycorrhizal fungi belonging to 27 genera, 13 families and seven orders of Ascomycota and Basidiomycota were identified (Tab. 1). The most of taxa belong to the Basidiomycota. Boletales is the largest order in number of species within Basidiomycota. It includes three families: Boletaceae (22 species, 2 forms and one variation), Gomphidiaceae (1), and Suillaceae (4). From the family Boletaceae the genus *Boletus* must be firstly mentioned. It includes four species: *B. aereus* Bull., *B. edulis* Bull., *B. purpureus* Pers., and *B. reticulatus* Schaeff. Besides, *B. edulis* is represented by two forms (f. *quercicola* Vassilkov, and f. *betulicola* Vassilkov) and one variation (var. *arenarius* H. Engel, Krieglst. & Dermek). The second genus *Rubroboletus* includes three species (*R. legaliae* (Pilát & Dermek) Della Magg. & Trassin., *R. lupinus* (Fr.) Costanzo & Gelardi, Simonini & Vizzini and *R. satanas* (Lenz) Kuan Zhao & Zhu L. Yang). Each genus listed below was presented by two species: *Butyriboletus* (*B. appendiculatus* (Schaeff.) D. Arora & J.L. Frank and *B. pseudoregius* (Helnr. Huber) D. Arora & J.L. Frank), *Leccinellum* (*L. griseum* (Qué.) Bresinsky & Manfr. Binder and *L. pseudoscabrum* (Kallenb.) Mikšik), *Suillellus* (*S. luridus* (Schaeff.)

Murrill and *S. queletii* (Schulzer) Vizzini, Simonini & Gelardi), and *Xerocomus* (*X. chrysenteron* (Bull.) Šutara. and *X. subtomentosus* (L.) Qué.). Remaining genera of this family were found to encompass a species of each. These were *Caloboletus* (*C. radicans* (Pers.) Vizzini), *Hemileccinum* (*H. depilatum* (Redeuilh) Šutara), *Hortiboletus* (*H. rubellus* (Krombh) Simonini, Vizzini & Gelardi), *Imleria* (*I. badia* (Fr.) Vizzini), *Leccinum* (*L. crocipodium* (Letell.) Della Magg. & Trassin.), *Neoboletus* (*N. erythropus* (Pers.) C. Hahn), *Rheubarbariboletus* (*R. armeniacus* (Qué.) Vizzini, Simonini & Gelardi).

Four taxa from the genus *Suillus* from the family Suillaceae distributed in Shaki. It was presented by three species (*Suillus collinitus* (Fr.) Kuntze, *S. granulatus* (L.) Roussel, and *S. luteus* (L.) Roussel), and one form (*S. luteus* f. *albus* Wasser & Soldatova). *Gomphidius roseus* (Fr.) Fr. from the family Gomphidiaceae was collected.

Following the biggest order is Russulales with 15 species from genera *Lactarius* and *Russula* (Russulaceae). Seven species belong to the genus *Lactarius* (*L. acris* (Bolton) Gray, *L. citriolens* Pouzar, *L. deliciosus* (L.) Gray, *L. piperatus* (L.) Roussel., *L. pyrogalus* (Bull.) Fr., *L. volemus* (Fr.) Kuntze, *L. zonarius* (Bull.) Fr.) and eight to the genus *Russula* (*R. albonigra* (Krombh) Fr., *R. delica* Fr., *R. foetens* Pers., *R. olivacea* (Schaeff.) Fr., *R. minutula* Velen, *R. sanguinaria* (Schumach.) Rauschert., *R. turci* Bres and *R. virescens* (Schaeff.) Fr.).

Another large order of the Basidiomycota is Agaricales, which is represented by nine species of mycorrhizal mushrooms from the families Amanitaceae, Cortinariaceae, Hymenogastraceae, Inocybaceae and Lyophyllaceae. Four of them belong to Amanitaceae (*Amanita*): *A. crocea* (Qué.) Singer, *A. pantherina* (DC.) Krombh., *A. rubescens* Pers., and *A. vaginata* (Bull.) Lam. Other five species are from the families Inocybaceae (*Inosperma maculatum* (Boud.) Matheny & Esteve-Rav. and *Pseudosperma rimosum* (Bull) Matheny & Esteve-Rav), Cortinariaceae (*Cortinarius triumphans* Fr.), Hymenogastraceae (*Hebeloma sinapizans* (Paulet) Gillet), Lyophyllaceae (*Calocybe gambosa* (Fr.) Donk).

The other orders are minor and include one or two species: Cantharellales (*Cantharellus cibarius* Fr. and *C. subalbidus* A.H. Sm. & Morse), Gomphales (*Clavariadelphus pistillaris* (L.) Donk), and Thelephorales (*Hydnellum conrescens* (Pers.) Banker.). *Tuber aestivum* (Wulfen) Spreng is a solely example of

Table 1. Taxonomic structure of species composition of mycorrhizal mushrooms of Shaki district.

Phylum	Orders	Families	Genera	Nos of taxa
Ascomycota	Pezizales	Tuberaceae	<i>Tuber</i> P. Micheli ex E.H. Wigg.	1
Basidiomycota	Agaricales	Amanitaceae	<i>Amanita</i> Dill. ex Boehm.	4
		Cortinariaceae	<i>Cortinarius</i> (Pers.) Gray	1
		Hymenogastraceae	<i>Hebeloma</i> (Fr.) P. Kumm.	1
		Inocybaceae	<i>Inosperma</i> (Kühner) Matheny & Esteve-Rav., <i>Pseudosperma</i> Matheny & Esteve-Ravş	2
		Lyophyllaceae	<i>Calocybe</i> Kühner ex Donk	1
	Boletales	Boletaceae	<i>Boletus</i> Tourn., <i>Butyriboletus</i> D. Arora & J.L. Frank, <i>Caloboletus</i> Vizzini, <i>Hemileccinum</i> Šutara, <i>Hortiboletus</i> Simonini, Vizzini & Gelardi, <i>Imleria</i> Vizzini, <i>Leccinellum</i> Bresinsky & Manfr. Binder, <i>Leccinum</i> Gray, <i>Neoboletus</i> Gelardi, Simonini & Vizzini, <i>Rheubarbariboletus</i> Vizzini, Simonini & Gelardi, <i>Rubroboletus</i> Kuan Zhao & Zhu L. Yang, <i>Suillellus</i> Murrill, <i>Xerocomus</i> Qué!l	25
		Gomphidiaceae	<i>Gomphidius</i> Fr.	1
		Suillaceae	<i>Suillus</i> P. Micheli	4
	Cantharellales	Cantharellaceae	<i>Cantharellus</i> Adans. ex Fr.	2
	Gomphales	Clavariadelphaceae	<i>Clavariadelphus</i> Donk	1
Russulales	Russulaceae	<i>Lactarius</i> Pers. <i>Russula</i> Pers.	15	
Thelephorales	Bankeraceae	<i>Hydnellum</i> P. Karst.	1	

the ascomycetous mycorrhizal fungus from the region.

Three species found in the result of this research (*Amanita crocea*, *Lactarius citriolens* and *L. pyrogalus*) are new for Azerbaijan. *A. crocea* was collected under *Fagus sylvatica* L. and *Corylus avellana* L., *L. citriolens* – under *Betula pendula* Roth, and *L. pyrogalus* – under *Corylus avellana* (Fig. 2).

Host plant specialization. Totally, 13 plant species from 11 genera belonging to the seven families have been recorded. The names of the host plants and their associated fungi are listed below. As can be seen from the table 2, *Quercus iberica* M. Bieb. forms mycorrhizal association with 41 fungal species. *Carpinus betulis* L. forms mycorrhizae with 39 species of fungi, the number of fungal species forming mycorrhiza by *Fagus sylvatica* L. is 36, with 21 species of fungi takes the fourth place, *Pinus sylvestris* L. and *Ulmus minor* Mill. form associations with 14 species of fungi, *Castanea sativa* Mill. with 12, *P. brutia* subsp. *eldarica* Medw. with 11, *Acer pseudoplatanus* L. with 10, *Taxus baccata* L. with six, *Fraxinus exelsior* L. with five and *Betula pendula* Roth formed mycorrhizal association with four fungal species. Only *Suillellus luridus* was found in association with the *Picea pungens* Engelm. (introduced tree species), growing in small groups of 5-10 trees in

Markhal resort complex.

Distribution of mushroom taxa depending of elevation. Collected mushrooms are distributed along three altitudes: low and middle mountain zone (500-800 m a. s. l.), middle and upper mountain zone (800-1800 m a. s. l.), subalpine and alpine zone (1800-2400 m a. s. l.). In the low and middle mountain zone *Amanita crocea*, *Lactarius pyrogalus*, *L. volemus*, *Russula foeten*, *Suillus collinitus*, *Tuber aestivum* were found. The species found in the middle and upper mountain zone are listed below: *A. vaginata*, *Boletus purpureus*, *B. reticulates*, *B. edulis* var. *arenarius*, *Butyriboletus appendiculatus*, *B. pseudoregius*, *Caloboletus radicans*, *Calocybe gambosa*, *Cantharellus cibarius*, *C. subalbidus*, *Clavariadelphus pistillaris*, *Cortinarius triumphans*, *Gomphidius roseus*, *Hebeloma sinapizans*, *Hemileccinum depilatum*, *Hortiboletus rubellus*, *Hydnellum conrescens*, *Imleria badia*, *Inosperma maculatum*, *Lactarius acris*, *L. deliciosus*, *L. piperatus*, *L. zonarius*, *Leccinellum griseum*, *L. pseudoscabrum*, *Leccinum crocipodium*, *Neoboletus erythropus*, *Rheubarbariboletus armeniacus*, *Rubroboletus legaliae*, *R. lupinus*, *Pseudosperma rimosum*, *Russula albonigra*, *R. delica*, *R. olivacea*, *R. minutula*, *R. sanguinaria*, *R. turci*, *R. virescens*, *S. granulates*, *S. luteus*, *S. luteus*

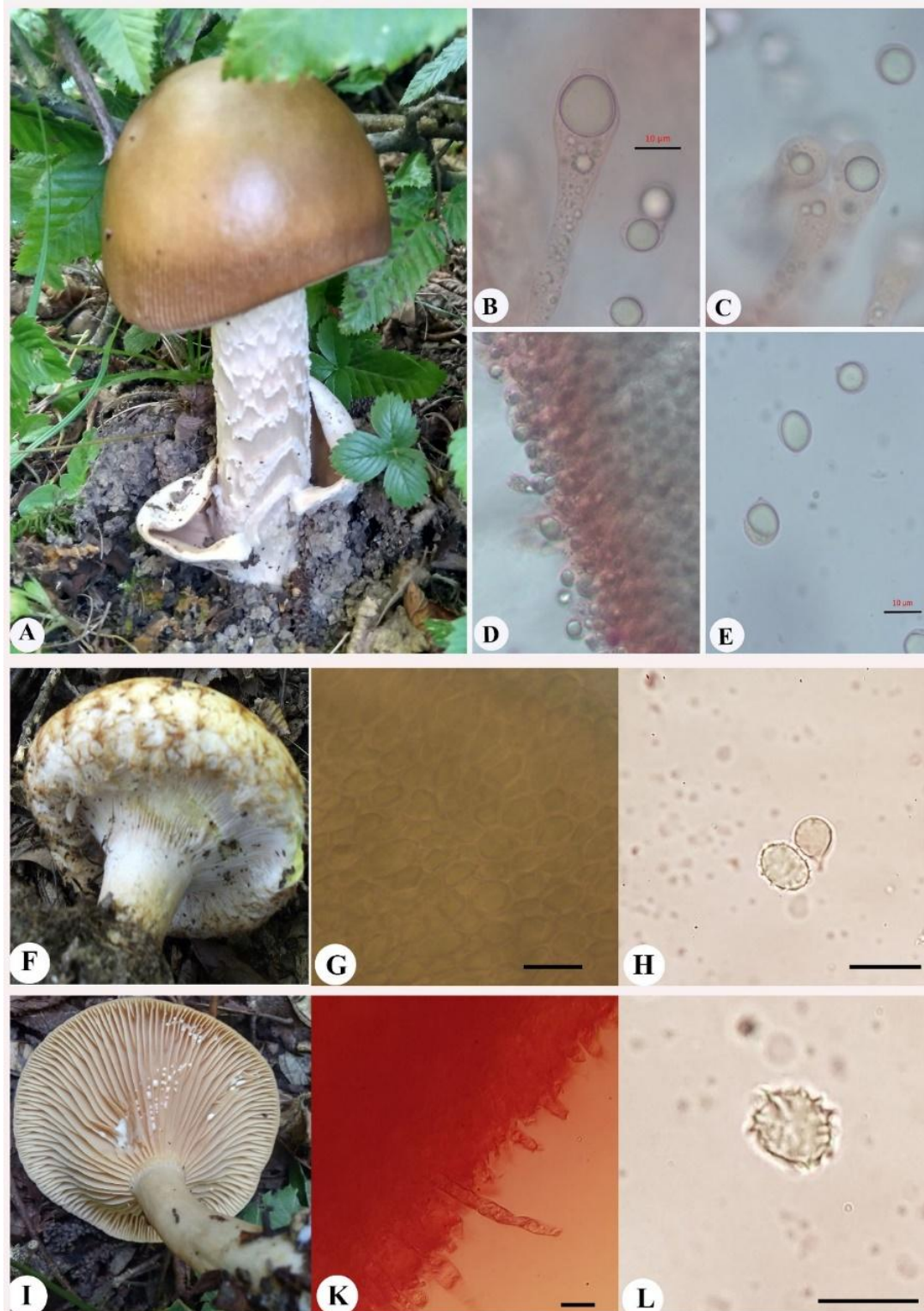


Figure 2. New records of mycorrhizal fungi species for Azerbaijan. *Amanita crocea*: A. Fruit body; B–D. basidia (Congo red has been applied); E. Basidiospores; *Lactarius citriolens*: F. Fruit body; G. Tissue of trama; H. Basidiospores. *L. pyrogalus*: I. Fruit body; K. Basidia; L. Basidiospores.

Table 2. Table of host plants of mycorrhizal fungi of Shaki district.

Mushroom species	Host plant													
	<i>A. pseudoplatanus</i>	<i>B. pendula</i>	<i>C. betulus</i>	<i>C. sativa</i>	<i>C. avellana</i>	<i>F. sylvatica</i>	<i>F. exelsior</i>	<i>P. pungens</i>	<i>P. brutia</i> subsp. <i>eldarica</i>	<i>P. sylvestris</i>	<i>Q. iberica</i>	<i>T. baccata</i>	<i>U. minor</i>	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
<i>Amanita crocea</i>				+	+	+								
<i>A. pantherina</i>	+	+		+	+	+								
<i>A. rubescens</i>		+	+								+		+	
<i>A. vaginata</i>			+	+	+	+					+			
<i>Boletus aereus</i>	+		+		+	+	+				+			
<i>B. edulis</i>	+		+			+					+		+	
<i>B. edulis</i> f. <i>betulicola</i>		+												
<i>B. edulis</i> f. <i>quercicola</i>											+			
<i>B. edulis</i> var. <i>arenarius</i>			+								+			
<i>B. purpureus</i>			+	+	+	+					+			
<i>B. reticulatus</i>	+		+		+	+	+				+		+	
<i>Butyriboletus appendiculatus</i>			+		+	+					+			
<i>B. pseudoregius</i>			+			+					+			
<i>Caloboletus radicans</i>			+		+	+	+				+		+	
<i>Calocybe gambosa</i>										+				
<i>Cantharellus cibarius</i>	+		+			+					+		+	
<i>C. subalbidus</i>			+			+					+			
<i>Clavariadelphus pistillaris</i>			+			+					+			
<i>Cortinarius triumphans</i>			+			+					+			
<i>Gomphidius roseus</i>									+	+		+		
<i>Hebeloma sinapizans</i>									+	+	+			
<i>Hemileccinum depilatum</i>			+			+					+			
<i>Hortiboletus rubellus</i>			+	+		+								
<i>Hydnellum conrescens</i>										+				
<i>Imleria badia</i>			+								+		+	
<i>Inosperma maculatum</i>						+			+	+	+			
<i>Lactarius acris</i>			+			+					+			
<i>L. citriolens</i>		+												
<i>L. deliciosus</i>									+	+		+		
<i>L. piperatus</i>			+		+	+					+		+	
<i>L. pyrogalus</i>			+		+									
<i>L. volemus</i>			+	+		+					+		+	
<i>L. zonarius</i>				+		+					+			
<i>Leccinellum griseum</i>			+	+	+									
<i>L. pseudoscabrum</i>			+		+						+			
<i>Leccinum crocipodium</i>			+								+			
<i>Neoboletus erythropus</i>				+	+	+					+			
<i>Pseudosperma rimosum</i>									+	+				
<i>Rheubarbariboletus armeniacus</i>			+			+								
<i>Rubroboletus legaliae</i>			+								+			
<i>R. lupinus</i>						+					+			
<i>R. satanas</i>	+		+	+	+	+	+				+		+	

1	2	3	4	5	6	7	8	9	10	11	12	13	14
<i>Russula albonigra</i>	+		+		+	+			+		+		+
<i>R. delica</i>	+		+		+	+					+		
<i>R. foetens</i>			+		+	+				+	+		
<i>R. olivacea</i>			+			+					+		
<i>R. minutula</i>			+			+					+		
<i>R. sanguinaria</i>			+		+	+					+		
<i>R. turci</i>									+	+			
<i>R. virescens</i>			+			+				+	+		+
<i>Suillellus luridus</i>	+		+	+	+	+	+	+			+		+
<i>S. queletii</i>			+	+	+	+					+		+
<i>Suillus collinitus</i>									+	+		+	
<i>S. granulatus</i>									+	+		+	
<i>S. luteus</i>									+	+		+	
<i>S. luteus</i> f. <i>albus</i>									+	+			
<i>Tuber aestivum</i>			+			+					+		
<i>Xerocomus chrysenteron</i>			+			+					+		
<i>X. subtomentosus</i>	+		+		+	+					+		+

f. *albus*, *Xerocomus chrysenteron*, *X. subtomentosus*. *Lactarius citriolens* is found in the subalpine and alpine zone.

Rubroboletus satanas, *Suillellus luridus* and *S. queletii* were found at two different heights (low and middle mountain zone and middle and upper mountain zone). These are other species found at two different (middle and upper mountain zone and subalpine and alpine zone) altitudes – *Amanita rubescens*, *Boletus aereus*, *B. edulis*, *B. edulis* f. *quercicola*, *B. edulis* f. *betulicola*. Only one species – *A. pantherina* was found at all three altitudes.

Mushroom seasonality. Most of fungi occur in summer period. Table 3 shows that the *Tuber aestivum* and *Inosperma maculatum* are found only in spring, *Amanita crocea*, *A. rubescens*, *Boletus purpureus*, *B. edulis* f. *quercicola*, *B. edulis* f. *betulicola*, *B. edulis* var. *arenarius*, *Butyriboletus appendiculatus*, *B. pseudoregius*, *Cantharellus subalbidus*, *Clavariadelphus pistillaris*, *Hemileccinum depilatum*, *Lactarius acris*, *L. citriolens*, *L. pyrogalus*, *L. zonarius*, *Leccinellum griseum*, *Neoboletus erythropus*, *Rheubarbariboletus armeniacus*, *Rubroboletus legaliae*, *R. lupinus*, *Russula minutula*, *R. virescens* and *Xerocomus chrysenteron* occur only in summer and *Calocybe gambosa*, *Cortinarius triumphans*, *Gomphidius roseus*, *Imleria badia*, *Pseudosperma rimosum*, *Russula turci*, *Suillus luteus* and *S. luteus* f. *albus* are found only in autumn. *Hydnellum concrescens* is found in winter and autumn. *Hebeloma sinapizans* is found in spring and autumn. *Amanita pantherina*, *A. vaginata*, *Boletus aereus*,

B. reticulatus, *Caloboletus radicans*, *Cantharellus cibarius*, *Hortiboletus rubellus*, *Lactarius piperatus*, *L. volemus*, *Leccinellum pseudoscabrum*, *Leccinum crocipodium*, *Rubroboletus satanas*, *Russula albonigra*, *R. delica*, *R. foetens*, *R. olivacea*, *R. sanguinaria*, *Suillellus queletii*, *Suillus collinitus*, *Xerocomus subtomentosus* are common in summer and autumn. *Boletus edulis*, *Suillellus luridus* mushroom species is found in spring, summer and autumn. Two mushroom species – *Lactarius deliciosus* and *Suillus granulatus* were found in all seasons.

The growth temperature for mushrooms varies in the range of 4°-35° C. The lowest temperature for growth was 4° for the species *Gomphidius roseus*, *Lactarius deliciosus*, *Suillus luteus*, *S. granulatus* and the highest temperature 35° C for *Leccinum crocipodium*, *Suillellus queletii*.

As can be seen from the graph in Figure 3, the monthly rainfall since January 2016 has been 101 mm and fluctuated to a minimum in August of that year (25 mm). The highest rate was observed in October (142 mm). The last month of the year was about 43 mm. In 2017 precipitation was around 37 mm in January and peaked in May and October (121 and 119 per each). In December of the same year, more precipitation (70 mm) fell than in the other three years. The amount of precipitation in January 2018 was 51 mm, and an increasing trend (192 mm) was observed until May. Fluctuation was observed between May (192 mm) and August, and the highest rainfall was observed in August (300 mm) for four years. In the last month of 2018,

Table 3. Monthly occurrence of mycorrhizal mushrooms in Shaki district.

Mushroom species	Months											
	January	February	March	April	May	June	July	August	September	October	November	December
1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Amanita crocea</i>							+					
<i>A. pantherina</i>						+	+	+	+	+		
<i>A. rubescens</i>							+	+				
<i>A. vaginata</i>						+	+	+	+	+		
<i>Boletus aereus</i>						+	+	+	+	+	+	
<i>B. edulis</i>				+		+	+	+	+	+	+	
<i>B. edulis f. betulicola</i>								+				
<i>B. edulis f. quercicola</i>							+					
<i>B. edulis var. arenarius</i>							+	+				
<i>B. purpureus</i>							+	+				
<i>B. reticulatus</i>						+	+	+	+			
<i>Butyriboletus appendiculatus</i>							+	+				
<i>B. pseudoregius</i>								+				
<i>Caloboletus radicans</i>						+	+	+		+	+	
<i>Calocybe gambosa</i>											+	
<i>Cantharellus cibarius</i>							+	+	+			
<i>C. subalbidus</i>							+	+				
<i>Clavariadelphus pistillaris</i>						+		+				
<i>Cortinarius triumphans</i>										+		
<i>Gomphidius roseus</i>										+	+	
<i>Hebeloma sinapizans</i>				+					+	+	+	
<i>Hemileccinum depilatum</i>								+				
<i>Hortiboletus rubellus</i>								+		+		
<i>Hydnellum conrescens</i>	+										+	
<i>Imleria badia</i>										+		
<i>Inosperma maculatum</i>					+							
<i>Lactarius acris</i>							+					
<i>L. citriolens</i>								+				
<i>L. deliciosus</i>	+		+					+			+	
<i>L. piperatus</i>							+	+	+			
<i>L. pyrogalus</i>								+				
<i>L. volemus</i>							+	+	+	+		
<i>L. zonarius</i>							+	+				
<i>Leccinellum griseum</i>							+					
<i>L. pseudoscabrum</i>								+	+	+		
<i>Leccinum crocipodium</i>							+	+	+			
<i>Neoboletus erythropus</i>							+	+				
<i>Pseudosperma rimosum</i>									+	+		
<i>Rheubarbariboletus armeniacus</i>								+				
<i>Rubroboletus legaliae</i>							+					
<i>R. lupinus</i>							+					
<i>R. satanas</i>						+	+	+	+	+		
<i>Russula albonigra</i>							+	+		+		

	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>R. delica</i>									+		+		
<i>R. foetens</i>									+	+			
<i>R. olivacea</i>									+		+		
<i>R. minutula</i>								+					
<i>R. sanguinaria</i>								+	+	+			
<i>R. turci</i>										+			
<i>R. virescens</i>									+				
<i>Suillellus luridus</i>						+	+	+	+	+	+	+	
<i>S. queletii</i>								+	+	+			
<i>Suillus collinitus</i>									+	+			
<i>S. granulatus</i>		+		+					+		+	+	+
<i>S. luteus</i>											+	+	
<i>S. luteus f. albus</i>											+	+	
<i>Tuber aestivum</i>						+							
<i>Xerocomus chrysenteron</i>								+	+				
<i>X. subtomentosus</i>								+		+	+		

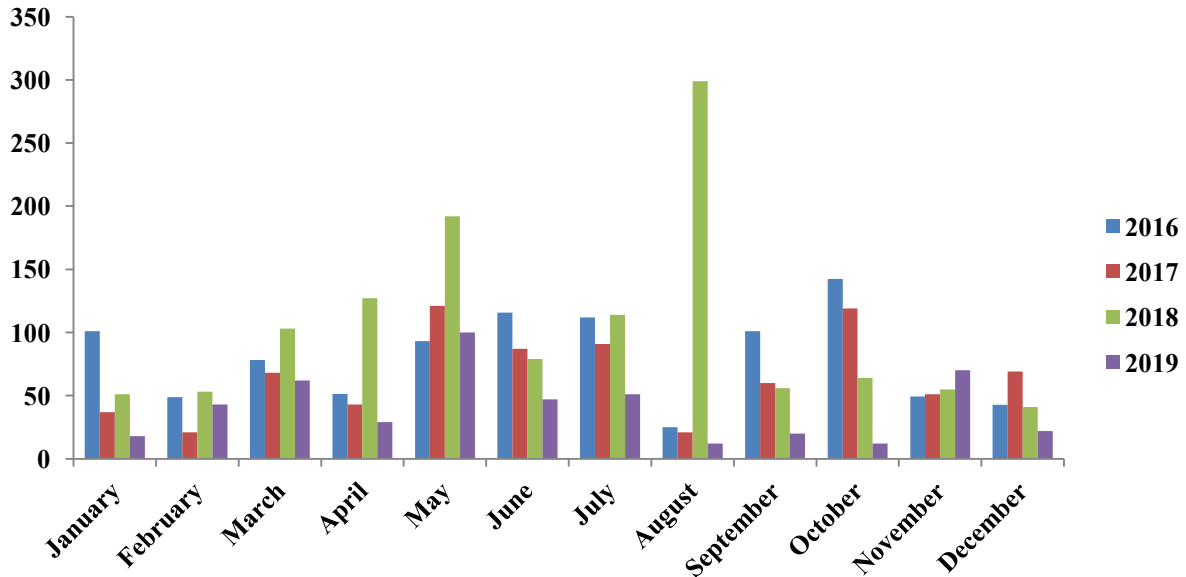


Figure 3. Annual humidity chart (mm): data for 2016, 2017, 2018 years was obtained from the National Hydrometeorology Department of the Ministry of Ecology and Natural Resources, for 2019 from the site World Weather Online.

about 41 mm of precipitation was observed. In 2019, a drier climate was observed than in the other three years. January precipitation averaged about 18 mm. The amount of precipitation fluctuated until May, reaching its peak this month (100 mm). The lowest annual rainfall was 12 mm in August and October. In December, the lowest amount (20 mm) of precipitation was observed compared to the same month of other years.

CONCLUSION

Mycorrhizal fungi are dominant components of

forest ecosystem, where members of Betulaceae, Dipterocarpaceae, Fagaceae, Myrtaceae, Pinaceae, Ulmaceae and Salicaceae are abundant [Funga Nordica, 2012]. Mycorrhizal associations proved to be evolutionary stable, despite the fact that the mechanism is not fully understood [Van der Heijden et al., 2015]. These associations increase water absorption and plant resistance to pathogens and other environmental stresses. Eventually such plant species has a positive impact on reproduction and spores dissemination, growth, and survival of different fungal taxa [Eom et

al., 2000; Mohammadi et al., 2011].

In this article we reported distribution of 59 mycorrhizal taxa and their hosts. Among mushroom species some of them represent food significance, there are many edible and poisonous species. Edible mushrooms such as *Boletus aereus*, *B. edulis*, *B. edulis* var. *arenarius*, *B. edulis* f. *quercicola*, *B. reticulatus*, *Butyriboletus appendiculatus*, *Cantharellus cibarius*, *C. subalbidus*, *Lactarius deliciosus*, *Leccinum carpini*, *Russula virescens*, *Tuber aestivum* are considered delicacies and eagerly collected by mushroom lovers. Also some *Amanita* species are edible and tasty, for example *A. crocea* and *A. vaginata*. Few mycorrhizal fungi (*Boletus purpureus* and *Suillellus luridus*) are non-edible. Also many poisonous mushrooms including lethal ones are known among found mycorrhizal symbionts. In Shaki district these are *Amanita pantherina*, *A. phalloides*, *Hebeloma sinapizans*, *Inosperma maculatum*, *Pseudosperma rimosum* and *Rubroboletus satanas*.

Mushrooms were little consumed as food and did not have much importance as edible product until the last two decades in Azerbaijan. Even now mushroom lovers know and collect only few species and these are mainly *Agaricus campestris* L., *Morchella esculenta* (L.) Pers., *M. conica* Pers., *Suillus granulatus* (L.) Roussel and *S. luteus* (L.) Roussel. The selling of cultivated mushrooms (*Agaricus campestris*, *Pleurotus ostreatus* (Jacq.) P. Kumm., *Lentinus edodes* (Berk.) Singer) has begun in recent years. Unfortunately the most of the Azerbaijan population does not know the edible mushrooms well, that leads to many deadly accidents each year. From this point of view this study is important for the country's mushroom wealth, as well as for introducing a wide audience the number of species.

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- Azərbaycanın Şəki rayonunda ağaclarla assosiasiyada olan mikorizalı göbələklər**
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- Son taksonomik və nomenklatur dəyişikliklər nəzərə alınmaqla Azərbaycanın Şəki rayonunda Ascomycota (Pezizales) və Basidiomycota (Agaricales, Boletales, Cantharellales, Gomphales, Russulales, Thelephorales) şöbələrinin 13 fəsilə, 27 cinsinə aid 59 papaqlı göbələk taksonu (55 növ, üç forma, bir variasiya) qeydə alınmışdır. Tədqiqat ərazisində *Boletus*, *Lactarius* və *Russula* cinsləri növ sayına görə dominantlıq edirlər. Mikorizalı göbələklərin hündürlükdən asılı olaraq yayılması, mövsümi rast gəlməsi taksonomik strukturu təhlil olunmuşdur. *Amanita crocea* (Quél) Singer, *Lactarius citriolens* Pouzar və *L. pyrogalus* (Bull.) Fr. Azərbaycan üçün yeni növlərdir.
- Açar sözlər:** hündürlük, göbələk, bitki, mövsümlülük, ixtisaslaşma, növ
- Микоризные грибы ассоциируемые с деревьями в районе Шеки Азербайджана**
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- На основе последних таксономических и номенклатурных изменений было выявлено всецело 59 так-

сонов (55 видов, три формы, одна вариация) грибов из 27 родов, 13 семейств, относящихся к отделам Ascomycota (Pezizales) и Basidiomycota (Agaricales, Boletales, Cantharellales, Gomphales, Russulales, Thelephorales) распространенных в районе Шеки Азербайджана. Рода *Boletus*, *Lactarius* и *Russula* доминируют по числу видов в районе исследования.

Проанализирована встречаемость микоризных грибов в зависимости от высоты, сезонности и таксономической структуры. *Amanita crocea* (Quél) Singer, *Lactarius citriolens* Pouzar и *L. pyrogalus* (Bull.) Fr. являются новым для Азербайджана.

Ключевые слова: высота, гриб, растения, сезонность, специализация, вид