BAKI UNİVERSİTETİNİN XƏBƏRLƏRİ

№1 ***Təbiət elmləri seriyası*** ***2015***

ECOLOGY AND DISTRIBUTION OF MUSHROOM SPECIES BELONGING TO THE GENERA *Boletus* AND *Xerocomus* IN AZERBAIJAN

***M.B.MERELAS, **D.N.AGHAYEVA, **A.S.SADIGOV**

**Universidade da Coruña. Campus da Zapateira. 15071 - A Coruña, Spain*

***nstitute of Botany, Azerbaijan National Academy of Sciences. 40, Badamdar highway,*

belen.mmeijide@gmail.com, adilzara@hotmail.com

Boletus Dill. ex Fr. and Xerocomus Quél. are phylogenetically closely related genera. These genera include numerous species. The purpose of this study was to characterize specimens belonging to these genera collected in various parts of Azerbaijan based on morphological features. The genus Boletus was identified as B. calopus, B. appendiculatus, B. edulis, B. erythropus, B. luridus and B. purpureus. The genus Xerocomus is represented with X. badius, X. chrysenteron, X. rubellus, X. spadiceus and X. subtomentosus species. Ecological characteristics and distribution of species belonging to both genera are also studied.

Key words: species, morphology, ecology, Boletus, Xerocomus

The genera *Boletus* Dill. ex Fr. and *Xerocomus* Quél. reside to Boletales (Agaricomycetes, Basidiomycota). Boletales characterized with a large diversity of forms of fruiting bodies. Namely, there has been extensive homoplasy in the evolution of this group [Binder, Hibbett 2006]. Within section *Boletus,* the species concept and species delimitation has been a matter of dispute, resulting in a fairly large number of specific and infraspecific names and a complex nomenclatural history [Beugelsdijk et al. 2008]. Many classifications have been made according to the different characters studied but experts have been unable to reach a consensus. Relationships of species among the genus have considerably been clarified by molecular data [Leonardi et al. 2005; Beugelsdijk et al. 2008; Dentinger et al 2010].

The genus *Boletus* was described by Linnaeus in 1753 in his famous scientific work - “Species Plantarum”. The genus represents a monophyletic group composed by more than 100 described species of mushrooms worldwide [Kirk et al. 2001]. The genus includes species with morphological features, such as fully developed hymenophoral trama, gelatinous, loosely arranged lateral strata, with hyphae distinctly distant each other. Pores roundish and mi-

nute, usually smaller than 1 mm, tubes at maturity up to 20-35 mm long, depressed around the stipe, sometimes almost free, not recurrent. Spore surface smooth, pileus surface usually slightly viscid or at least somewhat sticky when wet, lateral stipe stratum in favorable conditions more or less gelatinous and general appearance usually boletoid and fruit bodies mostly relatively robust and fleshy.

The genus *Xerocomus* was first described by C. Linnaeus in 1753 as *Boletus subtomentosus* L. and later in 1888 the name of species was changed to *Xerocomus subtomentosus* by Quélet. The concept of the genus is not clear and represents a heterogeneous mixture of several groups of species. Groups within the genus separated from each other by mainly anatomical and some other characters [Singer 1986; Ladurner, Simonini 2003; Šutara 2008]. The common features of species within the genus include phylloporoid hymenophoral trama with non gelatinous lateral strata and densely arranged hyphae, touching or almost touching each other. Pores at maturity angular, relatively large 1-3 mm, tubes at most 15 mm long, nearly adnate or somewhat depressed around the stipe and decurrent with a tooth. Spore surface bacillate. Pileus surface neither viscid nor sticky when wet, lateral stipe stratum never gelatinous. General appearance xerocomoid and fruit bodies relatively slender and less fleshy [Šutara 2008].

Nowadays still being many problems to get a conclusion about the taxonomy of some species that in past were considered as *Boletus* and in present are inside the *Xerocomus* genus or vice versa. The recent opinions on the taxonomic status of *Xerocomus* are very controversial. Some mycologists consider *Xerocomus* to be a good separate genus [Singer 1986; Engel et al. 1996; Lannoy, Estades 2001; Peintner et al. 2003; Ladurner, Simonini 2003], whereas some other authors do not accept it at the generic level [Watling 1968, Watling et al. 1970; Smith, Thiers 1971; Kirk et al. 2001; Watling, Hills 2005; Leggon, Henrici 2005].

In conclusion, there is as yet no agreement on the criteria that should be used to separate *Xerocomus* from *Boletus* [Hills 2009]. It is clear that there are differences between the genera but their limits are unclear. The aim of this work is to contribute to the taxonomic knowledge of the morpho-species of *Boletus* and *Xerocomus* occurring in the territory of Azerbaijan and study the ecological characteristics and distribution frequency of species belonging to these genera.

Materials and Methods

In the present work six species belonging to the genus *Boletu*s and five species of the genus *Xerocomus* were studied (Table). The study was based on air dried material due to the impossibility to collect fresh specimens. The air dried herbarium specimens were withdrawn from the Mycological Herbarium (MH), Institute of Botany, ANAS, Baku.

Table

***Boletus* and *Xerocomus* species used in this study**

Name	Collection	Location	Habitat
1	2	3	4
Boletus appendiculatus Schaeff.	MH159	Lankaran	Ironwood-oak forest
	MH160	Lankaran	Alekseyevka oak forest
B. calopus Pers.:Fr.	MH172	Lankaran	Hirkan National Park
B. edulis Fr.	MH161	Khachmaz	Yalama oak forest
	MH162	Khachmaz	Yalama oak-hornbeam forest
	MH163	Shamakhy	Pirqulu National Park
	MH166	Lankaran	Alekseyevka ironwood-oak forest
	MH167	Lankaran	Alekseyevka ironwood-oak forest
	MH170	Khachmaz	Yalama oak-hornbeam forest
	MH171	Qabala	Deciduous forest
	MH1356	Khachmaz	Yalama mixed forest
B. erythropus Fr.	MH173	Khachmaz	Yalama forest
	MH174	Lankaran	Alekseyevka oak forest
	MH175	Lankaran	Alekseyevka oak forest
B.luridus Schaeff.:Fr.	MH176	Absheron	Ceyranbatan forest
	MH177	Khachmaz	Yalama
	MH178	Khachmaz	Yalama oak forest
	MH179	Khachmaz	Yalama oak forest
	MH180	Ismayilly	Topchu mixed forest
	MH181	Khachmaz	Oak-hornbeam forest
B. purpureus Pers.	MH169	Lankaran	Hirkan National Park
	MH1357	Lankaran	Hirkan National Park
Xerocomus badius Fr.Gibb	MH220	Khachmaz	Yalama hornbeam-oak forest
	MH221	Khachmaz	Muxtadir broad-leaved forest
	MH222	Baku	Central Botanical Garden
X. chrysenteron (Bull) Sutara	MH214	Khachmaz	Yalama hornbeam-oak forest
	MH215	Khachmaz	Yalama oak forest
	MH216	Lankaran	Hirkan National Park
	MH217	Lerik	Mixed forest
	MH218	Lankaran	Hornbeam-oak forest
	MH1391	Khachmaz	Yalama hornbeam-oak forest
	MH1394	Baku	Central Botanical Garden
X. rubellus (Krombh) Quel.	MH1360	Khachmaz	Yalama hornbeam-oak forest
X. spadiceus (Fr.) Quel.	MH223	Khachmaz	Hornbeam Yalama forest
	MH224	Lankaran	Hirkan National Park
	MH225	Shaki	Forest surrounding Shaki
X.subtomentosus Fr.	MH226	Ismayilly	Topchu mixed forest
	MH227	Qabala	Mixed forest
	MH228	Khachmaz	Yalama oak forest
	MH231	Khachmaz	Yalama oak forest
	MH232	Khojavend	Open area in the forest

The samples are documented with appropriate field notes including location and the number of the collection or reference. The main characters used for the identification of the specimens were the size of the mushroom, the color, the cap, the pores and the stalk. The spore color and spore size were analyzed under the light microscope [Motic® DMB series]. The study of the morphological characteristics and the description of the specimens based on macroscopic and microscopic features of *Boletus* and *Xerocomus* species were performed according to the appropriate identification guides [Knudsen, Taylor 2008; Arora 1986; Sadıqov 2004].

The measurement values for basidiospores are presented as minimum and maximum values (min- ± σ -max) for length and width respectively [Assayov, Stoykov 2011]. Ecology and distribution of fungi were analysed according to large physiographic regions within Azerbaijan (Great Caucasus including Absheron, Minor Caucasus and Lankaran).

Results and Discussion

Six *Boletus* species and five *Xerocomus* species have been analysed based on their main characters. Color and shape of spores are regarded as important characters in the delimitation of species within the genera. Histograms represent comparative means of the mean or average of the spores (Figs. 1, 2).

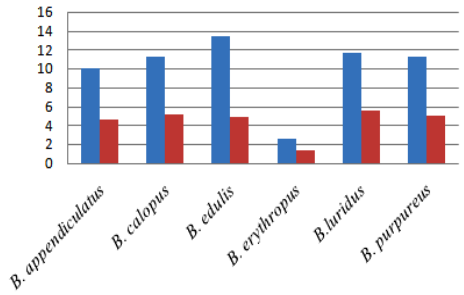

Fig. 1. Spore size differences in *Boletus* species.

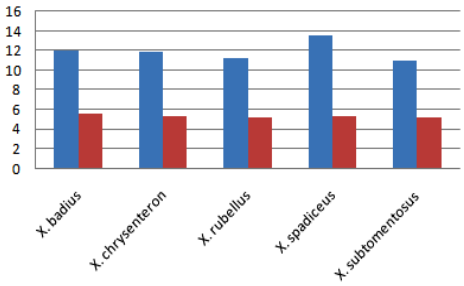

Fig. 2. Spore size differences in *Xerocomus* species.

Based on herbarium data, the distribution map of the species belonging to the genus *Boletus* and *Xerocomus* has been performed (Fig. 3). It helps to analyze the type of habitat for each species.

Beginning with the species belonging to the *Boletus* genus we can observe that most part of species are widely distributed in the north part of the country. This region is the one which is wetter and that present the main surface of forest within the country. In this region we can find the species *B. edulis*, *B. erythropus* and *B. luridus*. *B. edulis* has a wide ecological range, being associated with numerous different partners, both deciduous and coniferous trees.

The southern and center part of the country shows a different type of climate and type of vegetation. Broad-leaved forests are spread more in the Great and Minor Caucasus, the Talysh Mountains. In these regions we can find the species *B. appendiculatus*, *B. calopus*, *B. edulis*, *B. erythropus* and *B. purpureus. B. luridus* is widely distributed in the country. It is also distributed along the Caspian Sea shore including the region of Absheron peninsula, where vegetation mainly consists of psammophyte-littoral type.

Based on the number of specimens collected in the different regions of the territory of Azerbaijan, was performed the diagram representing the abundance of each species in Azerbaijan for the genera *Boletus* and *Xerocomus* (Figs 4, 5).

In the first graphic we can observed that the region which presents the greatest abundance of species is Lankaran, which is the richest region in biodiversity of *Boletus* with 5 species in Azerbaijan, followed by Khachmaz, situated in the north part of Great Caucasus, with 3 species.

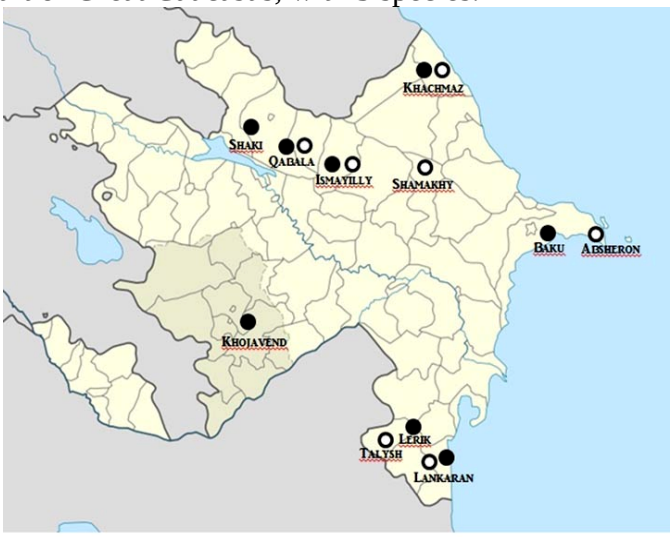

Fig. 3. Distribution of *Boletus* and *Xerocomus* species within Azerbaijan territory. White circles indicated distribution area of *Boletus* and black circles of *Xerocomus* species.

Fig. 4. Distribution of *Boletus* species in Azerbaijan.

Khachmaz Shamakhy Ismayilly
Qabala Absheron Lankaran

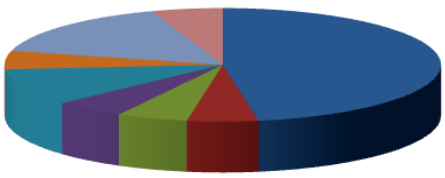

Fig. 5. Distribution of *Xerocomus* species in Azerbaijan.

Khachmaz Ismayilly Qabala Shaki
Absheron Khojavend Lankaran Lerik

The larger number of specimens collected in the territory belongs to the *B. edulis*. The species is wide-spread and we can find it along virtually the entire territory of Azerbaijan. *B. luridus* is also abundant in the territory, found mainly in the region of Great Caucasus and in Abseron. *B. erythropus* have been registered in north and in south part of country. *B. appendiculatus*, B. *calopus* and *B. purpureus* have been found only in Lankaran district. The distribution map for the *Xerocomus* species follows more or less the same pattern as *Boletus* species. Specimens where collected in the north part of the country, in Great Caucasus: Ismayilly, Qabala and Shaki districts; in Absheron, specifically in the Central Botanical Garden. There are also samples collected in Lankaran region: Lankaran and Lerik districts; and in the Minor Caucasus: Kojavend.

Because of its altitude and the variety of forest the Great Caucasus region, especially Khachmaz district is the richest with xerocomoid mushrooms. The most abundant species is *X. chrysenteron* which is distributed mainly in the north, around Khachmaz district, in Lankaran region and in Absheron. *X. subtomentosus* is the second wide-distributed species in the country, appearing mainly in Great (Khachmaz, Ismayilly, Qabala) and Minor Caucasus (Khojavend). Other species such as *X. badius* and *X. spadiceus* are less abundant. *X. rubellus* registered only in the north of the country. Therefore, due to the absence of any other additional information or other stocktaking studies, it may be interpreted that the north part of Azerbaijan is the only region of natural distribution for this *X. rubellus*.

The territory of Azerbaijan is distinguished by a high level of biodiversity. Therefore, there is a serious need to study and protect rare ecosystems and unique genetic resources. According to the Global Strategy for Plant Conservation of the Convention on Biological Diversity [CBD, 1992], the protection of endangered species is a major task of today. One of the effective methods of protection of endangered species is the compilation of a Red Book. The second edition of the Red Book of the Republic of Azerbaijan includes 14 species of mushrooms. The only *Boletus* species that is included to the Red Book is *B. calopus*. The National IUCN Status for *B. calopus* is VU D2, which means that this species is vulnerable and shows a very small population and restricted distribution in Azerbaijan (Sadıqov, 2004). Based on current study we suggest inclusion another *Boletus* species – *Boletus purpureus* to the next edition of the Red Book of Azerbaijan.

Acknowledgment

The first author thanks to the Trans-European Mobility Project on Education for Sustainable Development (TEMPO), financially supported by Erasmus Mundus Program of the European Union (2009-2013) and the Institute of Botany, ANAS for providing herbarium materials.

REFERENCES

1. Azərbaycan Respublika-sının Qırmızı kitabı. Nadir və nəsli kəsilməkdə olan bitki və göbələk növləri. II nəşr. Bakı: Şərq-Qərb, 2013, 676s.
2. Sadıqov A.S. 2004. Azərbaycan mikobiotası üçün yeni makromisetlər // AMEA Botanika Institutunun əsərləri. Bakı: Elm, 2004. cild XXV. S.255-257.
3. Arora D. 1986. Mushrooms demystified. Berkeley: Ten Speed Press, 2nd edition. Pp. 15-16; 517-530.
4. Assayov B., Stoykov D. 2011. *Boletus bubalinus* (Boletaceae). A New Addition for the Bolete Mycota of Bulgaria and the Balkans. Institute of Biodiversity and Ecosystem Research // The Bulgarian Academy of Sciences, 64(11): 1583-1588.
5. Beugelsdijk D.C.M., van der Linde S., Zuccarello G.C., den Bakker H.C., Draisma S.G.A., Noordeloos M.E. 2008. A phylogenetic study of *Boletus* section *Boletus* in Europe // Persoonia 20: 1–7.
6. Binder M., Hibbet D.S. 2006. Molecular systematics and biological diversification of Boletales // Mycologia, 98 (6), pp. 971-981.
7. Dentinger, B.T.M., Ammirati, J.F., Both, E.E., Desjardin, D.E., Halling, R.E., Henkel, T.W., Moreau, P-A., Nagasawa, E., Soytong, K., Taylor, A.F., Watling, R., Moncalvo, J-M.& McLaughlin, D.J. 2010. Molecular phylogenetics of porcini mushrooms (*Boletus* section *Boletus*) // Molecular Phylogenetics and Evolution 57: 1276–1292.
8. Den Bakker H.C., Gravendeel B., Kuyper T.W. 2004. An ITS phylogeny of *Leccinum* and an analysis of the evolution of minisatellite-like sequences within ITS1 // Mycologia 96: 102–118.
9. Engel H., Dermek A., Klofac W., Ludwing E. 1996. Schmier- und Filzröhrlinge s.l. in Europa. Weidhausen. p. 268, 56 pl.
10. Hills A.E. 2009. The genus *Xerocomus*. A personal view, with a key to the British species // British Mycological Society. 9 (3): 77-96.
11. Kirk P.M., Cannon P.F., David J.C., Stalpers J.A. 2001. Ainsworth and Bisby's Dictionary of the Fungi. 9th ed. Cambridge, United Kingdom: CAB International University Press. 655p.
12. Knudsen H., Taylor A. 2008. *Boletus*.- In: Kundsen, H., Vesterholt, J. (eds.): Funga Nordica, 163-168.
13. Lannoy G., Estades A. 2001. Les Bolets. Flore mycologiques d'Europe. 6, p. 1-161, 6pl. Lille.
14. Leggon N.W., Henrici A. 2005. Checklist of the British & Irish Basidiomycota. Kew. p. 517.
15. Leonardi M., Paolocci F., Rubini A., Simonini G., Pacioni G. 2005. Assessment of inter- and intra-specific variability in the main species of *Boletus edulis* complex by ITS analysis // FEMS Microbiol Lett. 243(2):411-6.
16. Peintner U., Ladurner H., Sominini G. 2003. *Xerocomus cisalpinus* sp. nov., and the limitation of species in the *X. chrusenteron* complex based on morphology and rDNA-LSU sequences // Mycol. Res. 107(6): 659-679.
17. Singer R. 1986. The Agaricales in modern taxonomy. 4th ed. Königstein, Germany: Koeltz Scientific Books. p. 981.
18. Smith A.H., Thiers H.D. 1971. The Boletes of Michigan. Ann Arbor, Michigan: University of Michigan Press. 428 p.
19. Šutara J. 2008. *Xerocomus* s.l. in the light of the present state of knowledge. Czech Mycol. 60(1): 29-62.
20. The Red Book of The Republic of Azerbaijan. Rare and endangered plant and mushhroom species. 2nd publication. Baku: Şərq-Qərb, 2013. C. 274-278
21. Watling R. 1968. Records of Boleti and notes on their taxonomic position // Notes Roy. Bot. Gard. Edimburgh 28(3): 301-315.
22. Watling R., Henderin D.M., Orton P.D. 1970. Boletaceae, Gomphidiaceae, Paxillaceae. In: Henderson, D.M., Orton, P.D. & Watling, R. [eds]. British Fungus Flora. Agarics and Boleti. Edimburgh: Royal Botanic Garden 1: 1-125.

23. Watling R., Hills A.E. 2005. Boletes and their allies. In: Henderson, D.M., Orton, P.D. & Watling, R. [eds]. British Fungus Flora. Agarics and boleti. Vol. **1**. Edinburgh: Royal Botanic Garden, p. 1-173.
24. The Republic of Azerbaijan. 2004. Country Study on Biodiversity and First National Report. Chapter 6. Existing Measures and Programmes for Biodiversity Conservation. Pp. 79-136.

AZƏRBAYCANDA *BOLETUS* VƏ *XEROCOMUS* GÖBƏLƏK CİNSLƏRİNƏ AİD NÖVLƏRİN EKOLOGİYASI VƏ YAYILMASI

M.B.MERELAS, D.N.AĞAYEVA, A.S.SADIQOV

XÜLASƏ

Boletus Dill. ex Fr. və *Xerocomus* Quél. filogenetik olaraq yaxın cinslərdir. Bu cinslərə çoxsaylı növlər daxildir. Tədqiqat işinin məqsədi bu iki cinsə aid Azərbaycandan toplanılan nümunələri morfoloji əlamətlərə görə xarakterizə etməkdir. *Boletus* cinsinə aid nümunələr *B. appendiculatus, B. calopus, B. edulis, B. erythropus, B. luridus* və *B. purpureus* kimi təyin edilmişdir. *Xerocomus* cinsi *X. badius, X. chrysenteron, X. rubellus, X. spadiceus* və *X. subtomentosus* növləri ilə təmsil olunmuşdur. Hər iki cinsə aid növlərin ekoloji xüsusiyyətləri və yayılması öyrənilmişdir.

Açar sözlər: növ, morfologiya, ekologiya, Baletus, Xerocomus

ЭКОЛОГИЯ И РАСПРОСТРАНЕНИЕ ГРИБОВ ИЗ РОДОВ *BOLETUS* И *XEROCOMUS* В АЗЕРБАЙДЖАНЕ

М.Б.МЕРЕЛАС, Д.Н.АГАЕВА, А.С.САДЫХОВ

РЕЗЮМЕ

Boletus Dill. ex Fr. и *Xerocomus* Quél. филогенетически близко стоящие роды. Эти роды включают многочисленные виды. Цель данного исследования - охарактеризовать экземпляры относящиеся к этим родам, собранные в различных частях Азербайджана по морфологическим особенностям. Виды рода *Boletus* были идентифицированы как *B. appendiculatus, B. calopus, B. edulis, B. erythropus, B. luridus* и *B. purpureus*. Род *Xerocomus* представлен видами *X. badius, X. chrysenteron, X. rubellus, X. spadiceus* и *X. subtomentosus*. Изучены также экологические особенности и распространение видов обоих родов.

Ключевые слова: вид, морфология, экология, Baletus, Xerocomus

Redaksiyaya daxil oldu: 17.02.2015-ci il
Çapa imzalandı: 21.04.2015-ci il