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ORIGINAL SCIENTIFIC PAPER

Phytocoenological and ecological typification of the March Mushroom (*Hygrophorus marzuolus* (Fr.) Bres.) habitat in Bijambare, Sarajevo Canton

Fitocenološka i ekološka tipifikacija staništa martovke (*Hygrophorus marzuolus* (Fr.) Bres.) u Bijambarama, Kanton Sarajevo

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ABSTRACT

Biodiversity of mushrooms in FBiH is poorly researched, as well as the areas of distribution and ecological conditions under which mushrooms develop. This is also the case with the March Mushroom, so the main goal of the paper is to present the ecological conditions under which it develops. For the research, we used the Braun-Blanket (1932) method with all necessary parameters related to the selected habitat. These are: phytocenological affiliation, flora element, indicator value, and life form. The abundance of fungi was provided according to Tortić and Lisiewska (1971). Chemical analysis of the soil with basic parameters was also done. March Mushroom was detected in the *Abieti-Fagetum* in the locality of Motike within the "ZP Bijambare". This is the new site for the March Mushroom. Primary indicator values prevail in the association. Species of the order *Fagetalia* are the most numerous within the researched association. Hemicryptophytes prevail among the life forms. A total of 25 floral elements from 9 groups were determined. The largest number of species belongs to the sub-Atlantic-sub-Mediterranean group. The floral element with the largest number of determined species is subatl-smed. Fortunately, this locality is quite far from hiking trails, which is important, considering it as an extremely rich site of the March Mushroom.

Key words: *March Mushroom, biodiversity, mushrooms, Bijambare, forest*

INTRODUCTION – *Uvod*

Biodiversity of mushrooms in FBiH is poorly researched. The areas of distribution and ecological conditions under which mushrooms fructify are even less researched. The aim of the paper is to provide new data on the distribution and ecological conditions under which March Mushroom appears.

Morfological and anatomical characteristics of the March Mushroom

According to Canduso (1997) March mushrooms has the following morfological and anatomical characteristics: cap 30-120 (150) mm, convex, convex plane, waxy, hemispherical, irregular, brown, brown gray, slate-light gray to blackish. The stem is cylindrical, stocky, compre-

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ssed, gibbous, curved, firm, very irregular, full, then it has a fistulous cavity, especially at the base, pale gray or witish. The flesh is tenacious, fibrous, consistent thtoughout the carpophore, white-greyish, grey, hygrophane; it has a light smell of withered and tastes pleasant. Gills are broadly adnate, sinuous, thich, spaced apart, subdeccurent, whitish, white-greyish, grey, waxy. Spore prints are white. Spore 6,5-8 x 4-5,5 µm, elliptical, ovoidal, smooth, with large apicle. Basidi 55-70 x 6-8 µm, club-shaped, subcilindrical, tetrasporic, with very slender basidies.

Palacios et al (2011) provide data about content of phenol and the antioxidant effect in March mushroom. Sulkowska-Zlaja et al (2018) give the information that *Hygrophorus marzuolus* (Fr.) Bres., *Boletus edulis* Bull. ex Fr., *Calocybe gambosa* (Fr.) Singer ex Donk and *Lactarius deliciosus* (L. ex Fr.) S. F. Gray, contain the high content (about 15 mg/g DM) of one the most active antioxidants in mushrooms-caffeic acid.

Ecology of the March Mushroom

Cetto (2008) points out that March Mushroom fruits "on acid soil, beneath conifers, oaks, and chestnuts, hidden by the dead leaves and that it is a typical early spring mushroom". Hasanbegović (2008) states that it grows "in thinned mixed forests, near fir, beech, oak, and chestnut". Uščuplić (2012) points out that it grows in "early spring during the snow melting", and as a habitat, he points out "mountain coniferous forests, especially spruce ". According to Focht (1979), March Mushroom grows near beech and fir, in pure pine and spruce stands, and even in a mixed sweet chestnut and oak forests. According to the same author (Focht, 1990), March Mushroom grows in a period I-V month, depending on the heat and insolation.

Distribution in the world

Tkalčec et al. (2008) point out that the March Mushroom is widespread in Europe, north Africa (Morocco), and North America, and that it has not been recorded in North Europe and in the area of evergreen vegetation of the Mediterranean part of Europe. March Mushroom is spread in following countries: Italy (Bianchi, 2022), Czech (Tejklova & Kramoliš, 2017), Spain (Martinez Pena & Altelarrea, 2007), Hungary (Zajta, 2012), Switzerland (Breitenbach & Kränzlin, 1991), Germany and Austria (Hennig, 1964), Great Britain (Bingham, 2023), Greece (Psalida & Argyropoulos, 2023) Montenegro (Kasom & Miličković, 2021), North Macedonia (Karadelev & Rusevska, 2012), Serbia (Ivančević et al, 2012), Romania (Tanase & Pop, 2005), Slovakia (Lizon, 2001), Slovenia (Poler, 2018), France (Eyssartier & Roux, 2017), Turkey (Akata, 2017) and in other Europian countries. Razaq and Shahzad (2005) give a new record in Pakistan.

Distribution in BiH

Tortić (1970) mentions that the March mushroom was found in Bosnia in one locality but without specific data where. Focht (1979) mentions the Kasindol site near Sarajevo. The same author (Focht, 1992) provides information about the presence of this species also in eastern Bosnia. Hasanbegović and Ademović (2021) find it at the Nišići plateau in the *Abieti-Piceetum* forest, Hasanbegović (2022) finds it in a planted Scots pine forest at the locality of Donji Mišević.

Protection of the March Mushroom in BiH and the surrounding region

It should be emphasized that the March mushroom is a protected species in many European countries, e. g. in Croatia- it has a status of endangered species (Tkalčec et al, 2008), in Montenegro it is on the preliminary Red List (Perić et al, 2001) but Kasom and Miličković (2010) put March mashroom on the "List of protected species of Macrofungi in Montenegro", in North Macedonia has status EN (Karadelev & Rusevska, 2012), in Serbia "strictly protected fungal species" (Ivančević et al, 2012) and in Bosnia and Herzegovina it also has the status of the endangered species (Đug et al, 2013).

MATERIAL AND METHODS – *Materijal i metode rada*

Sporocarps of the target species (March Mushroom) were traced in the field during its fructifying season in the year 2021. For each collection site of the March Mushroom, a phytocoenological record was made following the Braun-Blanquete (1932) method. The floral elements, life forms, indicator values and phytocoenological affiliation of plants were provided according to Oberdorfer (2001), Raunkiaer (1937) and Pavlović-Murarspahić (1995). For determining phytocenosis, Stefanović (1986) and Barudanović et al (2015). The number of mushrooms in the table has been given according to Tortić and Lisiewska (1971): ++ few samples, and +++ many samples. The altitude has been recorded using the "Magelan eXplorist 500"GPS device. The terrain inclination has been determined with the clinometer from the "Recta DP 6 GLOBAL"compass.

The researched locality is found within the "Bijambare" protected area, in a locality called Motike, in a fir-beech

forest. It is located in the north-eastern part of the protected area, between the coordinates 18° 30' 40" and 18° 30' 42" E, and 44° 00' 82" and 44° 00'84" N. Hypsometrically, the researched area belongs to the zone of 1.000 to 1.500 m altitude (Đug et al (2008)). Geologically, the area belongs to the Lower Triassic (Čičić, 1984, Čičić & Skopljak, 2008), and, as far as tectonis is concerned, it is located in the zone of the inner Dinarides (Čičić, 1984).

Map 1. Position of the researched locality: red-1st, green-2nd, blue-3rd and yelow-4th (the map taken from Google Earth Pro)

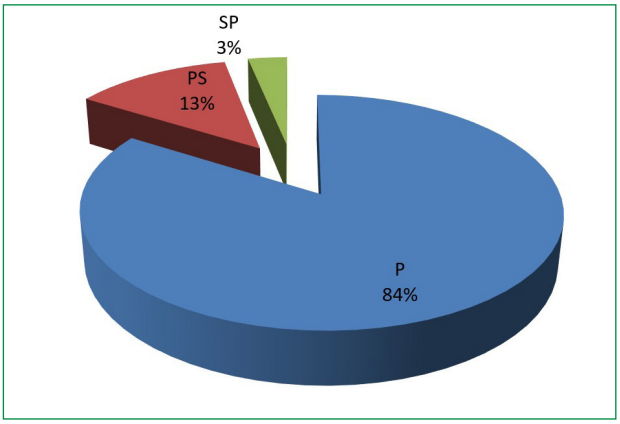
Karta 1. Položaj istraživanog lokaliteta: crveni-prvi, zeleni-drugi, plavi-treći i žuti-četvrti (karta preuzeta od Google Earth Pro)

According to Milosavljević (1970),this area is classified into the zone that during the vegetation period (March-October) has an average number of days with frost over 31, and a maximum number of days with frost (4-7) in a period when the vegetation has the most lush character (May). According to the same author (Milosavljević, 1976) this area belongs to the zone with increased air humidity. According to Đug et al (2008), the researched area belongs to the Dfbx" climate subtype which denotes humid boreal climate with warm summer and no dry period. Milosavljević (1968) points out that this area belongs to the zone with 1800-1900 hours of sunlight annualy. As far as the hydrothermal coefficient of the soil is concerned, the same author (Milosavljević, 1977), provides data on the state of soil moisture in the researched area, so it is wet during May and, moderately wet from June to September.

The soil is podzol. Chemical soil analysis were performed: pH (H2O), pH (KCl), humus (%), P2O5 and K2O (mg/100). A pH meter (ISO 10390) was used to determine the pH value. The humus content in the coil was determined by the dichromate method (ISO 14235), the reading was performed on a Thermo Spectronic Genesys 20 spectrophometer, the content of easily accessible forms K and P in the soil samples was determined by amonium lactate (AL) method (Egner et al, 1960), and, P content was determined on a Thermo Spectronic Genesys 20 spectrophometer, and K on a Microprocessor Flame photometer 671 Labtronics.

RESULTS AND DISCUSSION – *Rezultati i diskusija*

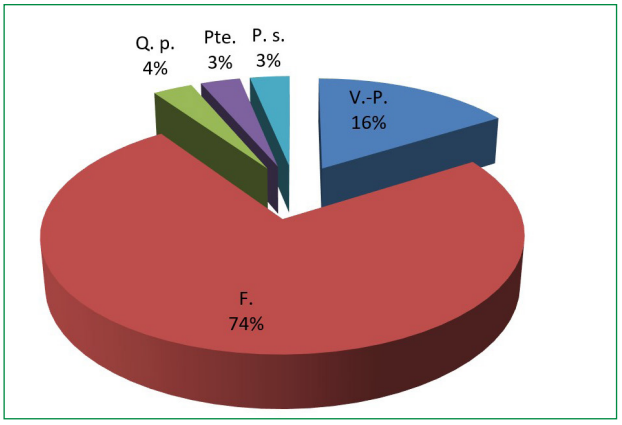
A total of 31 plant species from 25 families were found. Slightly more species, four, were found only from the family *Rosaceae*.



Graph 1. Ratio of indicator values in the researched *Abieti-Fagetum* vegetation (in %)

Grafikon 1. Odnos indikatorskih vrijednosti u istraživanoj vegetaciji Abieti-Fagetum (u %)

From the graph 1, it can be seen that the primary values far exceed the others. One could also read from the data that the anthropogenic influence is relatively small, for if it was present in a larger scale, it would be shown in the increased number of other values, and the reduced number of primary species.



Graph 2. Ratio of phytocenological affiliation in the researched vegetation

Grafikon 2. Odnos fitocenološke pripadnosti u istraživanoj vegetaciji

Table 1. Phytocoenological table of the researched vegetation

Tabela 1. Fitocenološka tabela istraživane vegetacije

Locality	**Bijambare-Motike**							
Altitude (m)	**1021**	**1032**	**1029**	**1028**				
Exposition	**W-SW**	**W-SW**	**W**	**W**				
Inclination (°)	**20**	**10**	**20**	**15**				
Geological basis	**Limestone**							
Soil type	**Brown acid soil**							
General coverage (%)	**90**	**85**	**90**	**90**				
Image size	**100 m²**							
Date	**15.V 2021.**							
Phytocenosis	Abieti-Fagetum							
Image number	**1**	**2**	**3**	**4**				
Floristic composition:								
Tree layer up to 30 m:					**I. v.**	**F. e.**	**P. a.**	**L. f.**
Abies alba Mill.	2.2	2.2	2.2	2.2	P	pralp(-smed)	V.-P.	P
Trees layer up to 20:								
Abies alba Mill.	2.2	2.2	1.1	+2	P	pralp(-smed)	V.-P.	P
Trees layer up to 5m:								
Abies alba Mill.	1.1	1.1	+2	+2	P	pralp(-smed)	V.-P.	P
Fagus silvatica L.	+1	+1			P	subatl(-smed)	F.	P
Trees layer up to 3 m:					P			
Abies alba Mill.	1.1	+2	+2	+2	P	pralp(-smed)	V.-P.	P
Fagus silvatica L.	+1	+1		+1		subatl(-smed)	F.	P
Bushs layer:								
Abies alba Mill.	1.1	1.1	1.1	2.2	P	pralp(-smed)	V.-P.	P
Rubus hirtus W. K.	1.1	1.1	1.1	1.1	PS	subatl	F.	P
Fagus silvatica L.	+2	+1			P	subatl(-smed)	F.	P
Euonymus europaeus L.	+1	+2			PS	subatl-smed	F.	P
Pyrus pyraster Burgsd	+1				P	smed (-gemässkont)	F.	P
Sorbus aucuparia L.	+1				P	no-eurassubozean	F.	P

Acer pseudoplatanus L.		+1	+1		P	subatl-smed (-pralp)	F.	P
Herbaceous plants layer:								
Galium rotundifolium L.	1.1	1.1	1.1	1.1	P	no-euras(kont), circ	V.-P.	H
Viola silvestris Lam.	1.1	1.1	+2	1.1	P	subatl-smed	F.	H
Brachypodium silvaticum (Huds.) P. B.	1.1	1.1		+2	PS	euras(subozean)-smed	F.	H
Aremonia agrimonioides	1.1		+1		P	osmed	F.	H
Asarum europaeum L.	1.1				P	euraskont	F.	H (G)
Oxalis acetosella L.	+2	+2	+2	+2	P	no-euras	F.	H (G)
Hieracium sylvaticum	+2	+2	+1	+2	P	no-subatl-smed	F.	H
Mycelis muralis (L.) Dum.	+2	+2	+2		P	subatl-smed	F.	H
Luzula silvatica (Huds.) Gaud.	+2	+2	+2		P	subatl(-smed)	V.-P	H
Epimedium alpinum L.	+2	+2			P	opralp	F.	G
Pteridium aquilinum (L.) Kuhn	+2	+1			SP	(no) eurassubozean	Pte.	G
Helleborus odorus W. K.	+2				PS	din	P. s.	H (G)
Euphorbia amygdaloides L.	+2				P	subatl-smed	F.	H
Pyrola secunda L.	+2				P	no-euraskont, circ	V.-P.	Ch
Melampyrum silvaticum L.	+2				P	no-pralp	V.-P.	T
Polypodium vulgare L.	+2				P	eurassubozean-smed, circ	F.	Ch
Anemone nemorosa L.		+2		+2	P	eurassubozean	F.	G
Athyrium filix-femina (L.) Roth		+2		+1	P	no-euras (subozean)	F.	H
Dryopteris filix-mas (L.) Schott		+2			P	eursassubozean (-smed)	F.	H
Melittis melissophyllum L.		+1			P	smed	Q. p.	H
Lamium luteum (Huds.) Krock.			+2		P	gemässkont	F.	Ch
Neottia nidus-avis L.			+2		P	euras (subozean)-smed	F.	G
Geranium roberianum L.				+2	P	eurassubozean-smed	F.	H (T)
Sanicula europaea L.				+2	P	subatl(-smed)	F.	H
Fungi								
Hygrophorus marzuolus	++	++	+++	++				

Table 2. Ratio of life forms in the researched *Abieti-Fagetum* vegetation

Tabela 2. Odnos životnih formi u istraživanoj vegetaciji Abieti-Fagetum

Life form	Total number	Σ	%	Σ %
H	12		37.2	
H(G)	3		9.3	
H(T)	1		3.1	
		16		**49.6**
P	7		21.7	
		7		**21.7**
G	4		12.4	
		4		**12.4**
Ch	3		9.3	
		3		**9.3**
T	1		3.1	
		1		**3.1**
Ukupno:	**31**	**31**	**100**	**100**

From the graph 2, it can be seen that species from the order *Fagetalia* dominate in the researched vegetation, while the other orders are represented with a significantly small number of representatives.

From the table 2, it can be seen that the largest number of species belongs to hemicryptophytes, while the other life forms have much lower values.

From table 3, it can be seen that the researched soil has a very acidic reaction, which, as a matter of fact, corresponds to fungi because "they mostly inhabit substrates with acidic reactions, i.e. they are acidophilic" (Marinović, 1972), and it is also characteristic for conifer forest ecosystems. The soil has a high content of humus (organic matter) and is poorly supplied with accessible forms P and K.

A total of 25 floral elements from 9 groups were determined. The largest number of species was recorded in the sub-Atlantic-sub-Mediterranean group, and the flo-

Table 3. The results of chemical analysis of soil samples

Tabela 3. Rezultati hemijske analize uzoraka zemljišta

Sample from the surface	pH (H_2O)	pH (KCl)	Humus (%)	P_2O_5(mg/100)	K_2O(mg/100)
1	4.9	3.6	7.3	2.3	8
2	4.1	3	12	2	5
3	4.6	3.6	10	2	5
4	5.3	4	7.2	0	2

Table 4. Spectrum of floral elements in the researched association *Abieti-Fagetum*

Tabela 4. Spektar flornih elemenata u istraživanoj asocijaciji Abieti-Fagetum

Floral element			Established number in the researched area	Σ	Percentage of participation	Total %
1.	1.	din	**1**	**1**	**3.2**	**3.2**
	2.	opralp	**1**		**3.2**	
2.	3.	pralp(-smed)	**1**	**3**	**3.2**	**9.36**
	4.	no-pralp	**1**		**3.2**	
	5.	osmed	**1**		**3.2**	
3.	6.	smed	**1**	**3**	**3.2**	**9.36**
	7.	smed(-gemässkont)	**1**		**3.2**	
	8.	subatl	**1**		**3.2**	
	9.	subatl(-smed)	**3**		**9.36**	
4.	10.	subatl-smed	**4**	**10**	**12.9**	**31**
	11.	subatl-smed(-pralp)	**1**		**3.2**	
	12.	no-subatl-smed	**1**		**3.2**	
5.	13.	euras(subozean)-smed	**2**	**2**	**6.4**	**6.4**
	14.	no-euras	**1**		**3.2**	
6.	15.	no-euras(subozean)	**1**	**4**	**3.2**	**12.9**
	16.	no-euras(kont). circ	**1**		**3.2**	
	17.	no-eurassubozean	**1**		**3.2**	
	18.	eurassubozean	**1**		**3.2**	
	19.	eursassubozean(-smed)	**1**		**3.2**	
7.	20.	eurassubozean-smed,	**1**	**5**	**3.2**	**16.1**
	21.	eurassubozean-smed,circ	**1**		**3.2**	
	22.	(no)eurassubozean	**1**		**3.2**	
	23.	euraskont	**1**		**3.2**	
8.	24.	no-euraskont, circ	**1**	**2**	**3.2**	**6.4**
9.	25.	gemässkont	**1**	**1**	**3.2**	**3.2**
			31	**31**	**100 %**	**100 %**

ral element with the largest number of determined species is subatl-smed.

At the end, having in mind that this is extremely rich site, the good thing is that this locality is far from any hiking trail.

Abbreviations:

Abbreviations for phytocoenological affiliation:

F.-*Fagetalia*, P. s.-*Prunetalia spinosae*, Pte.-*Pteridetalia*, Q. p.-*Quercetalia pubescentis*, V.-P.-*Vaccinio-Piceetalia*,

Abbreviations for indicator values:

P-primary, PS-primary secondary, S- secondary, SP-secondary primary

Abbreviations for life forms:

P-*phanerophyta*, H-*hemicriptophyta*, Ch-*chamaephyta*, G-*geophyta* and Ch (Pn)-*chamaephyta* (*nanophanerophyta*)

Abbreviations in the phytocoenological table:

I. v.-indicator value, F. e.-floral element, P. a.-phytocoenological affiliation, L. f.-life form.

Figure 2. March Mushroom (*Hygrophorus marzuolus*) from the researched area (Photo: A. Hasanbegović)

Slika 2. March Mushroom (Hygrophorus marzuolus) sa istraživanog područja (Photo: A. Hasanbegović)

Figure 3. Researched fir and beech forest *Abieti-Fagetum* (Photo: A. Hasanbegović)

Slika 3. Istraživana šuma jele i bukve Abieti-Fagetum (Photo: A. Hasanbegović)

CONCLUSIONS – Zaključci

1. This is a new locality forthe March Mushroom;
2. The locality is found within the "ZP Bijambare";
3. March Mushroomwas noted in the association of fir and beech (*Abieti-Fagetum*);
4. 31 plant species from 25 families were found in the association;
5. The *Rosaceae* familyhas the largest number of identified species;
6. Primary indicator values prevail in the association;
7. Species of the order *Fagetalia* are the most numerous ones within the researched association;
8. Hemicriptophytes predominate among life forms;
9. A total of 25 floral elements from 9 groups were determined;
10. The largest number of species belongs to the sub-Atlantic-sub-mediterranean group,
11. The floral element with the largest number of identified species is subatl-smed.
12. This locality is quantitavily extremely rich with the March Mushroom.

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SAŽETAK

Biodiverzitet gljiva FBiH je slabo istražen, kao i areali rasprostranjenosti i ekološki uslovi pod kojima se gljive razvijaju. Takav je slučaj i sa martovkom te je glavni cilj rada prikazati ekološke uslove pod kojima se martovka pojavljuje. Za istraživanje smo uzeli metod Braun-Blanketa (1932) sa svim neophodnim ostalim parametrima vezanim za odabrano stanište, kao što su: fitocenološka pripadnost, florni element, indikatorska vrijednost i životna forma. Brojnost gljiva je data prema Tortić & Lisiewska (1971). Takođe je urađena hemijska analiza tla sa osnovnim parametrima. Martovka je zabilježena u šumi *Abiet-Fagetum* na lokalitetu Motike u okviru "ZP Bijambare". Ovo je novo nalazište martovke. U asocijaciji preovaldavaju primarne indikatorske vrijednosti. Vrste reda *Fagetalia* su najbrojnije unutar istraživane asocijacije. Od životnih formi preovladavaju hemikriptofite. Ukupno je utvrđeno 25 flornih elemenata iz 9 skupina. Najveći broj vrsta pripada subatlansko-submediteranskoj skupini. Florni element sa najvećim brojem konstatovanih vrsta je subatl-smed. Sreća pa je ovaj lokalitet poprilično udaljen od bilo kojih pješačkih staza jer je riječ o izrazito bogatom nalazištu martovke.

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