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ORIGINAL SCIENTIFIC PAPER

Analysis of the financial performance indicators of forestry companies and the necessity for the application of sustainability reporting

Analiza finansijskih indikatora uspješnosti poslovanja preduzeća šumarstva i potreba za primjenom izvještavanja o održivosti

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ABSTRACT

Forestry business systems in modern conditions exist and function in a highly dynamic environment, significantly impacting business results. Evaluating the business performance of a forestry company involves using various financial indicators, which provide valuable information for making business decisions to ensure the company's short-term and long-term stability. These indicators can also be effectively used for benchmarking with other business entities in the same industry, facilitating the improvement of business results in line with best practices. In this paper, the financial reports of two selected forestry companies from Bosnia and Herzegovina were analyzed, and using a comparison method of financial indicators related to profitability, economy, productivity, activity, indebtedness, and liquidity the analysis was performed. The results show positive financial outcomes for both companies, with one company being more successful in terms of profitability, cost-effectiveness and lower debt levels. The other company has better liquidity and activity indicators, i.e. more efficient use of assets, a better collection system and shorter receivables collection periods. However, the reports have also shown that the numerous non-market benefits provided by forests aren't taken into consideration in both companies, and in that manner the financial reporting alone does not allow for evaluating the sustainability of forest resource management. Due to the specific nature of forestry production, sustainability reporting and the application of sustainability indicators could significantly enhance the ability to find solutions within the economic, ecological, and sociological aspects of forest resource use.

Key words: *Forestry companies, financial reports, performance indicators, sustainability reports, sustainability indicators*

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INTRODUCTION – *Uvod*

Šume i šumska zemljišta u Bosni i Hercegovini (BiH) predstavljaju jedno od najvažnijih prirodnih bogatstava ove zemlje, prostirući se na površini od oko 3,23 miliona ha, što čini 63% njene teritorije (prema nezvaničnim rezultatima II inventure šuma – FAO, 2015). Prema statističkim podacima, oko 78% šumskih površina su u državnom, a ostatak je u privatnom vlasništvu (Federalni zavod za statistiku FBiH 2019; Republički zavod za statistiku RS 2019). U skladu s administrativnim uređenjem države, uspostavljeni su različiti koncepti upravljanja i gospodarenja šumama. U Federaciji BiH je prisutan model decentralizovanog upravljanja i gospodarenja šumama, s formiranim šumskoprivrednim društvima na nivou pojedinih kantona, dok je u Republici Srpskoj prisutan centralizovan model, s jednim preduzećem šumarstva na nivou entiteta (Delić et al., 2012).

Na rezultate poslovanja preduzeća šumarstva veliki uticaj ima dinamično okruženje u kojem poslovni sistemi egzistiraju, a mjerenju uspješnosti poslovanja se pridaje sve veći značaj, jer pokazatelji uspješnosti poslovanja daju informacije o poslovnom učinku te predstavljaju alat za planiranje i upravljanje. Istovremeno, predstavljaju i sredstvo motivacije i kontrole unutar organizacije (Otley, 2004). Finansijsko izvještavanje pravnih subjekata ima za cilj osiguranje informacija o finansijskom položaju, finansijskoj uspješnosti i novčanim tokovima. Potpuni set finansijskih izvještaja uključuje: bilans stanja, bilans uspjeha, izvještaj o promjenama kapitala, izvještaj o novčanim tokovima i različite bilješke uz finansijske izvještaje koje uključuju pregled računovodstvenih politika i druga objašnjenja (Zakon o računovodstvu i reviziji u FBiH 2021). Finansijski izvještaji se sastavljaju u skladu sa zakonskim propisima zemlje u kojoj preduzeće posluje i Međunarodnim standardima finansijskog izvještavanja (MSFI). Izvještaji moraju istinito izvještavati i objektivno prezentirati finansijske rezultate. Preduzeća u BiH izrađuju finansijske izvještaje u skladu s entitetskim zakonima o računovodstvu i reviziji, MSFI i Međunarodnim računovodstvenim standardima (MRS). U skladu s relevantnim zakonima, navedeni izvještaji objavljuju se javno i dostavljaju Finansijsko-informatičkoj agenciji (FIA). Na taj način se omogućava preduzećima da ocjenjuju uspješnost poslovanja u različitim periodima, da se upoređuju s drugim preduzećima, da ocjenjuju bonitet poslovanja i da analiziraju poslovnu okolinu. Iz ovih izvještaja se dobivaju informacije o sredstvima i obavezama preduzeća, vlastitom kapitalu, rashodima i prihodima, ostalim promjenama kapitala i novčanim tokovima. Upoređivanjem i raščlanjivanjem određenih vrijednosti koje su sadržane u navedenim izvještajima utvrđuje se finansijsko stanje i uspješnost poslovanja preduzeća, kao i odstupanje planiranih i realizovanih veličina. Primjenom različitih analitičkih sredstava i tehnika provodi se horizontalna i vertikalna analiza, na osnovu čega se dobivaju informacije koje mogu biti kvalitetna podloga za donošenje poslovnih odluka.

Ocjena uspješnosti poslovanja se izvodi na osnovu različitih finansijskih pokazatelja uspješnosti poslovanja. Na osnovu izračunatih pokazatelja, dobivaju se vrijedne informacije za menadžere koji predlažu mjere za unapređenje poslovanja te donošenje kvalitetnih poslovnih odluka u cilju osiguranja kratkoročne i dugoročne stabilnosti preduzeća (Šunjić-Beus et al., 2011).

Šumarstvo, kao privredna djelatnost, odlikuje se nizom specifičnosti, od kojih posebno treba naglasiti dugoročnost proizvodnog procesa, potrebu za velikim ulaganjem te nemogućnost tržišne valorizacije svih koristi koje šumski resursi pružaju. Zbog toga je u ocjeni uspješnosti poslovanja šumarskih preduzeća nedovoljna primjena samo tradicionalnih finansijskih pokazatelja, te su sve više prisutne ideje za unapređenje indikatora uspješnosti poslovanja uz primjenu i nefinansijskih pokazatelja, a koji bi se bazirali na izvještajima o održivosti (Ševčík et al., 2014; Posavec et al., 2021). Nefinansijske informacije se odnose na ekološke, sociološke i upravljačke aspekte poslovanja, na osnovu kojih se daje cjelovita slika aktivnosti preduzeća u svim relevantnim oblastima društveno odgovornog poslovanja, orijentisanog na održivost. Značaj nefinansijskog izvještavanja je prepoznat i na međunarodnom nivou i sagledava se i kroz njegovo uključivanje u ciljeve održivog razvoja u Agendi za održivi razvoj 2030 *(Sustainable Development Goals - SDGSs)*. U okviru SDG 12 - Odgovorna potrošnja i proizvodnja, velike kompanije se podstiču da u svojim izvještajima uključuju i informacije o održivosti. Evropska unija reguliše izvještavanje kompanija o nefinansijskim učincima i održivosti putem nekoliko regulativa i to: Direktiva EU o nefinansijskom izvještavanju (Non-financial Reporting Directive - NFRD, *Directive 2014/95/EU*), kojom se propisuje obaveza objavljivanja nefinansijskih informacija za velike kompanije; Uredba o izvještavanju o održivom finansiranju (Sustainable Finance Disclosure Regulation - SFDR, *Regulation (EU) 2019/2088*, kojom se propisuje obaveza procjene ulaganja na održivi razvoj; Uredba o taksonomiji (EU Taxonomy, *Regulation (EU) 2020/852*, koja propisuje koje se privredne aktivnosti smatraju klimatski neutralnim; te prijedlog Direktive o korporativnom izvještavanju o održivosti (CSRD) kojom se od velikih kompanija traži izvještavanje o svim aktivnostima koje utiču na okoliš i društvo. Prema Ševčik et al. (2014) za izvještavanje o održivosti se mogu koristiti različite metodologije, ali se najčešće koristi metodologija Globalne Inicijative za izvještavanje (*Global Reporting Initiative - GRI*).

Izvještavanje o održivosti predstavlja jedan od ključnih alata strategije održivog razvoja, a preduzeća šumarstva imaju veoma važnu ulogu u ostvarivanju mnogobrojnih ciljeva, kao što su: borba protiv klimatskih promjena (SDG 13), doprinos očuvanju šumskih ekosistema, biodiverziteta i zaštiti ugroženih vrsta (SDG 15), doprinos stvaranju radnih mjesta i razvoju lokalne ekonomije (SDG 8), doprinos održivoj potrošnji i proizvodnji primjenom koncepta bioekonomije i cirkularne ekonomije (SDG 12), te uspostava partnerstva s vladinim i nevladinim organizacijama, lokalnim zajednicama i drugim interesnim grupama za zajedničko ostvarenje ciljeva (SDG 17).

Preduzeća šumarstva, kao korisnici šumskih resursa, u svom poslovanju su obavezna poštovati principe održivog gospodarenja i multifunkcionalnosti. Definicije održivog gospodarenja šumama mijenjale su se tokom vremena, ali u osnovi svih definicija je prisutan osnovni princip održivosti koji se sastoji u prilagođavanju strategije gospodarenja promjenljivim ekološko-sociološkim i ekonomskim uslovima (Schmithüsen, 2013). Održivo gospodarenje šumama je dinamičan i evoluirajući koncept, koji ima za cilj održati i unaprijediti ekonomske, društvene i ekološke vrijednosti svih vrsta šuma, za dobrobit sadašnjih i budućih generacija (FAO 2020). Dakle, u konceptu održivog gospodarenja šumskim resursima sadržana je suština paradigme održivog razvoja, odnosno zadovoljenje trenutnih potreba društva bez ugrožavanja potreba budućih generacija (Avdibegović et al. 2023). Multifunkcionalnost podrazumijeva sposobnost šumskih resursa da pružaju različite ekonomske, sociološke i ekološke koristi. Multifunkcionalnost šuma je u uskoj vezi s održivim gospodarenjem šumama i predstavlja bitan preduslov za njegovo osiguranje. Zbog toga je neophodno poznavanje i razumijevanje svih funkcija šuma koje, pored direktnih ekonomskih koristi, donose i indirektne koristi, a koje su važne za održavanje ravnoteže u prirodi, očuvanje biodiverziteta, ublažavanje klimatskih promjena, sprečavanje poplava i erozije, uticaj na ljudsko zdravlje, rekreaciju, turizam itd. Ove funkcije su se kroz historiju ispoljavale u različitom intenzitetu i značaju za društvo, a može se pretpostaviti da će tako biti i u budućnosti. Sadašnje stanje šuma i promjene koje su se desile mogu se dovesti u vezu s načinom korištenja i zahtjevima društva prema šumi (Pilli i Pase, 2018). Zbog toga je u konceptu održivog gospodarenja šumama važno uravnoteženje potreba i mogućnosti njihovog zadovoljenja.

U cilju procjene održivog gospodarenja šumama, neophodno je praćenje stanja šuma koristeći određene indikatore održivosti. Proces razvoja kriterija i indikatora održivog gospodarenja šumama započeo je 90-tih godina prošlog stoljeća kroz aktivnosti Ministarske konferencije o zaštiti šuma (danas Forest Europe), koje su rezultirale definisanjem seta unapređenih Pan-evropskih kvantitativnih kriterija i indikatora održivog gospodarenja koji imaju ekonomsku, ekološku i sociološku dimenziju te seta općih kvalitativnih indikatora (Forest Europe, 2015). Korištenjem kriterija i indikatora održivog gospodarenja šumama moguće je pratiti i izvještavati o trenutnom statusu i ostvarenom napretku u procesu održivog gospodarenja šumskim resursima, kako na nacionalnom, tako i na subnacionalnom nivou (Marić et al., 2024). Koncept certificiranja gospodarenja šumama dao je poseban doprinos različitim aspektima održivog gospodarenja šumama, te se ocjenjuje da ovo nije samo tržišni instrument šumarske politike, već sredstvo za promociju ekonomski održivog, ekološki odgovornog i društveno prihvatljivog gospodarenja šumama i očuvanje biodiverziteta (Avdibegović et al., 2021). Istraživanja pokazuju pozitivne učinke certificiranja na kvalitet gospodarenja šumama, a naročito sa sociooloških i ekoloških aspekata, kao i unapređenje performansi poslovanja preduzeća šumarstva (Pezdevšek Malovrh et al., 2019; Solaković et al., 2020).

Globalne promjene i izazovi poput klimatskih promjena, gubitak biodiverziteta, krčenje šuma, potreba za obnovljivim izvorima energije nameću potrebu stalnog unapređenja kriterija indikatora za mjerenje održivog gospodarenja šumama (Linser et al., 2015). Evolucija kriterija i indikatora održivog gospodarenja šumama će se kretati u skladu sa promjenljivim potrebama i zahtjevima društva s dugoročnim ciljem osiguranja ekološke, ekonomske i sociološko-kulturološke održivosti. Rezultati istraživanja potvrđuju važnost primjene kriterija i indikatora za praćenje i izvještavanje o stanju šuma i trendu razvoja šumarstva na globalnom, regionalnom i nacionalnom nivou. Periodično objavljeni izvještaji pomažu u donošenju strateških i operativnih odluka u šumarstvu, te u komunikaciji i dijalogu s drugim relevantnim sektorima (Linser i Wolfslehner, 2022).

Zato je glavni cilj ovog rada ukazati na to da tradicionalni finansijski indikatori uspješnosti poslovanja (profitabilnosti, ekonomičnosti, produktivnosti, aktivnosti, zaduženosti i likvidnosti) nisu dovoljni za ocjenu održivosti gospodarenja šumama, te je potrebno uvođenje nefinasnijskog izvještavanja i primjena ekonomskih, ekoloških i sociooloških indikatora održivosti. Na taj način bi se upotpunile informacije o performansama poslovanja i postignutom nivou okolišne i društvene odgovornosti preduzeća šumarstva.

MATERIALS AND METHODS – *Materijal i metode*

Za provođenje ekonomsko-finansijske analize i ocjene uspješnosti poslovanja prema finansijskim indikatorima odabrana su dva preduzeća šumarstva: ŠPD "Unsko-sanske šume" d. o. o. Bosanska Krupa i ŠPD "Srednjobosanske šume" d. o. o. Donji Vakuf, koja gospodare državnim šumama na područjima Unsko-sanskog i Srednjobosanskog kantona, čija je ukupna površina, kao i prosječna godišnja proizvodnja približno jednake. Osnovne informacije o ovim preduzećima za 2021. godinu su date u tabeli 1.

Tabela 1. Osnovne informacije i bilansne pozicije (stanje 31.12. 2021. godine)

Table 1. Basic information and balance positions (as of December 31, 2021)

Osnovni elementi	ŠPD "Unsko-sanske šume"	ŠPD "Srednjobosanske šume"
Površina šuma i šumskog zemljišta (ha)	190.800	185.949
Broj zaposlenih	743	914
Obim proizvodnje - neto (m^3)	504.446	484.745
Ukupni prihodi (KM)	39.337.879	43.615.021
Ukupni rashodi (KM)	37.765.042	42.154.494
Dobit prije oporezivanja (KM)	1.570.835	1.455.448
Ukupna neto dobit perioda (KM)	1.524.701	1.357.094
Poslovna aktiva (KM)	41.756.143	83.087.505[1]
Učinak m^3/ zaposlenom	679	530
Prihod KM/ zaposlenom	52.945	47.719

Izvor: Zvanični finansijski izvještaji preduzeća

Analizom je obuhvaćen period od 2016. do 2021. godine, a informacije i podaci za analizu su korišteni iz zvaničnih finansijskih izvještaja odabranih preduzeća (bilans stanja i bilans uspjeha), Godišnjih izvještaja o radu i poslovanju, Izvještaja dostavljenih Finansijsko-informatičkoj agenciji (FIA) FBiH te drugih dostupnih izvora (Mahmutović 2022).

1 Vrijednost aktive prikazana u bilansu stanja je umanjena za iznos vrijednosti šuma i šumskog zemljišta koje se u ovom preduzeću vode kao dio aktive, a ne kao vanbilansna stavka prema Odluci Vlade FBiH o isknjižavanju šuma i šumskog zemljišta kao temeljnog kapitala iz sudskog registra i poslovnih knjiga preduzeća.

Relevantni podaci iz izvještaja su poslužili kao ulazni faktori za izračunavanje finansijskih indikatora uspješnosti poslovanja kroz vremensko razdoblje. Indikatori omogućavaju dobivanje usporedivih podataka o uspješnosti preduzeća u odabranim područjima. U ovom radu su korišteni neki od finansijskih indikatora poslovanja, prema kojima se može dati ocjena profitabilnosti, likvidnosti, aktivnosti, zaduženosti, ekonomičnosti te produktivnosti. Indikatori i način njihovog obračuna su prikazani u tabeli 2.

Tabela 2. Indikatori uspješnosti poslovanja

Table 2. Bussines performance indicators

Pokazatelj	Način obračuna
Profitabilnost (rentabilnost) imovine ili profitabilnost poslovanja (*ROA - Return on Assets i ROE - Return on Equity*)	*ROA = Dobit (neto ili bruto) / ukupno korišteni kapital*
	ROE = Neto dobit / Vlastiti kapital
Pokazatelj tekuće likvidnosti (*Current Ratio*)	*Current Ratio = Obrtna sredstva / Kratkoročne obaveze*
Pokazatelji aktivnosti (*Activity Rations*)	*Koeficijent obrta ukupne imovine = Ukupan prihod / Ukupna poslovna imovina*
	Koeficijent potraživanja od kupaca = Ukupan prihod od prodaje / Potraživanja od kupaca
	Trajanje naplate potraživanja = 365 / Koeficijent potraživanja od kupaca
Pokazatelj zaduženosti (*Solvency Rations*)	*Pokazatelj zaduženosti (Debt Ratio) = Ukupne obaveze / Aktiva preduzeća*
Pokazatelj ekonomičnosti (*Economy Rations*)	*Ekonomičnost ukupnog poslovanja = Ukupni prihodi / ukupni rashodi*
Pokazatelj produktivnosti (*Productivity*)	*Produktivnost rada = Količina učinka (proizvedenih proizvoda) / Količina utrošenog rada*

Izvor: Delić i Bećirović, 2017.

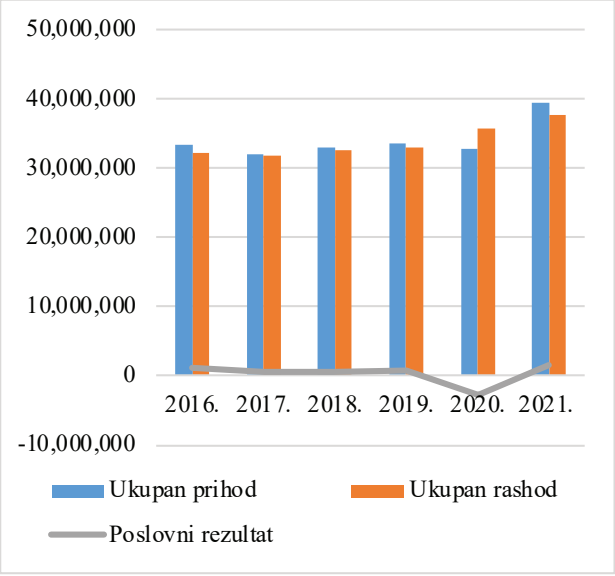
Na osnovu komparativne analize dobivenih indikatora za odabrana preduzeća moguće je dati ocjenu performansi i finansijskog stanja preduzeća, ali za ocjenu održivosti gospodarenja šumama su neophodni i indikatori koji bi u sebi trebali sadržavati informacije o ekološkim, društvenim i ekonomskim performansama preduzeća.

RESULTS AND DISCUSSION – *Rezultati i diskusija*

Analysis of the financial results of the selected companies - *Analiza finansijskih rezultata poslovanja odabranih preduzeća*

Trend prihoda i rashoda te finansijski rezultat odabranih preduzeća šumarstva u analiziranom periodu su prikazani na grafikonima 1 i 2.

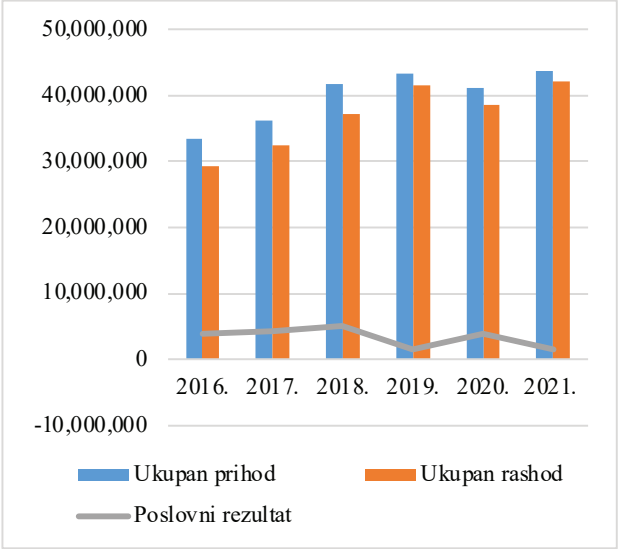
Analizirana preduzeća su imala približno isti iznos prihoda u baznoj 2016. godini. ŠPD "Srednjobosanske šume" je u narednim godinama imalo intenzivniji rast prihoda s prosječnom godišnjom stopom rasta od oko 24%, te je prihod u 2021. godini bio veći za 30,8% u odnosu na 2016. godinu. Razlozi za povećanje prihoda se, između ostalih faktora, nalaze i u povećanom obimu proizvodnje te boljoj strukturi proizvodnog asortimana, prilagođenog tržištu. To je rezultiralo ostvarenjem dobiti u iznosu od 1.460.527 do 5.031.376 KM.



Grafikon 1. Rezultati poslovanja ŠPD "Unsko-sanske šume" (KM)

Graph 1. Business results ŠPD "Unsko-sanske šume" (KM)

S druge strane, ostvareni prihodi u ŠPD "Unsko-sanske šume" su blago oscilirali u intervalu od 32 do 33 miliona KM u periodu 2016–2020. godina, da bi u 2021. godini dostigli iznos od 39,3 miliona, što je za 18% više u odnosu na 2016. godinu. Ovo preduzeće je bilježilo značajno niže iznose profita od prethodnog, ostvarujući čak i negativan finansijski rezultat u 2020. godini u iznosu od 2.674.594 KM. U narednoj godini je ostvarena dobit iznosila 1.572.837 KM, što je bilo više za oko 100 hiljada u odnosu na prethodno preduzeće. Tome su doprinijele aktivnosti na unapređenju rada i poslovanja, prodaja zaliha iz prethodne godine te primjena tržišno baziranih načina prodaje.



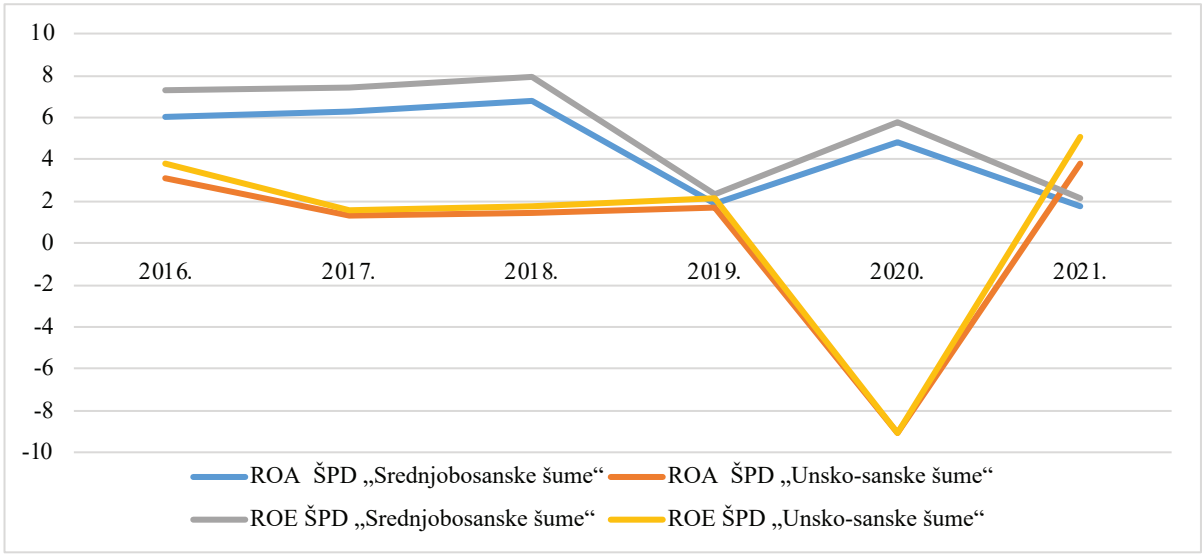
Grafikon 2. Rezultati poslovanja ŠPD "Srednjobosanske šume" (KM)

Graph 2. Business results ŠPD "Srednjobosanske šume" (KM)

Na osnovu ostvarenog rezultata poslovanja, na grafikonu 3 prikazani su indikatori **profitabilnosti poslovanja** (ROA i ROE) koji predstavljaju mjeru uspješnosti korištenja imovine.

Pokazatelji rentabilnosti (ROA i ROE) ukazuju na efikasnost i rentabilnost korištenja ukupne imovine koja se koristi u poslovanju, kao i efikasnost korištenja vlastitog kapitala. Ovo su najčešće korišteni pokazatelji uspješnosti upravljanja imovinom, odnosno vlastitog kapitala u ostvarenju dobiti. Na osnovu komparacije dobivenih vrijednosti ovih indikatora za dva analizirana preduzeća možemo zaključiti da su tokom cijelog analiziranog perioda vrijednosti ROA i ROE veće kod ŠPD "Srednjobosanske šume" što je i logično, s obzirom na ostvareni profit. Najveće vrijednosti ovih indikatora su ostvarene u 2018. godini, kada je preduzeće ostvarilo 6,78 KM prirasta dobiti iz poslovanja, odnosno 7,95 KM iz vlastitog kapitala. U istoj godini je ŠPD "Unsko-sanske šume" imalo vrijednosti ROA 1,43 i ROE 1,73 KM, dok je u 2020. godini preduzeće poslovalo negativno. U 2019. godini su vrijednosti indikatora bile približno iste, da bi u 2021. godini, ŠPD "Unsko-sanske šume" imale nešto veću stopu efikasnosti korištenja imovine i vlastitog kapitala u odnosu na komparirano preduzeće, kao i u odnosu na raniji period.

Pokazatelj tekuće likvidnosti kojim se mjeri sposobnost preduzeća da izmiri svoje kratkoročne obaveze, odnosno dugovanja, prikazan je na grafikonu 4. Izra-

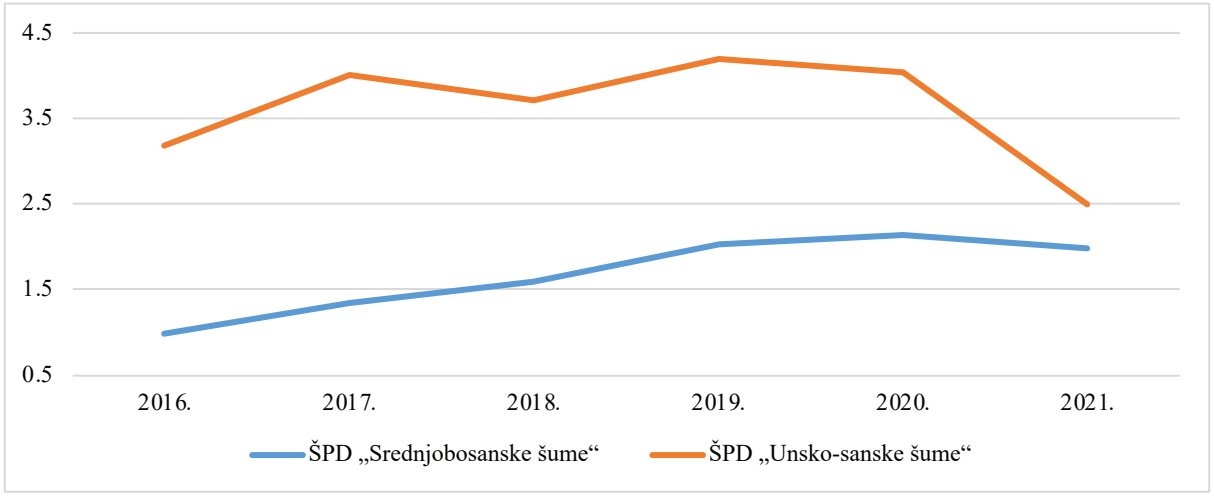


Grafikon 3. Rentabilnost poslovanja (%): ROA (Return on Assets) i ROE (Return on Equity)

Graph 3. Profitability (%): ROA (Return on Assets) and ROE (Return on Equity)

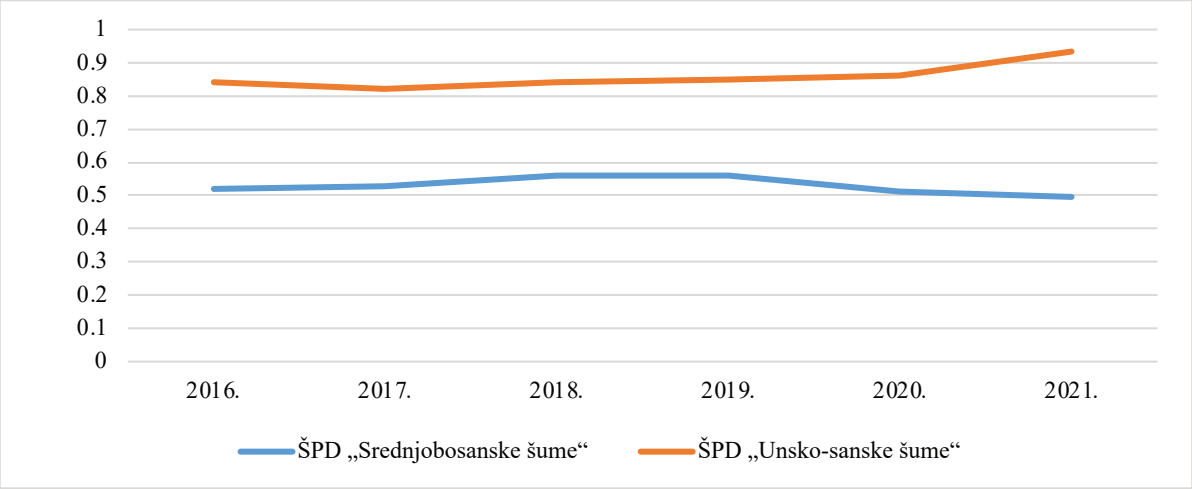
čunavanjem tekuće likvidnosti ocjenjuje se sposobnost preduzeća da podmiri tekuće obaveze, odnosno dugovanja u datom momentu, što zavisi od strukture kapitala i obaveza preduzeća. Smatra se da je "zlatno pravilo likvidnosti" zadovoljeno ako ovaj pokazatelj ima vrijednost veću od dva, što znači da kratkotrajna imovina (uključujući i zalihe) mora biti dvostruko veća od tekućih obaveza. Likvidnost je pokazatelj stabilnosti poslovanja i što je taj pokazatelj veći, to su mogućnosti i sigurnost za održavanje likvidnosti veće.

Za razliku od prethodnog pokazatelja, ovaj pokazatelj je značajno povoljniji u ŠPD "Unsko-sanske šume" u odnosu na ŠPD "Srednjobosanske šume" i ovo preduzeće je tokom cijelog analiziranog perioda bilo likvidno, s vrijednostima koeficijenta likvidnosti i do 4,19. U 2021. godini je došlo do značajnog smanjenja koeficijenta likvidnosti jer su se povećale kratkoročne obaveze za oko 90%. S druge strane, ŠPD "Srednjobosanske šume" je imalo niže koeficijente likvidnosti u cijelom periodu, ali ipak s rastućim trendom. Na osnovu ovog koeficijenta možemo ocijeniti finansijski položaj i sigurnost u poslovanju preduzeća, što menadžment mora imati u vidu, kako se preduzeće ne bi suočilo sa problemom likvidnosti.



Grafikon 4. Tekuća likvidnost

Graph 4. Current liquidity



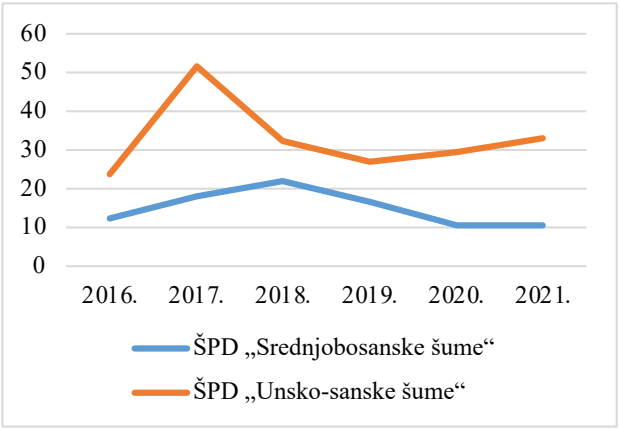
Grafikon 5. Koeficijent obrta ukupne imovine

Graph 5. Turnover ratio of total assets

Pokazatelji aktivnosti preduzeća predstavljeni su preko koeficijenta obrta ukupne imovine koji ukazuje na efikasnost upravljanja imovinom preduzeća, odnosno pokazuje koliko se generiše prihoda na osnovu korištene imovine (grafikon 5).

Prema ovom koeficijentu vidimo koliko jedna novčana jedinica aktive (ukupne imovine) inicira stvaranje jedinice prihoda, što je daleko povoljnije u ŠPD "Unsko-sanske šume". Vrijednosti ovog koeficijenta u ovom preduzeću su dvostruko veće u odnosu na komparirano preduzeće, što ukazuje na bolju sposobnost ovog preduzeća da generira prihode koristeći svoju imovinu. S obzirom da ovaj koeficijent u oba preduzeća nije značajno varirao u analiziranom periodu, to nas upućuje na opći zaključak da prosječno trajanje obrta u preduzećima šumarstva nema tendenciju promjene zbog specifičnosti reprodukcionih procesa. Međutim, stabilnost koeficijenta ukazuje na to da preduzeća u sektoru šumarstva imaju tendenciju da zadrže slične obrasce u korištenju imovine za generiranje prihoda, usprkos specifičnostima sektora. U budućnosti, istraživanje dodatnih faktora koji utiču na ovaj koeficijent, kao što su promjene u tehnologiji, regulativnom okviru ili tržišnim uslovima, moglo bi pružiti dodatne uvide u potencijalne prilike za poboljšanje poslovne efikasnosti i optimizaciju korištenja imovine u sektoru šumarstva.

Na osnovu koeficijenta potraživanja od kupaca (grafikon 6), dolazimo do informacije koliko se puta vrši naplata potraživanja prosječno u toku godine, odnosno koliko je prosječno vrijeme naplate potraživanja od kupaca (grafikon 7). Iz prikazanih grafikona se vidi da je sistem naplate bolji kod ŠPD "Unsko-sanskih šuma" te da je prosječno vrijeme trajanja naplate potraživanja od kupaca od 7 do 15 dana, dok je kod ŠPD "Srednjobosanske šume" to vrijeme iznosilo od 16 do 35 dana. Ovaj pokazatelj ima značajnog uticaja na likvidnost preduzeća, te je cilj povećati koeficijent potraživanja od kupaca, odnosno smanjiti vrijeme trajanja naplate.

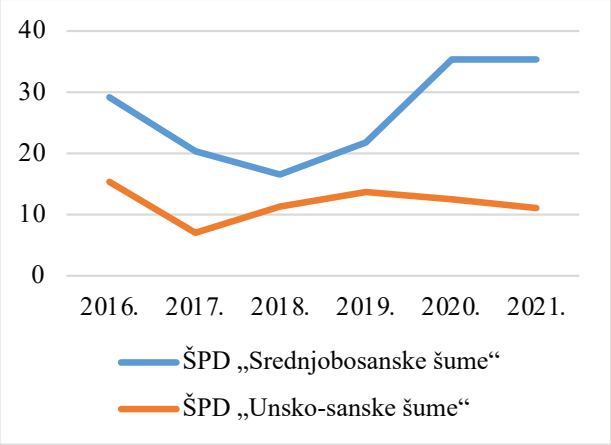


Grafikon 6. Koeficijent potraživanja od kupaca

Graph 6. Accounts Receivable Ratio

Pokazatelj zaduženosti preduzeća pokazuje do koje mjere preduzeće koristi zaduživanje kao način finansiranja poslovanja, odnosno koliki je postotak imovine nabavljen zaduživanjem. Što je učešće pozajmljenih sredstava veće, to je finansijski rizik u poslovanju veći. Na grafikonu 8 se vidi da ŠPD "Srednjobosanske šume" ima približno iste vrijednosti ovog pokazatelja bez većih oscilacija, što sugeriše da je preduzeće održalo konstantan nivo zaduženosti u odnosu na svoju imovinu, što može biti indikator stabilnog finansijskog upravljanja. S druge strane, kod ŠPD "Unsko-sanske šume" u 2021. godini je došlo do povećanja stepena zaduženosti zbog povećanja kratkoročnih obaveza, a koje se odnose

na primljene avanse od kupaca, obaveze po osnovu plaća, obaveze po osnovu naknada za korištenje državnih šuma za posljednji kvartal tekuće godine i sl. S obzirom na zlatno pravilo finansiranja po kojem stepen zaduženosti ne bi trebao da bude veći od 50%, možemo zaključiti da ne postoji finansijski rizik poslovanja za analizirana preduzeća.



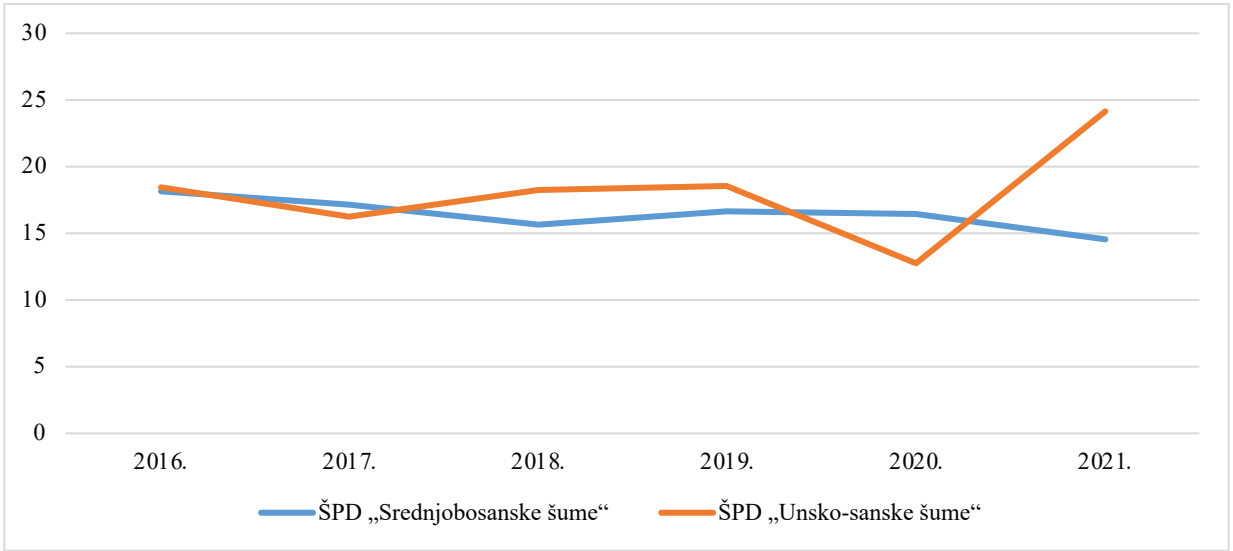
Grafikon 7. Trajanje naplate potraživanja (dani)

Graph 7. Receivables Collection Period (days)

Pokazatelj ekonomičnosti je jedan od osnovnih pokazatelja uspješnosti poslovanja i pokazuje racionalnost poslovnog procesa. ŠPD "Srednjobosanske šume" su tokom cijelog analiziranog perioda imale ekonomično poslovanje sa koeficijentom ekonomičnosti od 1,03 do 1,14. S druge strane, ŠPD "Unsko-sanske šume" su imale prilično nizak stepen ekonomičnosti (1,01 - 1,04), a u 2020. godini su ostvarili gubitak s koeficijentom ekonomičnosti od 0,92 (grafikon 9).

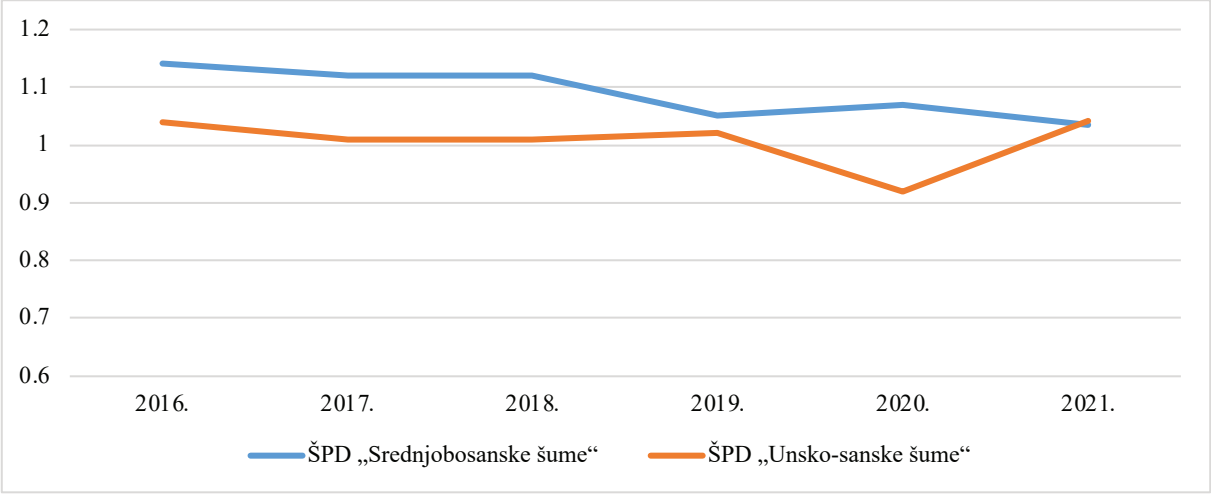
Pokazatelj produktivnosti rada predstavlja vrijednost ostvarenog prihoda po jednom radniku i ukazuje na efikasnost korištenja radne snage. Komparirajući ova dva preduzeća, uočava se da je u prve tri godine analiziranog perioda produktivnost rada bila veća u ŠPD "Unsko-sanske šume", da bi nakon toga došlo do opadanja njegove vrijednosti. U 2021. godini se ponovo bilježi trend porasta produktivnosti, premašujući vrijednost ostvarenu u drugom ŠPD. S druge strane, u ŠPD "Srednjobosanske šume" se bilježi kontinuiran trend rasta produktivnosti rada, s kulminacijom u 2019. godini, a nakon toga dolazi do značajnog pada vrijednosti ostvarene proizvodnje po jednom radniku za oko 25% (grafikon 10).

Na osnovu provedene analize i komparacije finansijskih pokazatelja odabranih preduzeća šumarstva, mogu se donijeti zaključci o različitim aspektima poslovnog uspjeha. Ovi pokazatelji su temeljeni na godišnjim izvještajima koji uključuju prihode i troškove ostvarene, uglavnom, prodajom šumskih drvnih proizvoda, dok ostale netržišne funkcije šuma (rekreacijske, ekološke, zaštitne, estetske, kulturološke) ne ulaze u obračun, čime se podcjenjuje puna vrijednost šumskih resursa i njihov doprinos nacionalnoj ekonomiji i blagostanju. Kroz mnogobrojne studije i radove ukazuje se na potrebu uključivanja svih koristi u nacionalne računovodstvene sisteme (Goio et al. 2008).



Grafikon 8. Pokazatelj zaduženosti (%)

Graph 8. Leverage indicator (%)



Grafikon 9. Koeficijent ekonomičnosti

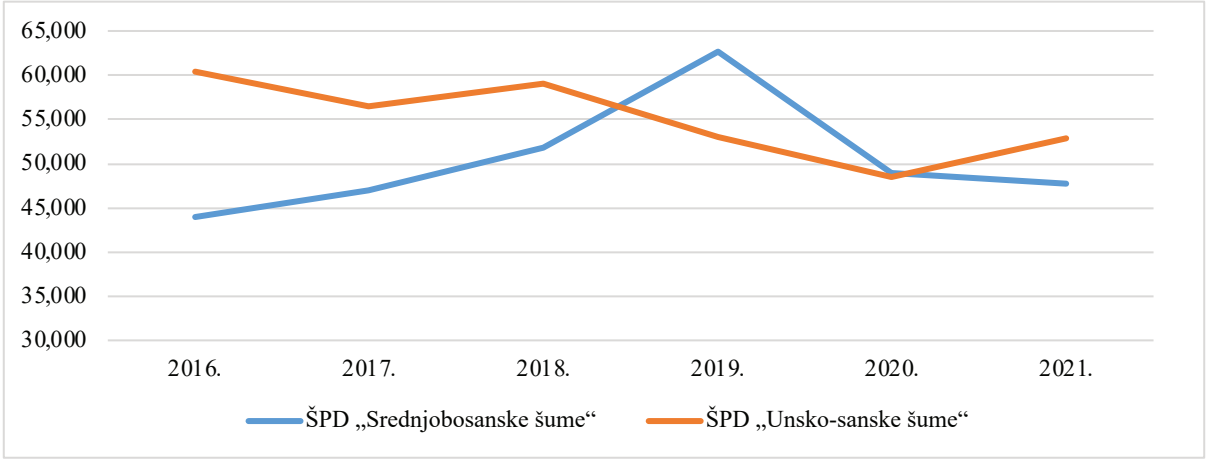
Graph 9. Economy coefficient

Analysis of production volume and the degree of realization of planned silvicultural works in selected companies – *Analiza obima proizvodnje i stepena realizacije planiranih šumskouzgojnih radova u odabranim preduzećima*

U nastavku je data analiza trenda realizacije obima sječa za analizirana preduzeća, kao i izvršenje planova šumskouzgojnih radova na osnovu izvještaja preduzeća o realizaciji planova proizvodnje. Ovo mogu biti važni indikatori održivog korištenja resursa i neophodnih ulaganja u osiguranje održivosti.

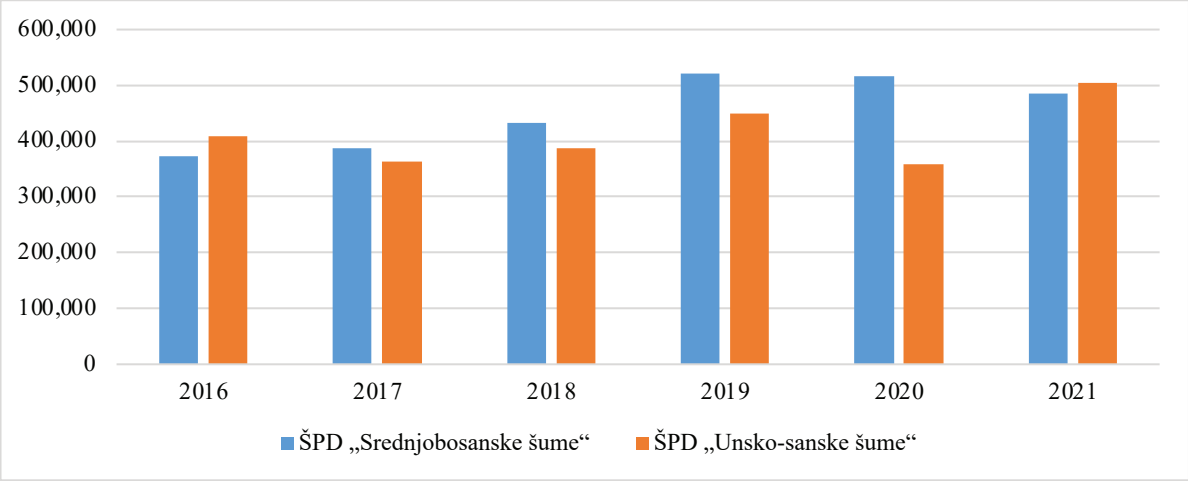
Godišnji obim sječa je varirao kod oba preduzeća u analiziranom periodu, ali uz jasno vidljiv trend porasta (grafikon 11). ŠPD "Srednjobosanske šume" su imale intenzivniji rast proizvodnje, s prosječnom godišnjom stopim rasta od 25,3%, dok je stopa porasta proizvodnje kod ŠPD "Unsko-sanske šume" iznosila 10,8%. U skladu s porastom obima proizvodnje, kretao se i porast prihoda od prodaje šumskih drvnih sortimenata (grafikoni 1 i 2).

S druge strane, izvršenje pošumljavanja i ostalih šumsko-uzgojnih radova (popunjavanje, čišćenje i njega šuma i kultura te priprema zemljišta za pošumljavanje i prirodnu obnovu) su značajno zaostajali za planiranim obimom (grafikoni 12 i 13). To se posebno uočava kod ŠPD "Srednjobosanske šume" kod kojih je stepen izvršenja planova pošumljavanja iznosio od 23 do 87%, dok su ostali šumskouzgojni radovi realizirani u obimu od 39 do 85% od planiranog obima. Planirani obim pošumljavanja u ŠPD "Unsko-sanske šume" je u prve tri godine



Grafikon 10. Pokazatelj produktivnosti rada (KM / radniku)

Graph 10. Labor productivity indicator (KM / worker)

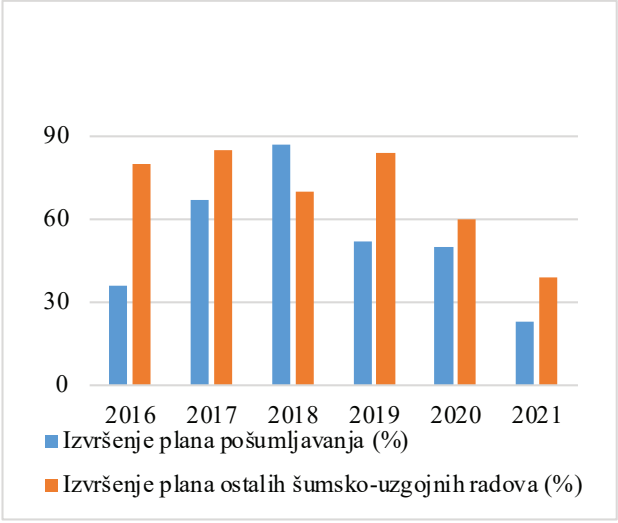


Grafikon 11. Obim sječa - neto masa (m^3)

Graph 11. Logging volume - net mass (m^3)

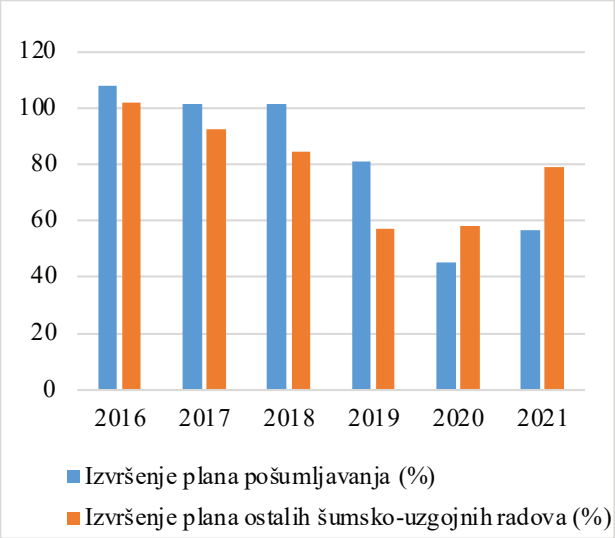
analiziranog perioda u potpunosti realiziran, a kasnije je došlo do opadanja stepena realizacije (od 45 do 81%). Kad su u pitanju ostali šumsko-uzgojni radovi, stepen njihovog izvršenja se kreće od 57 do 102%.

Važan pokazatelj održivog korištenja šumskih resursa je iznos uloženih finansijskih sredstava u biološku reprodukciju, a koji bi trebao biti u korelaciji sa stepenom izvršenja planiranog obima šumskouzgojnih radova. Ulaganje u biološku reprodukciju ima ključnu ulogu u očuvanju i unapređenju šumskih ekosistema, a odgovarajuće praćenje tih ulaganja može značajno doprinijeti održivom gospodarenju šumskim resursima. Na grafikonu 14 prikazan je trend ulaganja u šumskouzgojne radove, gdje se uočava da je ŠPD "Srednjobosanske šume" u prve tri godine analiziranog perioda imalo značajno veća ulaganja u odnosu na drugo preduzeće, da bi kasnije došlo do značajnog opadanja ulaganja, ostvarujući svega 25% od planiranog iznosa u 2021. godini. Ulaganja u 2021. godini bila su manja za 4,5 puta u odnosu na 2018. godinu, što ukazuje na značajno smanjenje investicija u biološku reprodukciju i šumske radove. Ulaganja u šumskouzgojne radove u ŠPD "Unsko-sanske šume" su, također, imala opadajući trend, pri čemu su u 2021. bila niža za oko 40% u odnosu na baznu godinu, odnosno svega 48% od planiranog ulaganja. Ova opadajuća ulaganja u oba preduzeća ukazuju na moguće probleme u realizaciji planiranih šumskouzgojnih radova. Imajući u vidu slične rezultate istraživanja u prethodnom periodu, to može imati dugoročne posljedice po očuvanje šumskih ekosistema i održivo gospodarenje šumskim resursima (Delić et al. 2016). U cilju obezbjeđenja održivog gospodarenja šumskim resursima, neophodno je kontunuirano investiranje i usklađivanje načina korištenja šuma s raspoloživim potencijalom. Potrebno je detaljno istražiti i preispitati uzroke ovakvih trendova u budućim istraživanjima i unaprijediti strategije za poboljšanje finansijskih ulaganja u biološku reprodukciju kako bi se osigurala dugoročna održivost, vitalnost, zdravlje i otpornost šumskih resursa.



Grafikon 12. Realizacija plana pošumljavanja i ostalih šumskouzgojnih radova u ŠPD "Srednjobosanske šume"

Graph 12. Realization of the afforestation plan and other forestry works in the ŠPD "Srednjobosanske šume"



Grafikon 13. Realizacija plana pošumljavanja i ostalih šumskouzgojnih u ŠPD "Unsko-sanske šume"

Graph 13. Realization of the afforestation plan and other forestry works in the ŠPD "Unsko-sanske šume"

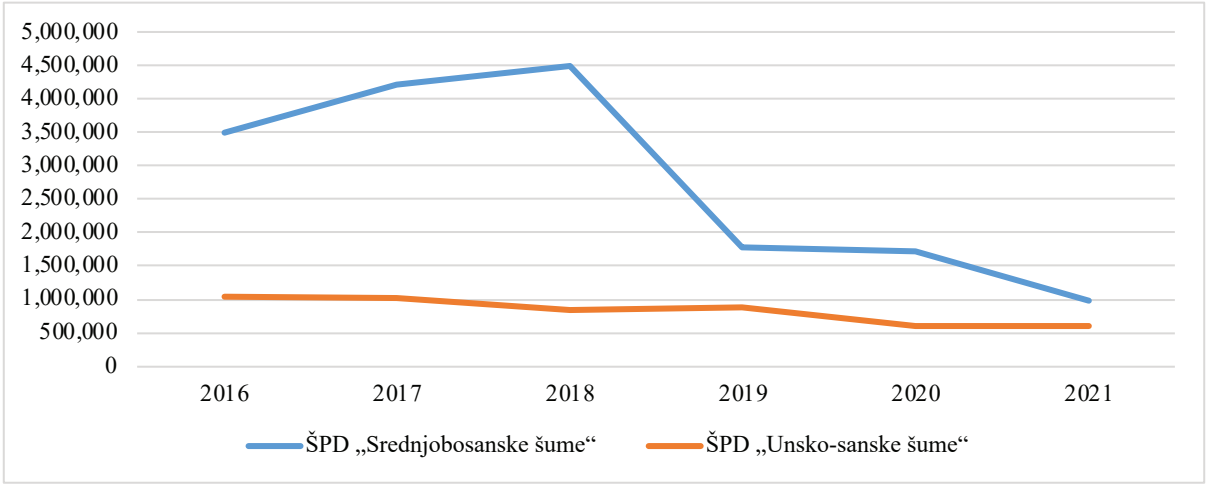
CONCLUSIONS – *Zaključci*

Na osnovu analize finansijskih izvještaja i komparacije izračunatih finansijskih indikatora za dva odabrana preduzeća šumarstva, mogu se donijeti zaključci o nivou i trendu profitabilnosti, ekonomičnosti, produktivnosti, aktivnosti, zaduženosti i likvidnosti. S obzirom na drastično rastući trend ukupnih prihoda, a s tim u vezi i ostvarenog većeg profita, ŠPD "Srednjobosanske šume" su posljedično imale bolje pokazatelje profitabilnosti, ekonomičnosti i nižeg stepena zaduženosti u analiziranom periodu. S druge strane, ŠPD "Unsko-sanske šume" su imale bolje pokazatelje aktivnosti, koji se ogledaju kroz efikasnije korištenja imovine u realizaciji poslovnih zadataka, te boljeg sistema naplate i kraćih rokova. Također, ovo preduzeće je u prednosti u pogledu likvidnosti, što ukazuje na bolji finansijski položaj i sigurnost u poslovanju.

Rastući trend obima sječa s jedne strane, a nizak stepen realizacije planiranih šumskouzgojnih radova i opadajući trend ulaganja u biološku reprodukciju s druge strane, mogao bi dugoročno ugroziti princip kontinuiteta reprodukcije i dovesti u pitanje održivo korištenje šumskih resursa.

Imajući u vidu da analizirana preduzeća ostvaruju preko 90% prihoda od prodaje šumskih drvnih sortimenata, opravdano se može zaključiti da je zanemaren koncept multifunkcionalnosti u korištenju šumskih resursa. Korištenjem raspoloživih potencijala, stekli bi se uslovi za proširenje proizvodno-poslovnog portfolia, stvaranje nove vrijednosti, što bi moglo značajno unaprijediti finansijske pokazatelji poslovanja preduzeća. S druge strane, preduzeća bi poboljšala svoju akumulativnu i reproduktivnu sposobnost za investiranje u unapređenje stanja šumskih resursa.

Za ocjenu održivog gospodarenja šumama nisu dovoljni samo finansijski indikatori, već je neophodno analizirati indikatore održivosti zbog ekonomskih, ekoloških i društvenih koristi od šumskih resursa. Pored uobičajenih metodologija za izvještavanje o održivosti (najčešće korištena metodologija Globalne inicijative za izvještavanje – GRI), neophodno je razvijati indikatore održivosti u svim aspektima gospodarenja šumama, zbog mnogobrojnih specifičnosti u šumarstvu i netržišnih koristi od šumskih resursa. Kao polazna osnova za njihovo definisanje može biti set Pan-evropskih kriterija i indikatora održi-



Grafikon 14. Uložena finansijska sredstva u ukupne šumskouzgojne radove (KM)

Graph 14. Financial resources invested in total silvicultural works (KM)

vog gospodarenja šumama, koji je potrebno prilagođavati potrebama i zahtjevima društva za informacijama o praćenju stanja šumskih resursa i evolucije koncepta održivog gospodarenja šumama.

Za potrebe izrade metodike izvještavanja održivog gospodarenja šumama neophodno je jasno definisati ekonomske, ekološke i sociološke indikatore održivosti. Ekonomska dimenzija održivosti se može sagledati kroz sljedeće indikatore: vrijednost ukupnih prihoda od svih šumskih proizvoda i usluga te, s tim u vezi, troškova gospodarenja šumama, stepen izvršenja planova gospodarenja, a naročito planova šumskouzgojnih radova, investicije i inovacije u unapređenje proizvodnje u šumarstvu, investicije u biološku reprodukciju, plate uposlenika u sektoru šumarstva i sl.

Ekološka dimenzija održivosti se ogleda u procjeni uticaja gospodarenja šumama na okoliš, uključujući zemljište, vazduh, vodu i ekosisteme. Pozitivni uticaji šume na očuvanje biodiverziteta, hidrološka funkciju, zaštitna funkciju, uloga šume u regulaciji klime i skladištenju CO2 te očuvanje stepena prirodnosti, mogu se procijeniti primjenom različitih metoda vrednovanja pojedinih funkcija, koristeći praktična iskustva i pozitivne prakse (Ševčik 2014).

Sociološki indikatori se odnose na: zapošljavanje lokalne radne snage u sektoru šumarstva, podršku lokalnoj ekonomiji, kontinuiranu obuku i razvoj vještina uposlenika, zaštitu prava radnika i promociju zdravog radnog okruženja, uključenost lokalnih zajednica u proces donošenja odluka i dijalog, dostupnost šuma lokalnom stanovništvu za potrebe rekreacije, obrazovanja i tradicionalnih aktivnosti i sl.

Izvještaj o održivosti šumarskih preduzeća bi trebao sadržavati konkretne informacije vezane za navedene indikatore, uključujući ciljeve, mjere i planove za unapređenje održivosti u budućnosti. Primjena i praćenje indikatora održivog razvoja bi omogućila bolje praćenje ljudskih aktivnosti u odnosu na šumske ekosisteme, povećala transparentnost, odgovornost, pozitivno uticala na razvoj svijesti javnosti o važnosti šumskih ekosistema i omogućila donošenje adekvatnih upravljačkih odluka. Iako je nefinansijsko izvještavanje pravno neobavezujuće u našoj zemlji, smatramo da ono može biti veoma korisno jer obuhvata širok spektar informacija o društvenim, okolišnim i ekonomskim performansama preduzeća šumarstva, a koje nisu uključene u finansijske izvještaje, što može doprinijeti održivom gospodarenju šumskim resursima. U svijetu raste interes preduzeća za primjenu izvještavanja o održivosti te se može očekivati dalji napredak u razvoju i unapređivanju indikatora, specifičnih za gospodarenje šumama. Za praćenje i poređenje indikatora održivosti u BiH, bilo bi neophodno izraditi jedinstvenu metodiku za nefinansijsko izvještavanje.

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SUMMARY

Forestry companies in Bosnia and Herzegovina, as users of state forests, were established following state administrative and legal regulations. Business results and success are determined based on the annual financial reports. By applying various analytical tools and techniques, horizontal and vertical analyses are conducted to obtain information that can serve as a quality basis for making business decisions. Financial performance indicators are particularly significant in analyzing planned values, trends, and comparisons with other business entities within the same industry. This work aimed to analyze the financial reports of two selected forestry companies from Bosnia and Herzegovina and to calculate indicators related to profitability, economy, productivity, activity, indebtedness, and liquidity. Additionally, the goal was to highlight the shortcomings of financial reporting in providing information on environmental and social responsibility, emphasizing the need for non-financial reporting to assess the company's performance regarding environmental impact, employee care, consumer relations, and the broader community.

The comparison of financial indicators shows that ŠPD "Srednjobosanske šume" had better profitability, economy, and lower indebtedness indicators compared to ŠPD "Unsko-Sanske šume" during the analyzed period. This is logical, given the continuously growing trend of total revenues and the resulting higher profit. Conversely, ŠPD "Unsko-Sanske šume" had better activity indicators, reflecting more efficient use of assets, a better collection system, and shorter deadlines. This company also had an advantage in terms of liquidity, indicating a better financial position and business security. Both companies showed a growing trend in the volume of felling, while the degree of planned forestry work realization and investment in biological reproduction was decreasing. In the long term, this could threaten the continuity of reproduction and jeopardize the sustainable use of resources. Considering that the analyzed companies generate over 90% of their income from the sale of forest wood assortments, it can be reasonably concluded that the concept of multifunctionality in forest resource use has been neglected. Utilizing available potential could create conditions for expanding the production-business portfolio and creating new value, significantly improving the financial indicators of the company operations. Additionally, companies would enhance their accumulative and reproductive capacity to invest in improving forest resources.

For assessing sustainable forest management, financial indicators alone are insufficient. It is necessary to analyze sustainability indicators due to the economic, ecological, and social benefits of forest resources. Beyond the commonly used GRI methodology for sustainability reporting, it is crucial to develop sustainability indicators in all aspects of the forest management due to numerous specificities in forestry and the non-market benefits of forest resources. A starting point for their definition can be the set of Pan-European criteria and indicators for sustainable forest management, which need to be adapted to societal needs and demands for information on the forest resource status and the evolving concept of sustainable forest management.

For developing a reporting methodology for sustainable forest management, it is essential to clearly define economic, ecological, and sociological sustainability indicators. The sustainability report of forestry companies should contain specific information related to these indicators, including goals, measures, and plans for future sustainability improvements. Applying and monitoring sustainable development indicators would enable better tracking of human activities concerning forest ecosystems, increase transparency and accountability, positively influence public awareness of the importance of forest ecosystems, and facilitate adequate management decisions. Although non-financial reporting is not legally binding in our country, it can be very useful as it encompasses a wide range of information on the social, environmental, and economic performance of forestry companies, not included in the financial reports, thus contributing to the sustainable management of forest resources.

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ORIGINAL SCIENTIFIC PAPER

Predictive distribution modelling of newly described endemic Dinaric species *Cirsium greimleri* Bureš

Prediktivno modeliranje distribucije novoopisane endemične dinarske vrste *Cirsium greimleri* Bureš

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ABSTRACT

Cirsium (thistle) is one of the most taxonomically demanding genera within the Compositae. These taxonomic difficulties are hypothesized to result from limited morphological differentiation, incipient speciation and/or hybridisation among taxa, and misinterpretations of faded and incomplete herbarium specimens. According to the latest data, the Dinarides and the Eastern Alps are inhabited by the endemic, diploid, newly described species *Cirsium greimleri*, which often occurs in sympatry with *C. rivulare* and *C. erisithales*. The area of the related, vicarious, tetraploid, and endemic species *C. waldsteinii* is limited to the southeastern Carpathians. Considering that the new knowledge refutes the existence of *C. waldsteinii* in Bosnia and Herzegovina, it was necessary to review all *C. waldsteinii* data discovered so far in Bosnia and Herzegovina. The results obtained from the distribution of the species, the predictive modelling of its ecological niche, and the analysis of the genome size confirmed the existence of the species *C. greimleri* in Bosnia and Herzegovina and its potential hybridisation. This study indicates the need for further research into the sympatry of *C. greimleri* and its relatives, as well as the essential taxonomic revision of this complex.

Keywords: Endemic, Greimler's thistle, predictive modelling, taxonomic complexities

INTRODUCTION – *Uvod*

The genus *Cirsium* Mill., known as thistle, is one of the largest genera in Compositae, containing approximately 250 taxa (Segarra-Moragues et al., 2007; Ackerfield et al., 2020) or roughly 400–450 species (Michálková et al., 2018; Bureš et al., 2018) widely distributed across the Northern Hemisphere. *Cirsium* species are either perennial or biennial, with good adaptability to various environments such as wetlands, meadows, steppes and even desert landscapes (Charadze, 1963; Davis & Paris, 1975; Petrak, 1979; Keil, 2006; Kadereit & Jeffrey, 2007; Segarra-Moragues et al., 2007; Yildiz et al., 2016). During the 17th and 18th centuries, early references to the

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genus *Cirsium* were often inconsistent, and diverse taxa were understood as representatives of different genera (Tournefort, 1694; Linnaeus, 1753; Miller, 1754; Adanson, 1763; Necker, 1790; Sweet, 1825; Cassini, 1826; Candolle & Duby, 1828; Lessing, 1832; Candolle, 1837; Koch, 1851; Fourreau, 1869; Gray, 1874; Greene, 1892). According to the Flora Europaea (Werner, 1996), *Cirsium* species belong into three *Cirsium* sections: *Eriolepis*, *Cirsium* and *Cephalonoplos*.

It was considered that *Cirsium waldsteinii* Rouy is naturally present in Eastern Alps, Carpathians and Dinarides, where its presence in the western Balkans region is confirmed by the local floras (Domac, 1967; Josifović, 1970; Bjelčić et al., 1983). However, botanists have encountered challenges in identifying this species due to discrepancies in its descriptions across different Florae. Molecular investigations have revealed taxonomic complexities within the genus *Cirsium* due to the frequent hybridisation of its representatives (Bureš et al., 2004). As a result of a comprehensive study by Bureš et al. (2018) it was described that endemic diploid species *C. greimleri* Bureš (Greimler's thistle), inhabited the Dinaric and Eastern Alpine regions. The range of its closely relative tetraploid vicar species *C. waldsteinii* is limited to the southeastern Carpathians. The new findings by these authors unreservedly refute the existence of the species *C. waldsteinii* in the region of the Dinaric and Eastern Alps.

This issue presents a challenge that is effectively solved through advanced modelling techniques. Species Distribution Models (SDMs) are used to estimate a species' current and future geographic distribution and environmental niche. Today, MaxEnt is the most commonly used model and has been used in studies assessing the effects of climate change on species distribution, species richness, invasive species, endemism hotspots, as well as in estimating the range and protection status of rare species (Cunningham et al., 2009; Wan et al., 2021; Qazi et al., 2022). Additionally, QGIS is widely used in scientific research across various disciplines due to its capabilities for handling spatial data and conducting geospatial analysis. This method is helpful for visualising urban development (Zaki et al., 2022), tree species mapping (Choudhury et al., 2020), forest inventory (Pica et al., 2022), tracking outbreaks, and analysing the spread of infectious diseases (da Silva et al., 2021), but also for asses distribution patterns and predictive models for plant species (Cursach et al., 2020).

The objectives of this study were to contribute to the revision of the current species count within the genus *Cirsium* in Bosnia and Herzegovina (B&H) and to detect potential localities of allopatric and sympatric populations of newly described *C. greimleri* using predictive modelling methodology.

MATERIALS AND METHODS – *Materijal i metode*

Input data

Herbarium collections data from the National Museum of Bosnia and Herzegovina (SARA), relevant literature sources (Kušan, 1956; Bjelčić et al., 1983; Mišić, 1984; Barudanović, 2003; Đug, 2004) and field investigations were used for the estimation of the potential distribution of *C. greimleri* (ex *C. waldsteinii*) in Bosnia and Herzegovina (Supplement Table 1). All references for the species *C. waldsteinii* in Bosnia and Herzegovina were treated as *C. greimleri* in this study. Additionally, available distribution data of *C. rivulare* and *C. erisithales*, as *C. greimleri* frequent hybridization partners (Heimerl, 1884; Fritsch, 1906; Khek, 1908; Benz, 1922; Leute and Zeitler, 1967; Bureš et al., 2018), were used to detect sympatric populations.

Unfortunately, herbarium and literature data regarding the geographic locations of detected populations in B&H for the investigated species were often incomplete. Consequently, reliability statuses were assigned as follows: (1) unreliable – indicating the absence of a narrower locality and/or altitude, and (2) reliable – indicating the presence of a narrower locality and/or altitude. All obtained initial parameters for the target species were utilized in designing the distribution map and predictive modelling of ecological niches.

The areal map and predictive ecological niches

The Desktop version of QGIS Hannover 3.16.16 was used to create the area map. Climate data were extracted from the WorldClim 2.1 database, which includes 19 bioclimatic variables in the form of raster layers at a resolution of 30 arc-seconds (Fick & Hijmans, 2017; https://www.worldclim.org). This global database contains data obtained through the interpolation of temperature and precipitation values from over 3.500 national meteorological stations included in the global network. The data were derived from a 30-year average (1970-2000) and are widely used (Hijmans et al., 2005; Fick & Hijmans, 2017).

MaxEnt software functions by predicting the potential spatial distribution based on existing occurrence data (Phillips et al., 2006; Dai et al., 2022). An ecological niche model was created using the maximum entropy met-

Table 1. Investigated *Cirsium greimleri* populations

Tabela 1. Istraživane populacije Cirsium greimleri

Locality	GPS-N	GPS-E	Altitude (m)	Exposition
Mt. Igman, RavnaVala (rainforest reserve)	43°44'22"	18°16'23"	1257	N
Mt. Jahorina, Bistrica-Paljevina	43°44'51"	18°33'48"	1454	N-NW
Mt. Jahorina, Bistrica-Mušak	43°44'49"	18°33'55"	1460	
Mt. Jahorina, Grahov Dol	43°44'35"	18°34'00"	1478	

hod in MaxEnt 3.4.4. software (Phillips et al., 2006), and the results were projected into geographic space, producing a predictive map. On this map, pixel values range from 0 to 1, with cooler (blue) to warmer (red) colors indicating habitat favorability. Values closer to 1 signify more favorable habitats, while values closer to 0 indicate less favorable habitats for *C. greimleri*.

In the graphic representation of model accuracy, the x-axis represents specificity, ranging from 0 to 1, indicating the proportion of locations correctly identified as species-absent. The y-axis shows sensitivity (1 – omission rate), also on a scale from 0 to 1, reflecting the proportion of locations where the species' presence was accurately predicted.

Fieldwork

According to the created preliminary distribution map, four possible localities of the newly described diploid species *C. greimleri* were selected (Table 1): the Ravna Vala microhabitat with an allopatric population, and three sympatric populations on Jahorina Mt. (with *C. erisithales* and *C. rivulare*). The field investigations were carried out between May and September of 2022. and 2023.

Genome size

Three to six individuals per population were sampled for genome size estimation (Table 1). The nuclear genome size was determined according to Bourge et al. (2018). Fresh leaves of the internal standard species, *Petunia hybrida* (Hort.) PxPc6 (2C=2.85 pg) (Marie & Brown, 1993), were shredded with *C. greimleri* dried leaves in a sterile plastic Petri dish with 600 µL of cold GiF buffer for nuclear isolation. The GiF buffer included 45 mM MgCl2, 30 mM sodium citrate, 60 mM MOPS acid pH 7, 0.1% PVP 10 000, 10 mM sodium metabisulfite (Na2S2O5), RNA-se (2.5 U/mL), and 0.1% Triton X-100. To remove cell and tissue debris, the nuclei suspension was filtered through a nylon filter (r=30 or r=50 µm). Nuclei were stained with 100 µg/ml propidium iodide (PI) for at least 5 minutes at 4°C.

To obtain mean genome size values, approximately 5.000 stained nuclei were analysed for each sample using a CytoFLEX S cytometer with 561 nm excitation, 26 mW, and emission through a 610/20 nm band-pass filter (Beckman Coulter-Life Science, United States). Samples for each population had three to six separately measured individuals, each with replication. CytExpert 2.3 software was used for histogram analysis. The mean value (± st. dev.) of 2C DNA was calculated by comparing the linear relationship between the fluorescent signals of the stained nuclei of the examined species and the internal standard. Genome size values are expressed in absolute units of 2C (pg), monoploid values of 1Cx (pg and in Mbp), recalculated using the conversion factor 1 pg DNA = 978 Mbp (Doležel et al., 2003).

RESULTS AND DISCUSSION – *Rezultati i diskusija*

Bureš et al. (2018) state that *Cirsium waldsteinii* is widespread in the Eastern and Southern Carpathians, with no distribution in the Eastern Alps and Dinaric region. Also, they suggest that *C. greimleri* is distributed across southeastern Austria, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, and Serbia. Therefore, all data published for Bosnia and Herzegovina (Bjelčić et al., 1983; Kušan, 1956; Mišić, 1984; Barudanović, 2003; Đug, 2004) and SARA's specimens were treated as *C. greimleri*. According to the available literature data, SARA specimens and field work a total of 40 localities of the species *C. greimleri* were detected in B&H (Supplement Table 1).

The distribution map and habitat suitability of *C. greimleri* are presented in Figure 1. Based on the conducted software analysis, logistic output data were obtained.

The formation of the given distribution was primarily influenced by the Mean Temperature of the Wettest Quarter (Bio8 variable; 51.8%). The following variables include the Mean Temperature of the Driest Quarter (Bio9; 30.2%) and Precipitation of the Wettest Quarter (Bio16; 9.4%). According to our findings, habitats for the potential spread of *C. greimleri* in B&H engage areas from the high mountains to the subalpine belt. This is in agreement with Bureš et al. (2018) conclusions about *C. greimleri* habitat ecology. These authors state that *C. greimleri* occupies ecological niches within high-mountain and subalpine ecosystems with a preference for open high-mountain and subalpine park-like forest/woodlands, as well as moist slopes of forested valleys and shaded forest roads, at altitudes ranging from 800 to 2.000 m above sea level.

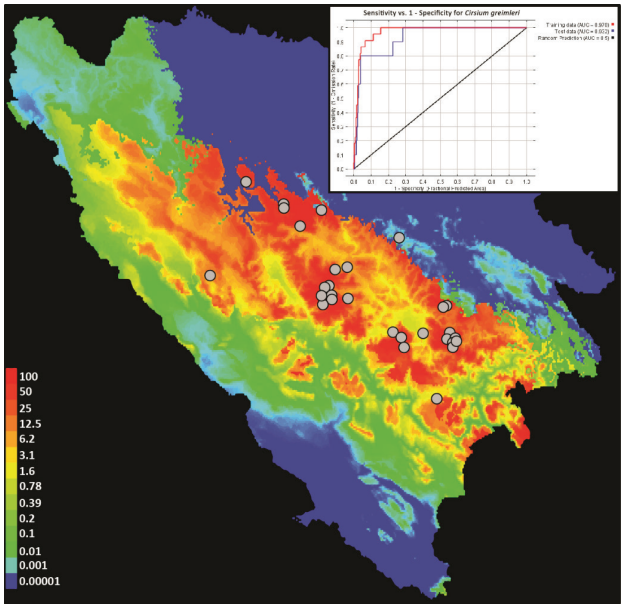

Figure 1. Recorded localities for *C. greimleri* in B&H (see Supplement Table 1) overlaid by SDM (Species Distribution Model)

Karta 1. Evidentirane populacije C. greimleri *u B&H (vidjeti Dodatnu tabelu 1), predstavljene kroz distributivni model vrste*

Detected *Cirsium greimleri* populations (Supplement Table 1) with obtained habitat suitability using the MaxEnt software, including a graphic representation of the model accuracy, are presented in Figure 1. Some of the localities are not visible on the map of this scale due to their proximity. In the graphic representation of the model accuracy (Figure 1), the ROC curve shows the relationship between the true positive rate (sensitivity) and the false positive rate (specificity) for different model cut-offs, using them as evaluation criteria. Small differences in omission rates and their standard deviations, which indicate a good match of the model with literature data were visible. An AUC value of 0.970 means the model is highly accurate and capable of distinguishing between regions with the presence of species with those without them. Additionally, the graph shows the omission gap between the modelled and observed values.

The obtained potential distribution model of *C. greimleri* and its predictive ecological niches (Figure 1) confirmed that the Alpine biogeographical region of the B&H is an optimal habitat and potential zone for further research and monitoring to better understand the spread of the species.

The case of selected allopatric and sympatric Cirsium greimleri populations

Figure 2 presents localities for the three target species according to the Supplement Table 1.

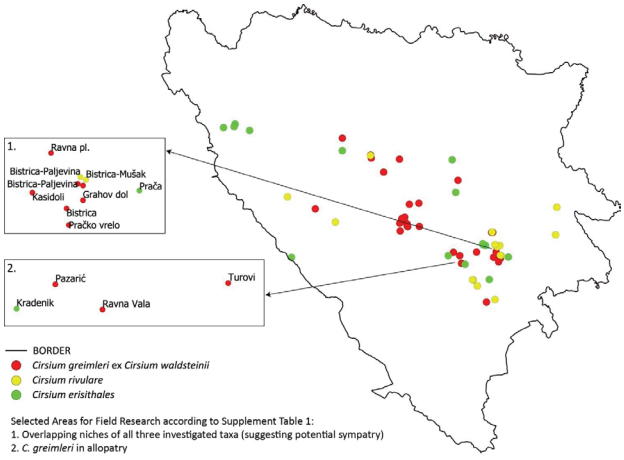

Figure 2. Distribution of the investigated *Cirsium* species in Bosnia and Herzegovina

Karta 2. Distribucija istraživanih Cirsium *vrsta na području Bosne i Hercegovine*

C. greimleri in Bosnia and Herzegovina has been recorded at 40, *C. rivulare* at 13, and *C. erisithales* at 15 sites (Figure 2). *C. greimleri* preferences for moist slopes of forested valleys and shaded forest roads (Bureš et al. 2018) occasionally overlap with *C. rivulare* and *C. erisithales* habitats ranging from moderate elevation foothills to mid-level mountainous areas with preferences for moist environments (Gajić, 1975; Bjelčić et al., 1983). Niche-overlapping that includes preferences for high moisture content in the air and soil in habitats such as forest hydrophilous fringe communities might explain why these species are frequently found in sympatric populations.

According to the Figure 2, two areas were selected: one with an allopatric population of *C. greimleri*, and the other with sympatric populations of all three analysed species. Field research confirmed the presence of the

C. greimleri allopatric population at the Ravna Vala site (Table 1, Figure 2). The individuals from the population Ravna Vala exhibited uniform leaf and flower morphology. In three Jahorina Mt. localities *C. greimleri* individuals showed significantly different morphological features compared to the Bureš et al. (2018) diagnosis. Namely, individuals with very variable leaf blade shapes: from narrower and less deeply lobed to deeply lobed median cauline leaves, were discovered in these populations (Figure 3).

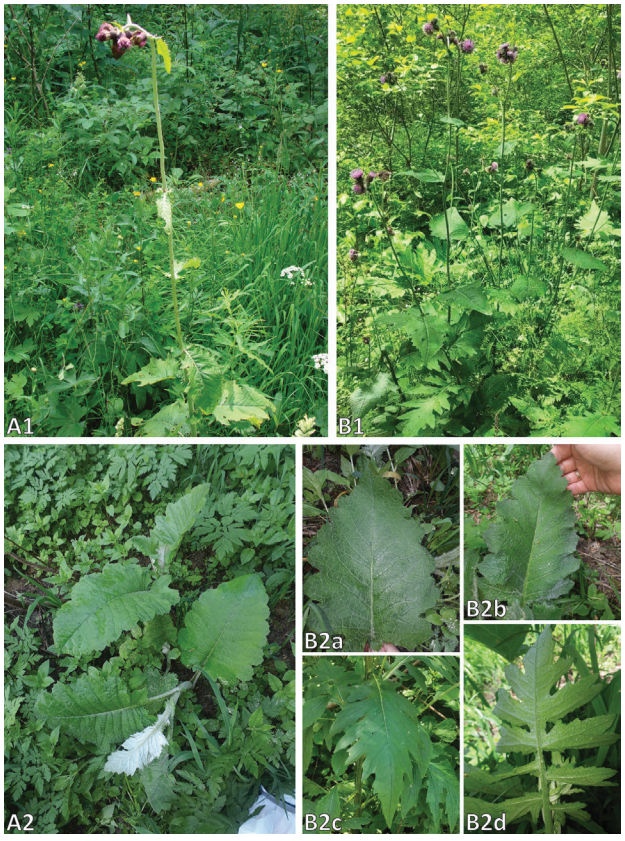

Figure 3. *Cirsium greimleri* on A) Igman Mt. A1: Individual in allopatric population. A2: Leaf morphology; B) Jahorina Mt. B1: Individuals in sympatric population. B2a-B2d: Leaf morphology variations.

Slika 3. Cirsium greimleri *na planini A) Igman. A1: Individua u alopatričnoj populaciji. A2: Izgled lista; B) Jahorini. B1: Indvidue u simpatričnoj populaciji. B2a-B2d: Varijacije u morfologiji lista.*

A more detailed analysis of the herbarium *C. greimleri* specimens from SARA, labelled as *C. waldsteinii*, revealed that some specimens have uncommon leaf morphological features, particularly in upper and medium cauline leaves as we found in studied sympatric populations. Unfortunately, flower colour, the stable taxonomic feature in genus *Cirsium* (Wagenitz, 1987; Yildiz et al., 2016; Bureš et al., 2018), could not be determined due to the long storage of these exsiccates. The observed morphological variability is most likely a consequence of the presence of a hybrid species of *C. greimleri* as one of the parents. Namely, *Cirsium* species, particularly those from the type's section, frequently hybridise (Wagenitz 1987; Bureš et al., 2004, 2010; Stöhr 2006; Segarra-Moragues et al., 2007) and *C. greimleri* is the most common among them with a significant frequency of hybrids in natural populations compared to the "pure" individuals (Bureš et al., 2018). Obtained predictive modelling results for *C. greimleri* and distribution map (Figures 1 and 2) of its most common possible hybridisation partners (*C. erisithales* and *C. rivulare*; Heimerl, 1884; Fritsch, 1906; Khek, 1908; Benz, 1922; Leute & Zeitler, 1967; Bureš et al., 2018) are used for highlighting of potential sympatric populations in B&H.

The appearance of sympatry further complicates the determination of the species *C. greimleri* and the assessment of its distribution. This is especially evident in localities such as Jahorina, Treskavica and Zvijezda Mts. The results of the predictive analysis have confirmed the actual distribution of the studied species. This methodology is justified for investigating complex ecological interactions in vivo.

Genome size

The nuclear DNA amount values for all analysed individuals varied in the range from 1.72 to 2.25 pg (Table 2), which corresponds to the diploid ploidy level. The genome size in all populations, except in Bistrica-Paljevina, was uniform. In the mentioned population, two significantly different genome size values were observed (1.76-1.82 pg and 2.22-2.25 pg). Individuals from Bistrica-Paljevina with higher genome size values had similar leaf morphology and ruby red capitulum as individuals from the allopatric *C. greimleri* population (marked with grey) which is in accordance with Bureš et al. (2018) diagnosis. In all other cases, individuals with lower 2C values showed great variability in leaf blade shapes (Figure 3).

According to Bureš et al. (2018), genome size values for *C. greimleri* vary from 1.87 to 2.17 pg whereas 2C values of Bosnian samples varied from 1.88 to 1.98 pg. The obtained finding of the range of genome size variation in this study is wider than the stated results in Bureš et al. (2018). Additionally, our results suggest that the mean 2C value in the allopatric population of *C. greimleri* (2.18 pg; Ravna Vala) is higher than the highest value reported by Bureš et al. (2018) joined the species. Based on the results presented in Table 2, Figures 2 and 3, it is possible to infer that individuals with variable leaf morphology and lower nuclear DNA values may be the offspring of sympatric hybridisation.

Table 2. The nuclear DNA amount values for *Cirsium greimleri* populations (individuals with uniform morphological features in gray)

Tabela 2. Vrijednosti nuklearne DNK za populacije Cirsium greimleri (individue sa ujednačenim morfološkim karakteristikama su označene sivom bojom)

Locality	Sample	2C (pg)	2C (pg)±SD	CV%	1C (pg)	1C (Mpb)
Jahorina Mt., Bistrica-Paljevina	1	2.23	2.24±0.01	0.65	1.12	1,095
	2	2.22				
	3	2.25				
	4	1.82	1.80±0.04	2.00	0.90	1,760
	5	1.81				
	6	1.76				
Igman Mt., RavnaVala	1	2.19	2.18±0.04	1.82	1.09	2,132
	2	2.14				
	3	2.15				
	4	2.17				
	5	2.24				
Jahorina Mt., Bistrica-Mušak	1	1.83	1.80±0.02	1.35	0.90	1,760
	2	1.77				
	3	1.82				
	4	1.80				
	5	1.80				
Jahorina Mt., Grahov Dol	1	1.78	1.79±0.05	2.65	0.90	1,751
	2	1.84				
	3	1.72				
	4	1.82				
	5	1.83				
	6	1.76				

During the hybridisation process, as rapid genomic changes, the gain or loss of DNA is commonly evident. Among the genera with a high hybridisation rate is the genus *Cirsium*, within which *C. greimleri* is characterized by a particular "interspecific promiscuity" (Bureš et al., 2018). The hybridisation often leads to the genetic erosion of the species and the loss of one of the hybrid parents in sympatric populations, which is a possible case in this study.

CONCLUSION – *Zaključak*

This study confirms the findings of Bureš et al. (2018), who determined the presence of *C. greimleri* in Bosnia and Herzegovina at the investigated localities. This species in B&H predominantly occurs in sympatric populations with related species, as was also observed in this study. The consequence of the above is challenging taxonomic differentiation of the genus. The study also demonstrated that the MaxEnt model yields reliable results even with limited samples. Therefore, predictive modelling can be utilized to study sympatric populations, which can improve the efficiency of fieldwork.

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Supplement Table 1. Distribution of *Cirsium greimleri* (ex *C. waldsteinii*), *C. erisithales* and *C. rivulare* in Bosnia and Herzegovina

Dodatna Tabela 1. Distribucija vrsta Cirsium greimleri *(ex* C. waldsteinii*),* C. erisithales *i* C. rivulare *u Bosni i Hercegovini*

Locality	Species	Literature data, SARA's herbarium specimens and field investigation
Vranica Mt.	***C. greimleri***	Above Točila, 1.320 m, beech and conifer forest (Barudanović, 2003); Estuary of the Požarna, Mt. Vranica, 1.140 m, beech and conifer forest (Barudanović, 2003); Donja Bistrica, 610 m, mountain beech forest (Barudanović, 2003); Vrtače, 980 m, mountain beech forest (Barudanović, 2003); Estuary of the Požarna, 1.090 m, mountain beech forest (Barudanović, 2003); Estuary of the Požarna, 950 m, mountain beech forest (Barudanović, 2003); Above Kaćuni, 430 m, *Ulmo-Aceretum*, forest with *Symphyandra hofmannii* (Barudanović, 2003); Stream Zavol, 1.190 m, hygrophilous forest (Barudanović, 2003); Above Jezernica, 1.160 m, hygrophilous forest (Barudanović, 2003); Turkovići-Klisure, 1.160 m, hygrophilous forest (Barudanović, 2003); Borovnica stream, 870 m, hygrophilous forest (Barudanović, 2003); Zelena Gromila, 1.750 m, *Agrosti-Alnetum viridis* (Đug, 2004); Stražica, 1.700 m, *Athyrio-Alnetum viridis* (Đug, 2004); Zelena Gromila, 1.660 m, *Alnetum viridis* (Đug, 2004); Banjaluk, 1.600 m, *Alnetum viridis* (Đug, 2004); Bukov vrat, 1.545 m, *Salicetum waldsteinianae* (Đug, 2004); Ćoso, 1.830 m, *Pinetum mugi calciolum* (Đug, 2004); Podine, 1.870 m, *Pinetum mugi calciolum* (Đug, 2004); Nadkrstac, 2.105 m, *Pinetum mugi calciolum* (Đug, 2004).
Jahorina Mt.	***C. greimleri***	Kasidol, 1.360 m, ex Maly, 1903, SARA 43 791; Bistrica, Ravna planina in Pale, 1.250 m, ex Maly, 1907, SARA 43 792; In the forest near Pračko river spring, 1.460 m, *Abietum albae*, ex Maly, 1921, SARA 43 787; Bistrica-Paljevina, 1.454 m, N-NW, Muratović & Pustahija, 2022; Bistrica-Mušak, 1.460 m, Muratović & Pustahija, 2022; Grahov Dol, 1.478 m, Muratović & Pustahija, 2023.
	C. rivulare	In wet bushes, 840 m, ex Maly, 1919. SARA 43 801; ex Fiala, 1895. SARA 43 803; In the wet meadows near Pale, ex Maly, 1931. SARA 43 807.
	C. erisithales	Ravna planina towards Bistrica, 1.320 m, ex Maly, 1933. SARA 43 719.
Bjelašnica Mt.	***C. greimleri***	Babin Do, 1.260 m, ex Maly, 1906. SARA 43 788.
	C. erisithales	Hranisava, above Kradenik river spring, 1.000 m, ex Ritter, 1935. SARA 43 713; Along the stream, below Javornik spring, ex Bjelčić, 1950. SARA 43 714.
Pazarić	***C. greimleri***	Zovik near Pazarić, 1.300 m, ex Ritter, 1935. SARA 43 794.
Treskavica Mt.	***Cirsium greimleri***	Turovi, towards Kazani (Željeznica river), 1.218 m, Trakić, 2023 (personal communication).
	C. rivulare	Bara above Gvozno, 1.430 m, *Trollio-Juncetum*, Mišić, 1984; Veliko jezero, ex Popović, 1952. SARA 43 799; Veliko jezero, 1.550 m, ex Maly, 1911. SARA 43 808.
OzrenMt.	***C. greimleri***	Han Jezero, 1.200 m, ex Maly, 1908. SARA 43 782; In the valley Babin potok towards Han Toplica, 1.170 m, ex Maly, 1919. SARA 43 783.
	C. rivulare	On meadows between Han Jezero and Han Toplice, 1.270 m, ex Maly, 1922. SARA 43 796.
Vlašić Mt.	***C. greimleri***	Gujni Do, 1885. SARA 43 790; Above Paklarevo, Gujni do, Korićani, ex Brandis, 1884. SARA 43 780; Above Paklarevo, Gujni do, Korićani, ex Brandis, 1885. SARA 43 780.
	C. rivulare	Gujni do, 1885. SARA 43 802.
Zvijezda Mt.	***C. greimleri***	Bukovački spring, Vareš, Šarić, 2011; Pogar near Vareš, Šarić, 2014, 2016, 2020.
	C. erisithales	In Bobovac, ex Plavšić, 1940. SARA 43 718.
Zelengora Mt.	***C. greimleri***	In the valley Stabrovača on Mt. Husad and Ravna gora towards Jelašća, 1.380 m, ex Maly, 1931. SARA 43 786.
	C. rivulare	Konjska voda towards Jelašća, 1.400 m, ex Maly, 1931. SARA 43 797.
Hrbljina Mt.	***C. greimleri***	In Glamoč, ex Santorius, 1897. SARA 43 789.
Vučija Mt.	***C. greimleri***	Towards Nemila, Javorak, 1.400 m, ex Maly, 1913. SARA 43 784.
Igman Mt.	***C.greimleri***	Ravna Vala, 1.257 m, Muratović & Pustahija, 2022.
Mehorić village	***C. greimleri***	Mehorić near Kakanj, Šarić, 2017.
Borika	***C. rivulare***	Towards Oprašići (distr. Rogatica), 950 m, ex Maly, 1931. SARA 43 806.
Podžeplje	***C. rivulare***	On wet meadows near Podžeplje (near Rogatica), 950 m, ex Maly, 1923. SARA 43 805.

Locality	Species	Literature data, SARA's herbarium specimens and field investigation
Kupreško polje	***C. rivulare***	ex Lažetić, 1958. SARA 43 804.
Glamočko polje	***C. rivulare***	On marshy meadows, ex Ritter, 1954. SARA 43 798.
Trebević Mt.	***C. erisithales***	Alpinetum, ex Šilić, 1959. SARA 50 005; Dovlići, 1.560 m, ex Maly, 1924. SARA 43 722; 1.560 m, ex Maly, 1937. SARA 43 724.
Klekovača Mt.	***C. erisithales***	In Petrovac, ex Fiala, 1891. SARA 43 709; Drinić in Petrovac, ex Fiala, 1891. SARA 43 716; In Petrovac, ex Fiala, 1891. SARA 43 717.
Prača	***C. erisithales***	Banja stijena, 570 m, ex Maly, 1909. SARA 43 711.
Kamenica Mt.	***C. erisithales***	In the valley Gostović river, 350 m, ex Maly, 1920. SARA 43 712.
Osječenica Mt.	***C. erisithales***	In Petrovac, 1.800 m, ex Fiala, 1891. SARA 43 721.
Jajce	***C. erisithales***	Vrbas canyon near Jajce, ex Maly, 1908. SARA 43 726.
Kamešnica Mt.	***C. erisithales***	Pre-mountain beech forest, Kušan, 1956.

SAŽETAK

Prema najnovijim podacima, Dinaride i Istočne Alpe naseljava endemična, diploidna, novoopisana vrsta *Cirsium greimleri* umjesto, do sada navođene, tetraploidne *C. waldsteinii*. Ova studija, koristeći podatke iz literature, herbarijske zbirke SARA i terenskih istraživanja, potvrdila je prisustvo vrste *C. greimleri* u Bosni i Hercegovini na 40 lokaliteta. Upotrebom MaxEnt modela i GIS alata izrađena je karta rasprostranjenosti i ekoloških niša za novu bh. vrstu, pri čemu su ključni faktori za njenu distribuciju identificirani kao srednja temperatura najvlažnijeg i najsušnijeg kvartala te količina padavina. Model je pokazao visoku tačnost (AUC vrijednost 0.970), što ukazuje na sposobnost preciznog razlikovanja područja sa i bez prisustva vrste. Pored toga, model je ukazao na prisustvo vrsta sa kojima *C. greimleri* često hibridizira (*C. rivulare* i *C. erisithales*) na više lokaliteta. Terenskim istraživanjima je potvrđeno prisustvo diploidnih populacija istraživane vrste s rasponom variranja nuklearne veličine genoma od 1.72 do 2.25 pg. Također, na osnovu prezentiranog prediktivnog modela izvršena je provjera odabranih lokaliteta na kojima *C. greimleri* koegzistira sa *C. rivulare* i *C. erisithales*. Tako je na lokalitetu Bistrica-Paljevina uočena populacija u kojoj su individue imale značajno iskazanu morfološku varijabilnost, što je i odgovaralo dvjema vrijednostima veličine genoma (1.76-1.82 pg i 2.22-2.25 pg). Ova studija ukazuje na potrebe daljih istraživanja problema simpatrije *C. greimleri* i njenih srodnika te neophodnu taksonomsku reviziju ovog kompleksa.

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ORIGINAL SCIENTIFIC PAPER

Influence of the Ratio of Water and Organic Solvents on the Antioxidative Activity and Content of Bioactive Components in *Artemisia annua* L. and *Artemisia absinthium* L. Extracts

Utjecaj omjera vode i organskih otapala na antioksidativno djelovanje i sadržaj bioaktivnih komponenti u ekstraktima *Artemisia annua* L. i *Artemisia absinthium* L.

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ABSTRACT

Bitter and sweet wormwoods are traditional plant species in the Asteraceae (Compositae). Their use in traditional medicine has long been known. Numerous preparations of bitter and sweet wormwood (teas, tinctures) are used in the treatment of diseases of the digestive system. The content of bioactive components (polyphenols and flavonoids) and antioxidant activity of *Artemisia absinthium* L. (bitter wormwood) and *Artemisia annua* L. (sweet wormwood) were examined in this paper. A series of extracts were prepared by mixing selected organic solvents (methanol, ethanol and acetone) and water in different volume ratios for both analyzed species. Antioxidant activity was tested using FRAP and DPPH methods. Extracts of sweet wormwood contain more bioactive components and have a higher antioxidant capacity compared to extracts of bitter wormwood. In terms of extraction efficiency, the mixture of acetone and water (20:30 v/v) proved to be the most efficient. Regarding pure organic solvents, the most effective for bioactive components isolation is ethanol, while acetone showed the weakest extraction power.

Keywords: *Wormwood, Polyphenols, Flavonoids, FRAP, DPPH inhibition*

INTRODUCTION – *Uvod*

Wormwoods are a medicinal, aromatic plants from the Artemisia genus, which represents one of the largest and most widespread genera of the Asteraceae (Compositae). According to the literature, this genus includes more than 500 species of aromatic plants (Abad et al., 2012). The two most famous species of this genus are *Artemisia. absinthium* L. (bitter) and *A. annua* L. (sweet) wormwoods. *Artemisia absinthium* is a resistant perennial shrub that is widespread mainly in the temperate zones of Asia, Europe and North America (Beigh and Ganai, 2017). *Arte-*

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misia annua is a fragrant annual weed of Asian origin, but it is naturalized in many other sunny and warm regions (Wan et al., 2016). Wormwoods have a long history of use in folk medicine. Namely, *A. absinthium* has traditionally been used to treat several disorders including hepatocyte enlargement, hepatitis, gastritis, jaundice, wound healing, splenomegaly, dyspepsia, indigestion, flatulence, stomach pain, anaemia, and anorexia (Batiha et al., 2020). In the form of teas or tinctures, it is used to stimulate the appetite and improve digestion, which is a consequence of its bitter taste, which stimulates the secretion of digestive juices. *Artemisia annua* has been used in traditional Chinese medicine to remove toxins from the blood, treat arthritis and fever, prevent the recurrence of malaria and treat jaundice (Qin et al., 2020). Due to the presence of different active substances in the plants, the chemical composition of *A. absinthium* and *A. annua* differs. *Artemisia absinthium* contains many phytochemical compounds, such as lactones, terpenoids, flavonoids, essential oils, organic acids, resins, tannins and phenols, which are responsible for its properties and therapeutic effects (Omer et al., 2007). One of the key compounds the essential oil of *A. absinthium* contains is thujone, a monoterpene ketone. Research has shown that both the α and β forms of thujone in the volatile oil obtained from *A. absinthium* act as anthelmintics (Tariq et al., 2009). The essential oil and aqueous extract of *A. absinthium* have shown analgesic and anti-inflammatory effects as a result of the flavonoids present (Hadi et al., 2014). Also, some studies have shown that isolated chlorogenic acid from *A. absinthium* shows an inhibitory effect on carcinogenesis in the liver, colon and tongue, while another active component, artemisinin, extracted from *A. absinthium* showed a significant antitumor effect against melanoma B16 (Tsuchiya et al., 1996; Goff et al., 2008). Analysis of the chemical composition of *A. annua* found that it contains many phytochemicals, such as monoterpenoids, sesquiterpenoids, flavonoids and coumarins, as well as aliphatic and lipid compounds (Bhakuni et al., 2001). *Artemisia annua* provided a class of highly effective antimalarials due to the presence of the endoperoxide sesquiterpene lactone, artemisinin. This compound is a highly oxygenated sesquiterpene containing a unique 1,2,4-trioxane ring structure, which is responsible for its antimalarial activity (Brown, 2010). Artemisinin-based combination therapies are now considered the best current treatment for uncomplicated *Plasmodium falciparum* malaria (He et al., 2009). The antimalarial efficacy of artemisinin is significantly improved when combined with other compounds such as terpenes, flavonoids, phenolic acids and polysaccharides (Weathers et al., 2011). Artemisinin and its derivatives can also be used in the treatment of various diseases, such as cancers, autoimmune diseases, diabetes, viral infections, parasitosis, and atherosclerosis (Efferth, 2017). Likewise, it was established that artemisinins significantly improve the success rate of chemotherapy (Meng et al., 2021). In addition to artemisinin, *A. annua* also contains many other bioactive components such as monoterpenoids, flavonoids, alkaloids, coumarins, etc. (Septembre-Malaterre et al., 2020). Thanks to its chemical composition, *A. annua* has been the subject of extensive research since its discovery, and it became popular again during the COVID-19 pandemic because it supposedly prevents and helps treat the symptoms of this disease (Irfan et al., 2024). Of the flavonoids present in sweet wormwood, the most significant are artemethin, casticin, chrysosplenetin, chrysosplenol D, cirsilineol and eupatorin, which show synergistic antimalarial effects (Septembre-Malaterre et al., 2020). Phenolic compounds increase the antitumor and antimalarial effects of artemisinin (Ferreira et al., 2010). Scopoline and scopoletin represent the main coumarins found in alcoholic extracts *of A. annua* and contribute to the anti-inflammatory, antioxidant, antipyretic and anti-allergic effects of sweet wormwood (Thabet et al., 2018; Fu et al., 2020).

In this research, the antioxidant activity and the content of bioactive components (polyphenols and flavonoids) of sweet and bitter wormwoods were compared. The influence of the ratio of water and selected organic solvents on the efficiency of extraction of bioactive components in in vitro conditions was also examined.

MATERIALS AND METHODS – *Materijal i metode*

Plant material, chemicals and instruments

Dried aerial parts of bitter and sweet wormwood were purchased in a local market in Tuzla, Bosnia and Herzegovina. The sample was determined in the pharmacognosy laboratory of the Faculty of Pharmacy, University of Tuzla. The plant was ground into powder using an electric mill. Aqueous solutions needed for the analysis were prepared using demineralized water. All reagents were p.a. purity and were used without further purification. Spectrophotometric measurements were performed on a Perkin Elmer Lambda 25 spectrophotometer, in the wavelength range of 510-765 nm.

Preparation of extracts

Extracts of sweet and bitter wormwood were prepared by mixing 0.5 grams of chopped plant material with 50 mL of solvent or solvent mixture. The plant material was mixed on a vibromix for 60 minutes, then the mixture was filtered and the collected extract was analyzed immediately. All extracts were clear after filtration.

Determination of total phenolic content (TPC)

Total phenolic compounds present in the extracts were quantified spectrophotometrically using the Folin-Ciocalteu test following the protocol of Singleton et al. (1999), with some modifications. Namely, 200 µL of extracts was mixed with 2540 µL of 10% Folin-Ciocalteu reagent. After 5 minutes 420 µL of 10% sodium carbonate was added. The absorbance of the resulting blue-coloured solution was measured at 765 nm after incubation at room temperature for 1 hour. The total phenolic content was expressed as gallic acid equivalents (GAE) in milligrams per gram of dry plant material.

Determination of total flavonoid content (TFC)

The total flavonoid content in the extracts was determined by the previously described method of Olajire and Azeez (2011), with some modifications. Namely, 1 mL of extract solution was mixed with 0.3 mL of 5% sodium nitrite, and 0.3 mL of 10% aluminium chloride was added after 5 minutes. After 6 minutes of incubation at room temperature, 1 mL of 1 M sodium hydroxide was added to the reaction mixture. Immediately the final volume was made up to 10 mL with distilled water. The absorbance of the sample was measured against the blank at 510 nm using a spectrophotometer. The results were derived from the calibration curve of quercetin and expressed in quercetin equivalents (QE) per gram of dry plant material.

Ferric-reducing antioxidant power (FRAP) Assay

The reducing powers of the extracts that reflected their antioxidant activity were determined following the protocol of Benzie and Strain (1999). Per it, 3 mL of prepared FRAP reagent is mixed with 100 µL of extracts. Absorbances at 593 nm are recorded after a 30-minute incubation at 37 °C. The FRAP value was calculated from the calibration curve of iron(II) sulfate heptahydrate and expressed in mol per gram of dry plant material.

DPPH radical scavenging activity

2, 2-diphenyl-1-picryl-hydrazyl (DPPH) method was performed according to the earlier described method of Horozić et al. (2019). The percentage of DPPH radical inhibition was tested by mixing 2 mL of 0.5 mg/mL extract solution with 0.5 mL of 0.5 mM DPPH radical solution. The samples were left to incubate for 30 minutes in a darkened room at room temperature. As a control sample 0.5 mL of 0.5 mM DPPH dilution, diluted with 4 mL of methanol, was used. The radical scavenging

Table 1. Results of the content of bioactive components and antioxidant activity of *Artemisia annua* L. extracts

Tabela 1. Rezultati sadržaja bioaktivnih komponenti i antioksidativne aktivnosti ekstrakata Artemisia annua L.

Sample	Extraction solvent	Solvent ratio (v/v)	TPC [mg GAE/g DW]	TFC [mg QE/g DW]	FRAP value [µmol/g DW]	DPPH inhibition [%]
A-1	EtOH	-	11.05	0.013	115.7	71.25
A-2	EtOH:Water	40:10	16.27	0.028	289.7	80.50
A-3	EtOH:Water	30:20	20.24	0.037	353.0	85.47
A-4	EtOH:Water	20:30	23.03	0.039	375.1	88.94
A-5	EtOH:Water	10:40	17.05	0.034	321.5	81.80
A-6	MeOH	-	10.12	0.017	112.5	56.25
A-7	MeOH:Water	40:10	15.77	0.029	283.5	61.67
A-8	MeOH:Water	30:20	19.31	0.033	339.1	68.02
A-9	MeOH:Water	20:30	20.41	0.036	342.5	74.20
A-10	MeOH:Water	10:40	16.86	0.031	315.8	64.96
A-11	Ace	-	1.86	0.005	67.3	5.86
A-12	Ace:Water	40:10	14.62	0.029	319.0	93.85
A-13	Ace:Water	30:20	19.36	0.041	357.0	95.77
A-14	Ace:Water	20:30	24.08	0.044	392.3	97.05
A-15	Ace:Water	10:40	19.15	0.038	331.1	94.57
A-16	Water	-	14.74	0.035	120.4	84.46

*TPC - Total phenolic content; TFC - Total flavonoid content, FRAP - Ferric-reducing antioxidant power

effect (%) or percentual inhibition of DPPH radical was calculated according to the equation:

[(Ac - As) / Ac] x 100

Where As is the absorbance of the solution containing the sample at 517 nm and Ac is the absorbance of the DPPH solution.

RESULTS AND DISCUSSION – *Rezultati i diskusija*

Tables 1 and 2 show the results of the analysis of the content of polyphenols and flavonoids, as well as the antioxidant capacity of extracts of sweet and bitter wormwoods. It is clearly noticeable that bitter wormwood contains fewer bioactive components and reflects lower antioxidant activity compared to extracts of sweet wormwood. The results of the content of total phenolic compounds and flavonoids in the extracts and the antioxidant activity of the extracts indicate their significant correlation.

In the extraction of bioactive components from both plant species, mixtures of organic solvent and water, in a volume ratio of 20:30 v/v were proved to be the most effective. The concentrations of the determined bioactive components were increased by the water content in all used solvents from 40:10 v/v to 20:30 v/v, while the concentration of the investigated components decreased in extracts with an increased water content to 10:40 v/v. Acetone mixtures generally proved to be more efficient in the extraction of bioactive components compared to ethanol and methanol mixtures. In terms of pure solvents, the most efficient extraction was achieved with water, followed by ethanol, and methanol, and the weakest extraction effect was recorded for acetone extracts.

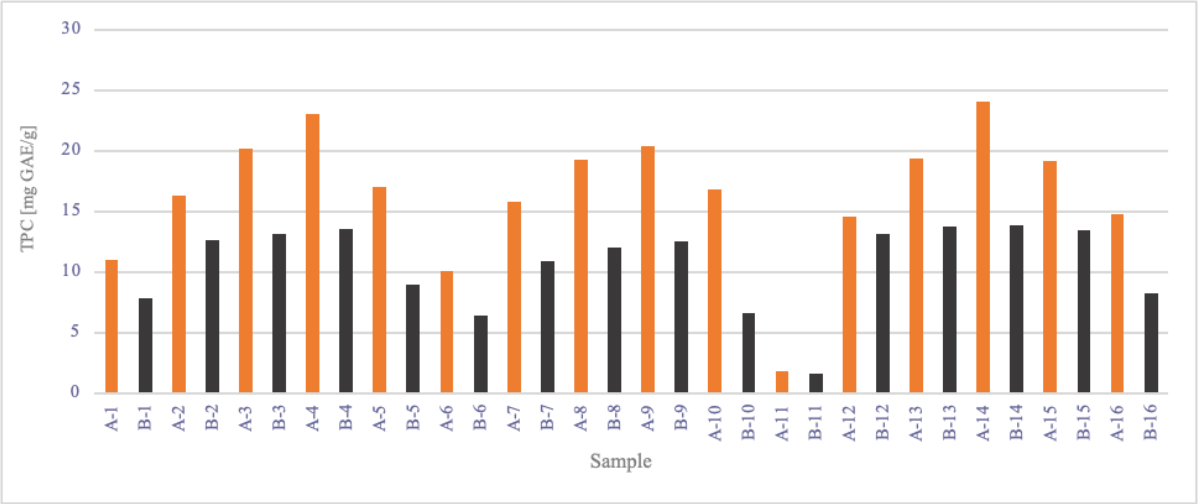
A minimally invasive extraction technique was used, which preserved a significant proportion of polyphenols, which explains the relatively high values of the proportion of the mentioned components in the extracts. Extraction efficiency is enhanced by the small particle size, which improves solvent penetration and solute diffusion. In general, the finer the particle size, the better the extraction results (Begić et al., 2020). During the extraction of dry plant material, a better effect is achieved with a higher proportion of the aqueous phase in the organic phase (Bimakr et al., 2011), which explains the higher extraction capacity of mixtures of organic solvents and water in this research. Altiok et al. (2008) confirmed the importance of the presence of water in the organic solvent, which increases the diffusi-

Table 2. Results of content of bioactive components and antioxidant activity of *Artemisia absinthium* L. extracts

Tabela 2. Rezultati sadržaja bioaktivnih komponenti i antioksidativne aktivnosti ekstrakata Artemisia absinthium L.

Sample	Extraction solvent	Solvent ratio (v/v)	TPC [mg GAE/g DW]	TFC [mg QE/g DW]	FRAP [µmol/g DW]	DPPH inhibition [%]
B-1	EtOH	-	7.83	0.014	94.55	47.92
B-2	EtOH:Water	40:10	12.60	0.016	135.44	78.43
B-3	EtOH:Water	30:20	13.12	0.017	164.54	80.34
B-4	EtOH:Water	20:30	13.55	0.018	224.12	84.92
B-5	EtOH:Water	10:40	8.96	0.016	141.50	59.14
B-6	MeOH	-	6.45	0.014	84.24	45.15
B-7	MeOH:Water	40:10	10.91	0.016	122.8	60.01
B-8	MeOH:Water	30:20	11.98	0.017	191.2	66.21
B-9	MeOH:Water	20:30	12.58	0.017	195.4	70.25
B-10	MeOH:Water	10:40	6.57	0.016	131.1	56.95
B-11	Ace	-	1.58	0.005	58.28	4.99
B-12	Ace:Water	40:10	13.15	0.018	206.84	69.23
B-13	Ace:Water	30:20	13.75	0.019	241.44	88.84
B-14	Ace:Water	20:30	13.90	0.020	256.24	92.11
B-15	Ace:Water	10:40	13.50	0.019	221.22	68.75
B-16	Water	-	8.27	0.014	95.84	48.82

*TPC - Total phenolic content; TFC - Total flavonoid content, FRAP - Ferric-reducing antioxidant power



Graph 1. Comparison of polyphenol content in *Artemisia annua* and *A. absinthium* extracts

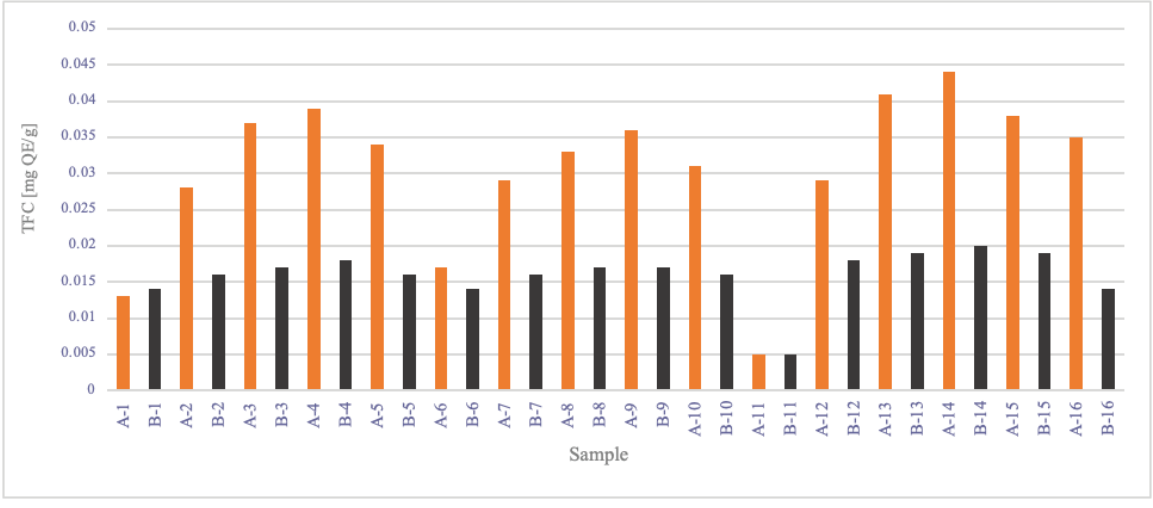
Grafikon 1. Komparacija sadržaja polifenola u ekstraktima Artemisia annua i A. absinthium

on process and thus facilitates the extraction of phenolic compounds from plant tissue.

Extraction of flavonoids of the studied wormwoods species showed a strong correlation with the polarity of the solvents used. These results agree with Spingo et al. (2007), who suggested that polar solvents are the best medium for flavonoid extraction, which may be due to the increase in polarity of flavonoids after conjugation via glycosides with hydroxyl groups, which increases their solubility in polar solvents (Mohsen and Ammar, 2009). The trend of phenol extraction among different solvents was similar to that of flavonoids, i.e. phenols were more efficiently extracted in polar solvents, specifically in water, ethanol and methanol compared to acetone, which proved to be the weakest medium for their extraction.

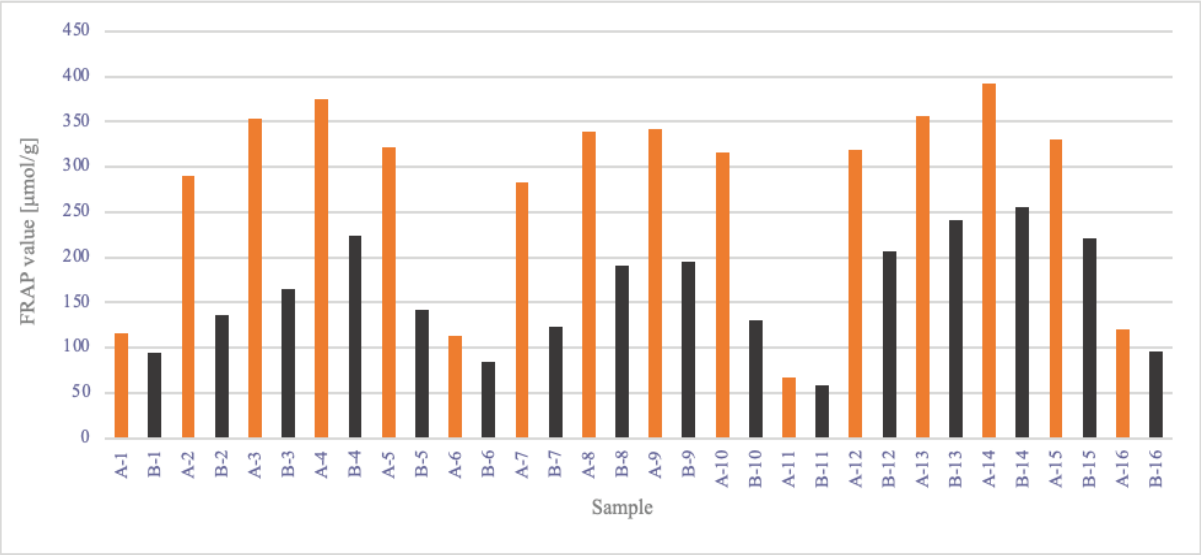
Comparative diagrams of the content of bioactive components and antioxidant capacity in *in vitro* conditions for extracts of sweet and bitter wormwoods are shown in Graphs 1 to 4.

The solvents and polarity used in the extraction process can influence the amount of extracted bioactive compounds, as well as the value of antioxidant activity (Budiana et al., 2017). The results obtained on the basis of FRAP and DPPH analysis of the extracts of the analysed



Graph 2. Comparison of flavonoid content in *Artemisia annua* and *A. absinthium* extracts

Grafikon 2. Komparacija sadržaja flavonoida u ekstraktima Artemisia annua i A. absinthium

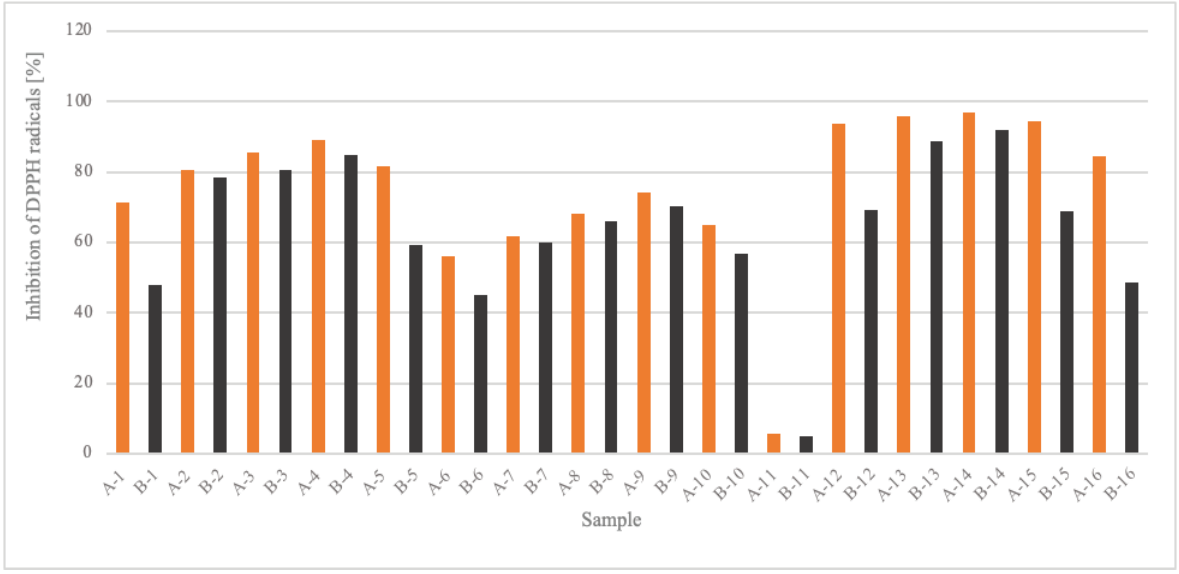


Graph 3. Comparison of the reduction potential of *Artemisia annua* and *A. absinthium* extracts

Grafikon 3. Komparacija redukcijskog potencijala ekstrakata Artemisia annua i A. absinthium

wormwood species obtained with pure solvents indicate that the best antioxidant activity was achieved with water and the weakest with acetone. The antioxidant activity of ethanolic extracts was higher than methanolic extracts. In general, with an increase in the water content, the obtained ethanolic, methanolic and acetone extracts of analyzed *Artemisia* species show an increase in antioxidant activity, respectively, except for the 10:40 v/v extract mixtures, which showed a moderate decrease.

The antioxidant activity of analyzed *Artemisia* species was also examined in a study conducted by Sembiring et al. (2022). The ethanol and methanol solvents in different concentrations and water as a control were used to prepare the extracts. The type and concentration of the solvent significantly influenced the yield and antioxidant activity of the *Artemisia* extract. The use of ethanol as a solvent resulted in a higher extract yield and antioxidant activity than methanol. The antioxidant activity of the ethanolic extract of *Artemisia* was stronger than the methanolic extract (Sembiring et al., 2022).



Graph 4. Comparison of DPPH radical inhibition by *Artemisia annua* and *A. absinthium* extracts

Grafikon 4. Komparacija inhibicije DPPH radikala ekstrakata Artemisia annua i A. absinthium

CONCLUSIONS – *Zaključak*

This research can help in the preparation of extracts of other plant species because it gives a more detailed insight into the efficiency of mixtures of organic solvents and water, as well as the ideal proportions of water and organic solvent that extract the highest content of polyphenols and flavonoids. It is important to emphasize that the mentioned mixtures cannot be effective for all plant species and samples, which is why there is a great interest in this type of research.

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SAŽETAK

Gorki (*Artemisia absinthium* L.) i slatki pelin (*A. annua L.*) tradicionalne su biljne vrste u porodici Asteraceae (Compositae). Njihova upotreba u tradicionalnoj medicini odavno je poznata jer se čajevi i tinkture spravljeni od njih koriste u liječenju bolesti probavnog sistema. U radu je ispitan sadržaj bioaktivnih komponenti (polifenola i flavonoida) i antioksidativno djelovanje (FRAP i DPPH metodom) navedenih vrsta. Za analizirane vrste pripremljena je serija ekstrakata s odabranim rastvaračima (voda, metanol, etanol i aceton) te smjesama navedenih organskih rastvarača s vodom u različitim volumnim omjerima. Rezultati istraživanja su pokazali da ekstrakti slatkog pelina imaju više bioaktivnih komponenti, a time i izraženije antioksidativno djelovanje u odnosu na ekstrakte gorkog pelina. U smislu učinkovitosti ekstrakcije, najučinkovitijom se pokazala mješavina acetona i vode (20:30 v/v). Što se tiče čistih organskih otapala, najučinkovitija za izolaciju bioaktivnih komponenti je voda, dok je aceton pokazao najslabiju ekstrakcijsku moć.

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ORIGINAL SCIENTIFIC PAPER

Dimensions of the constructive elements of forest roads

Dimenzije konstruktivnih elemenata šumskih puteva

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ABSTRACT

Forest roads must be maintained in a condition that allows them to handle traffic loads at any given time, which is only achievable if their dimensions remain within the prescribed limits. The dimensions of the elements of the plan, profile, and cross-section of forest roads depend on factors such as soil type in a constructive context, the category of the forest road, and the type of vehicles that will use these roads. In this study, a forest road constructed on soil types IV, V, and VI was examined, and its dimensions were determined. The share of soil type in a constructive sense is 63% of V category, 34% of IV category and 3% of VI category. The average width of the roadway is 6.11 m, with an upgrade of approximately 3% and a downgrade of 6.5%. The cross slope of the roadway is 3.1%, while the slope of the cut areas is 120% (1.2:1), and the slope of the fill areas is 86% (0.86:1). It was concluded that the forest road is in a condition capable of accommodating traffic load. However, attention should be given to the wider roadway width and the lower slopes of the cut-and-fill areas, as these may require adjustments to ensure efficiency and safety.

Keywords: *plan, cross sections, grade of profile, cut and fill slopes*

INTRODUCTION – *Uvod*

Forest roads provide permanent accessibility to forests, leading to long-term or permanent changes to the forest ecosystem. The construction of forest roads represents the largest infrastructure project within a forest and enables sustainable management of this natural resource. Their primary purpose is the long-distance transportation of industrial roundwood. Forest roads are planned, designed, constructed, and maintained structures within the forest, consisting of components such as a plan, profile, cross sections, and data on the volume of earthworks (Jeličić, 1983). The plan of a forest road represents its horizontal alignment, including both horizontal curves and straight segments before and after the curves. The radius (R) is the most critical element of a curve, as it influences driving speed, safety, and the construction cost of the forest road. The width of the roadbed depends on the standard vehicle width used on forest roads, particularly trucks, as well as the width of the safety zone. The safety zone width should range from 0.4 to 0.6 m (Aćimovski, 1997). Forest roads are typically constructed with a single roadbed, having a minimum width of 3 m, with two shoulders width of 0.5 m. According to the IRPC (2002), the average width of the roadway is 4 m. The roadway width should range from 3.5 to 5 m (FAO, 1998) or from 5.5 to 7 m, according to Ryan et al. (2004). The cross slope of the roadbed is

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a key element in the surface drainage. Its value depends on factors such as the gradient of the forest roadbed, the radius of horizontal curves, the type of material used in roadbed construction, surface roughness, and other conditions. Typically, the cross slope is 3% for straight sections of forest roads and for curves with a radius of up to 70 m. For curves with a radius of up to 70 m, the cross slope ranges from 3% to 6%, depending on the roadbed grade and curve radius (IRPC, 2002). The longitudinal profile represents the vertical aspect of the forest road, featuring vertical curves and straight grade lines that connect these curves. The key element of the forest road longitudinal profile is the grade of the surface, often referred to as roadbed, denoted as i%. This grade is influenced by several factors, including the type of forest road, the type of vehicles used, soil characteristics, traffic load, and rainfall, among others. The maximum longitudinal grade of a roadway generally ranges from 8% to 14% (FAO, 1998; IRPC, 2002; Potočnik, 2004; Ryan et al., 2004).

The cross-section of a forest road is its projection on the vertical plane which is perpendicular to the axis of the forest road. The cross-section of forest roads consists of: clearing width, roadway width, cut and fill slopes, shoulders width, roadbed width and drainage ditch (Figure 1) and cross slope of roadbed.

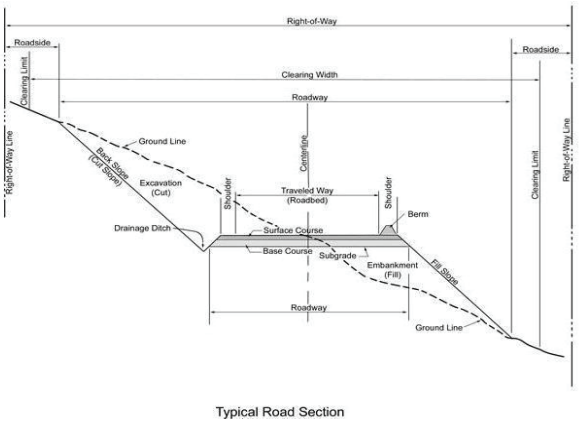

Figure 1. Typical road section (Petković et al., 2014)

Slika 1. Tipični poprečni profil (Petković et al., 2014)

The slope of cut and fill slopes depends on factors such as the type of soil and the height of the slopes. The slope of cut slopes can range from 1:1 (100%) for deep and soft soils (classified as Type III in a construction context) to 2:1 (200%), 3:1 (300%), or even 4:1 (400%) for gravelly and rocky soils (Types IV, V, and VI). For fill slopes, the ratio ranges from 1:1.5 (66%) or 1:2 (50%) for Type III soils to 1:1.25 (80%) in gravelly soils, and 1:1 (100%) in rocky soils (IRPC, 2002; Keller & Sherar, 2003).

The aim of this research is to determine the dimensions of the main constructive elements of forest roads and compare them with the dimensions prescribed by the "Manual for Designing Forest Roads in the Republic of Srpska" (IRPC, 2002) and other relevant references. Forest traffic infrastructure is a prerequisite for modern forest management and utilization (Pentek and Poršinsky, 2012).

MATERIALS AND METHODS – Materijal i metode

The subject of this research is the forest road "Lokva – Compartment 66," which belongs to the Forest Management Area (FMA) "Srednjevrbasko." This FMA is located in the western part of Bosnia and Herzegovina (B&H) and the southwestern part of the Republic of Srpska (RS). It encompasses the vegetation-geographical region of the inner Dinaric Alps, specifically the Western-Bosnian carbonate-dolomite area. This area contains forests of sessile oak and hornbeam (Querco - Carpinetum) (Stefanović et al., 1983). The geological base is composed of limestone and dolomite, on which several soil types are developed, including calcomelanosol, calcocambisol, luvisol, and rendzina.

The total length of roads in the Forest Management Area (FMA) "Srednjevrbasko" is 627.07 km, with forest roads accounting for 617.11 km, resulting in a primary forest accessibility of 11.96 km per 1,000 ha. The forest road "Lokva – Compartment 66" is situated within the Forest Management Unit (FMU) "Gornji Janj." The FMU covers an area of 7,776.77 ha, with a total road length of 133.97 km, of which forest roads constitute 122.72 km. This total length includes both public and forest roads, ensuring forest accessibility. The primary forest accessibility for this FMU is 14.20 km per 1,000 ha (IRPC, 2018). The average primary forest accessibility in the Republic of Srpska (RS) is approximately 10 m/ha (Dražić et al., 2018; Petković et al., 2022).

The total length of the forest road "Lokva – Compartment 66" is 4.015 km. It branches off from the forest road "Bravnice-Natpolje" at a location called "Lokva," passes through compartments 65 and 66, and ends at the boundary between compartments 66 and 67, at a place called "Hrastova kosa" (Figure 2). In this area, forests predominantly consist of beech and fir, with spruce and pine also present.

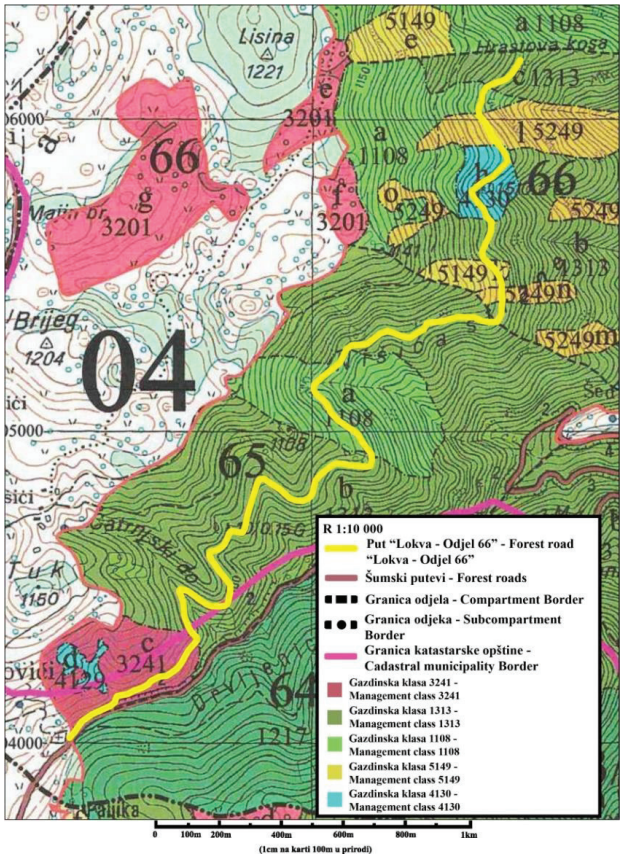

Figure 2. Location of forest road "Lokva-Compartment 66" (IRPC, 2013)

Slika 2. Položaj šumskog puta "Lokva-Odjel 66" (IRPC, 2013)

The terrain through which this road passes is characterized by numerous narrow ridges and ditches, which pose a significant limitation for determining the road alignment. The route is predominantly oriented towards the north. Due to the terrain configuration, 30% of the road consists of curves, while the remainder is composed of straight sections.

The forest road profile is optimally adapted to the terrain conditions, and in areas with a greater cross slope, it is positioned below the ground line to ensure roadway stability and enhance traffic safety. The profile of the forest road resembles a broken line with a general downward slope from start to finish. The maximum gradient encountered in the forest road longitudinal profile is 10.63% over a distance of 70.6 m (IRPC, 2013).

Based on geological conditions, three categories of soil have been identified in a constructive context along the forest road:

- IV category - fractured rock,
- V category - soft rock,
- VI category - solid rock (IRPC, 2013).

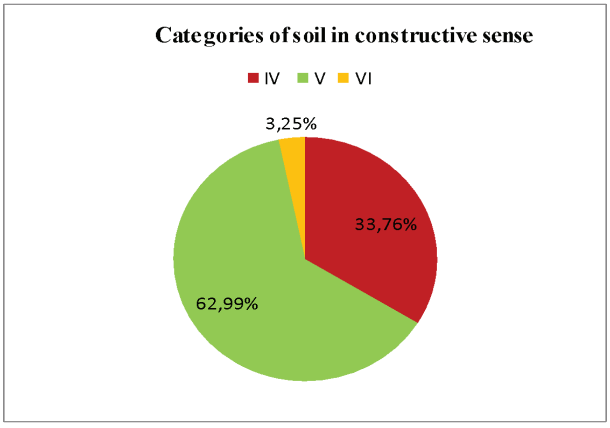

Figure 3. Categories of soil in the constructive sense at the forest road (IRPC, 2013)

Slika 3. Kategorije terena (IRPC, 2013)

Field data collection

The width of the roadway, grade of the roadway, cross slope of the roadway, and the slope of cut and fill slopes were measured at every 10-meter interval along the forest road "Lokva – Compartment 66.

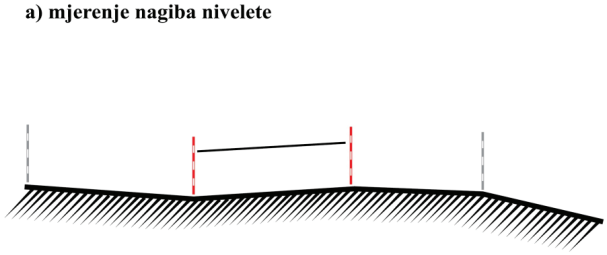

Figure 4. Measurements of the grade of the longitudinal profile of the roadway

Slika 4. Mjerenje nagiba nivelete

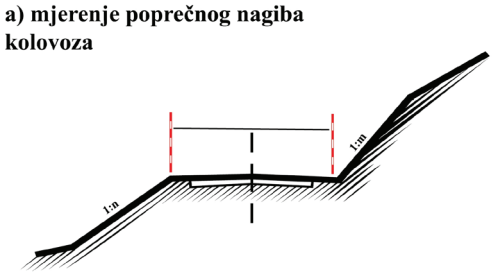

Figure 5. Measurements of the width and cross slope of the roadway

Slike 5. Mjerenje širine i poprečnog nagiba planuma

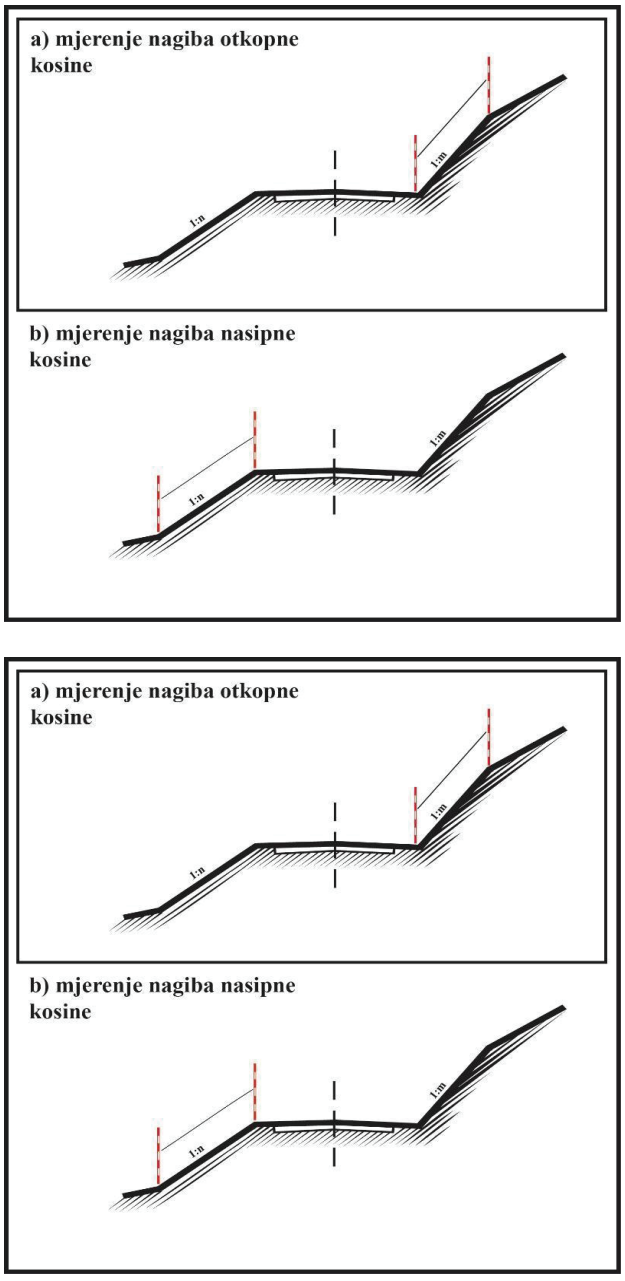

Figure 6. Measurements of the slope of cut and fill slopes

Slika 6. Mjerenje nagiba otkopne i nasipne kosine

The curves were also defined, and the beginning (PK), middle (SK), and end (KK) of each curve were marked. The location of the curve points was estimated on the forest road. The distance between the beginning and the end of the curve was measured, and a point C was established at the midpoint of this distance. Subsequently, the distance from this midpoint (C) to the middle of the curve (SK) was measured. These measurements (half the distance between the beginning and end of the curve, along with the distance from the midpoint to the centre of the curve) are essential for calculating the curve radius R (Petković et al., 2014).

$$R = \frac{x^2}{2y}$$

Where:

R - radius of the curve (m),

x - half the distance between the beginning and the end of the curve (m),

y - distance from the point at the half of the distance between the beginning and the end of the curve and the middle of the curve (m) (Petković et al., 2014).

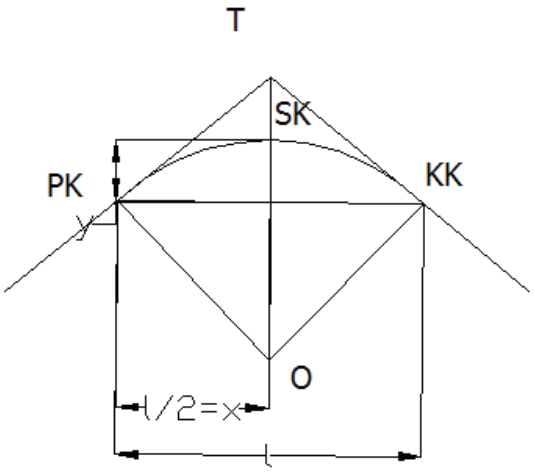

Figure 7. Determination of the radius of horizontal curve (Petković et al., 2014)

Slike 7. Određivanje poluprečnika horizontalnih krivina (Petković et al., 2014)

The width of the roadway and the distances between points were measured using a measuring tape, while the slope of cut and fill areas, the grade of the roadway, and the cross slope of the roadway were measured using a clinometer.

Processing of collected data

Microsoft Excel was used to analyze the collected data, obtaining minimum, maximum, and average values. The results are presented in tables and figures. These findings were then compared with both domestic and international regulations on forest road construction, as well as with results from research conducted on forest roads in various terrain and soil conditions. The outcomes of these comparisons aim to draw conclusions about the current state of the analysed elements of the forest road and recommend measures for its improvement.

RESULTS AND DISCUSSION – *Rezultati i diskusija*

The results of the statistical analysis of the collected data are presented in Table 1. The average roadway width is 6.11 m, and it ranges from around 4 to around 11 m (Table 1).

Table 1. The dimensions of constructive elements of the forest road "Lokva-Compartment 66" (Laketa, 2021)

Tabela 1. Dimenzije konstruktivnih elemenata šumskog puta "Lokva-Odjel 66" (Laketa, 2021)

Statistics	Width of roadway (m)	Cross slope of roadway in the straight lines (%)	Radius of the curves (m)	Cross slope of roadway in the curves (%)
Min	3.83	0	10	0
Max	10.81	9	200	9
Average	5.81	3.3	50	3.4
Prescribed (IRPC, 2002)	4	3	15-20*	3-6**

* minimal radius of the horizontal curves

** depends on the radius of the horizontal curves and grade of the roadway in the longitudinal profile

The average width of the roadway is greater than what is prescribed in the "Manual for Construction of Forest Truck Roads" from 2002, as well as the standards outlined by Jeličić (1983). The reason why the roadway width is greater can be the fact that there is no clear border between road and ditch, the presence of the passing lanes and landings for timber. The dependency of roadway width on the radius of horizontal curves has not been analyzed.

The dimensions of forest roads constructed in the FMU "Potoci-Resanovača" under similar soil conditions are as follows: the average roadway width is 4.5 m, the average grade of the roadway is 2.8%, and the cross slope of the roadway is 3%. The maximum measured grade is 8% (Petković et al., 2014). In comparison, the dimensions of the forest road "Lokva-Compartment 66" are larger, and they also exceed the average dimensions measured on forest roads in FMU "Prosara," which were constructed on Type III soil in a constructive context (Petković et al., 2014).

The allowed maximum upgrade of the roadway is 8%, while the downgrade ranges from 6% to 10%. Although the average values are within these limits, the maximum measured grades of the roadway (12% upgrade and 17% downgrade) exceed the prescribed values. The average upgrade of around 3% and a downgrade of around 6% (Table 2).

Table 2. The grade of the longitudinal profile of roadway (Gavranić, 2022)

Tabela 2. Nagib nivelete (Gavranić, 2022)

	IV category		V category		VI category	
	Average [%]:	Length [m]:	Average [%]:	Length [m]:	Average [%]:	Length [m]:
Down-grade:	6.65	1070	7.21	1620	5	120
Upgrade:	3.75	320	3.95	600	2	10

The slope of cut slope is lower than the prescribed values for the types of soils in the constructive sense, and the average slope of the fill slope is within prescribed boundaries for IV type of soils and lower for V and VI type of soils in the constructive sense (Figure 8).

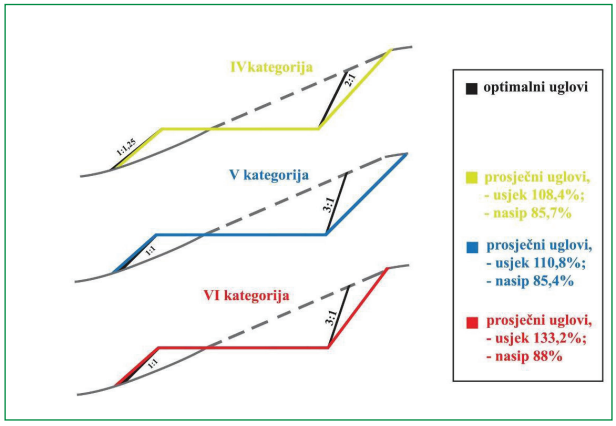

Figure 8. Average slopes of cut and fill slopes depend on the type of soil in a constructive sense (Laketa, 2021)

Slika 8. Prosječni nagibi otkopnih i nasipnih kosina zavisno od kategorije terena (Laketa, 2021)

The cut and fill slopes depend on the type of soil in a constructive context, the height of the slopes, the cross slope of the terrain, and other influencing factors. According to Jeličić (1983), the slope of cut and fill areas for deep soils should range from 1:1 to 1:1.5, while for rocky soils it should be 2:1 or between 1:1.3 and 1:1.5. Aćimovski (1997) suggests that for ordinary and sandy soils, the slope of cut and fill areas should be 1:1 and 1:1.5, respectively. For rocky substrates, cut slopes should range from 1:0, 1:0.2, 1:0.5, to 1:0.75, while fill slopes should be either 1:1 or 1:1.25.

In FMU "Prosara," the average slope of cut areas is 1:1.4 (71%), while the fill areas have an average slope of 1:2.2 (45%) on deep soils. In FMU "Potoci-Resanovača," the average slope of cut areas on shallow soils is 1:1.7 (59%), and the average slope for fill areas is 1:0.9 (111%) (Petković et al., 2014).

There are 99 horizontal curves on the forest road "Lokva-Compartment 66". The radius of these horizontal curves ranges from 10 m to 200 m, with an average radius of 50 m (Table 1). According to IRPC (2002), the minimum radius of curves should be 15 m; however, four curves on this road fall below this prescribed minimum. Sixty-two of the curves have a radius of less than 70 m, which, according to the Manual for Construction of Forest Truck Roads in the Republic of Srpska" (IRPC, 2002), requires calculation for roadway widening. This indicates that the alignment of the forest road "Lokva-Compartment 66" has been adapted to the existing terrain conditions.

The average radius of horizontal curves on forest roads ranges from 110 m to 140 m in FMU "Prosara" and FMU "Potoci-Resanovača". The minimum radius ranges from 15 m in Prosara to 20 m in Potoci-Resanovača. According to Aćimovski (1997), the minimum radius of curves should be 8 m for trucks that are 12 m long and 12 m for trucks that are 18 m long. Butulija (2000) suggests a minimum radius of 20 m for horizontal curves. Potočnik (2004) recommends a minimum radius of 15 m for horizontal curves, depending on the turning capabilities of typical vehicles, such as trucks and trailers.

The average cross slope of the roadway on the forest road "Lokva-Compartment 66" is 3.3%, increasing to 3.4% in curves (Table 1). The cross slope of the roadway in curves depends on the longitudinal profile grade of the roadway and the radius of the curves, ranging from 3% to 6%, while for straight sections it should be 3% (IRPC, 2002). The average cross slope of forest roads in FMUs "Prosara" and "Potoci-Resanovača" is approximately 3%. In curves, the average cross slope is about 3% in FMU "Potoci-Resanovača" and 4% in FMU "Prosara" (Petković et al., 2014). The average cross slope of the roadway on the forest road "Lokva-Odjel 66" aligns with the prescribed standards.

The ditches are filled, preventing them from effectively collecting rainfall runoff from the road. Additionally, there is no distinct boundary between the forest road surface and the ditch, which further complicates water drainage management.

CONCLUSIONS – *Zaključak*

The forest road "Lokva-Compartment 66" was constructed on soil types IV (34%), V (63%), and VI (3%) in a constructive context.

The average width of the roadway is greater than what is prescribed in the "Manual for Construction of Forest Truck Roads in the Republic of Srpska" (IRPC, 2002) and as specified by Jeličić (1983). The average values of the roadway's upgrade and downgrade are within acceptable ranges, but the maximum measured grades exceed the recommended limits.

The average slope of the cut areas along the forest road "Lokva-Compartment 66" is higher compared to the average slope of cut areas on forest roads in FMUs "Potoci-Resanovača" and "Prosara," both of which are also below the prescribed values for cut and fill slopes.

The minimum radius of the curves on the forest road aligns with the recommendations of the authors and the Manual (2002). Similarly, the average cross slope of the roadway for "Lokva-Compartment 66" complies with the prescribed standards.

Based on the results of the study, it can be concluded that, from a cost-efficiency perspective and considering the type of soil in a constructive context, the width of the roadway should be reduced and the maximum longitudinal profile grade of the roadway, while the slopes of cut and fill areas should be increased to optimize road construction costs but this must take into account the driving safety.

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SAŽETAK

Rad istražuje konstruktivne elemente šumskog puta "Lokva-Odjel 66", smještenog u Šumskom gazdinstvu (ŠG) "Srednjevrbasko", i analizira dimenzije puta u odnosu na postojeće norme i standarde. Glavni cilj istraživanja bio je utvrditi dimenzije osnovnih konstruktivnih elemenata šumskog puta i usporediti ih s propisanim standardima prema "Priručniku za projektovanje šumskih kamionskih puteva u Republici Srpskoj" iz 2002. godine i drugim relevantnim izvorima. Ova studija daje uvid u trenutnu situaciju šumskih puteva, naglašavajući potrebne mjere za poboljšanje efikasnosti i sigurnosti puta.

Ukupna dužina puta "Lokva-Odjel 66" iznosi 4.015 km, a prolazi kroz odjele 65 i 66, završavajući na granici između odjela 66 i 67. Putevi prolaze kroz područja sa šumama bukve i jele, sa smrčom i borom kao dodatnim vrstama. Teritoriju kroz koju prolazi ovaj put karakterišu uski grebeni i jarkovi, što je predstavljalo izazov prilikom određivanja trase puta. Ruta je većinom orijentisana prema sjeveru, a 30% puta čine krivine, dok ostatak čine pravci.

Izmjereni podaci uključuju širinu kolovoza, uzdužni nagib, poprečni nagib, te nagibe otkopnih i nasipnih kosina na svakih 10 metara puta. Prosječna širina kolovoza iznosi 6.11 m, uz prosječan uspon od 3% i pad od 6.5%. Poprečni nagib kolovoza iznosi 3.1%, dok su nagibi otkopnih kosina 120% (1.2:1), a nagibi nasipnih kosina 86% (0.86:1). Rezultati pokazuju da je prosječna širina puta veća od propisane prema Priručniku iz 2002. godine i standardima koje je utvrdio Jeličić (1983). Također, maksimalno izmjereni uzdužni nagibi puta prelaze preporučene vrijednosti, iako su prosječne vrijednosti unutar granica.

Kada se dimenzije puta "Lokva-Odjel 66" usporede sa sličnim putevima u ŠG "Potoci-Resanovača" i "Prosara", ustanovljeno je da su dimenzije šire, a nagibi otkopnih kosina veći. Prosječna širina kolovoza na putevima ŠG "Potoci-Resanovača" iznosi 4.5 m, dok je prosječni uzdužni nagib 2.8%, a poprečni nagib kolovoza 3%. Maksimalni izmjereni uzdužni nagib iznosi 8%. U poređenju s ovim dimenzijama, put "Lokva-Odjel 66" ima veće vrijednosti, što ukazuje na potrebu za usklađivanjem sa standardima.

Nagib otkopnih i nasipnih kosina zavisi od vrste zemljišta, visine kosina, poprečnog nagiba terena i drugih faktora. Prema Jeličiću (1983), nagib otkopnih i nasipnih kosina za duboka tla treba biti u rasponu od 1:1 do 1:1.5, dok za stjenovita tla treba biti 2:1 ili između 1:1.3 i 1:1.5. Prema Aćimovskom (1997), za obična i pjeskovita tla, nagib otkopnih i nasipnih kosina treba biti 1:1 i 1:1.5. U FMU "Prosara" prosječni nagib otkopnih kosina iznosi 1:1.4 (71%), dok prosječni nagib nasipnih kosina na dubokim tlima iznosi 1:2.2 (45%). U FMU "Potoci-Resanovača" prosječni nagib otkopnih kosina na plitkim tlima iznosi 1:1.7 (59%), a prosječni nagib nasipnih kosina iznosi 1:0.9 (111%).

Na šumskom putu "Lokva-Odjel 66" nalazi se 99 krivina, a radijus horizontalnih krivina varira od 10 m do 200 m, s prosječnim radijusom od 50 m. Prema IRPC (2002), minimalni radijus krivina treba biti 15 m, međutim četiri krivine na ovom putu imaju radijus ispod ove propisane minimalne vrijednosti. Šezdeset i dvije krivine imaju radijus manji od 70 m, što prema Priručniku (2002) zahtijeva izračunavanje proširenja kolovoza. Ovo pokazuje da je trasa puta "Lokva-Odjel 66" prilagođena terenskim uvjetima.

Zaključeno je da šumski put "Lokva-Odjel 66" može prihvatiti saobraćajno opterećenje u trenutnom stanju. Međutim, potrebno je obratiti pažnju na veću širinu puta i niže nagibe otkopnih i nasipnih kosina. Prema rezultatima studije, radi optimizacije troškova izgradnje i prilagođavanja uslovima tla, širina kolovoza treba biti smanjena, dok nagibi otkopnih i nasipnih kosina trebaju biti povećani kako bi se smanjili obim i troškovi građevinskih radova, ali treba biti i oprezan zbog sigurnosti vožnje.

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ORIGINAL SCIENTIFIC PAPER

Study of Antioxidative and Antibacterial Activity of Extracts of Plant Species *Lysimachia vulgaris L.* and *Lythrum salicaria L.*

Ispitivanje antioksidativne i antibakterijske aktivnosti ekstrakata biljnih vrsta *Lysimachia vulgaris L.* i *Lythrum salicaria L.*

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ABSTRACT

Two highly invasive plant species, *Lysimachia vulgaris* and *Lythrum salicaria* are well-known for their anti-inflammatory, hemostatic, and antidiarrheal activity. These plants are most widespread on the territory of Euroasia, where their traditional medicinal use has been reported. Due to their invasiveness, they are undesirable plants in other parts of the world. To this day, many studies have been conducted regarding the biological and pharmacological activity of *L. salicaria*. In this study, the polyphenol content of plant extracts was examined using the Folin-Ciocalteou method. The antioxidant activity of selected plant species was also determined, using DPPH and FRAP methods. Extracts of different polarities were prepared using methanol, water, and acetone. Extraction was performed by maceration and ultrasonic extraction. The results of the study show that both plant species possess antioxidant activity. *Lythrum salicaria* extracts show a significant polyphenol content and antioxidant capacity, with results notably higher than the results of studies conducted so far. The different antioxidant activity of the prepared extracts confirms the influence of solvents and extraction methods on the utilization of the antioxidant potential of plants. Additionally, for the aqueous extracts prepared by the ultrasonic extraction method, an in vitro study of antibacterial activity was conducted. Both plant species show antibacterial activity, with an emphasis on the very strong antibacterial activity of *L. salicaria* extracts against selected bacterial strains.

Keywords: *Lysimachia vulgaris, Lythrum salicaria, antioxidative activity, antibacterial activity*

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INTRODUCTION – *Uvod*

Lysimachia vulgaris is a rhizomatous perennial plant from the *Myrsinaceae* family (Yildirim et al, 2017). In recent years, the genus Lysimachia has been moved from the family *Primulaceae*, which includes mainly species growing in temperate regions, to the family *Myrsinaceae*, typical of tropical and subtropical areas. The medicinal properties of many species of *Lysimachia* are well known (Hanganu et al, 2016). Due to its astringent properties, it is used to treat gastrointestinal conditions such as diarrhoea and dysentery, to stop internal and external bleeding and for wound cleaning in traditional medicine (Turker & Guner, 2013; Podolak et al, 2013). It is used in the treatment of fever, ulcers, diarrhoea and wounds in folk medicine. It also has analgesic, expectorant, astringent and anti-inflammatory effects. It is used as a mouthwash in the treatment of sore gums and mouth ulcers (Turker & Guner, 2013). In Chinese folk medicine, *Lysimachia vulgaris* is used to treat high blood pressure (Yasukawa & Takido, 1988). There are reports of antileishmanial and anthelmintic properties and use as a means of treating cholecystitis (Hanganu et al, 2016). Recent studies have revealed that *L. vulgaris* has antifungal, antibacterial, antitumor, and antioxidant effects (Son et al, 2021).

Lythrum salicaria is a perennial plant (Piwarowski et al, 2015). Its medicinal use has been known since ancient Greek and Roman times and has been an important medicine for centuries (Piwarowski et al, 2015). The whole flowering plant and the tops of the flowering branches of this plant are used in folk medicine and pharmacy (Humadi & Istudor, 2009). Beekeepers also used it as a honey plant (Thompson et al, 1987; Pellet, 1977). The seed has been included in a commercial "wildflower" seed mix (Tunalier et al, 2007). Many biological and pharmacological activities of *L. salicaria* have been studied (Manayi et al, 2013). Although *L. salicaria* is today considered an invasive plant, it has a long use in folk medicine as a medicinal plant due to its significant biologically active compounds (Šutovská et al, 2012). In external use, due to its astringent, anti-inflammatory, and hemostatic properties, this plant species is useful in the treatment of eczema, bleeding gums, eye inflammation, sinusitis (rinsing the nose with a diluted tincture), varicose veins, haemorrhoids, menorrhagia, haemorrhages, leukorrhea, and ulceration. Moreover, Campardon (1878) recommended *Lythrum salicaria* in the treatment of chronic and acute vaginitis and pruritus of various etiologies (Tunalier et al, 2007; Piwowarski et al, 2015). Internal use of this plant is intended for the treatment of diarrhoea, chronic intestinal catarrh and dysentery (Tunalier et al, 2007; Çoban et al, 2003). There are individual reports on the use of *Lythrum salicaria* in rheumatism, benign prostatic hyperplasia, infections and irritation of the urinary system mucosa, rabies, and as a tonic and fever remedy (Piwarowski et al, 2015). For oral and external use it is recommended to prepare infusions or decocts of the herb (Shakeneva 2019). The aim of this study is to determine the antioxidant activity and antimicrobial activity of invasive plant species, *Lythrum salicaria L. and Lysimachia vulgaris L.*, and to understand the effects of using the different solvents and extraction methods on final antioxidant activity and antimicrobial activity.

MATERIALS AND METHODS – *Materijal i metode*

For the purpose of this research, the plant material was collected in the area of Banovići (Bosnia and Herzegovina) in August 2024. The plants were cleaned and air-dried with natural airflow, in a ventilated area, for 2 days at a temperature of 37°C. The dried plants were ground in an electric mill and used to prepare extracts. All chemicals used were of analytical grade and were used as received without any further purification. Chemicals were purchased from Merck (Darmstadt, Germany) and Sigma Chemical Co. (St. Louis, Missouri, USA).

Preparation of extracts

For the evaluation of polyphenol content and antioxidant capacity, extracts were prepared by mixing 5 grams of pulverated plant material with 50 mL of solvent (methanol, water and acetone). The extraction was performed using 2 different techniques, in an ultrasonic bath and maceration in Vibromix (at 300 rpm) for one hour. The extracts were filtered through a blue dot filter paper. After filtering, the extracts were evaporated to dry extracts. The dry extract was dissolved in dimethyl sulfoxide and used to test the antibacterial activity. Extracts obtained by maceration are marked with (M) and extracts prepared by ultrasonic extraction with (UE). For the antimicrobial testing, solely water extracts were prepared by maceration in Vibromix (at 300rpm) for one hour.

Determination of total phenolic content (TPC)

Total phenolic compounds were quantified by the spectrophotometric method using the Folin-Ciocalteu test according to the protocol (Singleton et al, 1999), with some modifications. 100 µL of the extract was mixed with 1270 µL of 10% Folin-Ciocalteu reagent. After 5 minutes, 210 µL of 10% sodium carbonate was added. After incubation for an hour, 455 µL of distilled

water was added to the incubated solution. Absorbance was measured on a spectrophotometer at a wavelength of 765 nm. Quantitative analysis was performed based on the gallic acid standard calibration curve. Total phenolic content is expressed as gallic acid equivalent (GAE) in milligrams per gram of sample.

Determination of antioxidant capacity

The antioxidant activity of the extracts was tested *in vitro* using the DPPH and FRAP methods. The 2,2-diphenyl-1-picryl-hydrazyl (DPPH) method was carried out according to the described method (Horozić et al., 2019). 0.1 mL of the extract was added to the test tube and made up to 2 mL with methanol. Then 0.5 mL of 0.5 mM DPPH solution was added. The samples were incubated for 30 minutes in a dark place at room temperature. Absorbance was measured at 517 nm with methanol as a blank. The radical scavenging effect (%) or DPPH radical inhibition percentage was calculated according to the equation:

$$[(Ac - As) / Ac] \times 100$$

where As is the absorbance of the sample solution at 517 nm and Ac is the absorbance of the control.

The FRAP (Ferric-Reducing Antioxidant Power) method is based on the ability of the extract to reduce Fe(III) to Fe(II) ions. The test was conducted according to a published protocol (Benzie and Strain, 1999). 3 mL of prepared FRAP reagent was mixed with 100 µL of diluted extracts. Absorbance at 593 nm was recorded after incubation for 30 minutes at 37 °C. The FRAP value was calculated from the calibration curve of ferrous-sulfate-heptahydrate.

Determination of antibacterial activity

Antibacterial activity was tested using the diffusion method on reference bacterial strains from the ATCC collection, from the group of Gram-positive (*Staphylococcus aureus* and *Enterococcus faecalis*) and Gram-negative bacteria (*Escherichia coli* and *Pseudomonas aeruginosa*) as prescribed by the Clinical and Laboratory Standards Institute, 2009. Turbidity suspensions of 0.5 McFarland (density 10^7-10^8 CFU/mL, depending on the strain) were prepared from overnight culture of bacterial strains. The strains were then applied to the surface of the nutrient medium - Mueller-Hinton agar (MH), spread in sterile Petri plates, where the thickness of the medium was 4 mm. Indentations ("wells") were made in the agar using sterile drills and 100 µL of extract was added. After the plates were left at room temperature for 15 minutes to allow the extract to diffuse into the agar, they were incubated at 37°C/24 hours. After the incubation period, the zone of inhibition was measured. Ciprofloxacin was used as the positive control, with an inhibition zone >20mm.

RESULTS AND DISCUSSION - *Rezultati i diskusija*

Polyphenol content

The content of polyphenols in the extracts of the plant species *L. salicaria* and *L. vulgaris* is shown in Table 1. According to the obtained results, it can be concluded that the content of polyphenols in *L. salicaria* is very high, for all applied solvents and extraction methods. All previously conducted studies, covered in this discussion, on this plant species had a somewhat lower level of polyphenols, which can be justified by a number of factors such as: the geographical origin of the plant, degree of comminution of the plant material, types of solvents and extraction, extraction conditions, time of collection of the plant species for analysis, methods of drying and preservation of plant species, and solvent concentration. The results obtained in this study show that the methanol extracts of *L. salicaria* have the highest content of polyphenols. A more efficient extraction method is maceration, with the obtained polyphenol content of extracts being 848.86 mg GAE/g. A possible reason for the somewhat lower content of polyphenols in the methanolic extracts of *L. salicaria* obtained by ultrasonic extraction (603.15 mg GAE/g) is the known degrading effect of ultrasonic waves (stronger than 20 kHz) on active plant components (Vuleta et al, 2006; Tiwari et al, 2011). The content of polyphenols in terms of the different solvents used is in the following order: methanolic extracts > aqueous extracts > acetone extracts. The effect of solvent polarity on the content of phenolic compounds can be noticed, where acetone, as the least polar solvent used, shows the lowest extraction efficiency. The efficiency of acetone extraction can be increased by combining acetone with water, where the dielectric constant of the solvent is lowered. In addition, water causes the plant material to swell and facilitates the penetration of the organic solvent into the plant material. Lopes et al., (2016) examined the level of polyphenols in water-acetone extracts of *L. salicaria*, obtained by maceration (overnight, under stirring, at room temperature, 16h RT), whose content was 278 ± 3.04 mg GAE/g. However, this content is lower than the content of polyphenols obtained in this research, which is 392.63 mg GAE/g for acetone extracts obtained by maceration and 434.55 mg GAE/g for extracts obtained by ultrasonic extraction. It is known that *L. salica-*

ria blooms from June to September, but the highest content of active components is associated with August (Benscik et all). The different levels of polyphenols for these two studies can be attributed to the period in which the plant species was collected, which was the month of June for the study by Lopes et al, (2016). The reason for such results may be different extraction methods, the level of fragmentation of the plant material and the concentration of the solvent. A study conducted with methanol extracts, obtained by maceration, by Srećković et al. (2020) shows a lower level of polyphenols compared to the results obtained in our study (201.50 ± 11.49 mg GAE/g). It should be emphasized that such results may be the result of a different geographical origin of the plant (Serbia), different concentrations of methanol used and different conditions of maceration (3 times with 30 mL of methanol each, 24h with occasional mixing in the study of Srećković et al.). In the same study, a higher content of polyphenols was obtained in the root compared to the green part of the plant (326.36 + 10.25 mg GAE/g), which indicates the possibility of using the root of *L. salicaria* for medicinal purposes, in contrast to more often use of aerial parts of this species. Water-methanol extracts obtained by the percolation method, by Manayi et al (2013), showed a polyphenol level of 331 ± 3.7 mg GAE/g, which is lower than the obtained results in this study. A selection of solvent, extraction technique and the time period when the plant species was collected, which for the Manayi et al study was May, affected the total polyphenol content of plant species.

Table 1. Results of polyphenol content in extracts of plant species *L. salicaria* and *L. vulgaris*

Tabela 1. Rezultati mjerenja sadržaja polifenola u ekstraktima biljnih vrsta L.salicaria i L. vulgaris

Sample	Polyphenol content [mg GAE/g of sample]	
	L. salicaria	***L. vulgaris***
Methanol extract (M)	848.86	77.95
Aqueous extract (M)	434.43	70.06
Acetone extract (M)	392.63	34.17
Methanol extract (UE)	603.15	86.19
Aqueous extract (UE)	525.39	65.59
Acetone extract (UE)	434.55	37.99

All extracts of *L. vulgaris* showed a polyphenol content greater than 20 mg GAE/g. The results show that methanol extracts contain the highest concentration of polyphenols. The methanol extract obtained by ultrasonic extraction has the highest content of polyphenols (86.19 mg GAE/g). The higher content of polyphenols, obtained by ultrasonic extraction compared to maceration, indicates that active components of this plant species are possibly resistant to degrading effects of ultrasonic waves. It is also noticeable that the polyphenol content in this case is also closely related to the polarity of the solvent, where the acetone extracts obtained by maceration show the lowest content of polyphenols (34.17 mg GAE/g). A study conducted by Yildirim et al., (2017) shows a higher level of polyphenols for aqueous extracts of *L. vulgaris* (88.69 ± 0.0 mg GAE/g). These are extracts obtained by extraction in a water bath at 45°C for 12 hours. It is understandable that the higher content of polyphenols in these extracts was obtained because of the action of high temperature, where high temperature enhances the thermal movement of molecules in the liquid phase, so the diffusion rate is higher (Vuleta et al., 2006). In the same study, ethanolic extracts were also prepared using the Soxhlet extraction method, which showed twice the polyphenol content (161.42 mg GAE/g) compared to the aqueous extracts obtained by maceration and ultrasonic extraction in this study (70.06 mg GAE/ g and 65.59 mg GAE/g respectively).

Antioxidant activity

Tables 2 and 3 show the results of the antioxidant activity of *L. salicaria* and *L. vulgaris* extracts obtained by maceration and ultrasonic extraction. According to the results obtained by the DPPH method, the methanol extract of *L. salicaria* obtained by maceration has the highest percentage of DPPH radical quenching, thus the highest antioxidant capacity, while the acetone extract obtained by maceration has the lowest antioxidant capacity. The results obtained by the FRAP method are in correlation with the results obtained by the DPPH method. The results of the antioxidant activity indicate a correlation between the level of polyphenols in the plant species and the strength of its antioxidant activity. The highest level of polyphenols was shown by the methanol extract obtained by maceration, which also has the highest antioxidant activity (% inhibition of DPPH radicals 71.73%; FRAP 4052.1 μmol/g). Water extracts obtained by ultrasonic extraction (% inhibition of DPPH radicals 39.89%) and maceration (% inhibition of DPPH radicals 35.87%) showed somewhat lower antioxidant activity, compared to methanol extracts. In this study, the optimal extraction method for the plant species *Lythrum salicaria* is maceration with methanol or water as solvent.

Table 2. Results of antioxidant activity of *L. salicaria* extracts

Tabela 2. Rezultati mjerenja aktioksidativne aktivnosti ekstrakata L. salicaria

Sample	FRAP [µmol/g of sample]	Inhibition of DPPH radical [%]
Methanol extract (M)	4052.1	71.73
Aqueous extract (M)	2853.9	35.87
Acetone extract (M)	960.48	2.06
Methanol extract (UE)	3597.58	60.99
Aqueous extract (UE)	2994.01	39.89
Acetone extract (UE)	1235.92	5.73

The highest antioxidant capacity, for the plant species *Lysimachia vulgaris*, was recorded in the methanol extract obtained by the ultrasonic extraction method. This is supported by the results obtained by the DPPH and FRAP methods, where the DPPH radical quenching percentage is 55.32% and the result obtained by the FRAP method is 1836.35 µmol/g. Acetone extracts showed the lowest antioxidant activity, with a quenching percentage for the acetone extract obtained by maceration of only 0.112 %. The value of the antioxidant activity measured by the FRAP method for the same sample is 116.89 µmol/g.

Table 3. Results of antioxidant activity of *L. vulgaris* extracts

Tabela 3. Rezultati mjerenja aktioksidativne aktivnosti ekstrakata L. vulgaris

Sample	FRAP [µmol/g of sample]	Inhibition of DPPH radical [%]
Methanol extract (M)	1555.89	52.59
Aqueous extract (M)	1468.79	46.79
Acetone extract (M)	116.89	0.112
Methanol extract (UE)	1836.25	55.32
Aqueous extract (UE)	1170.13	37.74
Acetone extract (UE)	142.51	2.79

Antibacterial activity

Water extracts with a concentration of 1 mg/mL were used to test the antibacterial activity of the plant species *Lythrum salicaria* and *Lysimachia vulgaris*. The test was conducted on strains of gram-positive (*Enterococcus faecalis* and *Staphylococcus aureus*) and gram-negative bacteria (*Escherichia coli* and *Pseudomonas aeruginosa*) with ciprofloxacin as positive control. Aqueous extracts of both plant species showed antibacterial activity, with a very high sensitivity of bacteria to *L. salicaria* extracts (inhibition zones in the interval of 18-23 mm) and medium sensitivity of bacteria to *L. vulgaris* extracts (inhibition zones in the interval of 11-13 mm). The absence of antibacterial activity is present only in the extract of *L. salicaria* on *Enterococcus faeacalis*. The results of antibacterial activity are presented in Table 4.

Table 4. Antibacterial activity of extracts of plant species *L. salicaria* and *L. vulgaris*

Tabela 4. Rezultati mjerenja antibakterijske aktivnosti ekstrakata biljnih vrsta L. salicaria I L. vulgaris

Sample	Inhibition zone [mm]			
	S. aureus	*E. faecalis*	*E. coli*	*P. aeruginosa*
L. salicaria extract	22	-	23	18
L. vulgaris extract	13	11	12	11
Ciprofloxacin (positive control)	>20	>20	>20	>20

On the *Escherichia coli* strain, *L. salicaria* extract showed an inhibition zone of 23 mm, which indicates the highest sensitivity of the microorganism. These results confirm the results of previous studies, where *L.salicaria* showed good antimicrobial activity against the *E. coli* strain (Çitoglu & Altanlar, 2003; Borchardt et al, 2008). The study conducted by Srećković et al. Srećković et al., (2021) showed the absence of antibacterial activity of *L. salicaria* on the *E. coli* strain, which points to the influence of the difference in the extraction conditions. *Pseudomonas aeruginosa* belongs to MDR strains (multidrug resistant strains). Today, there are very few antibiotics that can be used to treat infections caused by this bacteria (Guclu et al, 2014). *L. salicaria* extract showed promising results in this research with an inhibition zone of 18 mm, which indicates a good sensitivity of the bacteria. This result is confirmed by the results of a study conducted on MDR strains. Extracts of *L. salicaria* showed a strong ability to inhibit the growth of *Pseudomonas aeruginosa* and *Acinetobacter baumanni* strains isolated from infected patients (inhibition zones of 16.09 mm and 18.3 mm, respectively) (Guclu et al, 2014).

The *Staphilococcus aureus* strain also showed the highest sensitivity to the aqueous extract of *L. salicaria*, with an inhibition zone of 22 mm. Good antibacterial activity

against the *S. aureus* strain was also shown in other studies (Çitoglu & Altanlar, 2003; Rauha et al, 2000; Borchardt et al, 2008). Water extracts of *Lysimachia vulgaris* showed a weaker ability to inhibit the growth of all tested bacterial strains, with inhibition zones of 13 mm for the *S. aureus* strain, 11 mm for the *E. faecalis* strain, 12 mm for the *E. coli* strain and 11 mm for the *P. aeruginosa* strain. These results are confirmation of the study of the antimicrobial activity of *L. vulgaris* conducted by Yildirim et al., (2017). In other studies, good antimicrobial activity of *L. salicaria* against *L. monocytogenes* and *L. innocua* strains was confirmed (Altanlar et al, 2006). *Bacillus cereus* and *Mycobacterium smegmatis* strains showed sensitivity to *L. salicaria* extracts (Dugler et al, 2004). Very good activity of *L.salicaria* extract against *Candida albicans* has also been established (Rauha et al, 2000; Borchardt et al, 2008). Becker et al (2005) isolated the active components of *L. salicaria* by thin-layer chromatography, of which oleanolic and ursolic acids were found to be responsible for antifungal activity, and vescalgin was the active component responsible for the antibacterial activity of this plant species.

CONCLUSIONS – *Zaključak*

In this research, it was observed that the plant species *L. salicaria* and *L. vulgaris* show antioxidant and antimicrobial effects. *L. salicaria* extracts showed very strong antioxidant and antibacterial activity. Namely, the methanol extract obtained by the maceration method showed the strongest antioxidant activity and the highest level of polyphenols. In the case of *Lysimachia vulgaris*, the methanol extract obtained by ultrasonic extraction showed the highest antioxidant activity. It can be observed that choosing an adequate solvent, method of extraction and extraction conditions are the most important factors in the utilization of the biological activity of these plant species. According to the results of other studies conducted on *L. vulgaris*, it can be observed that the extraction method and conditions of extraction in this study were not satisfactory for the adequate extraction of polyphenolic compounds. Aqueous extracts of *L. salicaria* showed a very strong ability to inhibit the growth of *E. coli* and *S. aureus* strains, and aqueous extracts of *L. vulgaris* showed a medium strong ability to inhibit the growth of all strains of bacteria used. The good antibacterial activity of the aqueous extract of *L. salicaria* against strains of *Pseudomonas aeruginosa*, a bacterium that belongs to MDR strains, is particularly significant. Based on the results of this research, but also on the results of other scientific works, there is a good basis for further pharmacokinetic and pharmacodynamic research of the active compounds in *Lythrum salicaria*.

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SAŽETAK

Biljne vrste *Lysimachia vulgaris L. i Lythrum salicaria L.* su invazivne biljne vrste, čija su ljekovita svojstva poznata u tradicionalnoj medicini Evrope i Azije. Ove biljne vrste pokazale su blagotvorne efekte u tretmanu kožnih oboljenja, dijareje, proširenih vena, sinuzitisa, različitih vrsta krvarenja. Cilj ovog istraživanja bio je ispitivanje antioksidativnog i antibakterijskog potencijala ekstrakata navedenih biljnih vrsta. Pripremljeni su ekstrakti različite polarnosti korištenjem metoda maceracije i ultrazvučne ekstrakcije. Za ispitivanje sadržaja polifenola korištena je metoda Folin-Ciocalteou, a putem FRAP i DPPH metode ispitan je antioksidativni potencijal. Prema dobivenim rezultatima, možemo uočiti dobro poznat značaj odabira pravog otapala i metode ekstrakcije za maksimalno iskorištenje ljekovitog potencijala biljne vrste. Rezultati ispitivanja pokazali su prisustvo antioksidativne aktivnosti ekstrakata obje biljne vrste, što je evidentirano u tabeli 1, 2 i 3. Od naročitog značaja jeste upečatljivi rezultat antioksidativne aktivnosti metanolnog ekstrakta *Lythrum salicaria L.* dobivenog metodom maceracije. Antibakterijska aktivnost ispitana je za vodene ekstrakte dobivene metodom ultrazvučne ekstrakcije. Poseban akcenat stavlja se na rezultat antibakterijskog dejstva ekstrakta *Lythrum salicaria L.* na sojeve bakterije *Pseudomonas aeruginosa,* koja pripada MDR sojevima. Prema dobivenim rezultatima studije, evidentno je da biljna vrsta *Lythrum salicaria L.* ima naročit potencijal za dalja farmakokinetička i farmakodinamična ispitivanja njenih biološki aktivnih komponenti.

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REVIEW PAPER

New finding of Lesser butterfly orchid (*Platanthera bifolia* (L.) L. C. Rich.) in Bosnia and Herzegovina

Novo nalazište bijelog vimenjaka (*Platanthera bifolia* (L.) L. C. Rich.) u Bosni i Hercegovini

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ABSTRACT

The Lesser butterfly orchid is a rare species in our forests. By conducting two years of field research (2021-2023) on the flora around Sarajevo, a number of populations of this species were found at the Donji Miševići locality. The species was found in the former oak-hornbeam forest, where scotch pine had been planted. All available geological, pedological and ecological parameters were provided. The altitude was measured by GPS device "MagelaneXplorist 500". The slope of the terrain was determined by a clinometer from the "Recta DP 6 GLOBAL" compass. It was also noted that there is no herbarized specimen in the "Herbarium of the National Museum of Bosnia and Herzegovina (SARA)", so the part of the material will be herbarized and stored at the same Herbarium.

Keywords: *Platanthera bifolia, ecology, "Red list of flora BH", Orchidaceae, geophyta*

INTRODUCTION – *Uvod*

Bijeli vimenjak je rijetka vrsta naših šuma iz porodice orhideja. Prema Šilić (1977) i Nikolić i Topić (2005) ova orhideja se karakteriše brojnim velikim bijelim cvjetovima te ima samo dva, rjeđe tri lista smještena na dnu biljke. Stabljika je visoka, uspravna i šuplja. Listovi goli, svijetlozeleni, sjajni, okruglasto jajoliki, a na stabljici se nalaze još 1-2 (3) mala lancetasta, ušiljena listića. Brakteje su lancetaste do jajasto lancetaste s 5 ili više izraženih nerava, cvjetovi bijeli, veliki, jako mirišljavi. Čine cvast s 12 do 15 cvjetova. Medna usna uska, cjelovita, linealno izdužena, jezičasta i zelenkastobijela, ostruga jako dugačka, duža od plodnice, nitasta, a polinariji svijetložuti. Prašnica je široka, teke paralelne, na vrhu međusobno zbližene. Plod je tobolac sa sitnim sjemenkama.

Ova vrsta se nalazi na "Spisak biljnih vrsta (*Pteridophyta* i *Spermatophyta*) za Crvenu knjigu Bosne i Hercegovine" sa statusom (R), tj. rijetka vrsta u flori BiH (Šilić

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Slika 1. *Platanthera bifolia* na istraživanom lokalitetu Donjih Mišević; (Photo: A. Hasanbegović)

Figure 1. *Platanthera bifolia at the researched site of Donji Mišević;* (Photo: A. Hasanbegović)

1996), na "Crvenoj listi flore FBiH", status (NT) – gotovo ugrožena (Đug at al., 2013) te na evropskoj Crvenoj listi, status (LC) – najmanje zabrinjavajući (Bilz i sar. 2011). Na stranici www.naslijeđe.org ova vrsta se nalazi na Crvenoj listi vaskularne flore Republike Srpske, ali bez statusa. Vimenjak se nalazi i u "Crvenoj knjizi vaskularne flore Hrvatske" (Nikolić i Topić, 2005) sa statusom VU (NT).

MATERIALS AND METHODS – *Materijal i metode*

Tokom dvogodišnjih terenskih istraživanja (2021-2023) flore okoline Sarajeva, na lokalitetu Donjih Mišević, konstatovan je niz populacija vrste *Platanthera bifolia* (L.) L. C. Rich. Vrsta je nađena u nekadašnjoj hrastovo-grabovoj šumi na kojoj je zasađen bijeli bor (*Pinus silvestris* L.). Dati su svi dostupni geološki, pedološki i ekološki parametri. Nadmorska visina je izmjerena pomoću GPS uređaja "Magelan eXplorist 500". Nagib terena je utvrđen sa klinometrom iz kompasa "Recta DP 6 GLOBAL". Karta je urađena u programu ArcGis Pro 2. 8. 4.

RESULTS AND DISCUSSION – *Rezultati i diskusija*

***Platanthera bifolia* (L.) L. C. Rich. - bijeli vimenjak, šumnjak**

Sinonimi: *Orchis bifolia* L., *Gymnadenia bifolia* (L.) G. Mey.

Rasprostranjenost u svijetu:

Tutin et al., (1980) daje rasprostranjenje "skoro cijela Evropa, rijetka na Mediteranu". Šoljan at al., (2014a) daje sljedeću opću rasprostranjenost: srednja Evropa, Mala Azija, Kavkaz, Sibir i Sjeverna Afrika, dok Šilić (1977) ističe da je vimenjak, osim već pomenutih regiona, rasprostranjen i na sjevernim Himalajima.

Rasprostranjenost u BiH:

Bosna:

Beck (1903) daje sljedeće lokalitete: na Gomili (Beck), u Grmeč-pl. (Boller), Osječenici, Klekovači (Fiala), Vilenici (Beck-Mannagetta), oko Travnika, između Tolovića i Zenice, kod Sutjeske, Vareša (Sendtner), Vogjenice (Formanek), posvuda oko Fojnice i u Vranici pl. (Beck), na Pogorelici (Schwarz), dosta česta oko Sarajeva (Hofmann), na Trebeviću (Beck), Igmanu, Bjelašnici (Beck), Preslici (Vandas), Treskavici (Beck), Orovici kod Čajnića (Životsky), Šuljagi, Malovanu, Kamešnici, Vještici (Protić). Lakušić i sar. (1987) je nalaze na Dragoš Sedlu. Šoljan i sar. (2014a) za ovu vrstu daju sljedeće lokalitete: Trebević, Treskavica, Igman, Bjelašnica i Ozren kod Sarajeva. Hasanbegović (2002) je nalazi u hrastovo-grabovoj šumi na lokalitetu Šamin Gaj, a Redžić (1988) daje na lokalitetu Podgrab. Isti autor (Redžić 1991) daje sljedeće lokalitete: Crepoljsko-Vučija luka-Bukovik-Gornji Močioci 1300-1350 m, Šoljan et al., (2014b) daje lokalitet niže Čavljaka, 1200 m, Riter-Studnička (1953) daje lokalitet "u hrastovim gajevima kod Stojkovića u Ždralovcu. Isti autor (Riter-Studnička 1958), daje podatak da vimenjak raste "na umjereno vlažnim livadama u Šabinim barama u Podrašničkom polju kod Mrkonjić Grada. Bucalo i at al., (2008) ističu da je vimenjak vrlo rijetka vrsta u lomskom rezervatu i da je zabilježen samo na lokalitetu Donji južni stjenjak. Šabanović i sar. (2020) daju niz lokaliteta bijelog vimenjaka u Zeničko-dobojskom kantonu: Breza, Olovo, Tešanj, Vareš, Zenica, Zavidovići, Visoko i Žepče.

Hercegovina:

Beck-Mannagetta (1903) daje sljedeće lokalitete: na Porimu (Vandas), kod Nevesinja (Vandas), u dolini Trebišnjice kod Trebinja.

Ekologija vimenjaka:

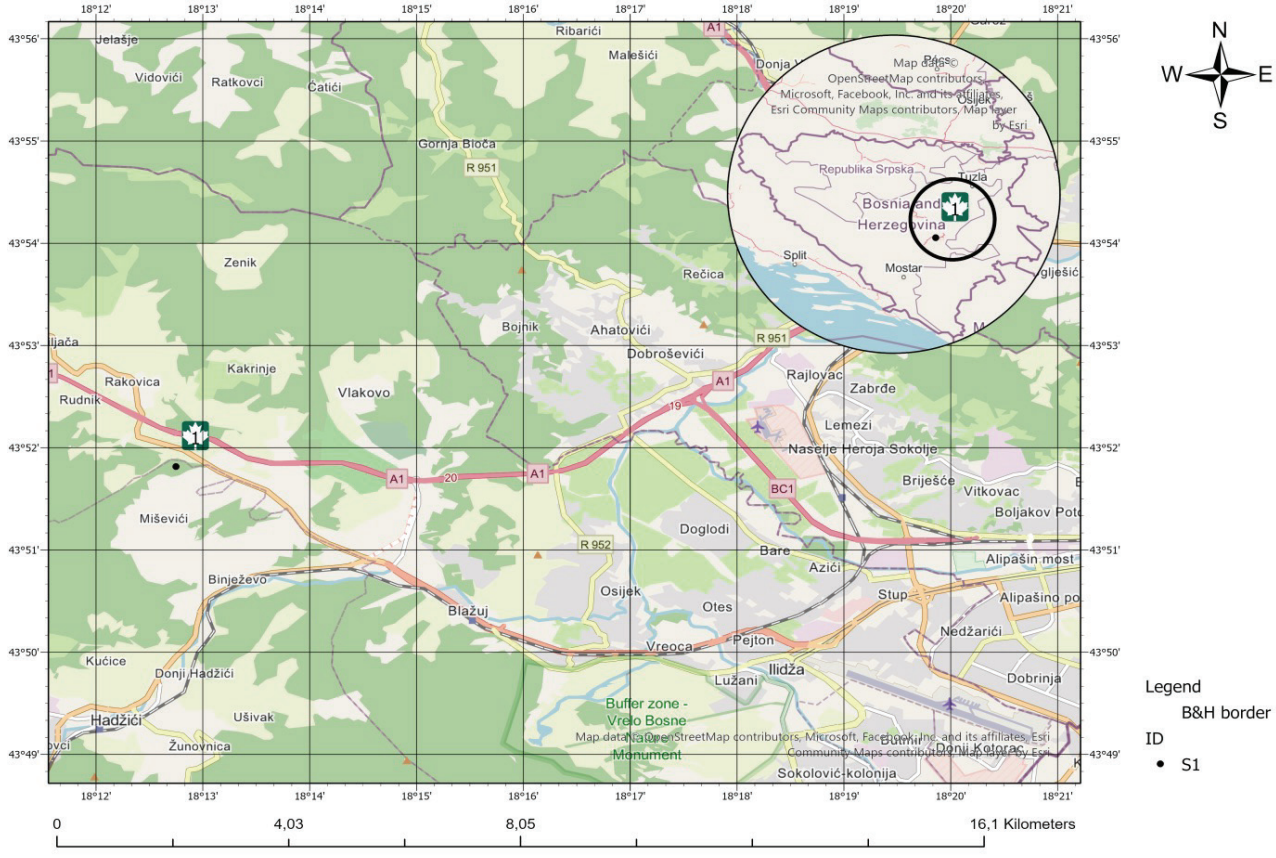
Stefanović (1986) vimenjak svrstava u značajnije biljne vrste prizemnog sloja mezofilnih šuma graba, bukve, jele i javora (red *Fagetalia* Pawl.). Fukarek (1957) u izučavanju zajednice jele i ljigavine (*Rhamneto-Abietum*) na hercegovačkim i zapadnobosanskim planinama je navodi kao vrstu koja je zabilježena u samo jednom fitocenološkom snimku, pri čemu ne daje konkretan lokalitet. Šilić (1977) ističe da je "zastupljena u tamnim listopadnim, mješovitim ili svijetlim četinarskim šumama od nizina pa do subalpinskog pojasa; dopire i do klekovine bora (*Pinetum mughi*)" dok Šoljan i et al. (2014a) kao staništa ističe sušne livade, svijetle šume, između grmlja od nizije do alpinskog pojasa. Redžić (1988) je nalazi u fitocenozi hrasta kitnjaka (*Quercetum montanum illiricum* Stef. (61) 64). Po Oberdorferu (2001) raste do 1860 m nadmorske visine i to u nizu asocijacija, sveza i redova. Tutin et al. (1980) ističu da naseljava otvorene šume, livade i vlažne vrištine skoro cijele Evrope, ali rjeđa je u regionu Mediterana. Nikolić i Topić (2005) daju podatak da se "rjeđe javlja u vlažnim livadnim zajednicama vegetacijskog razreda *Molinio-Arrhenatheretalia* Tx.". Prema CORINE klasifikaciji (Nikolić i Topić 2005) staništa ove vrste su: šikare bora krivulja (*Pinus mugo* L.), mezofilni travnjaci, ilirske neutrofilne bukove šume (*Fagion illyricum*), ilirske šume hrasta kitnjaka i pitomog kestena (*Querco-Castanetum*).

Prema Oberdorferu (2001) spada u nordijsko eurazijsko subozeanski florni element (no-eurassubozean), a što se tiče životne forme u geofite. Pavlović-Muratspahić (1995) je svrstava u indikatore primarnih ekosistema. Interesantan je podatak da biljku oprašuju noćni leptiri (Nikolić i Topić 2005).

Upotrebna vrijednost vimenjaka:

Mnogi autori (Šilić, 1977; Tucakov, 1973; Sarić, 1989) ističu da se iz gomolja vimenjaka dobija salep koji služi u ljekovite svrhe. Interesantno je da Tucakov (1973) daje čak 18 narodnih imena za ovu biljku. Također, ovdje bih dodao i jedan naziv za vimenjak iz istočne Bosne a koji nije zabilježen u literaturi – šumnjak.

Osim što se upotrebljava u medicinske svrhe, vimenjak može poslužiti za jelo jer, kako ističe Grlić (1990), "prilično veliki, produženo jajasti gomolji, u kojima ima mnogo



Karta 1. Područje istraživanja

Map 1. Research area

škroba i šećera, mogu se upotrebljavati kao i gomolji kaćuna", s tim što autor dodaje da bi se smjeli upotrebljavati samo u slučaju velike oskudice zbog ugroženosti od istrebljenja. Također, isti autor (Grlić, 1990) stavlja gomolje vimenjaka u C-skupinu, što znači najlošiji kvalitet te ga se i zbog toga ne bi trebalo previše iskorištavati.

Novo nalazište:

Novo nalazište se nalazi u sađenoj borovoj šumi, na mjestu nekadašnje hrastovo-grabove šume ispod Donjih Miševića. Geološki pripada mezozoiku, i to gornjokrednom razdoblju (Jovanović i et al., 1978), geološka podloga je neogen. Što se tiče tektonike, ovaj lokalitet pripada prelaznoj zoni (Čičić 1984), zemljište je luvisol, nagib iznosi 20°, ekspozicija je S-SW, a nadmorska visina iznosi 571 m. Geografski se nalazi između 43° 51´ 49" N i 18° 12´ 45" E.

Treba napomenuti i činjenicu da prilikom pregleda "Herbarijuma Zemaljskog muzeja BiH-SARA" nije nađen nijedan herbarizovan primjerak. Zbog toga će se 2 primjerka ove biljke herbarizirati i pohraniti u Herbarijum, tako da su primjerci s ovog lokaliteta prvi herbarizovani egzemplari.

CONCLUSIONS – *Zaključci*

Opisano područje predstavlja novo nalazište vimenjaka. Nalazi se u Donjim Miševićima, sađenoj šumi običnog bora na mjestu nekadašnje hrastovo-grabove šume. Teren geološki pripada mezozoiku, geološka podloga je neogen, dok u pogledu tektonike spada u prelaznu zonu. Utvrđeno je da u Herbarijumu Zemaljskog muzeja Bosne i Hercegovine (SARA) ne postoji nijedan herbarizovani primjerak te će se herbariziranjem 2 primjerka i njihovog ulaganja u ovaj herbar taj problem riješiti.

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SUMMARY

The Lesser butterfly orchid is a rare species in our forests. By conducting two years of field research (2021-2023) on the flora around Sarajevo, a number of populations of this species were found at the Donji Miševići locality. The species was found in the former oak-hornbeam forest, where scotch pine had been planted. All available geological, pedological and ecological parameters were provided. The altitude was measured by GPS device "MagelaneXplorist 500". The slope of the terrain was determined by a clinometer from the "Recta DP 6 GLOBAL" compass. It was also noted that there is no herbarized specimen in the "Herbarium of the National Museum of Bosnia and Herzegovina (SARA)", so the part of the material will be herbarized and stored at the same Herbarium.

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