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CONNECTION BETWEEN CALAMITY IN BEECH STANDS BY *Rhyngaenus fagi* L. (Coleoptera, Curculinidae), EXCESSIVE OF SPRUCE BARK BEETLES SPECIES POPULATIONS AND THE ABSENCE OF POSSIBILITY TO PROTECT THE RARE EPIPHYTIC LICHENS: EVIDENCE FROM THE MOUNTAIN SLOPES FORESTS – NP KOPAONIK IN 2024

*Renata Gagić -Serdar*¹, *Miroslava MARKOVIĆ*¹, *Suzana MITROVIĆ*¹, *Ljubinko RAKONJAC*¹, *Bojan KONATAR*¹

¹*Institute of forestry,*

Kneza Višeslava 3, Belgrade, Republic of Serbia

Corresponding author e-mail: serdarrenata79@gmail.com

ABSTRACT

The supplementary feeding of *Rynchaenus fagi* (Illiger, 1798), taxa with syn. or previously included within the genus *Orchestes*, as *Orchestes fagi* (L.) or beech miner's weevil lasted much longer this season and started earlier, even to 6 weeks. Due to the exceptional abundance of it this season and with the ever-present meteorological crisis this summer, it seems that in the end, the beech trees were damaged by 4 instead of two, both ones – per two adult and larval generations. The assumption is that the second generation of larvae appeared, so in addition to the much earlier appearance of the first, there is also a second this year due to the almost Mediterranean climate in areas where mountain summer normally starts late (in July) and ends quickly. Ever since the adults have been active and have been receiving supplementary feeding, all the time since the start of the growing season, it has created a picture and impression that the damage caused by this pest in the year 2024 is extremely strong and visible in many areas in Serbia where beech is widespread. Everything was affected, the chain of damages occurred (linking with three spruce bark beetles high abundance on Kopaonik from previous period) and all had been intensely reflected on even lichen diversity - as an indicator of the state of the environment, in the most negative sense. This the subject of our research and intervention this summer, results are present in paper here.

Keywords: *Rynchaenus*, Adults weevil, Larvae, Abundance, Kopaonik, Lichens

INTRODUCTION

On the basis of the tests presented here, it can be concluded that the entire forest stands on Kopaonik are affected by pests of both beech and spruce (the bark beetles prefer high mature trees). Attack on trees lasted much longer this season and started earlier. Mostly of many, dominant high beech trees in forests have suffered and are still suffering from a strong attack from these pests. This year new was serious pest of beech forests, known as *Rynchaenus fagi* (Illiger, 1798), taxa with syn. or previously included within the genus *Orchestes*, as

Orchestes fagi (L) or beech miner's weevil (Fauna Europaea: new - assessed July 17 2024). When a calamity occurs in the forests, one tends to avoid chaining, i.e. the circumstances that are considered favorable conditions for other pest either and when they are determined there is lack of defoliation, and much of chlorosis too. An almost identically intensified are attack by the bark beetle on spruce, and that of both or three types, usually at medium or to the strong attack of the presence of three his bark beetles - and all the insects as if synchronously attacked this summer, precisely protected and large areas that make up a natural asset (Kricke & Loppi, 2002), in NP Kopaonik. In relation to the presence of all other pathogenic fungi and insects, the forests of Kopaonik eventually lost their satisfactory state of health, meaning precise on high forests.

There was little chance and it is hardly possible that by gaining an insight into numerous different hitherto undisturbed ecosystems, they turned out to be an "almost lichen desert" - almost with the absence of a large number of species of these delicate organisms (Fрати & Brunialti, 2023). Nevertheless, the situation is clear and it is already registered or as non-lichen species localities as a direct connection with other harmful agents present - in the regions of Samokovska reka, Brzeća, Kriva reka, Brzećka reka (<https://www.infokop.net/>). In 16 localities from 2022, the measurements were repeated during the tour, but new ones were also marked as important, according to the evenly selected localities distributed and chosen in all Kopaonik economic units. More specifically, the regions: Grabovnička unit, Graševačka Unit and Đerekarska Unit (<https://www.infokop.net/>). As far as the base is concerned, on Kopaonik there is medium-deep to deep soil, skeletal to skeletal, dry, permeable to water and drained, everywhere and mostly. These are extremely bad living conditions for almost all lichens. However, the clean air is long fits to a species like the "silk from the trees", the bushy lichen, *Usnea barbata* (L.) F.H. Wigg. Parmeliaceae, at a safe distance from the ground thrived perfectly and even densely populated (Jahns & Masselink, 1982).

The presence of economically important pathogenic fungi and harmful insects could have made this year extremely dangerous, even for the occurrence of fires even. Nevertheless, this was risk on so many levels, Tab.1 (presence of miner weevils, Curculionidae) in beech forests together with bark beetles (in spruce forests) did occur as a set of conditions in many open areas, on the sun, and also on trees, i.e. on the bark of spruce, especially which were attacked and from moderate to strong on two levels; Interesting is storey as a layout for bark beetles with both or all tree spruce bark beetles, with lots emerge holes above the height of an adult man of *Pitiogenes chalcographus*(L.), visible emerge holes of adults of *Ips typographus* and *Xyloterus lineatus* (L.) everywhere where it normally lasts and has been observed for several years (only the lower-lower parts of the trees for *I.t.* upper parts for *P. Ch.*). It happened in the localities where lichens were counted and determined and *Chrysomixa abietis* (Wallr.) Unger, also occurs on needles as secondary pest within pests chaining i. e. from the effects of various economically harmful insects to phytopathogenic fungi (Henderson, A. 1991; Henderson, 1993; Henderson, 1994).

As for the NP as a protected area, it is in the V degree of endangerment (42% of the total area), which belongs to the category of weak endangerment. A large part of the farm unit, i.e. 18% of the total area, is in the 1st degree of danger and there are artificially raised stands of black and white pine and larch. From the point of view of the degree of danger from fire, the coniferous species of pine and larch are the most endangered, these species contain highly

flammable resins in the wood and oils in the needles, which makes them very vulnerable to fire. In the fourth level of threat, there are stands of oaks and black locust, which fall into the category of low threat (7% of the total area). Spruce, Douglas-fir and other conifer (Black pine, Scots pine, Fir...) stands and cultures are somewhat less endangered (Nali *et al.*, 2007), but they are also highly endangered by fire. These stands are represented by 3% of the area. The 6th level of threat includes clearings located on 425.52 ha, or 28%, as in park reports <https://www.infokop.net/>.

The vegetation period on Kopaonik slowly starts mostly at the end of April, usually are visible at latest or second decade of May and lasts until the second half of October, when it year is meteo-climaticly normal. At an altitude above 1000 m, the vegetation period lasts much shorter, from mid-May to mid-September. Comparing the new data with the data from the previous device period, we find that the average annual temperature has increased by 0.7°C, and the amount of precipitation has also increased by 56.7 mm, which fits into the general trend of global warming - crisis precisely called as natural tempest.

MATERIAL AND METHODS

As pest antagonists and indicators of a healthy environment, there are different types of lichens, from which group of organisms on the slopes of this mountain many have been developing since ice age changes and have been quite common until now, showing either a satisfactory number or at least resistance to the presence of harmful agents. Research from 2022, with the same methodology, and even in places not long after, showed that there were many, then in front of the factories, even, and at least they were recorded, marked as present. A wooden frame (Fig.1), 90 X 90 cm (Gagić-Serdar *et al.*, 2023), was brought to the field, and within the „2D“ surface this time, recognized lichens were immediately determined with both a magnifying glass and the naked eye, then which practise (we already possess some good practise from 2022) mandatory use of professional keys and dedicated literature (Murati, 1992; Savić& Tibell, 2006; Stamenković, 1997). This showed much sudden absence of many then even common lichen species, the kind of the most resistant lichens everywhere - from the meadows with direct sun to the correes of spruce trees in the shade, resembles the scenario just mentioned then, which was the so called than „lichen desert“ as worse case scenario. Visible changes and the highest number of diseases and pests were recorded this summer in 2024, both for surfaces, in all areas of Kopaonik as NP (<https://www.infokop.net/>).

There were 16 localities to observed, several times this year, in beech and spruce stands on Kopaonik, which we previously visited during 2022 research (Gagić-Serdar *et al.*, 2023). It is done on purpose, that these areas were visited several times during the Report-diagnostic forecasting service job, then through inspections within the ICP Forests project of both Levels, and finally within checking the nursery near or from Kruševac. The encounters with the areas on which lichens started to „thin out“ significantly in terms of diversity and abundance, but also in the areas which they cover on the ground and trees, but also not like that, like it was in 2022, have happened many times, but only it was worth fundamentally using a counting frame to check the situation in more detail, according lichen species and their Index of Atmospheric Purity. Everything can only partially be the result of a large number of samples and trips to the field, i.e. visiting some stands where natural species succession may be taking place, i.e. simple

adaptation to a new (everything is mountain with a two-month fresh summer) climate typical, but in many, many, other departments or localities, climate looks like almost Mediterranean than mountain like this summer).



Fig. 1 A wooden frame, 90 X 90 cm, was brought to the field, and inside the 2D surface this time, lichens were immediately determined with a magnifying glass and the naked eye.



Map 1. Location of the state of Serbia in Europe, with marked with blue X as National Park Kopaonik - (the one of the largest and specifically located in the Central Serbia)

Due to the innovative approach used and presented in this paper (use of the Lichen Biodiversity Index – LBI), it is necessary to provide a brief overview of the approach which has so far yielded notable and acceptable results, but from another aspect in terms of methodology. It was rather urgent to do and compare with findings from two years ago.

The method used to date is the lichen air quality indication method, performed through calculation of the value of IAP.

IAP- (Index of Atmospheric Purity) according to the formula (Fauna Europaea (new); Boqueras, 2000; Jovan, 2008) starts as calculation of :

$$IAP = \Sigma (Q \times f) \quad \square \quad \text{where:}$$

Σ – Sum for all localities

IAP–Index of Atmospheric Purity,

Q–ecological index of each lichen species,

f–coefficient representing the coverage of each registered lichen species on every researched site (expressed in the 1-5 value range).

Diversity and composition of lichen species were studied in relation to the level of protection of the sampled sites-localities. Two groups of sites were distinguished: In NP

Kopaonik-Protected Areas (PA, 8 localities, 30 on the ground, 18 on sampled trees) and Non-Protected Areas (NPA, 8 localities, 18 on the ground and on 32 trees). The statistical differences in species richness (gamma diversity) between PA and NPA were tested using the non-parametric test (SPSS), with $P < 0,05$; $P < 0,01$; $P < 0,001$. Results of this calculation are present in Tab. 2.

P-value was used to evaluate how likely an observed difference was due to chance (value of P narrow to 1 indicates perfectly homogenous groups of lichens taxa, while when P is more narrow to 0 indicates within-group of lichen determined taxa heterogeneity was more equal to that expected by chance (Fрати & Brunialti, 2023).

RESULTS AND DISCUSSION

Comparing the outings on the field in 2022 and this season, most of the types of lichen present then are as if they had never been there. In beech forests there is a weevil miner attack, and in spruce forests there is a bark beetles attack (Boqueras, 2000). What is certainly connected, unfortunately, is the unsuspected presence of trees that are in an advanced stage of rotting due to the attack of both bark beetles, and the beech crowns appear completely different from a great distance (everywhere yellow color and small leaves are became common this summer). In places like the one described above (there are also windbreaks), the thing that sent the lichens away as the first inhabitants of nature, who suffer due to the lack of moisture, must have been the first to be washed away - the heat, the lack of dew on the ground vegetation, which was sometimes present during the day. The absence of the morning dew, which was always present in the early hours of the morning, was also noticed. Next, the movement of the complex with the spruce and the availability of shade by the otherwise dense beech canopies - now completely exposed to insolation of an intensity almost unpleasant to any organisms., so their growth is no longer supported even by the bark of the spruce. Spruce trees with bark underneath, which is only a question of when peeling will affect it, are no longer a growing substrate for these sensitive organisms, and unfortunately, the beech tree is also unable to try to form any shade, neither as a group, nor individually (Cvijan & Stamenković, 1996), on many „new“ places.

Rynchaenus fagi prefers the highest, dominant and future trees, and the attack usually lasts at least 3+ years to 4 years. The opening of the assembly would be next and chaining in the worst scenario for a high-quality and mature beech forest could begin. There is hope that on other areas around Serbia, where the phenomenon has been recorded, and not everything around has "conspired" to extend the unfortunate circumstances into the next season.

- Very sensitive lichen taxa comfired are: *Candelariel laurella*, *Evernia prunastri*, *Lecanora* sp., *Ochrolechia pallescens* and *Parmelia sulcata*, but without *Physcia tenella* on naither one of 16 field localities. That fact, that this taxa was not found could mean that it is extinct, but it does not mean to.

Physcia tenella -an extinct species

- Sensitive lichen taxa are: *Buelia punctata*, *Lecanora argentata*, *L. intumescens*, *L. pulicars*, *Lecidella elaochroma* and *Physcia stellaris*.
- Tolerant lichen taxa are: *Phaeophyscia orbicularis*, *Physcia adscendens*, *Candelaria xanthostigma*, *Physconia distorta*, *Physconia grisea* and *Xanthoria parietina* (Savić & Tibell, 2006; Stamenković, 1997; Wirth, 1995).



Fig. 2 Very similar climate-meteorological crisis raging around the globe, same, there like here, so whole mankind in conjoined suffering.

We made our results, especially with particular *Fagus moesiaca* (Domin, Maly) Czech., now it is more than clear and surprise us, that its super-power to be bio radiator, preserving 1,5 x, or from 200 to 250% of different heavy metals within tissue. That promise us usually much healthier future, even in beech forests. That potential still should be examined with, we should stick with that until full success (Orig).



Fig. 3 The strength of the attack for *Rhynchaenus fagi* I. is determined by taking 5 branches each about 1 m long from three levels in the crown of the high forest. All of them are counted, then only the leaves with mines. In percentage (%) of leaves with mines are present or it is the share of attack strength (this year it was from 50 to even 80 %). It usually lasts 3+ or 4 years in a row. Then the tall (because it chooses the best) forests stagnate, and lose their safe and otherwise most important guaranteed share in growth and yield, they never even regain the same height-thickness status. Even - they cease to be the trees of the future, even though they have been that throughout their whole lives - insects of one mm. There is no experience with control outside the nursery, which may be wrong and is also the goal of this paper (Orig).

Our forecast believes that from 2022 we will not find or recognize our many species of lichens, but only in the period of the year when precipitation begins to appear on Kopaonik as a normal meteorological condition or as normal.

Also, this year their name shows just for even those were even just recognised or just made a remark about them – Those are species in disappearing phase. Lichen taxa sometimes, it's better say often, are as „2Ds organisms“ easy to determine and often has been growing on many forest stones -especially. It is – just for the stone „boldness“ (Dobson, 2005), or when Lichen desert starts to „show her bad ugly face“.

Risk of appearance several pests with huge abundance, always is more serious in Protected Area With the strong calamity of the beech weevil miner - *Rhynchaenus fagi* L., and a large number of spruce with both types of bark beetles on the surface of which the larvae incubate – and it is like that for several years, it was assumed that there must be a lack of moisture in Area of NP Kopaonik – Which could lead to the luck to end for environment priceless Lichens taxa (species) (Table 1).

Table 1. Risk of appearance several pests

Likelihood of Lichen taxa: Chance of risk not to be proven on previous sites, 2022
Rare: Slim possibility of happening on old, impossible to locate Lichen taxa on new site
Unlikely: Could occur but remote, not with proper surface, taxa stop to reproduce
Possible: Might happen to find Lichen species, just on old sites
Likely: Expected to occur, even per one of common Lichen taxa in frame
Almost Certain: Expected regularly, Lichen taxa are wide spread and reproducing
Severity: Impact on Lichen taxa findings on previous sites
Insignificant: Not worth, just worry about loss of Lichen taxa
Minor: Can cause delays or been rare of Lichen species even in 2022
Moderate: Likely delays or lost in start of Lichen taxa
Major: Possible failure to find (not back to all known, than also rare lichen taxa)
Severe: Definite failure in even existing on Kopaonik
Risk Level: Setting Priority just not to be extinct of Lichen taxa
Low: Not much, risk is not look in proper place or mix it with specific Lichen taxa
Medium: Some risk, in determination but here is low possibility that Lichen taxa is there
High: Major risk in losing Lichen taxa species on Kopaonik
Very High: Extreme risk, like lost Lichen species forever, even in country, extinction



Fig.4 Drying of spruce stands from bark beetles - *Pitiogenes chalcographus*, *Xyloterus lineatus* and *Ips typographus* (Orig.)



Fig. 5 Signs of trees physiological weakness, the result of a stronger attack in 2024 were trio of this pests - *Pitiogenes chalcographus* (L.), *Ips typographus* (L.), and *Xyloterus lineatus* (L.). Their supression was done by feromone trap and feromones (IT Ecolure, PC Ecolure i XL Ecolure). One of those signs - of attack of „Trio of Bark beetles“on high trees of spruce is usually occurence of fungus *Chrysomixa abietis* (Wallr.) Unger, also appears on needles (Orig.)

Table 2. Indicator species in relation to the level of protection of the sampled sites (Protected Areas and Non-Protected Areas) in the study area of Kopaonik (Protected and non-protected areas). Indicator values, (*gxf*) derived from Indicator Species Analysis (Dufrene & Legendre 1997), range from 0 (no indication) to 1 (maximum indication).
EC= extremely common, VC= very common, RC= rather common, C= common, R= rare, RR= rather rare, VR= very rare, ER= extremely rare.

Level of protection of the sampled sites	Species	Commonness Rarity	Indicator value
Non-Protected Areas (NPA)	<i>Xanthoria parietina</i>	EC	0.745**
	<i>Phaeophyscia orbicularis</i>	EC	0.586**
	<i>Hyperphyscia adglutinata</i>	EC	0.584**
	<i>Physconia grisea</i>	C	0.563*
	<i>Evernia prunastri</i>	VR	0.464**
	<i>Lecidella elaochroma</i>	RC	0.397*
	<i>Lecanora argentata</i>	C	0.343*
	<i>Physcia stellaris</i>	VC	0.343*
Protected Areas (PA)	<i>Lecanora sp.</i>	RR	0.730***
	<i>Candelariella xanthostigma</i>	VC	0.546*
	<i>Phaeophyscia orbicularis</i>	C	0.543**
	<i>Candelariella laaurella</i>	VR	0.540**
	<i>Buelia punctata</i>	C	0.531*
	<i>Physcia tenella</i>	ER (extinct)	0.524**
	<i>Ochrolechia pallescens</i>	VR	0.456*
	<i>Physcia adscendens</i>	RC	0.456

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

CONCLUSIONS

The strength of the attack for *Rhynchaenus fagi* L. is determined by taking 5 branches each about 1 m long from three levels in the crown of the high forest (Fig.2). All of them are counted, then only the leaves with mines. % is the share of attack power. It usually lasts 3+ or 4 years in a row. Then tall (because it chooses the best) forests stagnate, and lose their safe and otherwise most important guaranteed share in growth and yield, they never even regain the same height-thickness status. Even - they cease to be the trees of the future, even though they have been that throughout their whole lives - insects of one mm. There is no experience with control outside the nursery, which may be wrong and is also the goal of this work.

On of Signs of physiological weakness, of spruce forsts were the result of a stronger attack in 2024 – of *Pitogenes chalcographus* (L.), *Ips typographus* (L.) and *Xyloterus lineatus* (L.). Their supression was done by feromone traps and feromones (IT Ecolure, PC Ecolure i XL Ecolure). One of those signs -of „Trio of Bark beetles“on high trees of spruce is usually *Chrysomixa abietis* (Wallr.) Unger, also occurs on needles.

Determination of the collected lichen species was done using so-called identification books – serious and respected keys we once, first time have used it in 2022 (Wirth, 1995, Dobson, 2005, Jahns & Masselink, 1982; Murati, 1992, Murati, 1993, Boqueras, 2000). In thisresearch, we have used the numeric method of the Index of Atmospheric Purity (IAP) (Kricke & Loppi, 2002), calculated by NPA were tested using the non-parametric test (in SPSS), with $P < 0,05$; $P < 0,01$; $P < 0,001$.

By marking the researched points on a area map and joining the points with the same or similar values of the IAP we obtained a picture of the zones, and important – almost not

existence of it in the field. Those which were even neither found within frame, so that mean-it just was seen in micro versions, those are extremely sensitive lichen species: *Candelariel laurella*, *Evernia prunastri*, *Lecanora* sp., *Ochrolechia pallescens*, *Parmelia sulcata* -with IAP Indicator value are present in Tab. 2, with their presence in NP (protected area, one of III protection zones-which is different from zone of vulnerability). In first zone of protection are common presence of rarest species of lichens, as a final conclusion, so state is slight better.

Rarest until now *Physcia tenella* (was relatively present two years ago, so by this research it is now „extinct“ on Kopaonik, considering that we carefully searched on 16 localities, but it just a pic which shows that it had appeared within frame in 2022) (Tab. 2 with difference values for P).

Very similar climate-meteorological crisis raging around the globe, same, there like here, so whole mankind together with nature are in conjoined suffering.

As a mountain of this origin and age, Kopaonik will for a long time resist the harsh and almost unnatural scenarios of climate crisis situations that humanity is facing today. However, it is precisely clear on the surfaces where both are covered, both high and mature forest, due to insects whose presence cannot be confirmed without a serious bio monitoring at least, what is just happening now. Today it happens that it is by one of the more important but variable - water regime and for recognisable all bioagents (NO or YES) the presence of a large number of safety indicators in ecosystems are present, lichen for example (Corsini, 1997). That should be the one of the most favorable issues forests could possess. It has just been established that on some parts of the territory of NP Kopaonik, there are almost no more lichens taxa, which we found as species of even significant cover in the foothills, near Factories of Iron, towards Željin (or for some species of lichen they were almost everywhere, which not the case today). Now the scenario is completely confusing, and there's the need for this kind of work, research and paper finally.

We made our results, especially with particular *F.moesiaca* individuals in progress, now it is more than clear and surprise us, that its great-power to be bio-radiator, preserving 150% or from 150%- 200 to 250% of different heavy metals within tissue. That promise us usually a much healthier future, even in beech forests. That potential should still be examined with, as so we should stick with that until full success brought.

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