DOI 10.12905/0380.sydowia75-2023-0023 Published online 5 October 2022

Diversity and ecology of macrofungi on large decaying spruce trunks: what has changed after five years?

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Holec J., Holcová K. & Žák M. (2022): Diversity and ecology of macrofungi on large decaying spruce trunks: what has changed after five years? – Sydowia 75: 23–35, and electronic supplements at http://www.sydowia.at/

Macrofungi were monitored on huge decaying Norway spruce (*Picea abies*) trunks in Boubínský prales virgin forest in Czechia. The work was done in 2020 on the same trunks and by the same methods as the already published study from 2015. After five years, trunks of decay stage 1 shifted to stage 2, and of stage 2 to 3, whereas no substantial changes were observed on trunks of advanced decay stages 4 and 5. There has been considerable change in cover of bark and mosses. In 2020, higher number of species was recorded. Key role of decay stage followed by bark/moss cover and the total canopy cover for shaping fungal communities was confirmed. The shift in species composition was lowest in trunks of initial decay stages, then slightly increased towards medium stages, and finally decreased in final stage. Species turnover was fastest in the first ten years after tree fall. Consequently, the first survey should be conducted up to 3 years after tree fall and the second one 5–10 years after the fall. Much of the change in species richness and composition was due to different weather patterns in 2015 and 2020. The difference was best explained by the course of mean monthly precipitation. We recommend that field fruitbodies surveys should always be confronted with the course of precipitation and temperature in a given year for assessment of mycodiversity data completeness, while precipitation 1–2 months before mycological inspection is decisive. High conservation value of the locality was highlighted by records of rare old-growth forests fungi, above all *Dentipratulum bialoviesense*.

Keywords: coarse dead wood, fungal communities, succession, climate, Central Europe.

Many studies on diversity and field ecology of wood-decomposing fungi have been carried out in last decades showing that discrete wood units with their mycobiota are not only interesting for mycologists but also represent ideal systems for answering questions on general community ecology (for recent summaries see e.g. Ordynets et al. 2018, Thorn et al. 2018, Dawson & Jönsson 2019, Purhonen et al. 2019, Crowther 2020, Moor et al. 2020, Nordén et al. 2020, Odriozola et al. 2020, Tomao et al. 2020, Abrego et al. 2021). Studies focused on diversity, community assembly and various ecological aspects of fungi decaying Norway spruce (*Picea abies*) wood are also numerous. They are summarized e.g. by Bässler et al. (2012), Pouska et al. (2013), Strid et al. (2014), Rajala et al. (2012, 2015), Ottosson et al. (2015), Kubart et al. (2016), Juutilainen et al. (2017), Ruokolainen et al. (2018), Holec et al. (2020), Heine et al. (2021), and Runnel et al. (2021). Their usual design is to use a set of discrete wood units, mostly fallen trees, screened for occurrence of fruit bodies or DNA sequences once or several times a year or several consecutive years (Abrego et al. 2016, Purhonen et al. 2017). Surprisingly, there are no repeated studies monitoring fungal communities of the same wood units several years apart, i.e. focused on changes connected with ongoing fungal succession and wood decomposition. It is probably caused by lack of time and financial support for repeated surveys and the reluctance of scientists to perform the same (time consuming) research again. The most similar is the recent study by Moor et al. (2020), however, it compares species on plots merging data from various trunks.

A detailed fruitbodies-based study on factors affecting species richness and composition of macrofungi on large decaying spruce trunks in Boubínský prales virgin forest in the Czech Republic was carried out in 2015 (Holec et al. 2020). It showed that number of species per trunk was positively correlated with increasing tree cover and medium wood decay stages. Species composition on particular trunks was significantly influenced by percentage of bark cover, altitude and decay stage, and to a lesser degree also by percentage of trunk contact with the soil, and cover of mosses, trees and shrubs. In addition, the study captured many inconspicuous or rare species previously unknown from the locality. The validity of these general conclusions was subsequently confirmed by comparison with the study of Silver fir (*Abies alba*) trunks from the same locality and by agreement with published data (see studies cited above and detailed discussions in Holec et al. 2020, Holec & Kučera 2020).

All spruce trunks studied in 2015 were precisely located and documented (Holec et al. 2020). Consequently, there was a good opportunity to carry out a methodologically the same research again. We decided to do it five years later, i.e. in 2020. Such a time lag seemed reasonable in terms of continuing wood decomposition. We hypothesized that shift in wood decay would be sufficient to observe the associated changes in the fungal community. As a novelty over our previous research, we also included analysis of climate, an important factor shaping the composition and dynamics of fungal communities (e.g. Bässler et al. 2010; Büntgen et al. 2012; Diez et al. 2013; Boddy et al. 2014; Heilmann-Clausen et al. 2014; Andrew et al. 2016, 2018; Heegaard et al. 2016; Bidartondo et al. 2018; Ordynets et al. 2018; Thorn et al. 2018). The main questions were: 1. how was the change in trunks decomposition and related environmental parameters after five years, 2. has there been a change in the fungal species richness and composition on particular trunks, especially with regard to the shift in their decay stage, 3. which trunk/environmental/climatic parameters were decisive for these changes.

Materials and methods

Abbreviation

El. suppl.: Electronic supplement.

Study site

Central Europe, Czech Republic, Bohemian Forest (= Šumava Mts.), Boubínský prales National Nature Reserve on E slopes of Mt. Boubín, fenced core area protected since 1858 (central point: 48.97775° N, 13.81078° E; area 47 ha, elevation 925–1110 m a.s.l.), multi-aged montane virgin forest never affected by forestry interventions, tree dominants in 2019: *Picea abies* (53 %), *Fagus sylvatica* (42 %), *Abies alba* (5 %), trees age up to ±500 years. For reviews on forest history and habitat conditions, see e.g. Vrška et al. (2012), Daněk et al. (2019); for fungal diversity see Holec et al. (2015, 2020), Holec (2019), Holec & Kučera (2020).

Climate data

The nearest climatological stations of the Czech Hydrometeorological Institute, the official provider of climatological data in the Czech Republic, were used for obtaining climate data (El. suppl. H). Unfortunately, the nearest one, Kubova Huť on W slope of Mt. Boubín, measures precipitation only. For combining data of precipitation and temperature, the nearest usable stations were Churáňov (elevation 1118 m) plus combined measurements of Lenora and Volary stations (situated very close together at similar elevation: 804 and 749 m). The reason for this combination is end of measurements at Lenora station in June 2018 when the Volary station had begun to measure. Mean annual and monthly values were used. In addition, annual and monthly values of Lang factor (Tolasz et al. 2007) were computed to simply express the bilance between precipitation and temperature, i.e. the value of water availability for organisms which is determined by ratio between precipitation and concurrent evaporation, the latter one influenced by temperature (Minář 1948). In mycology, the Lang factor was used e.g., by Heilmann-Clausen et al. (2014).

Studied trunks and their characteristics

Basic trunk parameters were obtained from tree database administered by the Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Brno, Czech Republic (El. suppl. A). Characteristics recorded by J. Holec in 2020 (El. suppl. B): geographic coordinates (using hand-held Garmin GPSmap 60CSx device), direction of fall (in azimuth degrees), altitude (m a.s.l.), decay stage (1–5, average value for the entire trunk; for details, see below), contact with the soil (%), bark cover (%), moss cover (%), cover of trees (E3, %, estimated from a rectangle covering the trunk and 1 m more at both sides), cover of shrubs and young trees up to a height of 5 m (E2, %, estimated like E3), total canopy cover (E3 + E2, %).

The original set of 33 trunks studied in 2015 was described by Holec et al. (2020). In 2020, only 15 trunks were monitored. The number has been reduced as some of the original trunks became inaccessible. They were covered by other trees that fell during the cyclone Herwart on 29th October 2017 (https://en.wikipedia.org/wiki/Cyclone_Herwart). For each decay stage as estimated in 2015, three trunks were selected, namely those with the species-richest, medium rich and species-poor fungal community (Holec et al. 2020). As all trunks of the decay stage 1 shifted to stage 2 in 2020, three new trunks of stage 1 were added. They fell during the storm Herwart. Finally, 18 trunks were monitored in 2020.

Wood decay stages were estimated in accordance with Heilmann-Clausen (2001) and Holec et al. (2015, 2020) as follows: 1 – wood hard, almost impossible to penetrate with a knifepoint; 2 – wood slightly softened, knifepoint penetrates at most a few millimetres; 3 – wood soft, knife penetrates several centimetres, the wood can be pressed with fingers and larger wood parts can be removed with a knife; 4 – wood very soft, knife penetrates several centimetres and wood parts can be separated with fingers; 5 – wood in the form of mash, original trunk shape no more visible. The number of trunks in particular decay stages based on estimation in 2020 was as follows: stage 1: 3 trunks, stage 2: 3, stage 3: 5, stage 4: 4, stage 5: 3 (El. suppl. B).

Monitoring of fungi

Four mycological inspections were conducted on each trunk in 2020, always in a time of peak fructification (June 23–24, August 12–13, October 8–9, November 25–26). All visible macromycetes were recorded. For comparability, the field work and elaboration of fungal records was carried out exactly the same way as in 2015 (Holec et al. 2020). All fungi were recorded and identified by J. Holec. Some collections of polypores were revised by P. Vampola. Vouchers of hardly identifiable taxa are deposited in the mycological herbarium of the National Museum, Prague (PRM 955190–955278).

For analysis of response to trunk and habitat parameters, basidiomycetes were divided into functional groups (comparable with traits, see e.g. Crowther et al. 2014, Abrego et al. 2017, Purhonen et al. 2019) in which function especially concerns their decay power. The groups (Tab. 1) were distinguished by a combination of fruit body morphology, life style and the part of wood they mostly decompose (for details see Holec et al. 2020).

Statistical evaluation

Species richness per trunk for 15 trunks studied in 2015 and 2020 was compared using box plot and tested by t-test. P-values of t-test less than 0.05 were considered to be statistically significant for rejecting hypothesis about equal mean of species richness between 2015 and 2020. The species composition matrix on individual trunks based on cumulated presence/absence data from 4 visits per year (El. suppl. E) was analyzed by non-metric multidimensional scaling (NMDS). As distance measure, Bray-Curtis similarity was used. Quality of the result was controlled by Shepard plot and value of stress (<0.1). Similarity between species composition on individual trunks in 2015 and 2020 was evaluated using Jaccard similarity coefficient. All calculations were done using the free PAST 2.17 software package (Hammer et al. 2001).

Results

Trunk characteristics in 2020 versus 2015

After five years, all trunks of stage 1 shifted to stage 2, and of stage 2 to 3 (El. suppl. A, B). The shift was less pronounced in medium decay stage 3 (change from 3 to 4 in one trunk, no change in two trunks). No substantial changes were observed on trunks of advanced decay stages 4 and 5. Slight shift in their appearance caused by progressive decomposition did not exceed the boundaries of the decay stages as delimited in Methods.

There has been considerable change in cover of bark and mosses (El. suppl. C). The bark cover decreased on 8 of 9 trunks of decay stages 1–3 (in a wide range, maximally of 70%) and remained unchanged in stages 4–5. The change in moss cover had no relation to decay stage as both decrease (up to 30%) and increase (up to 40%) was observed in each stage.

Cover of trees and shrubs has more or less changed throughout the whole locality as a result of cyclone Herwart in 2017. A decrease of total canopy cover was observed in 12 of the 15 trunks (El. suppl. D). The decrease was mostly small (up to 10 %) but more pronounced in 3 trunks (15–30 %). No change was observed in 1 trunk (BB09) and slight increase in 2 trunks (BB12, BB28; of 5–10 %).

Species richness in 2020

We recorded 158 taxa of macrofungi (156 species plus 2 varieties of the same species) on 18 spruce trunks (El. suppl. E). The individual trunks were inhabited by 6–55 species. Average species number per trunk was 23.4 with standard deviation 11.4. None of the species was found on all trunks (El. suppl. E: last column). Eight species were found on more than half of the trunks (*Fomitopsis pinicola*: 12, *Lactarius subdulcis*, *Mycena stipata*: 11, *Armillaria cepistipes*, *Mycena laevigata*: 10, *Athelia epiphylla*, *Hyphodontia aspera*, *Mycena viridimargin-*

Tab. 1. Species richness of functional groups (traits) of basidiomycetes on the studied trunks.

Year	Resupinate fungi		Fleshy fungi		Polypores	
	Annual (corticioids and heterobasidiomycetes with annual basidiomata)	**Perennial** (corticioids with perennial basidiomata)	**Saprotrophic** (agarics, gasteroids, jelly fungi)	**Mycorrhizal** (agarics)	**Perennial**	**Annual**
2015[a]	66	5	60	4	10	16
2015[%]	41%	3%	38%	2%	6%	10%
2020[b]	51	5	68	12	8	9
2020[%]	33%	3%	44%	8%	5%	6%

[a] 33 trunks
[b] 18 trunks

ata: 9). Two thirds of the species (102, i.e. 65%) were infrequent, found only on one trunk (singletons: 79) and two trunks (doubletons: 23).

Most species were basidiomycetes (153). The species-richest genera were *Mycena* (16 species), *Hyphodontia* s. l. (8), *Galerina* (7), *Botryobasidium* (5), and *Hypochnicium* (5). The species-richest functional groups of basidiomycetes (Tab. 1) were fleshy saprotrophic fungi (agarics, gasteroids, jelly fungi) followed by resupinate fungi with annual basidiomata (corticioids + heterobasidiomycetes). Polypores were much species poorer. The proportion of fleshy mycorrhizal fungi was relatively high (8%). Macroscopic ascomycetes were represented by only 5 species belonging to discomycetes (*Ascocoryne cylichnium, Discina perlata, Pseudorhizina sphaerospora*) and pyrenomycetes (*Camarops tubulina, Bertia moriformis*). Only *C. tubulina* was more frequent (3 trunks).

Species richness in 2020 versus 2015

The total number of species on the 15 trunks studied in both years was 177, number of species found in both years 75, only in 2015 32 species, and only in 2020 70 species (El. suppl. E). The total number of species was clearly higher in 2020 (145 versus 107 in 2015). As regards individual trunks, the comparison (El. suppl. F, Fig. 1) shows increase of species number in 2020 in 12 of 15 trunks across all decay stages. The increase range was 6–317% per trunk (El. suppl. F) but in most trunks 24–94 %. Two trunks had the same number of species (decay stages 4, 5). The decrease was observed in 1 trunk only (– 12 %, decay stage 5). There was considerable increase in number of fleshy mycorrhizal fungi (from 2 % to 8 %) whereas the proportions of the other groups remained comparable (Tab. 1).

Species composition in 2020

The strongest parameters influencing species composition (Fig. 2: those oriented along coordinate 1 and having the longest vectors) proved to be the trunk decay stage in association with moss and total canopy cover, and bark cover projected in opposite direction. Trunks of decay stage 1 (almost completely covered with bark) form a well-defined group, rather distant from other trunks. Their mycobiota is similar to each other and, simultaneously, clearly different from fungal communities of later decay stages. Trunks of stages 2 and 3 are intermixed in the central part of the decay/bark gradient. They are scattered along coordinate 2 which is not clearly associated with environmental parameters analyzed. Trunks of late decay stages 4 and 5 are grouped in left part of the diagram in direction of increasing decay, but in different directions along coordinate 2. It documents that fungal community of the final decay stage 5 deviates from the previous stage 4.

Species composition in 2020 versus 2015

After five years, the species composition has changed considerably on the 15 trunks studied. Only 49 species of 177 were found on the same trunk in both years (El. suppl. G). The ratio of repeatedly found species, hereinafter referred to as "persisting species", represents 33–58 % (exceptionally 83 %) of all species per trunk recorded in 2015 and 20–50 % of species recorded in 2020 (El. suppl. F). Reversely, it means that species found in 2020 as new for particular trunks represent 50–80 % of their species composition recorded in 2020. Based on increase in new species (El. suppl. F: see row named "other species % 2020"), the species shift is largest on trunks of former decay stage 1 (state in 2015,

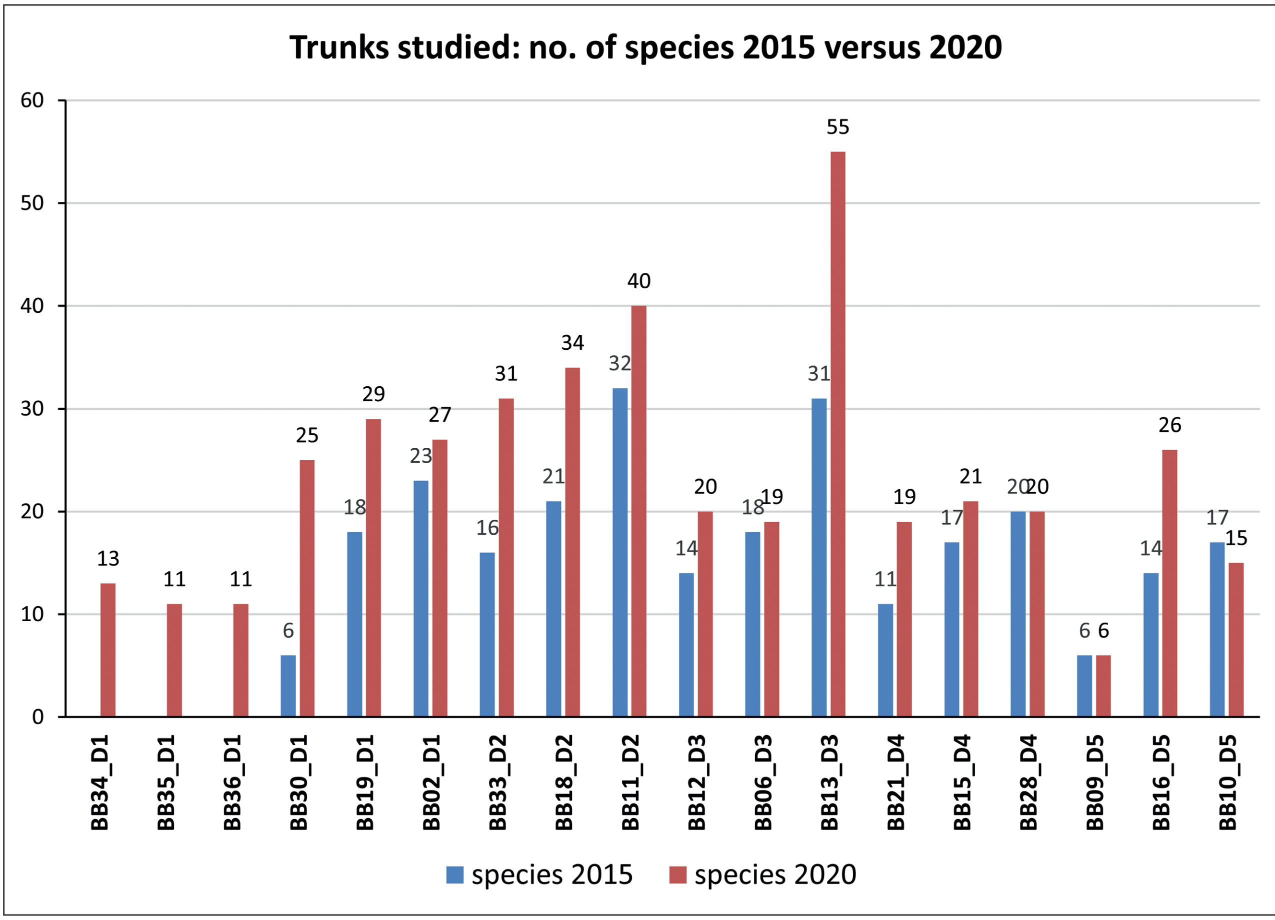

Fig. 1. Comparison of species richness on individual trunks in 2015 and 2020. Trunks are coded with BB number and decay stage (D1–D5 as recorded in 2015, except for trunks BB34–36 studied in 2020 only).

changed to 2 in 2020), namely 63–80 %, and slowly gradually decreases to stages 4 and 5 (50–69 %). When the shift is evaluated statistically, the results are similar. The values of similarity index are low for all trunks (Jaccard index: 0.19–0.33, see El. suppl. F). The similarity is lowest in trunks of initial decay stages 1 and 2 (in 2020 being in stages 2 and 3, respectively), then slightly increases towards 3 and 4, and finally decreases in stage 5 (Fig. 3).

The group of persisting species consists especially of fungi with larger fruit bodies like polypores and agarics (El. suppl. G). Both high-frequent (“common”) and low-frequent (singletones, doubletones) species are represented. The former group contains, for example, *Fomitopsis pinicola*, *Antrodia serialis*, *Mycena stipata* or *Hypholoma capnoides*. The latter group is represented, among others, by rarities like *Amylocystis lapponica*, *Rigidoporus crocatus* or *Skeletocutis stellae*. Annual corticioids are much less represented in this group which shows that their turnover in time is higher.

The direction of species composition change was analyzed using NMDS. Along first coordinate, 9 trunks shifted from lower to higher values (to the right in Fig. 4) of which 6 moved to higher decay stage. On contrary, 6 trunks shifted in opposite direction (to the left in Fig. 4) of which 5 remained in the same decay stage. It suggests that the coordinate 1 expresses change in decay stage between the years 2015 and 2020. As regards coordinate 2, the direction of change was more uniform. In 14 of the 15 trunks there was a shift from higher to lower values (Fig. 4). Searching for possible interpretation, we first considered the parameters decisive for species composition (Fig. 2). However, decay (collinear with other parameters) has already been associated with coordinate 1. Therefore, there must be another factor attributable to coordinate 2 that differed in 2015 and 2020. The only factor that can be considered among the studied parameters is the course of weather. It is analyzed in the following section.

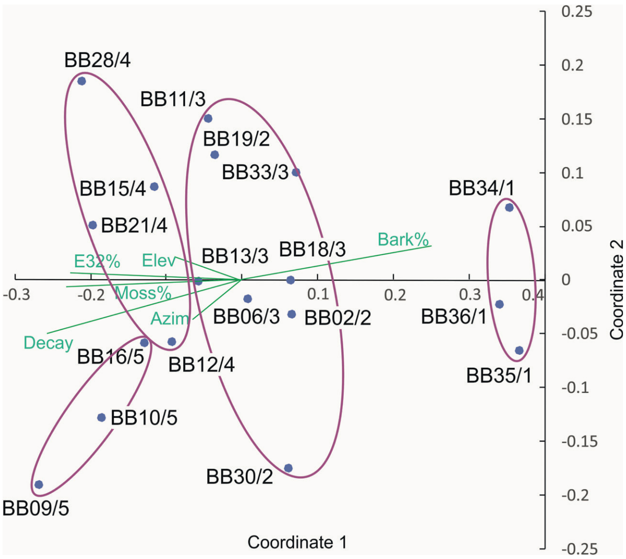

Fig. 2. Fungal species composition on 18 trunks studied in 2020 analysed by non-metric multidimensional scaling (NMDS). As distance measure, Bray-Curtis similarity was used. Stress for three-dimensional coordinate system = 0.015. The following supplementary (environmental) variables were correlated with the NMDS scores and presented in biplot: direction of fall in azimuth degrees (Azim), bark cover (Bark %), decay stage (Decay), elevation (Elev), total canopy cover (E32 %), moss cover (Moss %). See El. suppl. A, B for data. Only variables that were found to be statistically significant in the previous study (Holec et al. 2020: Tab. 1) were analyzed. Azimuth was added as a factor that was significant in another study (Holec et al. 2019). Ellipses border trunks with identical decay stage. BB: trunk code followed by trunk number, slush, trunk decay stage (e.g. BB30/2).

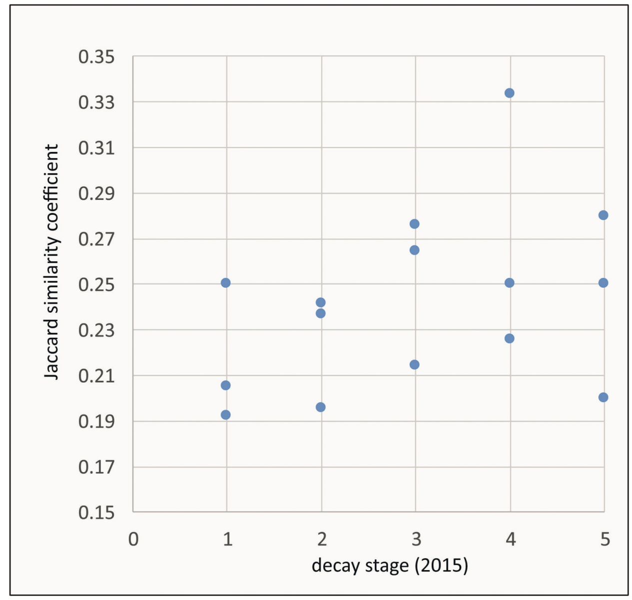

Fig. 3. Similarity of species composition on the same trunk in 2015 and 2020. Jaccard similarity coefficient was used. The 15 truns studied are divided according to decay stage recorded in 2015. Three trunks of each decay stage were studied.

In addition, there was a clear difference in fungal species composition (Fig. 5) between trunks of decay stage 1 studied in 2020 (BB34–36) and 2015 (BB02, 19, 30; being in stage 2 in 2020, see El. suppl. B). Moreover, trunks BB34–36 were similar to each other, whereas BB02, 19, 30 rather distant.

Response of fungal species and their functional groups

Fungal species frequency on the 15 trunks studied in 2015 and 2020 is shown in El. suppl. O. Two facts are seen: 1) species differ in their occurrence along scales of time and decay; 2) functional group of basidiomycetes react differently on decay stage. The latter fact is most evident in mycorrhizal fungi, the occurrence of which mostly starts from decay stage 3 and culminates in stage 5. The two species-richest groups, namely fleshy saprotrophs (consisting mostly of agarics) and annual resupinate fungi (mostly corticioids) behave similarly. They are formed by low number of ubiquists occurring on trunks of (almost) all decay stages (usually 2–5 or 2–4, but even 1–5 in *Mycena laevigata, M. stipata, M. viridimarginata, Galerina hypnorum*) and high number of low-frequent species distributed over

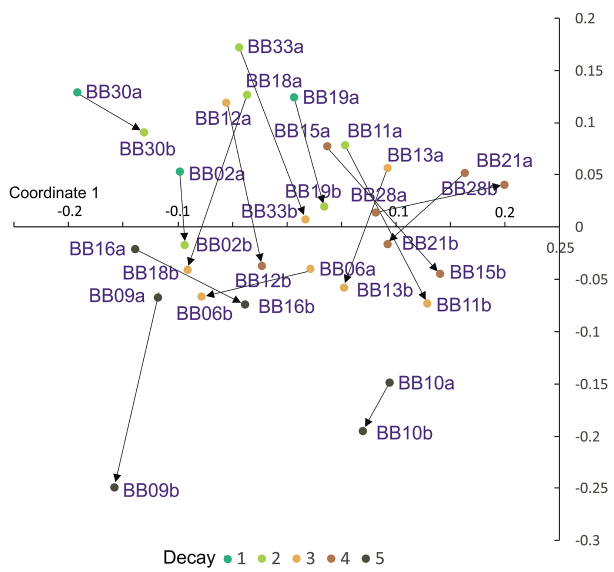

Fig. 4. Relative distances of fungal species composition on 15 trunks (BB) studied in 2015 and 2020 analysed by non-metric multidimensional scaling (NMDS). As distance measure, Bray-Curtis similarity was used. Stress for three-dimensional coordinate system = 0.098. Arrows connect the same trunk whose species composition was recorded in 2015 (indicated by "a" after trunk code) and 2020 ("b").

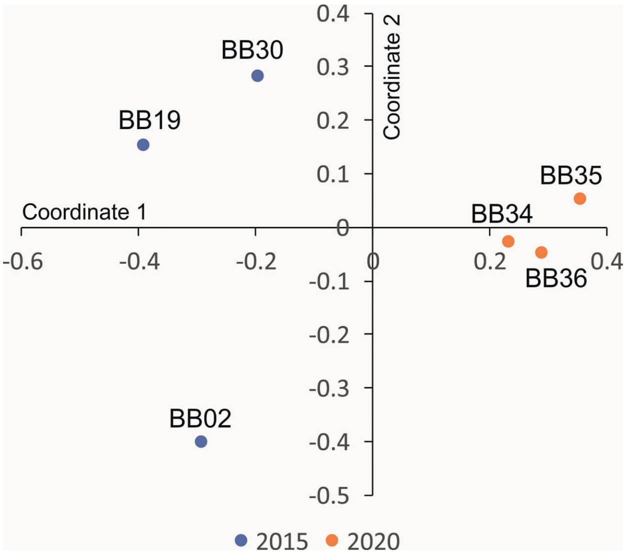

Fig. 5. Comparison of fungal species composition on trunks of decay stage 1 using non-metric multidimensional scaling (NMDS). As distance measure, Bray-Curtis similarity was used. Stress for two-dimensional coordinate system = 0.048. Trunks BB02, 19, 30 were studied in the year 2015, trunks BB34, 35, 36 in 2020.

various decay stages. Some species exhibit close relation to decay stages 1–3 (*Hypholoma capnoides, Mycena amicta*) or 3–5 (*Xeromphalina campanella, Calocera viscosa, Hygrophoropsis aurantiaca, Galerina pruinatipes*).

In polypores and perennial resupinates, the number of ubiquists is low (only *Antrodia serialis, Physisporinus sanguinolentus, Fomitopsis pinicola, Laurilia sulcata*) and the remaining species are divided into two groups – those occurring in early and medium decay stages 1–3 (most species) and those in medium and late stages 3–4 (*Phellinus nigrolimitatus, Gloeophyllum odoratum, Skeletocutis stellae, Trechispora hymenocystis, Veluticeps abietina*). *Phellinus chrysoloma* and *Trichaptum abietinum* were observed just in the early stages 1–2.

Course of weather in relation to fungal species richness and composition

The years 2015 and 2020 considerably differed in weather (El. suppl. H–N). Regarding total annual precipitation at the nearest climatological station Kubova Huť (El. suppl. I, J), the year 2015 with amount of 678 mm (the lowest one over period 2011–2020) was well below the ten-year average (882 mm) whereas 2020 was above the average (941 mm). The annual course of precipitation was also very different (Fig. 6). There was a below-average precipitation during summer 2015 and spring 2020 but high, above-average precipitation in summer 2020, especially in August. Graphs in El. suppl. H document that this pattern was identical at all climatological stations close to Boubínský prales regardless of their geographic position and elevation. It means that the macroclimate (in the sense of precipitation) of the wider area was the same or very similar.

The general annual course of mean monthly temperature was rather similar in the years 2011–2020 (El. suppl. K, L). The years 2015 and 2020 belonged to warmer years during this period (El. suppl. K). When compared with mean value for 2011–2020, July and August 2015 were considerably warmer (El. suppl. M). When the ratio of precipitation and temperature was evaluated cumulatively in the form of Lang factor, the year 2015 was considerably drier and warmer (smaller Lang factor) than 2020 during most of the vegetation period, namely from May to August (El. suppl. N).

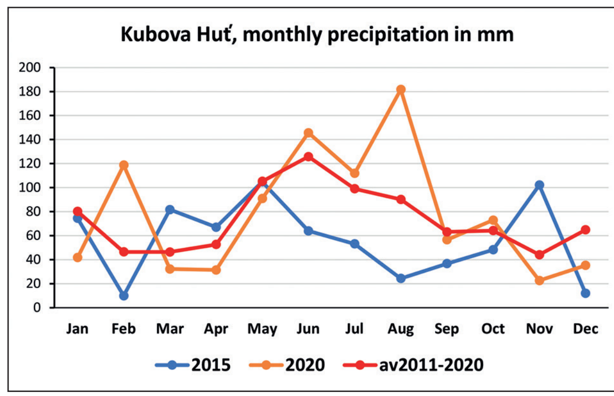

Fig. 6. Mean monthly precipitation at Kubova Huť climatological station, the nearest one to Boubínský prales virgin forest. av2011–2020: mean values for given period.

Fungal richness in 2015 and 2020 was comparable during spring, summer and late autumn inspections but much higher in autumn 2020 than in autumn 2015 (Fig. 7). The autumn difference was statistically significant based on two-sample t-test (El. suppl. 3). As regards weather, monthly mean temperature differed minimally in 2015 and 2020 (especially in September and October) but there was clerly higher precipitation in summer 2020 (Fig. 8). Thus, the very high species richness recorded in autumn 2020 compared to autumn 2015 (Fig. 7) can be attributed to high precipitation in summer 2020, especially in August. The slightly higher temperature in September 2020 (Fig. 8) could also support fructification in October 2020.

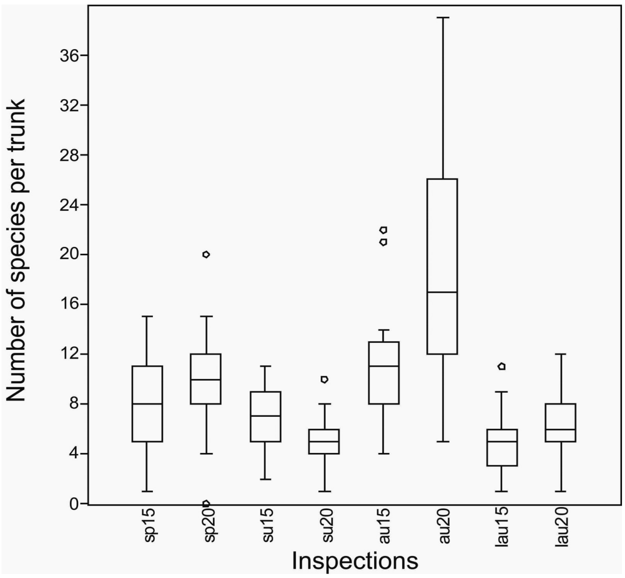

Fig. 7. Comparison of species richness during four inspections in 2015 and 2020 based on 15 trunks studied. Statistically significant difference between the years (see El. suppl. P) was confirmed only for autumn inspections (t-test, p-value <0.05). Abbreviations: sp: spring inspection, su: summer inspection, au: autumn inspection, lau: late autumn inspection, 15: year 2015, 20: year 2020.

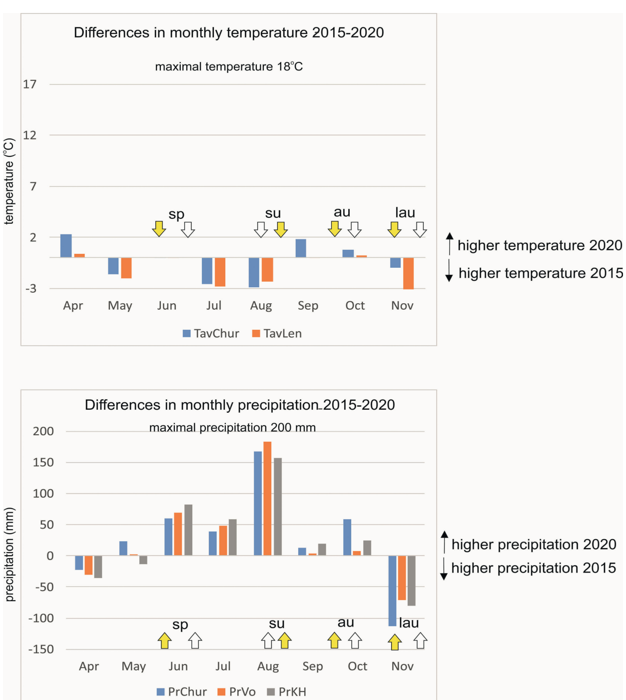

Fig. 8. Differences in climate parameters (Tav: mean monthly temperature, Pr: monthly precipitation) in individual months of the vegetation seasons 2015 and 2020 based on data from several climatological stations (Chur: Churáňov, HK: Kubova Huť, Len: Lenora, Vo: Volary). Inspection dates are indicated by arrows (yellow: 2015, white: 2020). For sources of climate data, see Materials and Methods and El. suppl. H–N.

Discussion

Environment, trunks, fungi, and their changes in time

The variables shaping fungal species richness and composition on spruce trunks studied in 2015 have already been discussed in detail (Holec et al. 2020, Holec & Kučera 2020). This also applies to other publications, both fruitbodies-based (e.g. Renvall 1995, Lindblad 1998, Jönsson et al. 2008, Ottosson et al. 2014, Bässler et al. 2012, Hofmeister et al. 2015) and sequences-based (Kubartová et al. 2012; Ottosson et al. 2015; Baldrian et al. 2016; Hoppe et al. 2016; Kubart et al. 2016; Rajala et al. 2011, 2012, 2015; Mäkipää et al. 2017). The data obtained in 2020 and presented here further confirm the previously documented key role of decay stage (Holec et al. 2020; see also Heilmann-Clausen et al. 2014 for fruitbodies-based diversity, Runnel et al. 2021 for OTUs), moss cover, bark cover and total canopy cover (Thorn et al. 2018: increasing closure is positively related to fungal diversity). Azimuth, i.e. direction of trunk fall influencing heat load/water bilance of dead wood, which proved to be significant in the study of oak trunks in Białowieża forest (Holec et al. 2019), was not so important in this study (Fig. 2). Trunks of decay stages 1–3 were inhabited by the highest number of fructifying macromycete species (El. suppl. F, Fig. 1). The species-richest were some trunks of stage 3 observed in 2020 (34–55 species per trunks).

Considerable dynamics of trunks decomposition, decortication and moss increase/decrease was recovered after 5 years. The intensity of decomposition deaccelerated in time, being most rapid in early decay stages (1, 2: all trunks moved to stages 2, 3, respectively) and slowing down in later stages (4, 5; trunks remained in the original decay stage). Decortication of 3–70 % took place in all trunks of decay stages 1–3 and was most rapid in stages 1–2 (El. suppl. C). In stages 4 and 5, all trunks have been fully decorticated already in 2015. As both decrease and increase was observed in moss cover independently of decay stage (El. suppl. C), its change seems to be a matter of the “decay history” of each individual trunk influnced by complex interactions of trunk/habitat parameters and all groups of decomposing organisms. The changes in canopy cover were caused either by sudden disturbance at the whole locality (Herwart windstorm in 2017, which decreased the total canopy around most studies trunks) or by increase of young beeches (*Fagus sylvatica*) gradually filling gaps in tree layer opened by fall of the studied trunks (BB12, 28).

Fungi and annual course of weather

Higher number of species was recorded in 2020, both in total number of species (2020: 145, 2015: 107) and number of species per trunk (Fig. 1, except for BB10). As shown in Results, this fact is connected with course of weather in 2020 (Figs. 7, 8), being more favourable for fructification than in 2015. The decisive factor was high precipitation in summer, especially in August (Fig. 8). The subsequent high fructification during autumn inspection (October 8–9) enabled to capture a high number of species (Fig. 7) including hitherto unknown ones for particular trunks. Greater growth was recorded especially in the group of mycorrhizal fungi appearing on the trunks since decay stage 3 and most frequent in stage 5 (El. suppl. O). Reversely, the small species richness recorded in autumn 2015 (Fig. 7) may have been an exception caused by extremely dry and hot summer 2015 (El. suppl. I–N). Generally, our study stresses the importance of the course of precipitation 1–2 months before mycological inspection (see also Salerni et al. 2002, Baptista et al. 2010, Diez et al. 2013). The course of weather in this period (i.e. involving also temperature) is decisive for fructification of macromycetes and consequently also for completeness of fruitbodies-based research. The mean monthly temperature and precipitation values are better for evaluation of fungal fructification during season (see also Straatsma et al. 2001, Büntgen et al. 2012, Andrew et al. 2016) than too generalized annual or vegetation season values used in most studies (e.g. Heegaard et al. 2016, Andrew et al. 2018, Moor et al. 2020). As shown also by us, precipitation is much more decisive factor for fructification than temperature (Diez et al. 2013). However, it needs to be added that temperature change at daily level can initiate fruiting (e.g. Kotilová-Kubičková et al. 1990, Pinna et al. 2010: "cold-shock"). As regards the response of the functional groups of fungi, it was shown that climate variables are important for community structure regardless of nutritional mode, namely saprotrophic and mycorrhizal (Andrew et al. 2016, 2018).

The much higher fructification in autumn 2020 also contributed to that species composition of particular trunks differed considerably in 2015 and 2020 (Fig 6), largely by increase of newly found species regardless of the decay stage. However, it is hard to distinguish this factor from species turnover caused by succession. Indeed, the decay stage proved to be the most important factor affecting species composition (Fig. 2) and its change in time (Figs. 3, 4). Statistical evaluation showed (Fig. 5) that stages 1 and 2 (shifted to 2 and 3 in 2020) were most dynamic as regards species turnover whereas stage 4 was relatively most stable. In terminal stage 5, the species composition changed again somewhat more, mainly by increased occurrence of mycorrhizal fungi.

Most studies on influence of climate on fungal fructification and occurrence were focused on terrestrial saprotrophs and mycorrhizal fungi (e.g. Kotilová-Kubičková et al. 1990, Straatsma et al. 2001, Salerni et al. 2002, Andrew et al. 2016, Heegard et al. 2016). Studies on wood-inhabiting fungi are less frequent. Bässler et al. (2010) showed that local factors, i.e. resource (dead wood) availability and microclimate (plus wood decay stage, see Heilmann-Clausen et al. 2014), were more important than macroclimate for the diversity of wood-decaying fungi. In our case, the macroclimate proved to be important for fructification and, consequently, for level of capturing fruitbodies-based diversity. In addition, microclimate (not studied by us) together with wood decay is also important for richness of fungal communities in dead wood (Pouska et al. 2017), especially for fungi fruiting on fine wood debris (Bässler et al. 2010).

Changes in fungal species and functional groups

Individual species of fungi differed in their fructification strategy with respect to time and wood decay stage (El. suppl. O). This is a well-known fact (Boddy et al. 2014) connected also with course of precipitation and temperature (Diez et al. 2013). Some species were observed only in 2015 (El. suppl. O: of more common species e.g. *Hyphodontia alutacea, Hypochniciellum ovoideum, Mycena leptocephala*) or only 2020 (*Armillaria cepistipes, Coniophora olivacea, Hyphoderma cremeoalbum, Mycena sanguinolenta, Cantharellus tubaeformis*). These data again confirm the fact that the year-on-year differences in fructification of particular species are considerable (see e.g. Pinna et al. 2010: "effect of year", Boddy et al. 2014, Heegaard et al. 2016) and affect the data obtained. Only about one third of the total number of species (49 of 177) was found on the same trunk both in 2015 and 2020. Fungi of two life strategies formed this group: mostly those with large and long-lasting mycelium and/or fruitbodies (like polypores or larger agarics) or small/annual ones but seemingly capable of rapid spread (typically corticioids and small agarics like *Galerina*, *Mycena* etc.).

As regards decay, some species occurred on trunks of all decay stages whereas others were more specific, typically those of early and medium decay stages 1–3 or medium stages 3–4 or medium to terminal stages 3–5 (see Results for examples of species and El. suppl. O for complete data). Moreover, each functional group of basidiomycetes (compare traits delimited e.g. by Purhonen et al. 2019) behaved differently in relation to decay.

Peculiarities of decay stage 1

In 2015, studied trunks of stage 1 were found rather species poor (Holec et al. 2020). It proved to be a consequence of dry and hot season 2015. In 2020, when weather was more appropriate for fructification, the stage 1 proved to be species-rich (Fig. 1). However, the situation was more complex. Trunks studied in 2020 fell in autumn 2017 (i.e. 2.5–3 years before trunk inspections). They were almost completely covered with bark and not grown by moss. Trunks studied in 2015 fell at least five years before their study (exact date is unknown, see El. suppl. A). Their bark was 40–50 % covered with moss. Even if their decay was classified as stage 1 in accordance with Methods, their decomposition was more advanced in comparison with trunks studied in 2020. This fact contributed to considerable differences of species composition between 2015 and 2020 sets of trunks (Fig. 5). It documents that species turnover on spruce trunks is rapid during the first ten years after tree fall. In the first five years (right cluster in Fig. 5) the fungal community is rather similar but later the fungal succession leads to divergence of species composition on individual trunks (left part of Fig. 5). It is connected with the colonization–extinction dynamics (Nordén et al. 2020) which differs in individual species of fungi (generalists versus specialists, see Moor et al. 2020).

Concluding remarks and practical implications

The species richness and composition data of trunks studied both in 2015 and 2020 clearly differed. It was caused by combined effects of progressing trunk decay, fungal succession and different course of weather in 2015 and 2020. On the other hand, the most important environmental variables shaping fungal species richness and composition on spruce trunks studied in 2020 (this paper) proved to be the same like in 2015 (Holec et al. 2020): decay stage, moss cover, bark cover and total canopy cover. Their general validity was confirmed also by literature review.

We argue that field fruitbodies surveys should always be confronted with precipitation and temperature in a given year for assessment of mycodiversity data completeness. Values from the nearest climatic station(s) at comparable elevation are to be used if direct values from study sites are not available. The commonly used values of annual precipitation and mean annual temperature are too raw but can well show position of the given year in relation to the ten-year average (in a general manner like "dry and hot", "mild and rainy" etc.). For comparison with fungal surveys during the year, the course of monthly precipitation and monthly mean temperature is much better, showing which survey visits were preceded by a sufficient precipitation (1–3 months prior). In accordance with published data, this interval proved to be decisive for subsequent high fructification which is a prerequisite for obtaining rich biodiversity data. Generally, low precipitation during a "bad" season considerably decreases obtained biodiversity results because less species are found. However, it does not principially affect conclusions on community structure and ecology (compare Holec et al. 2020 and this paper).

We also found that fungal species turnover is fastest in the first ten years after tree fall. To document this change, first survey should be conducted up to 3 years after tree fall (to capture species of initial succession phase), and the second one should take place at interval of 5–10 years after the fall.

Concerning informative value of our fruitbodies-based study in molecular era, we are of the same opinion like Heine et al. (2021) that both approaches are useful tools although they differ in terms of the scope and the number of potentially sampled fungal species. For community analyses they seem to be more comparable. This is supported also by similarity of our ecological conclusions to those obtained from fallen spruce trunks by DNA metabarcoding (Runnel et al. 2021).

Totally, 226 species of macrofungi are currently known from 36 spruce trunks monitored in Boubínský prales virgin forest (33 in 2015, 15 of them studied repeatedly in 2020, plus 3 trunks studied newly in 2020). It is a very high number from the biodiversity viewpoint (compare e.g. Renvall 1995, Lindblad 1998, Ottosson et al. 2014) reflecting high conservation value of the locality (Holec et al. 2015). This value lies mainly in extraordinary forest age, long continuity, high naturalness and total dead-wood volume/diversity, i.e. factors of key importance for wood-inhabiting fungi (e.g. Moor et al. 2020, Tomao et al. 2020). In 2020, the conservation value was further highlighted by records of rare old-growth forests species *Athelopsis subinconspicua*, *Clavulicium macounii*, *Chrysomphalina grossula*, *Cystoderma subvinaceum*, *Kneiffiella (Hyphodontia) curvispora* (Běťák et al. 2021), *Resupinatus striatulus* and above all extremely rare *Dentipratulum bialoviesense* (Holec & Zehnálek 2021). All these species were not found in 2015 (Holec et al. 2020).

Acknowledgements

We thank Dušan Adam (Silva Tarouca Research Institute, Brno) for providing stem position maps and data from tree databases and P. Vampola (Smrčná, Czech Republic) for revision of some polypores collections. The work of J. Holec was financially supported by the Ministry of Culture of the Czech Republic (DKRVO 2019 – 2023/3.I.d, 00023272). K. Holcová was supported by institutional project of the Charles University Prague (COOPERATIO).

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(Manuscript accepted 30 May 2022; Corresponding Editor: I: Krisai-Greilhuber)

Diversity and ecology of macrofungi on large decaying spruce trunks: what has changed after five years? (Sydowia, 2022)

Electronic Supplements A–N

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A. Characteristics of Norway spruce (*Picea abies*) trunks studied in the Boubínský prales virgin forest in 2015 and/or 2020.

Location, size, history.

Trunk code [BB]	Trunk ID* [ID]	Coordinate (N) [N]	Coordinate (E) [E]	Alt. (m a.s.l.) [alt]	Approximate time since fall** (years) [time]	Way of fall*** [fall]	DBH**** (cm) [DBH]	Length (m) [length]	Volume (m^3) [vol]	Number of trunk parts (incl. stump) [parts]	Stump height (cm) [stump]	Direction of fall (azimuth degrees) [azimuth]
BB02	102950_1	N48°58.501′	E13°49.012′	940	15	broken	100	38.1	12.25	1	0	245
BB06	103384_1	N48°58.451′	E13°48.945′	960	35	uprooted	100	43.1	12.37	2	0	345
BB09	101054_2	N48°58.401′	E13°48.922′	970	55	broken part	100	17.2	8.55	1	0	100
BB10	104748_1	N48°58.396′	E13°48.878′	980	35	broken	110	36.3	14.62	1	0	330
BB11	101681_1	N48°58.369′	E13°48.881′	985	15	broken	118	46.1	17.16	2	100	90
BB12	101555_1	N48°58.374′	E13°48.743′	1020	35	broken	110	30.1	13.79	2	50	320
BB13	104298_1	N48°58.411′	E13°48.787′	1010	35	broken	110	50.3	14.97	2	100	180
BB15	104062_1	N48°58.492′	E13°48.792′	1020	35	broken	100	41.7	12.36	2	50	220
BB16	106305_1	N48°58.551′	E13°48.705′	1035	35	uprooted	110	45.1	14.97	1	0	85
BB18	105479_1	N48°58.548′	E13°48.879′	980	15	broken	112	42.4	15.45	2	200	110
BB19	113283_1	N48°58.632′	E13°48.742′	1000	35	broken	110	38.5	14.78	2	300	180
BB21	106809_1	N48°58.574′	E13°48.893′	970	15	broken	132	43.5	21.18	2	150	150
BB28	108338_1	N48°58.994′	E13°48.424′	1095	15	broken	113	39.0	15.60	2	100	165
BB30	113310_1	N48°58.991′	E13°48.453′	1090	15	uprooted	121	50.5	17.99	2	0	105
BB33	115610_1	N48°58.624′	E13°48.790′	985	15	uprooted	150	47.6	26.88	1	0	90
BB34	105374_1	N48°58.531′	E13°48.913′	965	3	uprooted	109	50.0	13.61	1	0	160
BB35	105409_1	N48°58.510′	E13°48.887′	980	3	uprooted	135	46.2	22.26	1	0	110
BB36	105553_1	N48°58.555′	E13°48.899′	970	3	uprooted	105	43.5	12.47	1	0	115

* tree identification number from database administrated by the The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Brno, Czech Republic

** used as 3 categories of approximate values (15, 35, 55 years) derived from comparison of data from 3 subsequent tree mappings (1972, 1996, 2010), plus exact value known from field work (3 years: fall caused by Herwart windstorm in 2017)

*** *broken*: broken in basal part after some time of decay in standing position, *broken part*: broken in upper half with a high snag, *fall*: fall of dry standing tree shortly after death (mostly trees killed by bark beetles), *uprooted*: living trunk uprooted by wind including roots pulled out from soil

**** diameter at breast height

B. Characteristics of Norway spruce (*Picea abies*) trunks studied in the Boubínský prales virgin forest in 2015 and/or 2020.

Decay, appearance, cover by bark, moss, and surrounding trees and shrubs.

Trunk code [BB]	Decay stage 2015 (change compared to 2020 is indicated by bold red) [D]	Decay stage 2020 (change compared to 2015 is indicated by bold red) [D]	Contact with soil 2015 (%) [soil]	Bark cover 2015 (%) [bark]	Bark cover 2020 (%) [bark]	Moss cover 2015 (%) [moss]	Moss cover 2020 (%) [moss]	Cover of trees 2015 (%) [E3]	Cover of trees 2020 (%) [E3]	Cover of shrubs and young trees 2015 (%) [E2]	Cover of shrubs and young trees 2020 (%) [E2]	Total canopy cover 2015 (%) [E3+E2]	Total canopy cover 2020 (%) (decrease vs. 2015 indicated by colours, increase by bold red) [E3+E2]
BB02	**1**	**2**	5	90	20	50	20	40	30	50	20	60	50
BB06	3	3	50	3	0	30	70	60	30	80	80	90	85
BB09	5	5	100	0	0	60	50	10	5	80	85	85	85
BB10	5	5	98	0	0	90	90	70	60	40	30	80	65
BB11	**2**	**3**	95	95	50	80	50	70	60	50	60	80	75
BB12	**3**	**4**	90	3	0	40	80	40	40	50	70	70	80
BB13	3	3	97	0	0	50	50	80	70	60	50	90	80
BB15	4	4	90	0	0	80	70	80	70	80	50	90	80
BB16	5	5	70	0	0	90	70	80	70	40	30	90	75
BB18	**2**	**3**	90	100	80	80	70	60	50	40	40	70	65
BB19	**1**	**2**	40	85	60	40	30	70	40	85	50	90	60
BB21	4	4	100	0	0	60	80	70	65	80	60	80	75
BB28	4	4	100	0	0	80	80	50	40	10	50	55	60
BB30	**1**	**2**	90	100	65	40	60	35	30	5	30	40	35
BB33	**2**	**3**	60	98	70	50	60	15	10	30	30	40	35
BB34	n.s.	1	n.s.	n.s.	98	n.s.	0	n.s.	30	n.s.	20	n.s.	40
BB35	n.s.	1	n.s.	n.s.	98	n.s.	0	n.s.	25	n.s.	5	n.s.	25
BB36	n.s.	1	n.s.	n.s.	100	n.s.	2	n.s.	10	n.s.	5	n.s.	10

n.s. – not studied

white columns: data from 2015

grey columns: data from 2020

no change

change up to 10%

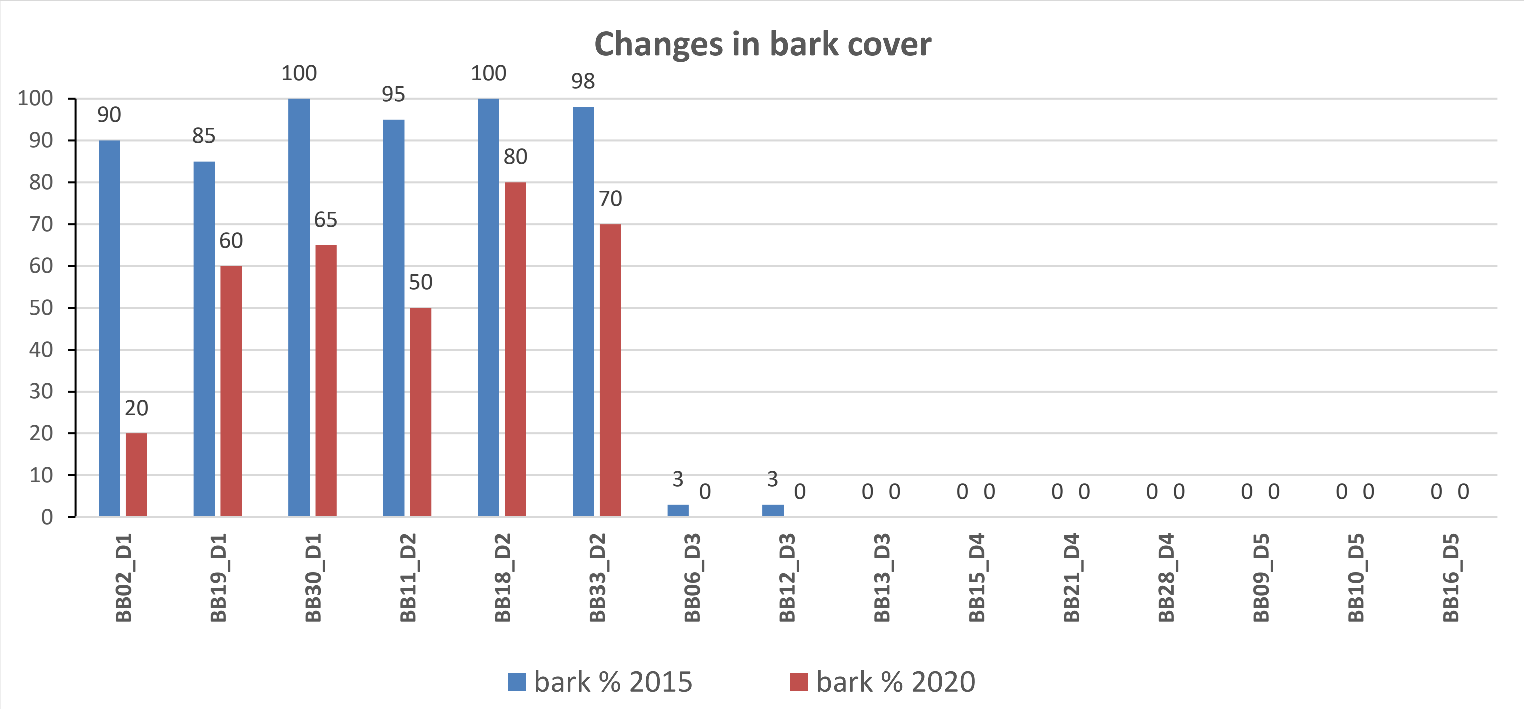
change up to 33%

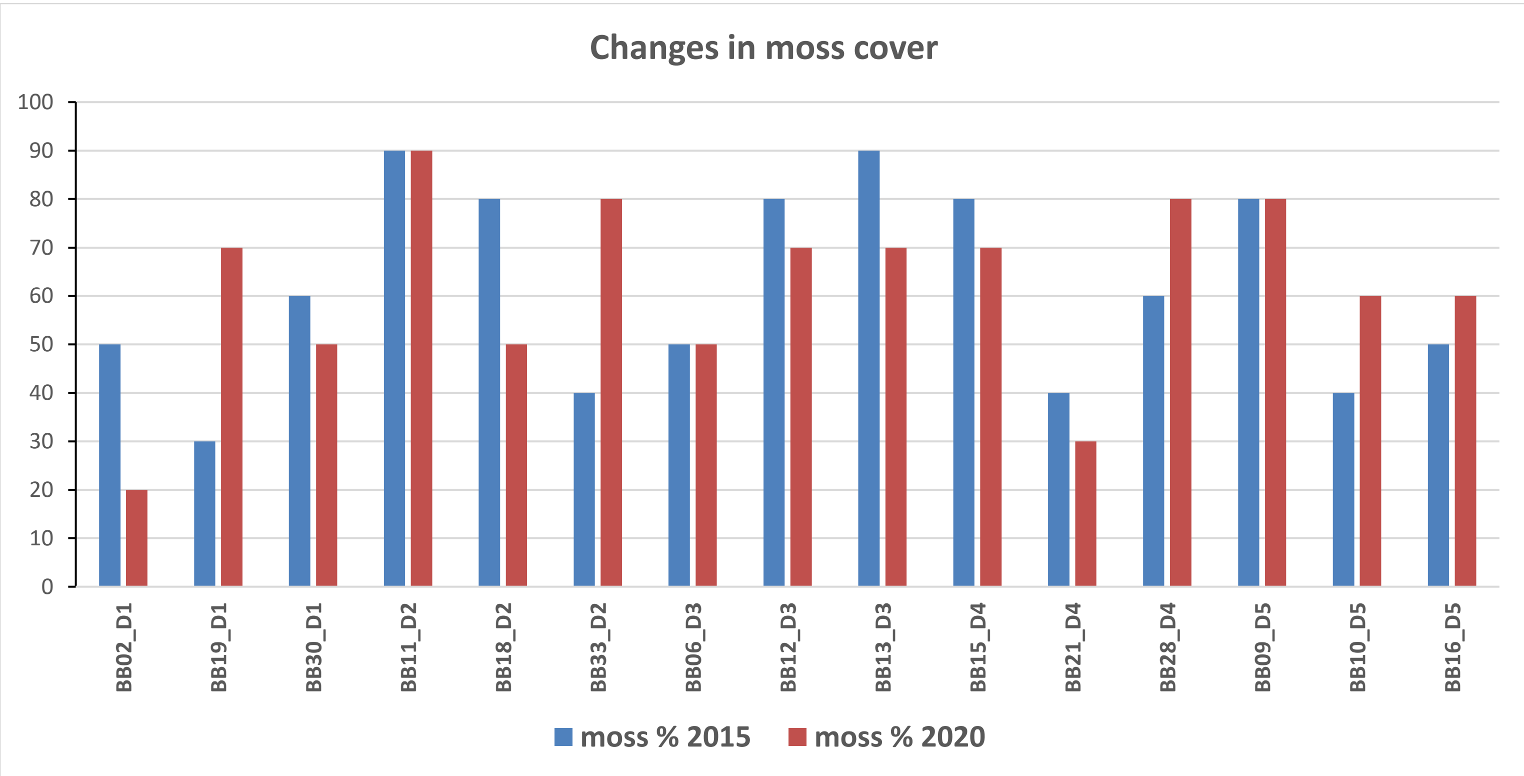
change above 33%

C. Changes of bark cover and moss cover of the trunks studied in 2015 and 2020.

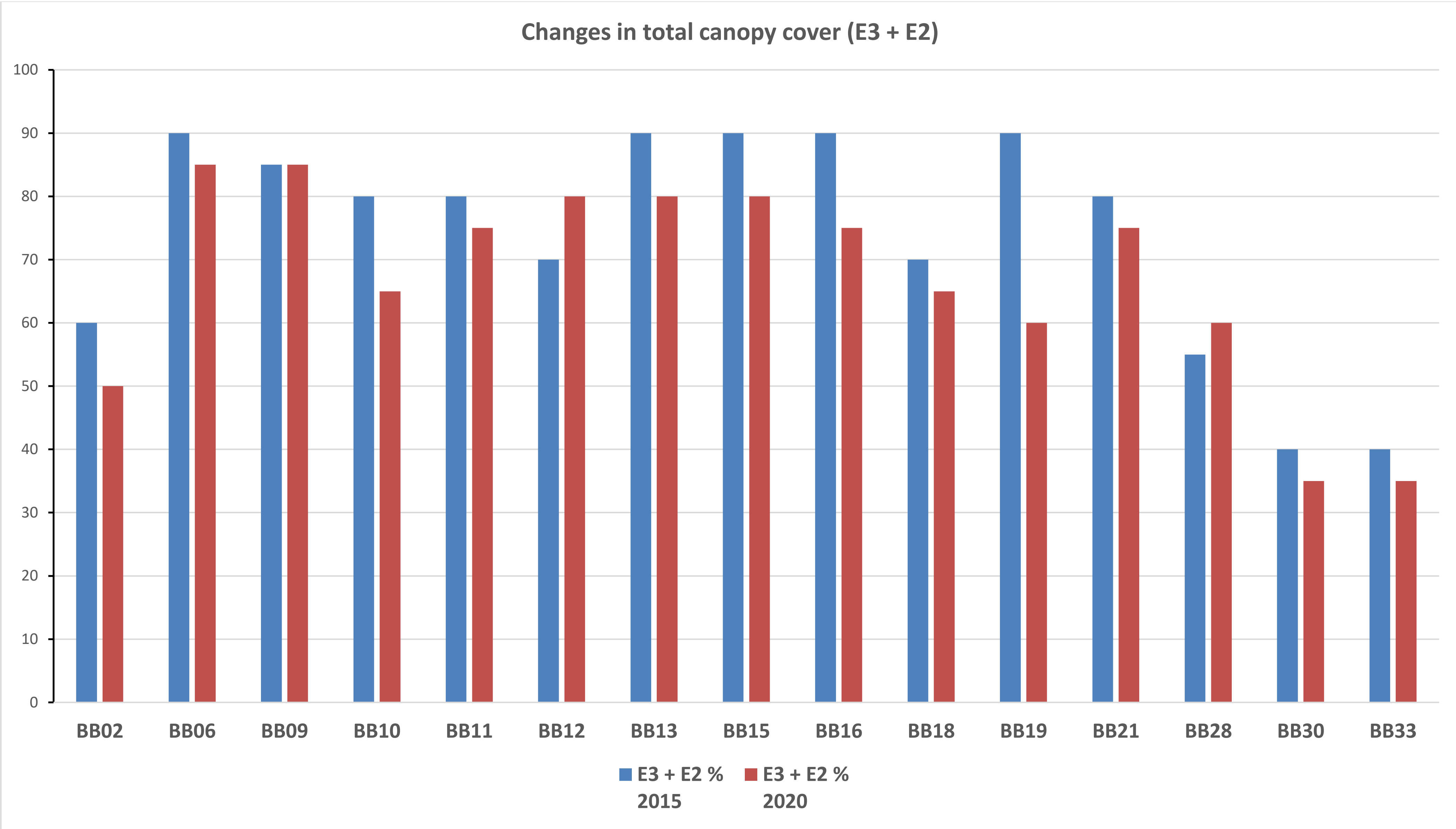
Individual trunks are labelled by BB codes.

Decay stage (D1–D5) of each trunk is given after BB trunk code.





D. Changes of total canopy cover (E3+E2) of the trunks studied in 2015 and 2020.
Individual trunks are labelled by BB codes.



E. Fungal species recorded on the studied Norway spruce (*Picea abies*) trunks in the Boubínský prales virgin forest.

Cumulated presence/absence data from 2015 (Holec et al. 2020) and 2020, in both cases based on 4 visits per year: in June, August, September/October, November. + means occurrence in 2015, **+** in 2020. Freq. = frequency in 2020 (on how many trunks the species was recorded). Species newly recorded for the whole set of studied trunks in 2020 are in **bold,** species new for the locality are in green. For details on trunks see supplements A, B.

Holec J., Kučera T., Běťák J., Hort L. (2020): Macrofungi on large decaying spruce trunks in a Central European old-growth forest: what factors affect their species richness and composition? – Mycological Progress 19: 53–66.

Trunk	BB02		BB06		BB09		BB10		BB11		BB12		BB13		BB15		BB16		BB18		BB19		BB21		BB28		BB30		BB33		BB34	BB35	BB36	Freq.
Year of study	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	**2020**	**2020**	**2020**	**2020**
Amylocystis lapponica (Romell) Singer													+	+																				1
Amylostereum areolatum (Chaillet ex Fr.) Boidin																						+												1
Antrodia serialis (Fr.) Donk									+		+	+	+	+	+	+					+	+	+	+	+	+			+	+				7
Antrodiella citrinella Niemelä & Ryvarden							+		+	+																								1
Armillaria cepistipes Velen.		+						+		+		+		+		+		+		+		+								+				10
Armillaria ostoyae (Romagn.) Herink																												+				+	+	3
Arrhenia epichysium (Pers.) Redhead, Lutzoni, Moncalvo & Vilgalys	+	+												+																				2
Ascocoryne cylichnium (Tul.) Korf		+		+									+																					2
Athelia binucleospora J. Erikss. & Ryvarden																													+					0
Athelia decipiens (Höhn. & Litsch.) J. Erikss.			+	+					+						+		+	+				+				+				+				5
Athelia epiphylla Pers.								+		+		+		+		+				+				+							+	+		9
Athelia fibulata M.P. Christ.																																	+	1
Athelopsis subinconspicua (Litsch.) Jülich														+																				1
Basidiodendron caesiocinereum (Höhn. & Litsch.) Luck-Allen																	+					+								+				2
Basidiodendron eyrei (Wakef.) Luck-Allen					+																													0
Bertia moriformis (Tode) De Not var. latispora (2020)										+	+																							1
Boidinia furfuracea (Bres.) Stalpers & Hjortstam																			+															0
Botryobasidium angustisporum (Boidin) J. Erikss. = intertextum														+	+		+	+							+	+		+						4
Botryobasidium botryosum (Bres.) J. Erikss. = vagum	+	+	+	+													+			+		+		+		+							+	7
Botryobasidium candicans J. Erikss.							+																											0
Botryobasidium ellipsosporum (4-species group ss. Bernicchia et al.)										+				+		+						+								+	+			6
Botryobasidium laeve (J. Erikss.) Parmasto																														+				1
Botryobasidium subcoronatum (Höhn. & Litsch.) Donk									+		+													+				+						2
Botryohypochnus isabellinus (Fr.) J. Erikss.				+					+	+				+							+	+							+	+				5
Brevicellicium sp.													+																					0
Calocera cornea (Batsch) Fr.										+																								1
Calocera furcata (Fr.) Fr.	+																																	0
Calocera viscosa (Pers.) Fr.				+		+				+				+				+												+				6
Camarops tubulina (Alb. & Schwein.) Shear			+	+						+							+	+					+											3
Cantharellus tubaeformis Fr.														+				+																2
Clavulicium macounii (Burt) J. Erikss. & Boidin ex Parmasto		+																																1
Climacocystis borealis (Fr.) Kotl. & Pouzar									+										+											+				1
Clitocybe vibecina (Fr.) Quél.												+																						1
Clitopilus hobsonii (Berk.) P.D. Orton												+																						1
Collybia cookei (Bres.) J. D. Arnold																				+								+						2
Conferticium ochraceum (Fr.) Hallenb.			+	+																														1
Coniophora olivacea (Fr.) P. Karst.										+				+								+				+		+						5
Coniophora puteana (Schumach.) P. Karst.																																+		1

Trunk	BB02		BB06		BB09		BB10		BB11		BB12		BB13		BB15		BB16		BB18		BB19		BB21		BB28		BB30		BB33		BB34	BB35	BB36	Freq.
Year of study	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	**2020**	**2020**	**2020**	**2020**
Cortinarius subporphyropus Pilát														+																				**1**
Costantinella micheneri (Berk. & M.A. Curtis) S. Hughes							+						+		+								+											**0**
Crepidotus kubickae Pilát																															+			**1**
Crepidotus stenocystis Pouzar																												+						**1**
Cystoderma jasonis (Cooke & Massee) Harmaja									+																+	+								**1**
Cystoderma subvinaceum A.H. Sm.																				+														**1**
Dacrymyces stillatus Nees									+																							+		**1**
Dentipratulum bialoviesense Domański														+		+																		**2**
Discina perlata (Fr.) Fr.														+																				**1**
Entoloma cetratum (Fr.) M.M. Moser									+					+														+						**2**
Fomitopsis pinicola (Sw.) P. Karst.	+	+	+	+			+		+	+	+	+	+	+	+		+	+	+	+	+	+					+	+	+	+		+	+	**12**
Fomitopsis rosea (Alb. & Schwein.) P.Karst.									+				+																					**0**
Galerina atkinsoniana A.H. Sm.		+	+				+	+	+					+														+		+				**5**
Galerina hypnorum (Schrank) Kühner	+				+				+	+		+	+					+				+		+	+	+								**6**
Galerina marginata (Batsch) Kühner										+										+		+												**3**
Galerina pruinatipes A.H. Sm.							+			+				+						+														**3**
Galerina sideroides (Bull.) Kühner										+							+																	**1**
Galerina stordalii A.H. Sm.							+	+				+						+																**3**
Galerina triscopa (Fr.) Kühner		+										+														+								**3**
Ganoderma applanatum (Pers.) Pat.									+	+																								**1**
Globulicium hiemale (Laurila) Hjortstam														+																				**1**
Gloeophyllum odoratum (Wulfen) Imazeki			+										+	+	+	+						+								+				**4**
Gymnopilus bellulus (Peck) Murrill														+																				**1**
Gymnopilus picreus (Pers.) P. Karst.											+																							**0**
Gymnopus aquosus (Bull.) Antonín & Noordel.														+																				**1**
Gyrophanopsis polonensis (Bres.) Stalpers & P.K. Buchanan									+																									**0**
Heterobasidion annosus (Fr.) Bref. agg.	+																												+	+				**1**
Hohenbuehelia auriscalpium (Maire) Singer																						+												**1**
Hydropus marginellus (Pers.) Singer		+								+																								**2**
Hygrophoropsis aurantiaca (Wulfen) Maire				+			+							+				+		+				+										**5**
Hymenochaete fuliginosa (Pers.) Lév.															+										+	+								**1**
Hyphoderma argillaceum (Bres.) Donk		+								+							+			+		+				+								**5**
Hyphoderma cremeoalbum (Höhn. & Litsch.) Jülich														+		+												+						**3**
Hyphoderma involutum (H.S. Jacks. & Dearden) Hjortstam & Ryvarden														+	+																			**1**
Hyphodontia abieticola (Bourdot & Galzin) J. Erikss.																										+								**1**
Hyphodontia alutacea (Fr.) J. Erikss.							+						+												+									**0**
Hyphodontia alutaria (Burt.) J. Erikss.			+							+																								**1**
Hyphodontia aspera (Fr.) J. Erikss.		+		+	+	+			+		+		+	+	+			+	+	+		+		+				+	+					**9**
Hyphodontia breviseta (P. Karst.) J. Erikss.			+					+									+													+				**2**
Hyphodontia curvispora J. Erikss. & Hjortstam						+								+																				**2**
Hyphodontia pallidula (Bres.) J. Erikss.				+					+	+			+			+								+		+				+				**6**
Hyphodontia spathulata (Schrad.) Parmasto																				+														**1**
Hyphodontia subalutacea (P. Karst.) J. Erikss.																				+														**1**
Hypholoma capnoides (Fr.) P. Kumm.	+	+	+	+															+	+	+						+	+	+	+	+	+	+	**8**
Hypholoma fasciculare (Huds.) P. Kumm.										+			+																					**1**
Hypholoma subviride (Berk. & M.A. Curtis) Dennis																			+															**0**
Hypochniciellum ovoideum (Jülich) Hjortstam & Ryvarden	+												+		+		+																	**0**

Trunk	BB02		BB06		BB09		BB10		BB11		BB12		BB13		BB15		BB16		BB18		BB19		BB21		BB28		BB30		BB33		BB34	BB35	BB36	Freq.
Year of study	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	**2020**	**2020**	**2020**	**2020**
Hypochniciellum sp.													+																					**0**
Hypochnicium albostramineum (Bres.) Hallenb.													+			**+**																		**1**
Hypochnicium erikssonii Hallenb. & Hjortstam																													+					**0**
Hypochnicium geogenium (Bres.) J. Erikss.	+																											**+**						**1**
Hypochnicium punctulatum (Cooke) J. Erikss.										**+**																								**1**
Hypochnicium subrigescens Boidin																														**+**				**1**
Hypochnicium wakefieldiae (Bres.) J. Erikss.		**+**								**+**	+	**+**	+	**+**	+		+	**+**		**+**														**6**
Chrysomphalina grossula (Pers.) Norvell et al.																				**+**														**1**
Imleria badia (Fr.) Vizzini																		**+**																**1**
Inocybe napipes J.E. Lange.					+	**+**												**+**																**2**
Inocybe petiginosa (Fr.) Gillet							+							**+**		**+**				**+**					+									**3**
Laccaria amethystina Cooke					+			**+**				**+**		**+**				**+**						**+**	+									**5**
Laccaria laccata (Scop.) Cooke		**+**																																**1**
Lactarius camphoratus (Bull.) Fr.												**+**																						**1**
Lactarius subdulcis (Pers.) Gray				**+**		**+**	+	**+**		**+**		**+**		**+**		**+**		**+**		**+**				**+**	+	**+**								**11**
Laetiporus montanus Černý ex Tomšovský & Jankovský													+																					**0**
Lasiochlaena benzoina (Wahlenb.) Pouzar	+	**+**	+	**+**															+	**+**		**+**								**+**				**5**
Laurilia sulcata (Burt) Pouzar									+	**+**			+	**+**							+		+	**+**	+	**+**								**4**
Lentinus adhaerens (Alb. & Schwein.) Fr.								**+**																										**1**
Leptosporomyces fuscostratus (Burt) Hjortstam		**+**		**+**						**+**				**+**						**+**		**+**								**+**			**+**	**8**
Leptosporomyces roseus Jülich																						**+**							+					**1**
Lycoperdon molle Pers.									+																									**0**
Lycoperdon perlatum Pers.																				**+**	+													**1**
Lycoperdon pyriforme Schaeff.																				**+**										**+**			**+**	**3**
Mucronella bresadolae (Quél.) Corner														**+**																				**1**
Mucronella calva (Alb. & Schwein.) Fr.	+																																	**0**
Mucronella flava Corner										**+**																								**1**
Musumecia vermicularis Musumeci														**+**																				**1**
Mycena amicta (Fr.) Quél.									+	**+**			+	**+**					+	**+**							+	**+**						**4**
Mycena aronsenii Maas Geest.	+																																	**0**
Mycena clavata (Peck) Redhead	+		+													**+**			+		+													**1**
Mycena epipterygia var. lignicola A.H. Sm.	+	**+**							+										+	**+**	+	**+**							+	**+**	**+**			**5**
Mycena epipterygia var. viscosa (Maire) Ricken									+	**+**				**+**					+			**+**						**+**						**4**
Mycena galopus (Pers.) P. Kumm.														**+**																				**1**
Mycena laevigata (Lasch) Gillet	+	**+**	+	**+**			+	**+**	+		+	**+**	+	**+**	+	**+**	+	**+**		**+**	+	**+**	+		+		+	**+**						**10**
Mycena leptocephala (Pers.) Gillet									+						+				+		+													**0**
Mycena maculata P. Karst.		**+**	+				+	**+**	+	**+**			+	**+**	+	**+**						**+**	+	**+**	+	**+**								**8**
Mycena metata (Fr.) P. Kumm.		**+**																																**1**
Mycena olida Bres.																					+													**0**
Mycena purpureofusca (Peck) Sacc.	+		+						+	**+**									+		+	**+**				**+**			+	**+**				**4**
Mycena rubromarginata (Fr.) P. Kumm.	+											**+**		**+**		**+**				**+**									+					**4**
Mycena sanguinolenta (Alb. & Schwein.) P. Kumm.										**+**		**+**																**+**						**3**
Mycena speirea (Fr.) Gillet												**+**																						**1**
Mycena stipata Maas Geest. & Schwöbel		**+**			+				+	**+**	+	**+**	+	**+**	+	**+**	+	**+**	+	**+**	+	**+**		**+**	+			**+**		**+**				**11**
Mycena viridimarginata P. Karst.			+				+	**+**	+	**+**			+	**+**		**+**		**+**	+		+	**+**	+	**+**	+	**+**				**+**				**9**
Mycena vitilis (Fr.) Quél.														**+**														**+**		**+**				**3**
Mycena zephirus (Fr.) P. Kumm.										**+**						**+**			+															**2**

Trunk	BB02		BB06		BB09		BB10		BB11		BB12		BB13		BB15		BB16		BB18		BB19		BB21		BB28		BB30		BB33		BB34	BB35	BB36	Freq.
Year of study	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	**2020**	**2020**	**2020**	**2020**
Mycetinis alliaceus (Jacq.: Fr.) Earle													+																					0
Panellus mitis (Pers.) Singer																															+		+	2
Phellinus chrysoloma (Fr.) Donk	+																		+												+			1
Phellinus nigrolimitatus (Romell) Bourdot & Galzin													+	+	+	+							+	+	+	+								4
Phellinus viticola (Schwein.) Donk		+																	+	+														2
Phlebia centrifuga P. Karst.																												+						1
Pholiota flammans (Batsch) P. Kumm.													+	+																				1
Pholiota lenta (Pers.) Singer																																	+	1
Pholiota scamba (Fr.) M.M. Moser	+																																	0
Physisporinus sanguinolentus (Alb. & Schwein.) Pilát		+		+					+					+			+	+	+	+	+				+		+	+	+	+	+			8
Physisporinus vitreus (Pers.) P. Karst.			+																		+													0
Pleurotus pulmonarius (Fr.) Quél.																															+	+		2
Pluteus atromarginatus (Konrad) Kühner																				+									+	+				2
Pluteus pouzarianus Singer	+										+									+		+			+					+				3
Postia stiptica (Pers.) Jülich														+						+														2
Pseudoclitocybe cyathiformis (Bull.) Singer																		+				+												2
Pseudohydnum gelatinosum (Scop.) P. Karst.				+					+	+																								2
Pseudorhizina sphaerospora (Peck) Pouzar														+																				1
Ramaria apiculata (Fr.) Donk										+																								1
Resinicium bicolor (Alb. & Schwein.) Parmasto																				+										+		+		3
Resinicium furfuraceum (Bres.) Parmasto											+	+	+	+									+	+	+			+						4
Resupinatus striatulus (Pers.) Murrill																								+										1
Rhodocollybia butyracea f. asema (Fr.) Antonín, Halling & Noordel.		+																																1
Rhodocollybia distorta (Fr.) Singer																		+																1
Rickenella fibula (Bull.) Raithelh.																												+						1
Rigidoporus crocatus (Pat.) Ryvarden	+	+							+											+														2
Russula fellea (Fr.) Fr.																		+																1
Russula nobilis Velen.																		+																1
Russula ochroleuca Pers.				+				+						+				+																4
Scotomyces subviolaceus (Peck) Jülich																			+															0
Serpula himantioides (Fr.) P. Karst.												+																						1
Simocybe sumptuosa P.D. Orton								+																										1
Sistotrema brinkmannii (Bres.) J. Erikss.																															+			1
Skeletocutis amorpha (Fr.) Kotl. & Pouzar																					+						+							0
Skeletocutis odora (Sacc.) Ginns	+	+									+																							1
Skeletocutis stellae (Pilát) Jean Keller											+												+											0
Steccherinum ochraceum (Pers. ex J.F. Gmel.) Gray	+	+																																1
Stereum sanguinolentum (Alb. & Schwein.) Fr.																															+	+	+	3
Thanatephorus brevisporus Pouzar																																+		1
Tomentella sublilacina (Ellis & Holw.) Wakef.						+	+	+																				+		+				4
Trechispora hymenocystis (Berk. & Broome) K.H. Larss.																										+								1
Tremella encephala Pers.																															+	+	+	3
Tremella foliacea Pers.																															+			1
Trichaptum abietinum (Pers. ex J.F. Gmel.) Ryvarden																			+		+								+					0
Tricholomopsis decora (Fr.) Singer													+	+											+									1
Tricholomopsis flammula Métrod ex Holec										+																								1
Tubulicrinis borealis J. Erikss.									+																									0

Trunk	BB02		BB06		BB09		BB10		BB11		BB12		BB13		BB15		BB16		BB18		BB19		BB21		BB28		BB30		BB33		BB34	BB35	BB36	Freq.
Year of study	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	2015	**2020**	**2020**	**2020**	**2020**	**2020**
Tubulicrinis subulatus (Bourdot & Galzin) Donk																								+		+								**2**
Tulasnella eichleriana Bres.																						+							+					**1**
Tulasnella inclusa (Christ.) Donk										+																								**1**
Tulasnella violea (Quél.) Bourdot & Galzin										+																								**1**
Tylospora fibrillosa (Burt) Donk			+					+																	+			+						**2**
Veluticeps abietina (Pers.) Hjortstam & Tellería							+						+	+		+								+										**3**
Vesiculomyces citrinus (Pers.) Hagström																														+				**1**
Xenasma rimicola (P. Karst.) Donk											+																							**0**
Xeromphalina campanella (Batsch) Kühner & Maire							+						+	+	+	+		+					+											**3**

F. Number of species on trunks studied in 2015 and 2020 and its evaluation.

Decay/Trunk	BB02	BB06	BB09	BB10	BB11	BB12	BB13	BB15	BB16	BB18	BB19	BB21	BB28	BB30	BB33	BB34	BB35	BB36
decay 2015	1	3	5	5	2	3	3	4	5	2	1	4	4	1	2	n.a.	n.a.	n.a.
decay 2020 (change since 2015 is in red)	2	3	5	5	3	4	3	4	5	3	2	4	4	2	3	1	1	1
Species																		
species no. 2015	23	18	6	17	32	14	31	17	14	21	18	11	20	6	16	n.a.	n.a.	n.a.
species no. 2020	27	19	6	15	40	20	55	21	26	34	29	19	20	25	31	13	11	11
increase species no. 2020 % (vs 2015)	17	6	0	-12	25	43	77	24	86	62	61	73	0	317	94	n.a.	n.a.	n.a.
common species 2015-2020	10	8	2	7	14	6	18	7	8	9	8	6	10	5	9	n.a.	n.a.	n.a.
common species % 2015	43	44	33	41	44	43	58	41	57	43	44	55	50	83	56	n.a.	n.a.	n.a.
common species % 2020	37	42	33	47	35	30	33	33	31	26	28	32	50	20	29	n.a.	n.a.	n.a.
other species 2015 (vs 2020)	13	10	4	10	18	8	13	10	6	12	10	5	10	1	7	n.a.	n.a.	n.a.
other species % 2015 (vs 2020)	57	56	67	59	56	57	42	59	43	57	56	45	50	17	44	n.a.	n.a.	n.a.
other species 2020 (vs 2015)	17	11	4	8	26	14	37	14	18	25	21	13	10	20	22	n.a.	n.a.	n.a.
other species % 2020 (vs 2015)	63	58	67	53	65	70	67	67	69	74	72	68	50	80	71	n.a.	n.a.	n.a.
total species no. 2015+2020	40	29	10	25	58	28	68	31	32	46	39	24	30	26	38	n.a.	n.a.	n.a.
Similarity of species composition 2015 vs 2020 (Jaccard's index)	0.25	0.28	0.20	0.28	0.24	0.21	0.26	0.23	0.25	0.20	0.21	0.25	0.33	0.19	0.24	n.a.	n.a.	n.a.

n.a.: not applicable as trunks BB34–36 were not studied in 2015

	small increase
	high increase
	very high increase
	same value
	decrease

G. Species recorded on the same trunk in 2015 and 2020 arranged according to decreasing number of trunks they inhabit.

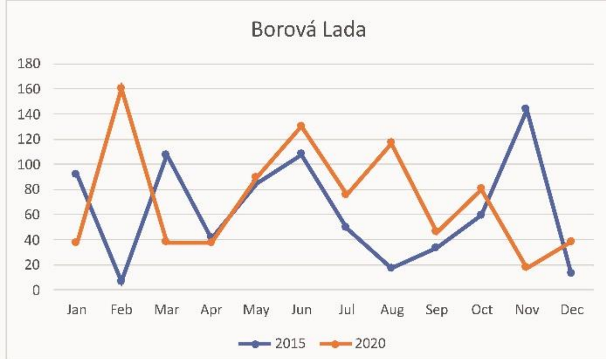
Name	Number of trunks
Fomitopsis pinicola	10
Mycena laevigata	9
Antrodia serialis	7
Mycena stipata	7
Mycena maculata	6
Mycena viridimarginata	6
Hypholoma capnoides	5
Laurilia sulcata	4
Mycena amicta	4
Mycena epipterygia var. lignicola	4
Phellinus nigrolimitatus	4
Physisporinus sanguinolentus	4
Botryohypochnus isabellinus	3
Hyphodontia aspera	3
Hypochnicium wakefieldiae	3
Lasiochlaena benzoina	3
Mycena purpureofusca	3
Resinicium furfuraceum	3
Athelia decipiens	2
Botryobasidium angustisporum = intertextum	2
Botryobasidium botryosum = vagum	2
Camarops tubulina	2
Galerina hypnorum	2
Gloeophyllum odoratum	2
Lactarius subdulcis	2
Phellinus viticola	2
Xeromphalina campanella	2
Amylocystis lapponica	1
Antrodiella citrinella	1
Arrhenia epichysium	1
Conferticium ochraceum	1
Cystoderma jasonis	1
Galerina atkinsoniana	1
Galerina stordalii	1
Ganoderma applanatum	1
Heterobasidion annosus agg.	1
Hymenochaete fuliginosa	1
Hyphodontia pallidula	1
Inocybe napipes	1
Mycena epipterygia var. viscosa	1
Pholiota flammans	1
Pluteus atromarginatus	1
Pseudohydnum gelatinosum	1
Rigidoporus crocatus	1
Skeletocutis odora	1
Steccherinum ochraceum	1
Tomentella sublilacina	1
Tricholomopsis decora	1
Veluticeps abietina	1

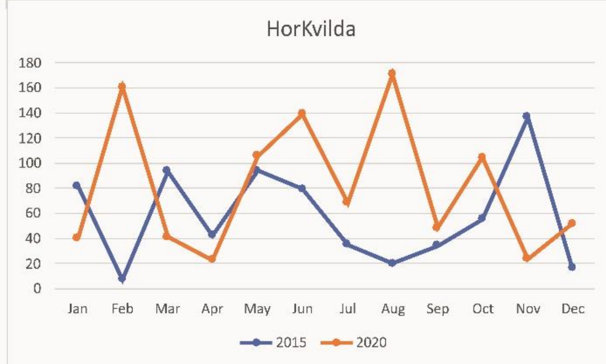
H. The course of monthly precipitation (in mm) at climatological stations closest to Boubínský prales.

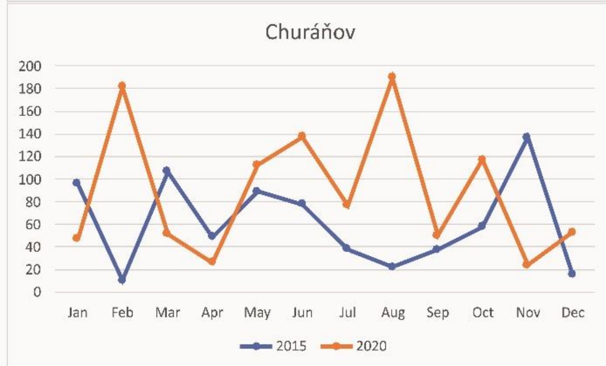
Basal data were obtained from the Czech Hydrometeorological Institute.

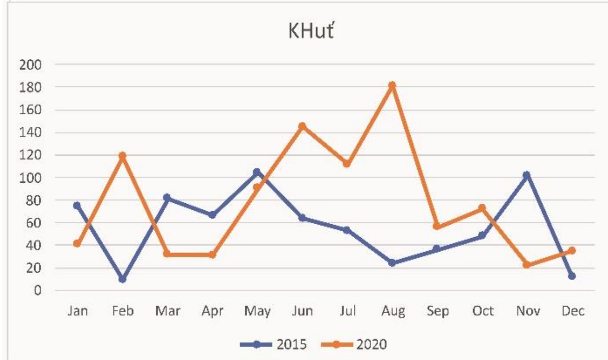
Station	Code	Latitude	Longitude	Elevation (m a.s.l.)	Distance from Boubínský prales	Data measured
Borová Lada	C1BLAD01	48.99055	13.66196	898	11 km W	precipitation + temperature etc.
Horská Kvilda	C1HKVI01	49.03217	13.57105	1052	19 km NWW	precipitation + temperature etc.
Churáňov	C1CHUR01	49.06833	13.61528	1118	18 km NW	precipitation + temperature etc.
Kubova Huť	C1KHUT01	48.98478	13.77169	1010	3 km NWW	precipitation only
Lenora*	C1LENO01	48.93440	13.76940	804	6 km SSW	precipitation + temperature etc.
Volary*	C1VOLR01	48.90881	13.88657	749	9 km SSE	precipitation + temperature etc.

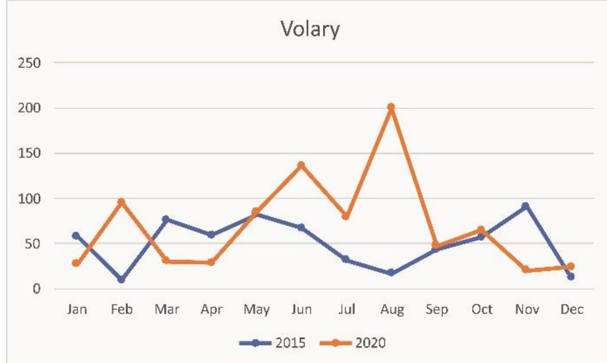
* very close stations at similar elevation; consequently, data from them were combined together to obtain a continuous series of measurements as Lenora stopped to measure in June 2018 and was replaced by Volary station







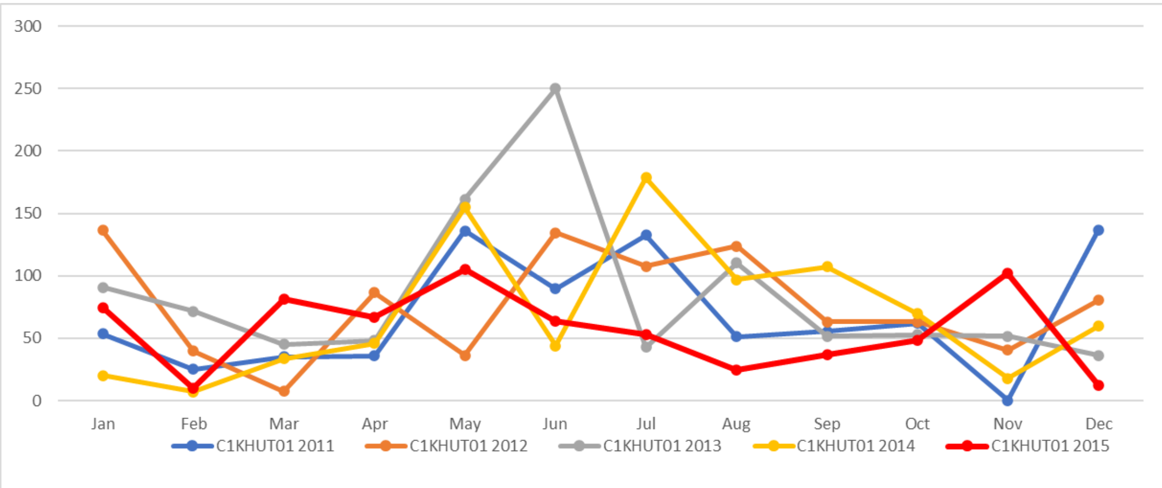


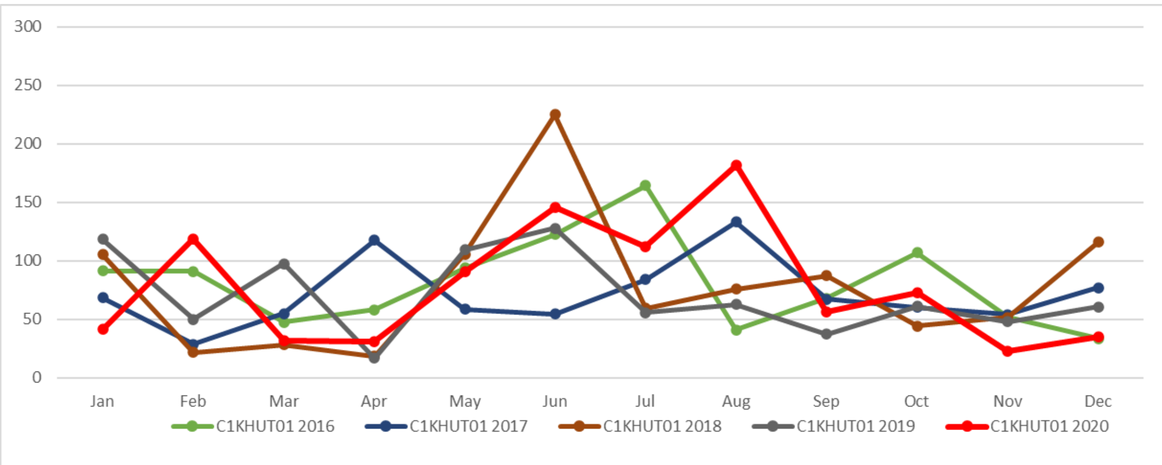


I. Monthly and annual precipitation at Kubova Huť climatological station, the closest one to Boubínský prales virgin forest.
Data were obtained from the Czech Hydrometeorological Institute. Years of fungal monitoring are in bold.

	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Kubova Huť	2011	53.4	25.3	35.1	35.8	135.9	89.6	132.5	51.1	55.4	62	0.2	136.6	812.9
Kubova Huť	2012	136.4	39.6	7.5	86.4	36.1	134.7	107.6	123.6	63.3	63	40.5	80.3	919
Kubova Huť	2013	90.7	71.6	45.1	48.3	161.4	250.1	42.7	110.2	51.8	52.9	51.8	36.4	1013
Kubova Huť	2014	20.3	7.2	33.4	45.8	154.9	44	178.8	97	107.4	69.5	17.8	59.8	835.9
Kubova Huť	**2015**	**74.4**	**9.9**	**81.7**	**67**	**104.8**	**63.9**	**53.1**	**24.3**	**36.7**	**48.2**	**102.1**	**12**	**678.1**
Kubova Huť	2016	91.4	91.2	47.8	58.4	93.9	122.6	164.3	41.2	68	107	51.9	33.8	971.5
Kubova Huť	2017	68.6	28.6	55.1	117.7	58.6	54.8	84.1	133.3	67.3	60.5	54.4	77.1	860.1
Kubova Huť	2018	105.3	21.9	28.4	18.6	105.8	224.9	59.4	76.1	87.5	44.3	51.9	116.1	940.2
Kubova Huť	2019	118.7	50.3	97.5	16.9	109.7	127.8	56	63	37.5	61.1	47.9	60.6	847
Kubova Huť	**2020**	**41.7**	**118.7**	**32.2**	**31.4**	**90.9**	**145.6**	**111.9**	**181.7**	**56.5**	**72.9**	**22.6**	**35.2**	**941.3**

J. Monthly precipitation at Kubova Huť climatological station (mm) in periods 2011–2015, and 2016–2020.
Years of fungal monitoring (2015, 2020) are in red.

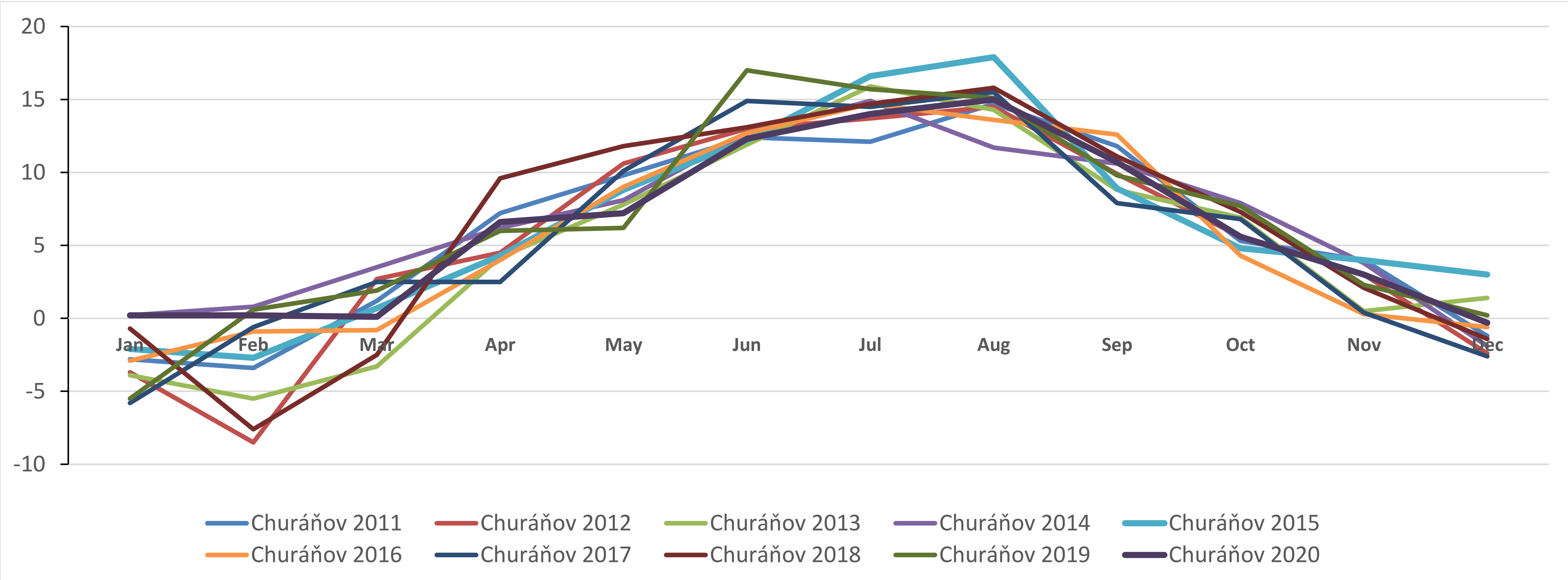




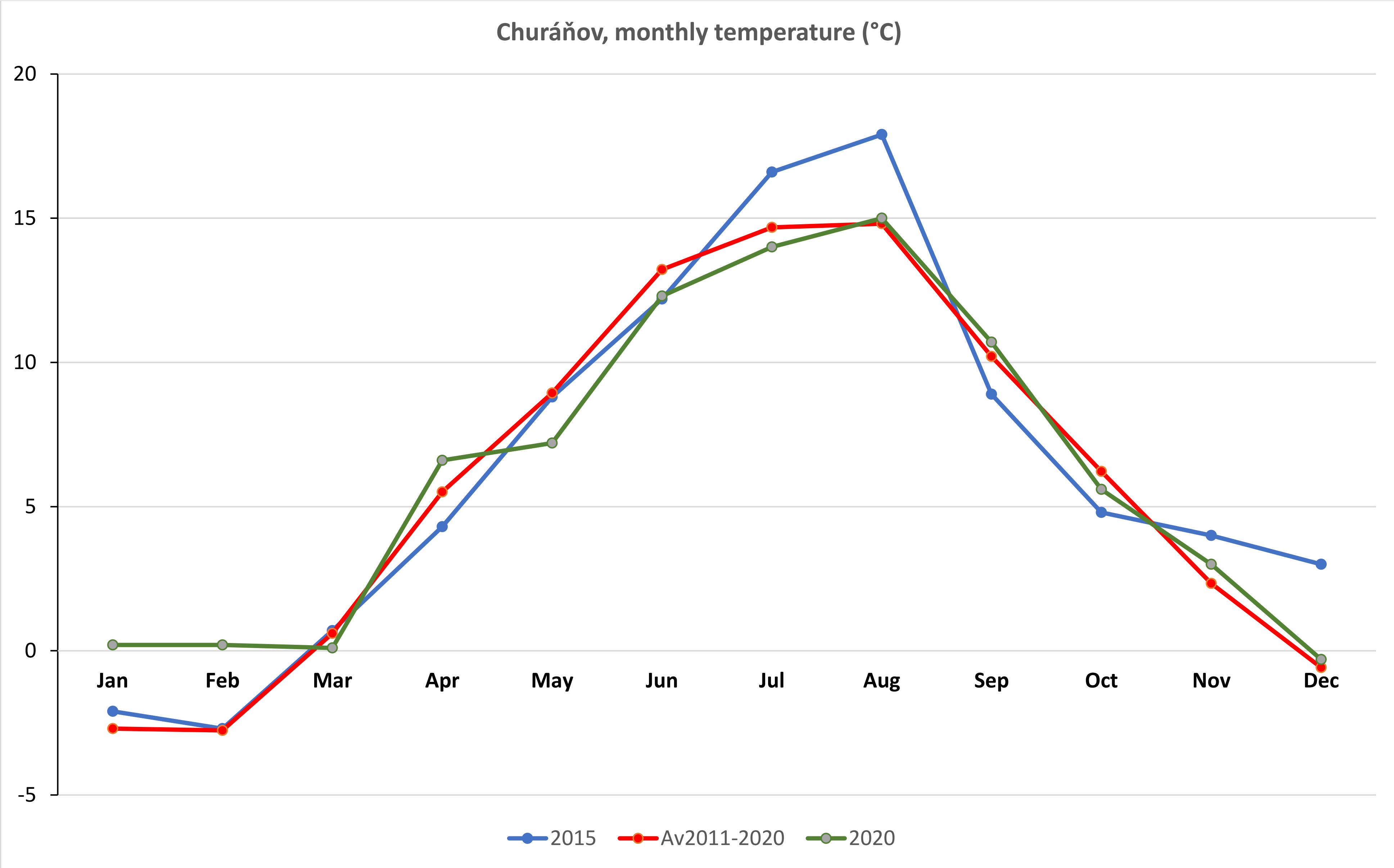
K. Mean monthly and annual temperature at Churáňov climatological station in period 2011–2020.
Data were obtained from the Czech Hydrometeorological Institute. Years of fungal monitoring are in bold.

	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MEAN YEAR
Churáňov	2011	-2.8	-3.4	1.2	7.2	9.8	12.4	12.1	14.7	11.8	5.3	4	-1.2	5.93
Churáňov	2012	-3.7	-8.5	2.7	4.5	10.6	13	13.7	14.5	9.9	5.6	3	-2.4	5.24
Churáňov	2013	-3.9	-5.5	-3.3	4.2	7.8	11.9	15.9	14.3	8.8	6.9	0.5	1.4	4.92
Churáňov	2014	0.2	0.8	3.5	6.2	8.1	12.7	14.9	11.7	10.6	7.9	3.8	-1.9	6.54
Churáňov	**2015**	**-2.1**	**-2.7**	**0.7**	**4.3**	**8.8**	**12.2**	**16.6**	**17.9**	**8.9**	**4.8**	**4**	**3**	**6.37**
Churáňov	2016	-2.9	-0.9	-0.8	4	9	12.7	14.7	13.6	12.6	4.3	0.3	-0.6	5.50
Churáňov	2017	-5.8	-0.6	2.5	2.5	10.1	14.9	14.5	15.5	7.9	6.8	0.4	-2.6	5.51
Churáňov	2018	-0.7	-7.6	-2.5	9.6	11.8	13.1	14.7	15.8	11.1	7.3	2.1	-1.4	6.11
Churáňov	2019	-5.5	0.6	1.9	6	6.2	17	15.7	15.1	9.8	7.7	2.3	0.2	6.42
Churáňov	**2020**	**0.2**	**0.2**	**0.1**	**6.6**	**7.2**	**12.3**	**14**	**15**	**10.7**	**5.6**	**3**	**-0.3**	**6.22**

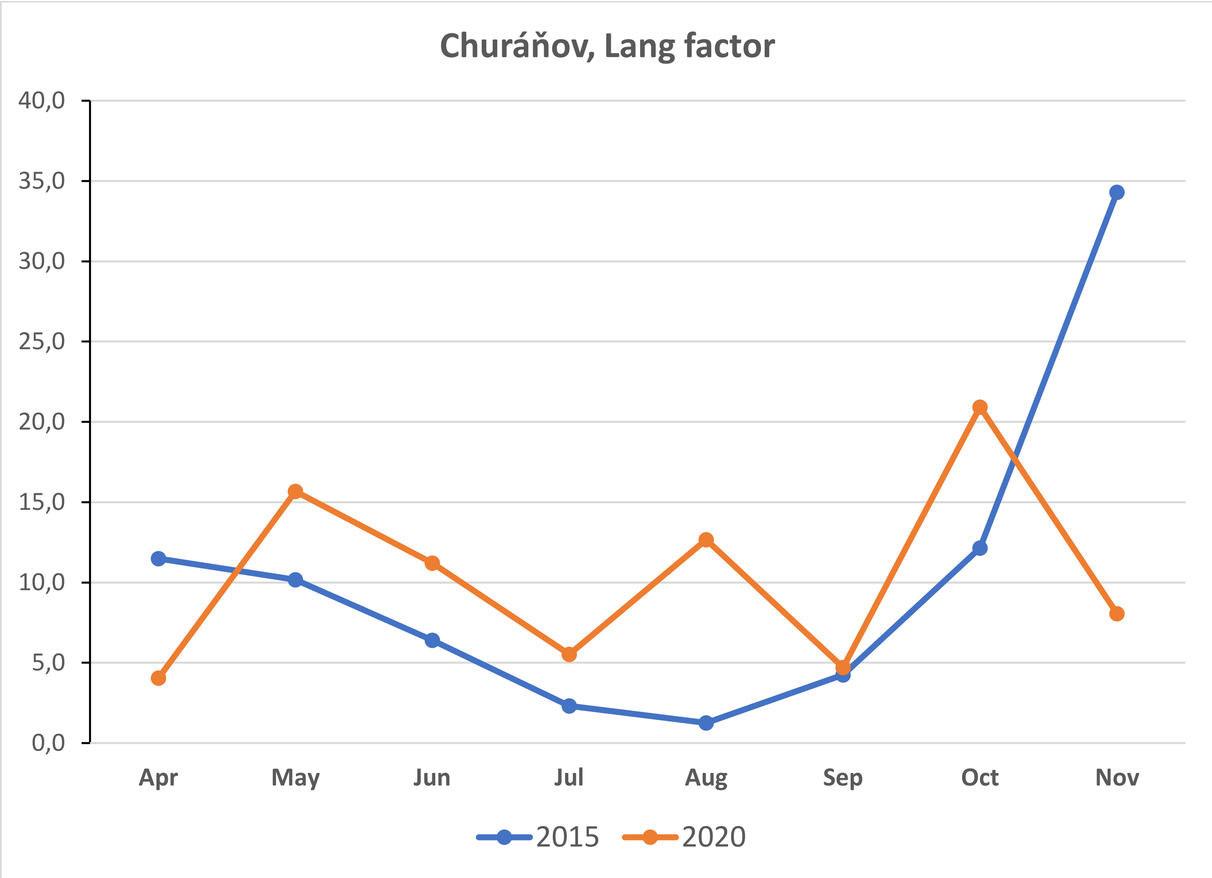
L. Mean monthly temperature (°C) at Churáňov climatological station in period 2011–2020.
Data were obtained from the Czech Hydrometeorological Institute.

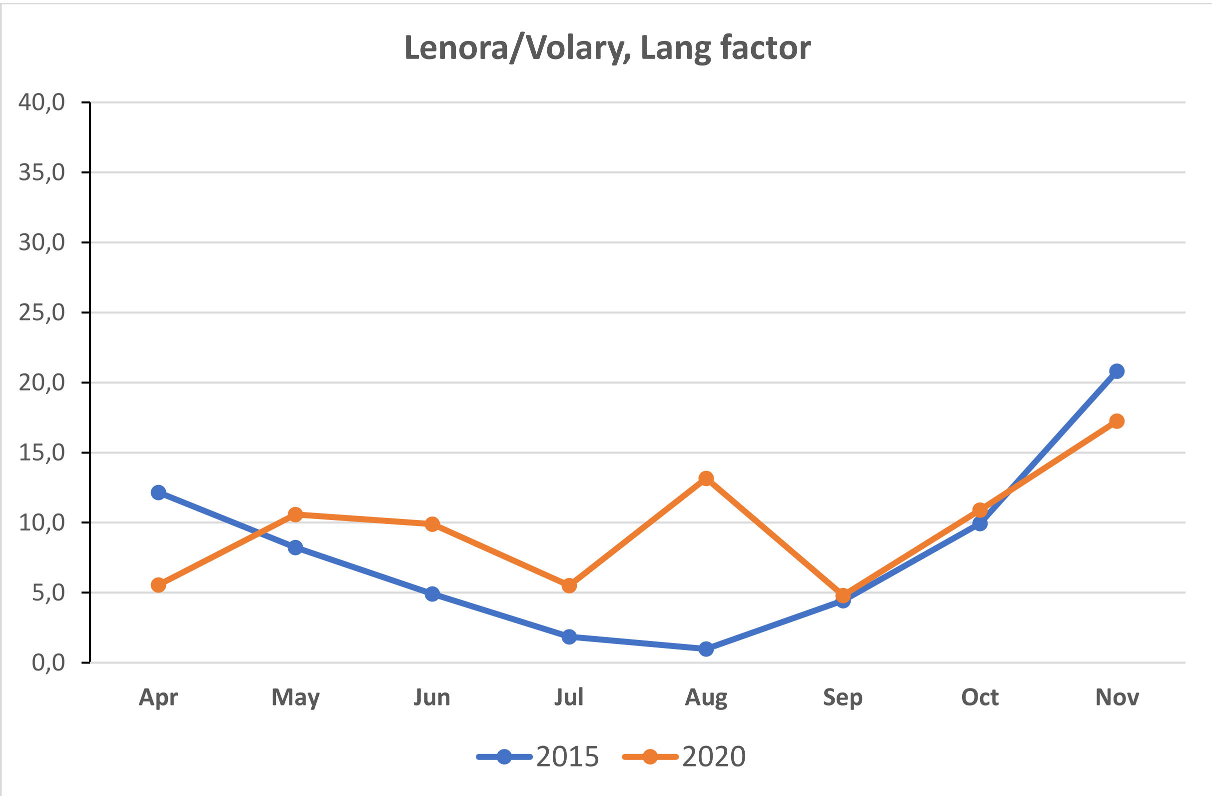


M. Mean monthly temperature (°C) at Churáňov climatological station in 2015 and 2020 in comparison with mean value for period 2011–2020.
Av2011–2020: mean value for period 2011–2020.



N. Monthly Lang factor at Churáňov and Lenora/Volary climatological stations, the closest ones to Boubínský prales virgin forest measuring both temperature and precipitation.
Only values during the vegetation season are displayed.





Electronic supplement O

Occurrence of individual species of basidiomycetes on 15 trunks studied in 2015 and 2020 with their relation to wood decay stages.
Fungi are divided into functional groups (from above: annual resupinate fungi, perennial resupinate fungi, annual polypores, perennial polypores, fleshy saprotrophic fungi, fleshy mycorrhizal fungi).
In each functional group, fungi are arranged according to decreasing frequency. Horizontal axis shows on how many trunks the species was recorded (annual cumulation of presence data derived from four visits per year).
From 2015 to 2020 some trunks of decay stages 2 and 3 shifted to 3 and 4 which is the reason why decay stages 3 and 4 are labelled by two differently-scaled x axes.
Blue colour: frequency in 2015.
Red colour: frequency in 2020.

Spring inspections

sp15		**sp20**	
N:	15	N:	15
Mean:	8,1333	Mean:	9,9333
95%:	(6.0416 _10.225)	95%:	(7.3658_12.501)
Var.:	14,267	Var.:	21,495

95%_conf._for_difference_between_means:	(-1.3629_4.9629)		
Bootstrapped:	(-1.2_4.7333)		

TESTS

F:	1,5067	p(same):	0,45281
t:	-1,1658	p(same):	0,25355
Uneq._var_t	-1,1658	p(same):	0,25395
Permutation_t_test_(N=9999):	p(same): 0,2378		

If p>0.05 - the means of species richness for 2015 vs. 2020 are equal

If p<0.05 - the means of species richness for 2015 vs. 2020 are not equal

Summer inspections

su15			**su20**	
N:	15		N:	15
Mean:	6,8		Mean:	5
95%:	(5.317_8.283)		95%:	(3.7097_6.2903)
Var.:	7,1714		Var.:	5,4286

95%_conf._for_difference_between_means:	(-0.077396_3.6774)	
Bootstrapped:	(0.13333_3.5333)	

TESTS

F:	1,3211		p(same):	0,60944
t:	1,964		p(same):	0,059533
Uneq._var_t	1,964		p(same):	0,059726
Permutation_t_test_(N=9999):	p(same):	0,0522		

Autumn inspections				**Late autumn inspections**	
au15		**au20**		**lau15**	
N:	15	N:	15	N:	
Mean:	11,267	Mean:	19,333	Mean:	
95%:	(8.4008_ 14.133)	95%:	(14.077_ 24.59)	95%:	
Var.:	26,781	Var.:	90,095	Var.:	
95% conf. for difference between means:	(2.3488_ 13.785)			95% conf. for difference between means:	
Bootstrapped:	(2.7333_ 13.267)			Bootstrapped:	
TESTS				TESTS	
F:	3,3642	p(same):	0,030201	F:	
t:	-2,8899	p(same):	0,007363	t:	
Uneq. var t	-2,8899	p(same):	0,0085904	Uneq. var t	
Permutation t test (N=9999):	p(same):	0,0073		Permutation t test (N=9999):	

	lau20	
15	N:	15
5,4667	Mean:	5,9333
(3.8744_ 7.0589)	95%:	(4.3605_ 7.5062)
8,2667	Var.:	8,0667

(-1.6708_2.6042)
(-1.5333_2.4667)

1,0248	p(same):	0,9641
-0,44721	p(same):	0,65816
-0,44721	p(same):	0,65816

p(same): 0,6103