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Pine diseases in Western Balkan countries

Master thesis

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Název práce: Onemocnění borovic ve státech Západního Balkánu

Abstrakt:

Borovice, jako jeden z největších rodů z čeledi *Pinaceae*, se vyskytují na celém světě. Balkán jako území, které v celosvětovém měřítku vykazuje třetí nejvyšší biologickou rozmanitost, má velmi různorodou flóru s množstvím rozličných druhů dřevin, včetně borovic.

V této studii jsou uvedeny nejběžnější a škodlivé houbové choroby vyskytující se na borovicích v regionu Západního Balkánu, tzn. Srbsko, Bosna a Hercegovina, Chorvatsko, Slovinsko a Černá Hora. V práci jsou popsány choroby borovic, jejich symptomy, prostorová distribuce, životní cykly a metody kontrolních opatření související s nejdůležitějšími druhy houbových patogenů borovic.

Nejvýznačnější a zároveň nejrozšířenějšími houbovými patogeny jsou *Mycospherella pini*, *Sphaeropsis sapinea*, *Heterobasidion spp.* (zejména v porostech s písčitou půdou), *Cenangium ferruginosum*, *Germmeniella abietina*, *Lophodermium pinastri*, *Lophodermium seditiosum*, *Cyclaneusma niveum*, *Armillaria spp.* atd.

Klíčová slova: borovice, onemocnění, Západný Balkán, fungi
As one of the biggest genera from *Pinaceae* family, pines are present all over the World. Recognized as the World's third most biologically diverse area - Balkan region has very various flora with a lot of different tree species, including pines.

In this study are shown the most common and harmful fungi diseases occurring on pines in Western Balkan region, i.e. Serbia, Bosnia & Herzegovina, Croatia, Slovenia and Montenegro. Here are described pine hosts, symptoms, distribution, life cycle and control treatments possibilities of the most important pine parasitic fungi.

The most significant and at the same time the most widespread pathogenic fungi are *Mycosphaerella pini*, *Sphaeropsis sapinea*, *Heterobasidion spp.* (especially in plantations on sandy soils), *Cenangium ferruginosum*, *Germmeniella abietina*, *Lophodermium pinastri*, *Lophodermium seditiosum*, *Cyclaneusma niveum*, *Armillaria spp.* etc.

**Key words:** pine, disease, Western Balkan, fungi
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1. Introduction

Nowadays, climate changing and environmental degradation, decreasing trend in global forests area, higher demands for timber production, are only some of the factors which are concerning creation of long-range strategies for sustainable development of forestry. It is well known that human population have multiply benefits from forests. But, from the other hand, we are losing them due to deforestation, pollution, drought, fires and widespread diseases. Because of this fact, it is not enough to show only loose of yield of wood to examine importance of some damaging factor. Economical importance of those damaging factors in forests has higher value in losing other benefits which forests give us.

According to FAO (2011) the World’s total forest area was just over 31 percent. One-third of the most common tree species World-wide belong to one of the five genera *Pinus, Quercus, Picea, Abies* and *Fagus*. Three coniferous genera (*Pinus, Picea* and *Abies*) together count for over 20% of the most common tree species. Numerous diseases affect these genera. The most specific group belongs to pine species, because they are the most susceptible to diseases if they do not grow in optimal conditions. Pines planted outside of their native range often encounter new relationships and present substantial management problems, while introduced pathogens have proven devastating to other pine ecosystems. Especially they become vulnerable to pathogens when underlying stresses are present, including drought, fire damage, flooding, mechanical damage and overcrowding.

In history of tree development, diseases were a key factor for big forest loses. They are present in all phases of production - seed production, seedling nurseries, forest plantations and in natural forests.

Intensive afforestation of bare lands and deforested areas in the area of the former Yugoslavia was undertaken in the second half of the 20th century. The most frequent species in afforestation were *Pinus* species. The establishment of monocultures over large areas was followed by numerous problems already from the beginning. In pine plantations, among harmful biotic factors, especially important were pests and diseases caused by parasitic fungi (e.g. needle diseases, branch and shoot dying, root rot, etc.).
The greatest damages have been caused by the fungi *Mycosphaerella pini*, *Sphaeropsis sapinea*, *Heterobasidion spp.* (especially in plantations on sandy soils), *Cenangium ferruginosum*, *Germmeniella abietina* (in the mountain regions) and occasionally *Armillaria spp.*, *Lophodermium spp.* and *Cyclaneusma niveum*.

In this study are shown distribution, symptoms, life cycle and the control possibilities of these pathogenic species and others which cause damages on pines in Western Balkan region (including Mediterranean and continental area).
2. Aim of the research

As one of the biggest genera from *Pinaceae* family, pines are present all over the World. In past but also nowadays, a lot of harmful abiotic and biotic factors have a big effect on growth of trees and among them parasitic fungi take special place. Recognized as the World's third most biologically diverse area - Balkan region has very various flora with a lot of different tree species, including pines.

The aim of this study was to research distribution, life cycle and the control possibilities of the most important pine parasitic fungi in Western Balkan region i.e. Serbia, Bosnia and Herzegovina, Croatia, Slovenia and Montenegro.
3. Materials and methods

In order to evaluate the effect of pine diseases and their distribution in Balkan countries i.e. Serbia, Bosnia and Herzegovina, Croatia, Slovenia, Montenegro, we collected the data and analysed them. General concept of these analysis was to assess all existing data of pathogen attacks using objective parameters and to put them together.

The pathogen species which appears in Balkan countries were described according to:

- their hosts,
- symptoms,
- distribution,
- control treatments.

Sequence of the fungi species is shown according to colonized part of the pine plant order (needles, shoots, branch bark, stem or root).

Description of almost each species is followed by photo images - micro and macro symptoms and attacked organ. Based on all collected data, for most significant species I have made distribution maps and the table with host, susceptibility, area etc.

During collecting the data, we were using following web services and databasis of scientific papers: ISI Web of Knowledge (www.wokinfo.com), ScienceDirect (www.sciencedirect.com), Scopus (www.scopus.com), Sci index (www.scindeks.ceon.rs), doiSerbia (www.doiserbia.nb.rs), KoBSON (www.kobson.nb.rs), Center for Online DataBases (www.online-baze.hr), Croatian Scientific Bibliography (www.bib.irb.hr), Hrčak – Web Portal of Scientific Papers in Croatia (www.hrcak.srce.hr), Forestry Institute in Slovenia (www.zgs.gov.si), Slovenia Forest Service (ZGS) (www.wetman.si). Some of the data and scientific papers we have got from oral communication with the Balkan phytopathologists.

For collecting photo images of the disease symptoms we were using data basis of Forestry Images (www.forestryimages.com), but also personal photos which were made in situ.
4. Results and discussion


**Synonyms:** *Coleosporium melampyri* (Rebent.) P. Karst  
*Coleosporium campanulae* (Pers.) Lév.,

**Local name:** Mjehurasta hrđa borovih iglica

**Cause:** Rust of pine needles

**Hosts:** *Pinus sylvestris, P. nigra, P. halepensis, P. maritima, P. contorta, P. resinosa, P. mugo* and alternative hosts: *Tussilago farfara, Senecio spp.*

**Distribution in the World:** Europe and North America

**Distribution in Balkan countries** (Fig. 2): Needle rust on pines in Balkan countries does not have big economical importance. So far in Bosnia and Herzegovina (Federation of Bosnia and Herzegovina) this fungus was found on several locations only on individual trees of Scots pine (Uščuplić, 1996). However, this disease was widespread in Slovenia and Croatia, causing damages on two years old plantings of Scots pine and Austrian pine near Psunj and Ogulin (Hočevar, 1967). According to Karadžić and Stanivuković (2010) in research for the most important phytopathological problems in Scots pine plantations in Bosnia and Herzegovina (Republic of Srpska) 38 species of fungi were observed. *Coleosporium tussilaginis* in Serbia occurs less frequently and the main hosts were *P. sylvestris* and *P. mugo*. In Montenegro this needle rust disease occurs quite rarely, too. Area near Virpazar was observed, but there were not big damages (Karadžić and Vujanović, 2009).

**Description:** Disease occurs only on nursery plants and young cultures in first years of their growth. First signs on pines occur during spring period, from April to June. On needles from past vegetation which are still green, appear yellow spots with spermogonia and aecidia, size 1 – 3 mm; these are sure determination signs for this species. Aecidia have capsule (peridium) with whitish color (type *peridermium*), which can be formed from both sides of the needle. They are often numerous and showy, look like small bubbles. By breaking capsule discharges orange aecidia spores. These spores being spread by wind infect herbaceous plants as well.
Figure 1 - *Coleosporium tussilaginis* on *Pinus sylvestris* (source: wikipedia.org)
Figure 2 – Distribution of Coleosporium tussilaginis on pines in Western Balkan
4.2. **Cyclaneusma niveum** (Persoon ex Fr.) DiCosmo, Peredo & Minter

**Synonyms:**
- *Naemacyclus niveus* /Pers.ex Fr./Fuck.
- *Stictiss nivea* Pers.
- *Propolis nivea* Pers. ex Fr.
- *Lophodermium gilvum* Rostr.

**Local name:** Veliki snježni osip borovih iglica

**Cause:** Chlorosis and needle cast

**Hosts:** *Pinus nigra*, *P. halepensis*, *P. brutia*, *P. laricio*, *P. maritima*, *P. pinaster*, *P. ponderosa*, *P. thunbergii*

**Distribution in the World:** Europe, North America and New Zealand

**Distribution in Balkan countries** (Fig. 4): In Bosnia and Herzegovina this fungus occurs on Black pine (Ušćuplić, 1996). According to Diminić (1994) in Istria attacks old needles of Black and Aleppo pine, while Glavaš (1981) explained that *C. niveum* in Dalmacija attacks *Pinus pinaster*, *P. nigra* and *P. halepensis* where is developed alone or in association with *Lophodermium pinastri*. This fungus lives in Europe, North America and New Zealand (Millar and Minter, 1980; Osorio and Rack, 1980; Fonseca 1981; Glavaš, 1981).

In Serbia, Karadžić and Milijašević (2008) have found that this fungus is most spread in Austrian pine plantations (Zavojsko Lake near Pirot, Vlasina, Deliblato sands, Pešter, Subotica-Horgoš sands, etc.), while in Montenegro *C. niveum* occurs on needles more than 2 years old, on the tree or in the litter of Aleppo pine – locations: Sutomore, Bar, Virpazar and Podgorica (Karadžić and Vujanović, 2009). In Slovenia in village Kastelec apothecia of *C. niveum* were found on already dead needles (Slovenian Forestry Institute, 2004). In North Dalmatia, Pernek et al. (2012) have found medium infection of *C. niveum* on *Pinus maritima* at Benkovac locality. In Crikveničko – Vinodolsko area this mycosis has been determined on black pine needles in Klenovica, Vinište and Ravna strana cultures (Diminić et al., 1995).

**Description:** *C. niveum* is secondary pathogen which occurs on the old needles, and never on one year old needles. According to some authors there is an opinion that this
fungus parasite causes chlorosis and cast on the needles (Butin, 1973; Millar and Minter, 1980; Glavaš, 1981; Fonseca, 1981) and the second opinion is that this fungus is only saprophyte.

First symptoms of this fungus are not typical. Browning of needles and their preterm cast can be seen. Symptoms for diagnosis of this pathogen can be found on two years old and older needles and sure sign for determination are apothecia. Color of the surface of apothecia is whitish and cream-like. In fissure of epidermis are commonly found 1 to 3 apothecia.

So far, this fungus is not treated, because it does not cause bigger damage in Balkan region. Treatment against this fungus has to be applied in nurseries and with young cultures of pines.

Figure 3 – left: C. niveum on dead needle of Pinus sylvestris (source: http://www.micologia.net); right: infected tree of Pinus nigra (photo Karadžić)
Figure 4 - Distribution of Cyclaneusma niveum on pines in Western Balkan
4.3. *Cyclaneusma minus* (Butin) DiCosmo, Peredo, Minter

**Synonyms:** *Naemacyclus minor* Butin

**Local name:** Mali snježni osip borovih iglica

**Cause:** Needle cast

**Hosts:** *Pinus sylvestris, P. mugo, P. ponderosa, P. montana, P. radiata, P. contorta, P. jeffreyi, P. strobus, P. patula and P. uncinata*

**Distribution in the World:** Australia, New Zealand, Africa, Europe, Asia, North and South America

**Distribution in Balkan countries:** In Serbia and Montenegro this species is widespread and found on Scots pine in nurseries, cultures and natural forests alone or together with *Lophodermium* species (Karadžić, 2010; Karadžić and Milijašević, 2008).

**Description:** In past this fungus was considered the same like previous one *C. niveum*, but Butin separated *C. minus* as a different species. This fungus causes necrosis and cast of two – years old pine needles. In USA this pathogen makes huge damages in plantations of Scots pine planted for Christmas event.

According to Zang and Merrill (1981) in plantations of *P. sylvestris* in Pennsylvania opening of ascospores starts in April, culminates in the middle of May and lasts till the end of November. Infection arises in the dormancy period and incubation lasts several months. Earliest symptoms appear next summer, firstly light green spots occur and after changing color into yellow with horizontal brown strips along needles. In the beginning apothecia appear on the brown strips, and after along whole needle. Further, development of symptoms, forming of apothecia and cast of needles last till the end of November. Apothecia have cream-like color and they are formed on both sides of the needle (Butin, 1995).

Chemical treatment against this fungus has to be applied from July till November with some of well known fungicides.
4.4. **Gremmeniella abietina** (Lagerb.) Morelet

**Synonyms:**
- *Scleroderis lagerbergii* Gremmen
- *Ascocalyx abietina* (Lagerberg) Schalpfer
- *Crumenula abietina* Lagerberg
- *Lagerbergia abietina* (Lagerberg) J. Reid
- *Scleroderris abietina* (Lagerberg) Gremmen

**Anamorph:**
- *Brunchorstia pinea* / Karst./Höhn.

**Synonyms:**
- *Brunchorstia destruens* Eriksson
- *Brunchorstia pini* Allescher
- *Excipulina pinea* P. Karsten
- *Septoria ponea* P. Karsten

**Local name:** Uzročnik raka i sušenja grana četinara

**Cause:** Scleroderris needle canker or *Brunchorstia* disease

**Hosts:** *Pinus, Larix, Picea, Pseudotsuga and Abies*

**Distribution in the World:** North and Central Europe, North America and Asia

**Distribution in Balkan countries** (Fig. 6): In Serbia and Montenegro this fungus is under quarantine diseases. In surrounding countries there are no data for this fungus.

Fungus *G. abietina* was indentified repeatedly in the area of Serbia and Montenegro. For the first time in the former Yugoslavia in 1979 appears in the area of NP Durmitor, in the vicinity of Žabljak, in mixed plantation of Austrian and Scots pine, aged between 25 and 30 years old (Marinković and Karadžić, 1983). Karadžić (1989) have found this fungus in Scots pine and spruce plantations on Kopaonik and after several years, by the end of 1992, on Scots pine on the mountains Vlasina and Goč (tree age between 18 and 20 years). During 1998 *G. abietina* was determined in the Scots pine plantation in the area of Ivica (site „Popov Do”, plantation age 10 years) and on the same area during 2002 plantations established in 1992-93 (sites „Mala Barna” and „Jvički Vukodoli”) (Karadžić et al., 2002). During 2006, pathogen occurs in Scots pine plantation in the area of NP Kopaonik (site „Samokovska Reka”, plantation age 50 years) (Karadžić, 2006). This Scots pine plantation was not tended, so there were numerous uprootings.
and broken trees. A severe infection by *G. abietina* was diagnosed on all trees, and in many cases also the young shoots of the current vegetation were destroyed. During 2008, fungus *G. abietina* was identified in the forest of Scots pine in nearness Black lake - NP „Durmitor“ (Karadžić and Milanović, 2008).

**Description:** This fungus forms both stages of development, i.e. the pycnidial stage and apothecial stage. The pycnidial stage (anamorph) described under the name *Brunchorstia pinea* (Karst.) Höhn, is much more frequent in the field and is more significant for the infection process. Pycnidia are black and formed at the base of the infected needles, on the bark of dead shoots and more rarely on cone scales. The conidia are colorless, sickle shaped curved, with a greater number of septa (from 3 to 7).

The perfect stage (teleomorph), i.e. apothecial stage forms two years after tree dying. Apothecia were found on the bark of dead shoots, on dead branches and cone scales. Apothecia are dark brown or black, with a short peduncle. It was determined that the asci formed in apothecia on the cones are smaller (Karadžić et al., 2002). Ascospores are colorless, ellipsoidal or elongated, 3-septate. Symptoms of the disease caused by the fungus *Gremmeniella abietina* can easily be confused with the symptoms of disease caused by fungus *Cenangium ferruginosum*.

In Scots pine plantations on Kopaonik it was observed for the first time that the fungus forms pycnidia and apothecia also on the scales of two-year old cones, which is a new data in literature. This data is very important because, by collecting seed cones, this dangerous quarantine disease can be spread to the new uninfected regions (Karadžić and Milanović, 2008).

Primary infections are caused by conidia (more rarely also ascospores), which are transmitted by rain splash and wind. Infection period lasts from the beginning of May to the end of November, but the critical period for infection is May-June. Infection is spread through the buds and bark of young shoots. During the first phase of infection, which lasts from May to September, fungus penetrates into the external dead cells of the bark, and during the second stage of infection (from December), The germ tubes penetrate into the living bark cells and cause more or less visible necroses. Sometimes plant by itself defense reactions can stop the spreading of the pathogen, and in cases that cannot defense shoots are girdled and killed. Incubation period lasts for 9 months,
i.e. if infection occurs in June of the current year, the first visible symptoms of infection occur in March of the following year.

The symptoms of infection are expressed in several ways. During winter months, on the bud cross section, brown discoloration of the tissue starts from the bud base, and the infected buds fail to flush. The already formed shoots turn brown at the base, due to the necroses of the tissue (in vital trees, these necroses can heal later on). On the shoots with formed needles, the needles are decolorized starting from the base (during June, the needle bases turn orange or reddish, and gradually they turn brown to the tip, which is followed by needle-cast during summer, leaving the shoot without needles). The shoots die down starting from the tip. Black fruiting bodies of pin-head size - pycnidia appear on dead buds and shoots and at the base of the needles. During the vegetation period, in place of dead shoots, secondary shoots appear from dormant buds. Form the infected shoots, the mycelium proceeds downwards along the branches in the stem and, if the younger trees are attacked, they die-back, while the development of the fungus in the old trees is stopped by the reaction of the host plant or saprophyte fungi. The trees die as the consequence of multiannual infections and shoot dying. The dead branches on the trees are usually broken by the wind and snow, and canker can be found on the mature trees. The fruiting bodies – apothecia form on the bark of dead shoots and branches not before two years after tree dying. It was found also that some infected trees can recover, if high precipitation in summer (in which the fungus disperses to epidemic proportions) is followed by dry weather. In such cases, the crown turns green again, but only in the upper part, while the branches in the lower part are dead.

According to Karadžić (2010), to reduce the damage caused by the fungus *G. abietina* to a tolerable degree, it is necessary to undertake the following protection measures:

– in the establishment of new plantations (primarily Austrian pine and Scots pine), wet and cold sites should be avoided and sites on which snow lasts long during winter;

– dense planting should be avoided and good air circulation should be ensured as much as possible to avoid air stagnation and high air humidity;

– disease-free planting material should be applied in plantation establishment and, if possible, the resistant provenances;

– all dead trees in the attacked plantations should be felled and eliminated;
– during the collection of seed cones in infected areas, care must be taken to prevent the spread of the disease to the new uninfected regions.

According to Butin and Siepmann (1980), good results in the suppression of this fungus were obtained by the application of Maneb (manganese ethylene bisdithiocarbamate), and tree spraying should be from June to September in 14-days intervals. Previous preliminary investigations in Serbia and Montenegro showed that the copper fungicides (for example copper oxychloride) have given the best results and protection. Protection is satisfactory if the treatment is carried out twice a year during the critical period of infection. However, such protection is possible and economically justified only in the nurseries and young plantations (Karadžić et al., 2002; Karadžić, 2006; Karadžić and Milijašević, 2008).
Figure 5 – left and up right: Dieback of Scots pine (NP Durmitor); middle left: black pycnides in the base of pine needle; down left: *G. abietina* apothecia on the bark (photo Karadžić)
Figure 6 - Distribution of *Gremmeniella abietina* on pines in Western Balkan
4.5. **Lophodermella sulcigena** (Rostrup) Höhnel

**Synonyms:**  
*Hypodermella sulcigena* (Rostr.) Tub.  
*Hypodermopsis pinicola* (Brunch.) Kuntze  
*Hypoderma pinicola* Brunch.

**Local name:** Uzročnik osipa iglica borova

**Cause:** Lophodermella needle cast

**Hosts:** *Pinus sylvestris*, *P. mugo*, *P. nigra var. maritima*, *P. contorta*

**Distribution in the World:** Europe

**Distribution in Balkan countries** (Fig. 8): This fungus has been found in Bosnia and Herzegovina on Scots pine in 1979 on Mountain Romanija (Lazarev, 1983); whereas in Montenegro it has been determined on *Pinus mugo* and *Pinus sylvestris* on Durmitor mountain in 1991 and in Serbia in the region of Vlasina during 1992 on the needles of Scots pine (Karadžić, 1996).

**Description:** *L. sulcigena* is primary pathogen, able to attack needles from current vegetation. Based on the bioecological study of this fungus during 1992-1995 it was concluded as follows: *L. sulcigena* infects young (not yet completely developed) needles from the current vegetation (Karadžić, 1996). The place of infection is the base of a needle. Infection period lasts from the end of May till the end of July, but the critical period for infections is June. Period of incubation on Scots pine lasts for about 30-45 days. First symptoms are ring like necrotic brown bands which start to develop on the middle of needle during the summer and beginning of autumn.

![Figure 7 - Infected pine *Pinus nigra var. maritima* (photo: Karadžić)](image-url)
Then necrosis starts to spread to top of the needle, so that till end of autumn whole upper part of the needle dries. Afterwards necrotic part of the needle starts to be light reddish and during the winter it has light brownish color. For sure diagnosis it is necessary to find apothecia, which are developed during winter season and in early spring. They are visible by naked eye grey-brownish or black bodies long 2 – 15 mm. Infected needles fall next year and often on them could be seen other secondary pathogens such as *Lophodermium pinastri* and *Cyclaneusma niveum*.

This pathogen is on the quarantine list of diseases in Serbia and Montenegro.

For successful control of this fungus chemical treatments should be applied immediately after starting new vegetation, with several repeating during development of needles. Copper or organic fungicides could be used.
Figure 8 - Distribution of Lophodermella sulcigena on pines in Western Balkan
4.6. **Lophodermium pinastri** (Schrad) Chév.

**Synonyms:** *Hysterium pinastri* Schrad.

*Lophodermium laricis* Dearn.

*Lophodermium pinicola* Teho

**Anamorph:** *Leptostroma pinastri* Desm.

**Local name:** Osipanje starih borovih iglica

**Cause:** *Lophodermium* needle cast

**Hosts:** *Pinus sylvestris, P. nigra, P. heldreichii, P. peuce, P. mugo, P. halepensis, P. pinaster*

**Distribution in the World:** Widespread in Europe, North America and Asia

**Distribution in Balkan countries** (Fig. 10): This fungus has been found in Croatia on *Pinus heldreichii* near Zadar and Benkovac, and on *P. nigra* near Zadar and Šibenik (Pernek et al., 2012). In Serbia and Republic of Srpska *L. pinastri* caused serious damages in pine plantations in Zlatibor, Šargan, Suvobor, Maljen, Južni Kučaj, Goč, NP Kopaonik, Deliblato sands etc. (Karadžić and Stanivuković, 2010; Karadžić and Milijašević, 2008). In Montenegro the fungus appears on the needles in the litter and on the needles of the trees previously infected by other fungi at the localities Virpazar, Bar, Sutomore, Podgorica (Karadžić and Vujanović, 2009).

**Description:** In Balkan region occurs on Scots pine, Black pine, Bosnian pine, Macedonian pine, Mountain pine, Aleppo pine, Maritime pine etc. (Karadžić, 2010; Kišpatić, 1956). It can be found in nurseries, young cultures and natural forests. This fungus colonizes only physiologically weak and old needles (two-years and older).

First signs of disease are chlorotic spots which occur during the summer. Spots spread gradually, connect and become yellow, reddish and brown, causing cast of needles. Fungus lives on dead needles on tree or in litter. First pycnides appears in autumn and in the winter (November – January) while apothecia in the beginning of next year (January – April). In this period between glossy black apothecia horizontal black stripes can be seen. Black stripes are very important diagnostic characteristics for this pathogen. Apothecia mature in spring and ascospores are spread by wind. Spreading
starts in March – April, after spring rains and lasts till September. Critical period for infections is May – June.

Control treatments against this pathogen have to be applied in nurseries in critical period for infection.

Figure 9 – up: Infected young Scots pine plants by *Lophodermium pinastri*; down: Fruiting bodies on needles (source: http://www.forestryimages.org)
Figure 10 - Distribution of *Lophodermium pinastri* on pines in Western Balkan
4.7. *Lophodermium seditiosum* Minter, Staley and Millar

**Anamorph:** *Leptostroma austriacum* Oud.

**Synonyms:** *Leptostroma rostrupii* Minter

**Local name:** Osipanje mladih borovih iglica

**Cause:** Redness and cast of needles

**Hosts:** *Pinus sylvestris*, *P. nigra*, *P. halepensis*, *P. mugo* etc.

**Distribution in the World:** Widespread all over the World

**Distribution in Balkan countries** (Fig. 12): In Croatia this pathogen was found on pines in Pališin cultures and did not cause any bigger damages (Diminić et al., 1995). Pernek et al. (2012) explained that drought, as a trigger, weakened *Pinus heldreichii* which was subsequently attacked by *L. seditiosum* in the localities near Zadar, Benkovac and Šibenik. In Serbia and in Republic of Srpska in plantations of *P. nigra* and *P. sylvestris*, *L. seditiosum* caused very big damages and it was found in areas of Zlatibor, Šargan, Suvobor, Maljen, Južni Kučaj, Goč, NP Kopaonik, Deliblato sands, Horgoš – Subotica sands, NP Durmitor (Karadžić and Stanivuković, 2010; Karadžić and Milijašević, 2008). In Montenegro, Karadžić and Vujanović (2009) observed appearance of *L. seditiosum* on Aleppo pine in Virpazar, Podgorica, Sutomore and Bar.

**Description:** This fungus appears on huge number of *Pinus* species (Minter, 1981). In Balkan region, it is very common on *Pinus sylvestris*, *P. nigra*, *P. halepensis*, *P. mugo* and on the other species of pines. *L. seditiosum* is very dangerous pathogen and causes very big damages in plantations of pines and can lead to massive decline and dying of seedlings. According to Karadžić (2010) this fungus attacks one – year old needles and needles from current vegetation which have the biggest influence on intensity of photosynthesis. Without control of this pathogen it is nearly impossible to produce good quality and healthy seedlings.

First symptoms of infection on needles appear in the end of autumn and manifested like a chlorotic spots. Chlorotic spots then gradually changes color and whole needles having brown – reddish color. On infected needles firstly are formed pycnidia of fungus and massive appearance of them is in April next year. Apothecia occur in June next year, on primary needles of naturally occurring seedlings, or on two-year old
needles of grown trees. Together with other fungi (i.e. *Lophodermium pinastri, Cyclaneusma niveum*) it causes needle blight (Karadžić and Vujanović, 2009). In continental regions, primary infection occurs from the middle of August to end of September (sometimes middle October). They can be found on the young needles and in the litter. Their maturing is followed by infection period. Apothecia are formed from the both side of needles, when they are wet they have black color, and when they are dry they dye to gray color.

According to Lazarev (1980, 2004) biology of *L. seditiosum* is characterized with 4 stages: infection phase, dormancy period, phase of transition to saprophytic life and generative reproduction. Critical period for infections is from the middle of August till the end of September.

Most effective protection against this pathogen is chemical treatment and has to be applied in August and September.

![Figure 11 – left: *Lophodermium seditiosum* fruiting bodies on pine needle; right: infected pine branches (source: http://www.arbofux.de)](http://www.arbofux.de)
Figure 12 - Distribution of Lophodermium seditiosum on pines in Western Balkan
4.8.  **Mycosphaerella dearnessii** M. E. Barr

**Synonyms:**  *Scirrhia acicola* (Dearness) Siggers

**Anamorph:**  *Lecanosticta acicola* (Thümen) H. Sydow

**Synonyms:**  *Lecanosticta pini* H. Sydow

  *Septoria acicola* (Thümen) Saccardo

**Local name:**  Smeda pjegavost borovih iglica

**Cause:**  Brown needle blight

**Hosts:**  *Pinus contorta, P. halepensis, P. muricata, P. palustris, P. pinaster, P. pinea, P. radiata, P. strobos, P. sylvesteris and P. taeda*

**Distribution in the World:**  North and South America, Europe, Asia and South Africa

**Distribution in Balkan countries:**  In Croatia this pathogen was found 1975 close to Biograd at sea (Crvena Luka) causing drying and cast of Aleppo pine needles (Glavaš, 1979). *Mycosphaerella dearnessii* has been identified on one-year-old needles of Scots pine (*Pinus sylvestris*) (Fig. 13A) and stone pine (*P. mugo*) (Fig. 13B) growing in parks in Bled and Ljubljana, Slovenia (Jurc and Jurc, 2009). In other Balkan countries there is no any data that this fungus was determined.

**Description:**  *M. dearnessii* is very common pathogen in USA and causes together with other pathogens disease of pine needles. This fungus is also present in Europe, Asia and South Africa. The hosts of this pathogen are *Pinus contorta, P. halepensis, P. muricata, P. palustris, P. pinaster, P. pinea, P. radiata, P. strobos, P. sylvesteris and P. taeda*. Certain species, such as *P. banksiana*, have been shown to be highly resistant to *M. dearnessii* (Skilling and Nicholls, 1974).

First signs of disease attack initially appear in August-September on older needles in the form of yellow, resin-soaked spots which later become dark-brown in the centre with a prominent yellowish-orange border. As infection spreads all needles become brown and shed in late autumn to early winter. While infection increases current – year needles can be also attacked. Over several years, this may result branch drying or even tree death.
In the development of this fungus there are two states: anamorph state – acervuli (*Lecanosticta acicola*) and teleomorph state – perithecium. In northern USA, rainfall and temperature are the critical factors for spores dispersal and infection, which occur from June to September (Skilling and Nicholls, 1974). The infection period is from June to July and incubation is variable from 2 months on young needles to 5 – 7 months on older ones. Acervuli are formed throughout the year and mature in late August, but conidia has most important role in spreading of disease. Disease cycle renews the following summer when the overwintering fruiting bodies release conidia while temperature and rainfall increase (Skilling and Nicholls, 1974).

According to Glavaš (1979) successful treatments in pine cultures against this pathogen are mechanical and chemical. Firstly, all infected branches and trees have to be removed and burned. After that, chemical treatments with copper fungicide have to be applied (4 times per season).

![Figure 13 - Brown to grey needles on (A) Scots pine and (B) stone pine infected with brown-spot needle blight; (C) conidial masses protruding from both sides of the conidiomata under damp conditions (bar 1 mm) (photo: Jurc)](image-url)
4.9. **Mycosphaerella pini** E. Rostrup ap. Munk

**Synonyms:** *Scirrhia pini* Funk & A.K. Parker

**Anamorph:** *Dothistroma septosporum* (G. Doroguine) Morelet

**Synonyms:** *Cytosporina septospora* G. Doroguine

**Local name:** Crvena pjegavost borovih iglica

**Cause:** Red Needle Blight

**Hosts:** *Pinus* (80 species are sensitive), *Larix decidua*, *Pseudotsuga menziesii*, *Picea abies*, *Picea omorika*, *Picea sitchensis*

**Distribution in the World:** Widespread all over the World

**Distribution in Balkan countries** (Fig. 16): This disease is widely spread all over the World, and the most sensitive species is *Pinus nigra var. austriaca*. Sensitive species are also *Larix decidua* (Basset, 1969), *Pseudotsuga menziesii* (Dubin and Walper, 1967) *Picea abies* (Lang, 1987), *Picea omorika* (Karadžić, 1994) and *Picea sitchensis* (Peterson and Graham, 1974).

In Serbia it was found on *Pinus mugo*, *P. halepensis*, *P. sylvestris* and other introduced pines (Karadžić, 1989). While in Bosnia and Herzegovina *M. pini* is widespread on *Pinus nigra var. corsicana*. For first time it was identified near Banja Luka, where it destroyed whole culture. Scots pine in Bosnia and Herzegovina is resistant (Uščuplić, 1996).

First strong attack of this fungus in Croatia has been recorded in area of Kožino near Zadar in 1970s, so this area has been described as focus place from where disease spreads wide further and scientific researches of this fungus in this area are still in progress. This fungus has been found on Aleppo pine and Austrian pine near Zadar again and on Maritime pine near Benkovac without bigger damage (Pernek et al, 2012; Novak – Agbaba and Halambek, 1997). In Slovenia first report about teleomorph stage was in 1975, on black pine (Macek, 1975).

Conidial stage of this fungus for first time was identified in Serbia near Trglan Bara (Ravna Reka) in all cultures of Austrian pine in Serbia, up to 1000 m AMSL (above this level fungus does not occur because of environmental conditions) (Krstić, 1958). In past 30 years very big infection intensity has been determined in cultures of Austrian pine in Deliblato sands, Pešter and Subotica-Horgoš sands, in Divčibare, Južni Kučaj,
Goč, Fruška gora, Rudnik, near Belgrade, Loznica, Kučevo, Negotin, Priboj, Prijepolje, Tutin (Karadžić, 2004). Especially cultures between 5 – 25 years old were damaged. In Montenegro it occurs in cultures of black pine near Pljevlje, Cetinje and Virpazar (Karadžić, 1986). Also it has been found on Aleppo pine near Podgorica, Virpazar and Sutomore (Karadžić and Vujanović, 2009).

Description: *Mycosphaerella pini* is the most widespread and dangerous fungi in the World. Today this fungus is one of the most important on introduced species of pines in tropical countries. *Mycosphaerella pini* is mostly known by conidial state (anamorph) which is described as *Dothistroma septospora*, causing needle blight called as “Dothistroma needle blight”, “red band needle blight”, “pine needle blight” etc. Second state (teleomorph) occurs less frequently in nature, and for first time was discovered and described by Funk and Parker (1966) called as *Mycosphaerella pini*. In Tab. 1 are shown species on which *M. pini* has been found in Serbia (Karadžić, 2010; Karadžić et al., 2011). From the most susceptible two are exotic species (*Pinus jeffreyi* and *P. ponderosa*) and they are not well spread in Serbia (only in a relatively old culture in Deliblato sands and on some individual species in urban parks). These data shows us that practical significance of *M. pini* in Serbia has only for black pine. *M. pini* has been found on *Pinus mugo*, but only in parks. Reason for that is because *Pinus mugo* naturally grows in very high altitude and ecological and environmental conditions do not allow development of *M. pini*.

Conidial stage of fungus (*Dothistroma septosporum*) has been determined on the needle of all species of pine, and perithecial stage (teleomorph) only on needles of black pine. Teleomorph stage has been found for first time in Serbia in 1979 and until now it has

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**Table 1 – Susceptibility of pines to *Dothistroma* needle blight in Serbia (Karadžić, 2010)**

<table>
<thead>
<tr>
<th>Hosts</th>
<th>Susceptibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pinus contorta</em></td>
<td>++</td>
</tr>
<tr>
<td><em>Pinus halepensis</em></td>
<td>++</td>
</tr>
<tr>
<td><em>Pinus jeffreyi</em></td>
<td>+++</td>
</tr>
<tr>
<td><em>Pinus nigra</em></td>
<td>+++</td>
</tr>
<tr>
<td><em>Pinus nigra var. maritime</em></td>
<td>+++</td>
</tr>
<tr>
<td><em>Pinus pinea</em></td>
<td>+</td>
</tr>
<tr>
<td><em>Pinus ponderosa</em></td>
<td>+++</td>
</tr>
<tr>
<td><em>Pinus mugo</em></td>
<td>+</td>
</tr>
<tr>
<td><em>Pinus sylvestris</em></td>
<td>+</td>
</tr>
<tr>
<td><em>Picea omorika</em></td>
<td>+</td>
</tr>
<tr>
<td><em>Picea sitchensis</em></td>
<td>+</td>
</tr>
<tr>
<td><em>Pseudotsuga menziesii</em></td>
<td>+</td>
</tr>
</tbody>
</table>

Legend: +++ high susceptibility; ++ moderate susceptibility; + low susceptibility
been found only in Deliblato sands and Južni Kučaj (Karadžić, 1986). This stage has been determinate only on needles of Austrian pine.

The first symptoms of infection are yellow bands on mature needles at the bases of branches and in the lower half of the crown. This chlorosis starts in late summer or autumn and stays like that till early spring. The bands later turn red in color, thus leading to the name red band needle blight. Generally, a reddening develops, and a red pigment may be present around the fructifications (Fig. 14). Its fructifications are rarely grouped, being dispersed linearly along the needles. As the disease develops, needle necrosis and subsequent needle cast spreads from the branch bases into the younger foliage. Infected needles are killed and drop, and conidia produced from them are splashed to other needles. On the host, it produces small, dark brown/black fruiting bodies (acervuli), visible during late spring and summer on attached needles infected in the previous year. These fruit bodies contain asexual spores (conidia) which are exuded in a white or pale-pink, secreting mass during light rain or misty conditions. The critical period for infection is spring and early summer when the fruiting bodies are formed on the needles. If spores land on a suitable host they may germinate on the needle surface and penetrate through the stomata. Moisture is required for germination and the optimum temperature for successful establishment under conditions of high humidity. The optimum temperatures for growth and spore germination are around 18 °C and 20 °C (Karadžić, 1989). By late summer to early autumn the older needles carrying the source of infection are fallen. This way M. pini life cycle continues. On fallen needles between red bands species such as Lophodermium seditiosum and Cyclaneusma niveum could be seen.

The most effective treatment against this fungus is appliance of copper fungicides. These fungicides stay longer on needles, so they can be applied only several times, and they are not harmful to fauna. Because of this fact it has low cost treatment. Treatments of cultures on bigger areas have to be applied by plane method, because of more less inaccessible terrains every other treatment is not applicable. Protection should be applied twice a year (Karadžić, 2004).
Figure 14 - Symptoms of red needle blight on Corsican Pine *Pinus nigra var. maritima*.

a) Early symptoms – yellow bands and tan spots

b) Advanced symptoms with visible brown fruiting bodies of *Dothistroma septosporum*

(source: [http://www.forestry.gov.uk](http://www.forestry.gov.uk))

Figure 15 – Infection by *Dothistroma* needle blight in cultures of black pine in Subotica-Horgoš sands (photo Karadžić)
Figure 16 - Distribution of *Dothistroma* needle blight on pines in Western Balkan

**Synonyms:** Phacidium abietis (Dearn.) J. Reid & Cain

**Local name:** Snježna bolest iglica četina

**Cause:** Necrosis and needle drying

**Hosts:** *Pinus sylvestris*, *P. mugo*, *P. contorta*, *P. pumila*, *P. sibirica*, *P. nigra var. laricio*, *Picea*, *Abies*, *Thuja*, *Pseudotsuga*

**Distribution in the World:** North and mountain regions of Europe, Asia (Turkey and Siberia) and North America

**Distribution in Balkan countries** (Fig. 18): In Serbia and Montenegro *P. infestans* could occur on high mountains (Durmitor, Prokletije, Golija, Kopaonik, Sinjajevina). In Serbia and Republic of Srpska, *Phacidium infestans* was recorded (in mountains region altitude more than 1200 m) both on Scots pine and Austrian pine. The fungus occurs on the needles of lower branches which were covered with snow during the winter (Marinković and Karadžić, 1983; Karadžić and Milijašević, 2008; Karadžić and Stanivuković, 2010). *P. infestans* is on the list of quarantine diseases in Serbia because it causing very huge damages in pine cultures.

**Description:** This pathogen was firstly discovered in Finland 1866. The second name for this pathogen is ‘snow fungus’ because it is stimulated with the depth of snow cover during the winter months. Disease causes drying of needles, buds and often a whole plant. *P. infestans* is very dangerous for young seedlings and can be seen only on the part of crown which is during the winter covered with snow. The most sensitive species to this pathogen is *Pinus sylvestris*, but this fungus also attacks *P. mugo*, *P. contorta*, *P. pumila*, *P. sibirica*, *P. nigra var. laricio*.

Ascospores are released in September and October and making infection on needles of current vegetation. Critical period for infection is September and October. Further
development of infection depends on snow. Depth of snow cover during the winter months has a huge effect on height till where needles will be necrotized. Next spring after infection needles have yellow, brown reddish and light gray color. On these needles during the summer apothecia are formed, maturing in September and October, and life cycle of fungus finishes in one year. Ascospores are spread by wind during the wet period. Beside ascospores, microsclerotia are also formed, but role of it in process of infection is still unknown. Mycelium is very important factor in spreading of the disease because it is spread from infected to healthy needles.

Control against *P. infestans* includes mechanical treatment, with a purpose to destroy infected seedlings in nurseries and cultures, before melting of snow and cast of infected needles. Chemical treatments (with copper fungicides) are also recommended in nurseries and with young cultures from September till end of October, in the time of maturing and opening of apothecia.
Figure 18 - Distribution of Phacidium infestans on pines in Western Balkan
4.11.  *Sphaeropsis sapinea* (Fr.) Dyko et Sutton

**Synonyms:**  *Diplodia pinea* (Desm.) Kickx  
*Sphaeria pinea* Desm.  
*Sphaeria sapinea* Fr.

**Local name:** Sušenje borovih izbojaka

**Cause:** Necrosis of needles shoots and branches, canker of stem, ring rot, diseases on root

**Hosts:** *Pinus sylvestris*, *P. nigra*, *P. halepensis*, *P. heldreichii*, *P. jeffreyi*, *P. peuce*, *P. pinaster*, *P. ponderosa*, *Abies*, *Cedrus*, *Araucaria*, *Chamaecyparis*, *Juniperus*, *Cupressus*, *Larix*, *Picea*, *Pseudotsuga*, *Thuja*

**Distribution in the World:** Widespread all over the World

**Distribution in Balkan countries** (Fig. 20): In the former Yugoslavia, *S. sapinea* was widely distributed both in the continental and in the Mediterranean parts. It was identified on ten pine species and six hosts from other coniferous genera. The new hosts of this fungus were detected - *Pinus jeffreyi*, *P. peuce* and *P. heldreichii* (Milijašević, 1994; 2000; 2002). The most endangered species is Austrian pine, both in urban environments, and in plantations (Milijašević and Karadžić, 1997).

According to accessible literature in Croatia *S. sapinea* for first time was found in 1959 by Böhm. He noticed that this fungus attacked around 60% of one year old seedlings of black pine in nursery Bosiljevo (Karlovac area). However, first research in Croatia has been recorded in 1991, in Istra locality, where this fungus was main cause of infections of black pine (Diminić, 1994). Further researches were continued in Crikveničko – vinodolsko area and on island Rab, where results have confirmed presence of fungus *S. sapinea*. In Croatia the fungus was found on dead needles, dieback shoots, branches and on cones (Diminić et al., 1995; Diminić and Jurc, 1999; Diminić et al., 2012). *S. sapinea* was found in Slovenia as an endophyte in green Austrian pine needles on a few localities (Diminić and Jurc, 1999). In Montenegro this fungus is one of the main causes of drying of Allepo pine. In research by Karadžić and Vujanović (2009), it has been found on all research localities (Suto-more, Bar, Virpazar, Podgorica). In Serbia *S. sapinea* for first time has been found in 1982 (Karadžić, 1983). In past years bigger
damages have been found on black pine in Deliblato sands, Subotica-Horgoš sands, and city parks Vrnjačka Banja, Beograd, Novi Sad, Zaječar (Karadžić, 2010).

**Description:** This fungus is widespread in the World and attacks plants in their all stages of growth, from one year old plants in nurseries to the oldest trees. It causes different damages to coniferous species, especially pines: necrosis of needles shoots and branches, canker of stem, ring rot, diseases on root etc. Some authors (Diminić, 1994) say that this fungus is a parasite of weakness, which occurs on physiologically susceptible plants which have been suffering some stress, defoliation from insects, drought, frost, imbalance in nutrition etc. According to Diminić the most sensitive species are in nurseries, which still do not have wooden stem and they die very quickly.

Diagnosis of this fungus is relatively easy, because symptoms are very showy, and fruiting bodies occur on specific places where possibility of confusion or misunderstanding is excluded. First showy symptom is appearance of resin drops and one or more very short needles from current vegetation. Needles lag in growth and change color to yellow-brownish or brown. Fungus spreads very fast and in short time it takes over all needles and tissue of young shoots. In case of mass attack the shoots on branches are totally dried and killed. If infections repeat more continuous years, individual branches, crown tops or whole trees could be dried and dead. *Spaeropsis sapinea* produces fruiting bodies pycnidia. Pycnidia occur on needles (mostly in base), cones, bark of the branches and stem, and even on the root. They could be placed individually or in group. Conidia (pycnospores) are whitish in the beginning, and by germination become yellow-brownish or brown and unicellular (rarely bicellular).

Critical periods for *Spaeropsis sapinea* are from middle of April till beginning of May, and second one in June (Karadžić and Stojadinović, 1988). First critical period is related mostly for new growing shoots, and second could be possible in case of some damages on the tree. Example for second critical period was in Bosnia and Herzegovina near Višegrad on June 08th 2008, where black pine trees were damaged by hail and those wounds were perfect place for infection by *Sphaeropsis sapinea*. Conidia of this fungus germinate in temperature interval from 6°C up to 36°C, and optimal temperature is 27°C (Milijašević, 2002). According to many authors in the World the best treatment of this fungus are silviculture and preventive protection.
Figure 19 – up left: *S. sapinea* pycnidia on cone scales of Austrian pine (source: [http://www.forestryimages.org](http://www.forestryimages.org)); down left: pycnidia on pine needle (photo Diminić); right: very infected tree of Austrian pine (photo Karadžić)
Figure 20 - Distribution of *Sphaeropsis sapinea* on pines in Western Balkan

**Local name:** Ukrivljavanje borovih izbojaka

**Cause:** Pine needle rust, bending of the shoots of young trees and tree decline

**Hosts:** *Pinus sylvestris, P. nigra, P. pinea, P. montana, P. mugo, P. maritima, P. pinaster,* alternative hosts: *Populus alba, P. tremula*

**Distribution in the World:** Only on the places were Scots pine and aspens lives together

**Distribution in Balkan countries** (Fig. 22): The disease in Bosnia and Herzegovina appeared after World War II (in late 1950s). In this period forestation started on large burned fire sites, where pioneer species already existed natively - *Populus tremula*, which is transient host in the life cycle of the pathogen. In Bosnia and Herzegovina the biggest damages were recorded in wide area of Romanija Mountain, where some cultures of Scots pine in 1961 were totally destroyed, and partially Austrian pine. That year in forestry nursery “Dikalji”, which has been made for forestation of burned land on Romanija, intensity of *Melampsorella pinitorqua* disease was 100%, so that all nursery plantings were destroyed and whole nursery production was stopped in this object. Disease has been found after again periodically in some places in Bosnia and Croatia (Slavonija), where was *Populus tremula* nearby pine (Uščuplić, 1996). In Serbia this disease occurs less frequently (Karadžić and Milijašević, 2008). It is similar in other countries in Europe. The biggest damages are present in young plants in nurseries and pine cultures young up to 10 years.

**Description:** *M. pinitorqua* infects shoots from current vegetation in their first phase of development, and causes their bending on the side where necrosis starts. On the necrosis side shoots stop to grow and on the other side tissue normally grow, this makes shoots bended. In cases that necrosis makes a ring around it, upper part of shoot totally dies. This fungus makes a huge demages or death of pine plants in nurseries. Aecidia are type caeoma, do not have a vascular capsule, orange layers of aeciospores. Orange aeciospores disappear quickly by wind, and on the plant stays brownish spot. Second stage of fungus develops on *Populus tremula* leafs creating basidia and basidiospores. These basidiospores infect again other pines, and fungus life cycle continues.
Treatment against this disease is directed to protection of pines. It is possible to do preventive and repressive treatments. Preventive include pine protection by removing *Populus tremula* from area of 200 – 300 m, appliance of fungicides based on copper in nurseries. Repressive treatments include destroying infected pine plants in nurseries and cutting aspen trees nearby.

![Image of pine needle infected with Melampsora pinitorqua](image1.png)

*Figure 21 - Melampsora pinitorqua on Pinus spp. (sources: first - photo by Jurec, second - wikipedia.org)*
Figure 22 - Distribution of *Melampsora pinitorqua* on pines in Western Balkan
4.13. *Cenangium ferruginosum* Fr.

**Synonyms:** *Cenangium abietis* (Pers.) Duby.

**Anamorphs:** *Dothichiza ferruginosa* Sacc.

**Local name:** Sušenje borovih grana

**Cause:** Limb canker, dieback of pines

**Hosts:** *Pinus nigra* var. *austriaca, P. sylvestris, P. strobus, P. ponderosa, P. peuce, P. mugo, P. heldreichii, P. halepensis, Abies alba, Picea abies*

**Distribution in the World:** widespread in whole Europe, North America and some parts of Asia

**Distribution in Balkan countries** (Fig. 24): First appearance of disease was recorded in Germany, 1891 – 95 (Schwartz). Later, the disease was found in other countries in Europe. In former Yugoslavia first time this fungus appears in 1957, then in 1962 and for last time in period of 1987 – 1988.

First time in Bosnia and Herzegovina *C. ferruginosum* was found in 1957 (same year was found in Macedonia) in natural forests of black pine, wide area of mountain Konjuh. Next year disease suddenly disappeared on the same way how it appeared. On the same area it was found in 1962 by Uščuplić. Attack was so strong that almost there was not pine tree without dried needles. Lot of trees were totally damaged, whole crown was reddish with dried tops. Regardless of the etiology of disease, consequences are secondary appearance of insects. Chain begins by attack of bark beetles, so their occurrence is more dangerous than threat of fungi disease.

In the past years in Bosnia and Herzegovina disease was found again on mountain Konjuh, than in forests around town Foča (Uščuplić, 1996).

In Croatia in forest cultures of *Pinus nigra* in Pališin *C. ferruginosum* was found on several lower branches of the trees. Fungus in this culture was not presented in that amount that can make big damages (Diminić et al., 1995). In Slovenia there were similar results in area near Kastelec, mostly disease attacked lower weak branches of *Pinus nigra*. This forest was struggling by stress on shallow soil on karst (Jurc, 2003). Intensive tree dieback of Scots and Austrian pine plantations in Serbia was observed during 1987 on localities Zlatibor, Maljen, Kopaonik and Šargan. The inspection of
dead trees proved the presence of *C. ferruginosum* stromata (apothecia), and also the presence of bark beetles and other secondary insects (Karadžić and Milijašević, 2008).

**Description:** *C. ferruginosum* usually occurs on lower branches of pines as saprophyte, but its pathogenic appearance has been differently accepted by some researchers. Most of them believe that this is a weakness parasite which attacks branches after effects of some stress factors (long-term drought in past years, imbalance of nutrition, attack by insects etc.), or trees living in dense forests. This fungus appears periodically in different intervals what makes complications for following and research etiology.

First signs of disease occur in early spring, before starting new vegetation, on top shoots where needles dry, and process of tissue dying goes from the base to top of the needle. Afterwards needles are totally red and starting to fall off. In this stage there are no other signs of disease. Drying of needles starts from the top to base of the branches, it takes part of the tree crown or even whole crown. In the end of spring and beginning of summer occurs drying of the tops of branches. If bark is cut, brown colored tissue on the wood will appear. By more detailed analysis of inside bark tissue in this phase of disease could be seen tiny (cca. 2 – 3 mm diameter) black stroma spots, from where later fruit bodies occurs. These stromas appear mostly in the zone of scars on needles. During the summer on the bark of dead branch apothecia starts to crop up. They are black with small developed stem, crop up under the bark in groups (buckets), so they can be seen by naked eye easily. Apothecia can be formed only on the thin branches, up to 7 cm diameter. During dry summer days edges of the apothecia are constricted by sides, so that apothecia in buckets are more compressed. After rainfall apothecia swell, edges are open and then they look like small bowls size around 1 mm. Rarely apothecia can be formed on needles, but in this case they are present individually only.

Regarding to experiences in Bosnia and Herzegovina it is not recommended application of special treatments, but mostly against bark beetles. After occurring of *C. ferruginosum* weak trees are target for bark beetles, and in order to protect pine forests control of insect’s population is obligatory. In this order some infected trees is necessary to cut.
Figure 23 – up left: Mass dieback of pine trees on Zlatibor 1987 (photo: Karadžić); right: Symptoms on infected tree (photo: Karadžić); middle left: Open apothecia *C. ferruginosum* on a twig after keeping moist (source: [http://www.forestryimages.org](http://www.forestryimages.org)); down left: Vertical section through ascoma (source: [http://fungi.myspecies.info](http://fungi.myspecies.info))
Figure 24 – Distribution of *Cenangium ferruginosum* on pines in Western Balkan

**Synonyms:** *Cronartium asclepiadeum* (Willd.) Fr.

**Local name:** Hrđa kore dvoigličavih borova

**Cause:** Stem pine rust, necrosis, hypertrophy and branch drying

**Hosts:** Two needle pines (*Pinus sylvestris, P. nigra, P. halepensis, P. mugo, P. pinaster, P. pinea*), and alternative hosts (*Vincetoxicium officinale, Gentiana spp., Impatiens spp., Verbena spp., Melampiprum spp., Paeonia spp. etc.*)

**Distribution in the World:** In Europe and in northern and eastern Asia

**Distribution in Balkan countries** (Fig. 26): In Bosnia and Herzegovina this fungus is not so frequent. It has been found only once near Zavidovići on one individual Scots pine, but without bigger damages. According to Kišpatić (1991) it causes big damages on Aleppo pine in Istra region (Croatia), but in Serbia *C. flaccidum* has been found only on Austrian pine and Scots pine (Karadžić and Milijašević, 2008). In Montenegro this fungus has been identified in the Aleppo pine plantation in the vicinity of the Skadar Lake near Virpazar, where it is of major significance (Karadžić and Vujanović, 2009).

**Description:** On infected pine branches firstly yellowness occurs, and after that needles become reddish. Sure sign of disease is appearance of aecidia in the base of these infected branches. Aecidia look like small vascular bodies (type *peridermium*), very showy, size 2 – 8 mm, and yellowish orange color. In the zone of aecidia bark is necrotic, canker wound is developed from where resin leaks. *Cronartium flaccidum* has the same full cycle of development as *C. ribicola*. Difference is that aecidia develop on bark of 2-needle pines, and aeciospores flow to other herbaceous plants (mostly on *Vincetoxicium officinale*). Then basidiospores are produced on herbaceous plants transported by wind to other pines. Infection starts again when basidiospores enter into needle stoma, and from there mycelium spread further to the base of needle and stem. According to experiences in Croatia (Kišpatić, 1991) it is not recommended to build Aleppo pine plantations where *Vincetoxicium officinale* is widespread. Other treatments include cutting of infected trees and reason for that is to destroy fungal inoculum on pines where fungus can be alive for several years.
Figure 25 - left: Died pine tree (*Pinus halepensis*), up right: Exudate of resin on infected wound; down right: *Cronartium flaccidum* aecidia (photo: Karadžić)
Figure 26 - Distribution of *Cronartium flaccidum* on pines in Western Balkan
4.15. *Cronartium ribicola* J. C. Fischer

**Local name:** Hrđa kore petoigličavih borova

**Cause:** Bark rust and necrosis on Pines and leaf rust, chlorosis and preterm defoliation on Blackcurrant (*Ribes* sp.)

**Hosts:** Five needle pines (*Pinus strobus, P. monticola, P. albicaulis, P. lambertiana, P. flexilis, P. cembra*), *Ribes* spp. (alternative host)

**Distribution in the World:** North America and Europe

**Distribution in Balkan countries** (Fig. 29): In 1970s this fungus was recorded in Bosnia and Herzegovina on young seedlings of *P. strobus*. It was imported by seedlings bought in Slovenia and Croatia, but disease did not spread more because blackcurrant is not so often plant there (Uščuplić, 1996). In Croatia only known location is Zelendvor near Varaždin where *C. ribicola* has made bigger damages to *Pinus strobus* with all phases of development. Individual attack was observed on three locations near Karlovac: Metla, Drenovac and Donje Izimje (Orlić et al., 1973).

**Description:** First disease sign on pines is deformation of crown. Trees lag in development, irregularly branching and on the bark of these trees (mostly on places of branch bifurcation) occur vesicular fungus aecidia (size 2 – 5 mm). Aecidia are whitish and by breaking of vesicular membrane discharge orange aeciospores which dye aecidia into same orange color. Then tumor is developed on this place of the tree or branches, where bark breaks and resin leaks. These signs are enough for diagnosis of this disease. Aeciospores flow by wind to blackcurrant, and finishing whole phase of fungus development. On infected blackcurrant basidia are created and discharge basidiospores. These basidiospores transported by wind again infect other pine, and cycle of disease continues (Fig. 28). They loose vitality fast, so that infection on the pines can be only possible if blackcurrant is near up to 500 m (according to experiences in Slovenia this distance is 300 m).

The best treatment for this fungus is separation of blackcurrant plantings from pine forests. In case that pines are already infected, it is necessary to remove/cut all plants of blackcurrant near pine forests or plantations. Destroying of blackcurrant plants is done by mechanical or chemical treatment.
Figure 27 – left and up: C. ribicola on Pinus strobus (sources: http://www.arbofux.de & http://www.forestryimages.org) right down: C. ribicola on Ribes leaf (source: http://www.discoverlife.org)

Figure 28 - Life cycle of Cronartium ribicola J. C. Fischer (source: http://www.apsnet.org)
Figure 29 - Distribution of Cronartium ribicola on pines in Western Balkan
4.16. *Phellinus pini* (Thore. Ex Fr.) Pilát

**Local name:** Borova guba

**Cause:** Stem rot, red ring rot

**Hosts:** *Pinus, Abies, Chamaecyparis, Larix, Libocedrus, Picea, Pseudotsuga, Taxus, Thuja and Tsuga*

**Distribution in the World:** Europe, North America, Africa and Asia

**Distribution in Balkan countries** (Fig. 31): In Bosnia this fungus is widespread on *Pinus sylvestris* and *Pinus nigra*, and in Herzegovina and Dalmatia attacks *Pinus halepensis, P. pinea, P. pinaster* etc. In Herzegovina near Ivanjica has been found in 1970s massively drying of Aleppo pine on area more than 10 ha. In Dalmatia this fungus has been determinated in 1978 by Glavaš and Halambek (Glavaš, 1979). *Phellinus pini* (*Basidiomycota*) form fructifications on standing trees which have been found in Sutomore, Podgorica and Ulcinj – Montenegro (Karadžić and Vujanović, 2009).

**Description:** This fungus is most important on the old pine trees, and so often causes their survival. In case of Scots pine it attacks only trees over 150 years old. Younger trees can defense against it better because of higher amount of resin, to protect the wood. Basidiospores become to be active on some wound on bark of the tree, where mycelium starts to grow. Through damaged tissue of the bark mycelium penetrates into the wood and then goes deep to the heartwood. In the first phase of disease heartwood becomes reddish, which color intensity by time is higher. In the next phase this wood gets the corrosion wood rot. And in the last phase on this part of the tree wood is totally destroyed and on these places holes are created.

![Image](wikipedia.org)
Figure 31 - Distribution of Phellinus pini on pines in Western Balkan
4.17. **Armillaria** spp.

**Cause:** “White rot” root disease, stem rot, dieback of the trees

**Hosts:** conifers and broadleaves

**Distribution in the World:** widespread all over the World

**Distribution in Balkan countries** (Fig. 33): In Europe there are at least 7 different species of Armillaria, 5 with annulus: *A. mellea*, *A. ostoyae*, *A. gallica*, *A. cepistipes*, *A. borealis*; and 2 ringless: *A. tabescens* and *A. ectypa*. There is no data for existence of all these species in Balkan region. According to the pathogenic properties mostly common in Bosnia and Herzegovina and surrounding countries are *Armillaria mellea* and *Armillaria ostoyae*. Both species attack broadleaf and coniferous trees in natural forests and plantations, but mostly *A. ostoyae* appears on conifers. On pine trees mortality caused by *Armillaria* is more associated with very weak trees or young plantings on the places where it was already established.

Appearance of local drying plants by *Armillaria* in coniferous cultures is always related to the environmental conditions. First known epiphyte like this in Bosnia and Herzegovina was recorded in 1960s in cultures of *Pinus sylvestris* and *Pinus nigra* on Romanija Mountain near Sokolac. After forest fires in this area rhizomorphs of *Armillaria* have been widened. By appearance of self growing vegetation (aspen, birch etc.), fungi get the substratum for its development, what helped to increment of amount of infectious inoculums (Uščuplić, 1986).

In Slovenia (Munda, 1997) in four years of research were found six common species of *Armillaria* (*A. mellea*, *A. ostoyae*, *A. gallica*, *A. cepistipes*, *A. tabescens*, *A. borealis*), collected from 168 specimens from different climatic and geographical regions. The most widely was *A. ostoyae*, other species were found locally. Host pines were *Pinus strobus* attacked by *A. ostoyae* and *Pinus sylvestris* by *A. tabescens*.

In Serbia and Montenegro *Armillaria* spp. are one of the most widespread root disease fungi and have been recorded on over 650 hosts (Karadžić and Milijašević, 2008). Keča et al. (2004, 2006, 2009) identified five *Armillaria* species in Serbia and Montenegro (*A. gallica*, *A. cepistipes*, *A. mellea*, *A. ostoyae* and *A. tabescens*) on Austrian and Scots pine.
Description: *Armillaria* species are one of the most opportunistic fungi living as parasites on living plants or as saprophytes on dead wood.

These fungi are naturally members of forest ecosystems, living as pathogens on diverse conifers and broadleaves and causing pause in development of plant, rot of the root and death. *Armillaria* can attack totally healthy (vital) trees, causing their decline or predisposing by other harmful biotic agents (e.g. insects), but also it can live as parasite of weakness, i.e. to attack trees already weak by other harmful ageneses – usually plant stress.

As this fungus attacks root, from where it spreads to stem of the tree, diagnosis of the tree is very difficult, because first signs are unspecific (partial drying of the branches, occurrence of the resin on conifers etc.). These changes on old trees usually last for years. Only when such a trees are cut down, you could see central rot on the stem and stump. At an advanced stage of rot at this point results tree cavity. Rot by these fungi is white, fibrous and wet. Because of big content of water (by hand grip from rotten wood appears leaking fluid), color of the rot is reddish – brown before wood dries, than it becomes white. This type of wood rot is specific sign for *Armillaria*. On young culture trees *Armillaria* in short time makes invisible ring around stem, such that plant becomes yellow in short time, and crown gets reddish color, as the consequence by stoppage of flow of the liquid. For determination in case of this fungus, it is necessary to cut the bark in the base of the stem. If under the bark on the xylem appears leathery mycelia, for sure cause of the disease is *Armillaria*. If there is no occurrence of white leathery mycelia in this area, it is necessary to do same analysis on the root (10 – 15 cm deep). In case that the same sign of disease cannot be found, it is necessary to search for exact cause. These sporadic cases of decline are present on old trees as well.

One of the specific symptoms of *Armillaria* are rhizomorphs, thin filiform hypha aggregations, which are spread under the bark (*rhisomorphe subcorticalis*) and in soil (*rhisomorphe subterraneae*). Under-bark rhizomorphs are more flat, reddish brown to black color, wide 3 – 5 mm, but soil rhizomorphs are more cylindrical, black and thinner. Soil rhizomorphs are spread monopodially or dichotomially in top layer of ground (up to 30 cm into depth), making root-like system up to 5 m wide from the center (stump or stem). On attacked trees on stem it could be seen resin exudate, as additional unspecific sign of this disease. Later in autumn around old infected trees or
around old stumps crop carpophores up (mushrooms), with light brownish or honey color caps (as it is called Honey fungus). Mushrooms rarely appear individually, mostly in buckets, and they are one of the best signs for diagnosis, especially if it is necessary to determinate which species of *Armillaria*.

Figure 32 – Left: *Armillaria spp.* root rot on *Pinus spp.* (source: http://www.insectimages.org); Right: *Armillaria meleae* fruiting bodies (photo: Jurc)
Figure 33 – Distribution of Armillaria spp. on pines in Western Balkan

Local name: Truležnica korijena

Cause: Red Root Rot

Hosts: *Pinus, Abies, Cedrus, Juniperus, Larix, Picea, Pseudotsuga, Sequoia, Sequoiadendron, Tsuga*

Distribution in the World: Widespread all over the World

Distribution in Balkan countries: According to Keča (2008), three *Heterobasidion* species are present in forest ecosystems in Serbia (*H. annosum, H. parviporum* and *H. abietinum*). Pines are very rarely subject to butt rot (“Annosus Root Rot”), but in dry areas on sandy soils many trees, especially Scots pine, may be declined. In Serbia, serious damage was observed in Scots pine plantations on the Deliblato Sands (Marinković and Popov, 1980). In the other Balkan countries there is no any data for this pathogen.

Description: *Heterobasidion* spp. attacks a very large number of woody species. The fungus is, in economic terms, the most important causal agent of disease and of yield loss in coniferous trees in the northern temperate regions. On Scots pine *Heterobasidion* produces conks, which are often attached to the bark at the root collar area of the trees or sumps. Spores are responsible for most long distance spreading of the disease from one stand to another. The spores germinate readily on the surface of fresh stumps, producing mycelium that grows through the stump roots to the roots of adjacent living trees. Tree-to-tree transmission is through root contacts. The most important single factor in the infection of Scots pine stands is thinning. While fungus spores occasionally infect roots, most infection originates on the surface of freshly cut stumps. Some infected Scots pine trees show signs of decline for one or more years before dying, with shortened needles and internodes, yellowish color, and often a heavy crop of cones. Other trees die quickly without any previous indication of disease. Some preventive measures are applied in Scots pine plantations on high hazard sites. *Heterobasidion* initially enters crops mainly by means of airborne spores that colonize the surface of freshly cut stumps.

Infection by *Heterobasidion* on surface of freshly cut stumps can be prevented by thoroughly painting the fresh stump surfaces with creosote immediately after felling, a
mixture of this with tar, with titanium white, zinc oxide, sodium nitrite, ammonium sulphamate, urea or borax. Borax is effective, safe to use, easy to apply, inexpensive, and it is not detrimental to the environment.

Figure 34 – *Heterobasidion annosum* fruiting bodies (source: [http://botany.cz](http://botany.cz))
Table 2 – The most common fungi species which attack pines in Western Balkan region

<table>
<thead>
<tr>
<th>Fungus species</th>
<th>Colonized part of plant</th>
<th>Hosts</th>
<th>Significance</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armilaria spp.</td>
<td>Root Rot. (Armillaria root disease)</td>
<td><em>Pinus nigra</em>, <em>Pinus sylvestris</em>, <em>Pinus strobus</em></td>
<td>+ + +</td>
<td>Serbia (SR), Slovenia (SL), Croatia (CRO), Bosnia and Herzegovina (BH), Montenegro (MN)</td>
</tr>
<tr>
<td>Cenangium ferruginosum Fr.</td>
<td>Cenangium “die-back” - causes dying of twigs and small branches.</td>
<td><em>Pinus nigra</em>, <em>Pinus sylvestris</em></td>
<td>+ +</td>
<td>BH (Konjuh), CRO (Pališin), SL (Kastelec), SR (Zlatibor, Maljen, Šargan, Kopaonik etc.)</td>
</tr>
<tr>
<td>Coleosporium tussilaginis (Pers.) Lév.</td>
<td>Needles from the current vegetation and one year old.</td>
<td><em>Pinus nigra</em>, <em>Pinus sylvestris</em>, <em>Pinus mugo</em></td>
<td>+ +</td>
<td>BH, CRO (Ogulin and Psunj), SLO, SR and MN (Virpazar)</td>
</tr>
<tr>
<td>Cronartium flaccidum (Alb. &amp; Schw.) Wint.</td>
<td>Bark rust (causes tree dying).</td>
<td><em>Pinus nigra</em>, <em>Pinus sylvestris</em>, <em>Pinus halepensis</em></td>
<td>+ +</td>
<td>BH (Zavidovići), CRO (Istria), SR, MN (Skadar Lake near Virpazar)</td>
</tr>
<tr>
<td>Cronartium ribicola J. C. Fischer</td>
<td>Bark rust</td>
<td><em>Pinus strobus</em></td>
<td>+ +</td>
<td>SLO, BH, CRO (Zelendvor near Varaždin and near Karlovac)</td>
</tr>
<tr>
<td>Cyclaneusma niveum (Persoon ex Fr.) DiCosmo, Peredo &amp; Minter</td>
<td>Needles more than 2 years old, on the tree or in the litter.</td>
<td><em>Pinus nigra</em>, <em>Pinus halepensis</em></td>
<td>+ +</td>
<td>BH, SR (Zavojsko Lake near Pirot, Vlasina, Deliblato sands, Pešter, Subotica-Horgoš sands etc.), MN (Sutomore, Bar, Virpazar and Podgorica), SL (Kastelec), CRO (North Dalmatia, Istria, Benkovac, Crikveničko – Vinodolsko area - Klenovica, Vinište and Ravna strana).</td>
</tr>
<tr>
<td>Cyclaneusma minus (Butin) DiCosmo, Peredo, Minter</td>
<td>One- and two-year old needles</td>
<td>Pinus sylvestris</td>
<td>+ +</td>
<td>SR, MN (Nurseries)</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>Gremmeniella abietina (Lagerb.) Morelet</td>
<td><em>Brunchorstia</em> “die-back”. In Serbia it caused Scots &amp; Austrian pine dying back. The pycnidia of the imperfect stage of <em>Brunchorstia pinea</em> are formed at the base of the needles, or on the bark of killed shoots.</td>
<td>Pinus nigra, Pinus sylvestris</td>
<td>+ + +</td>
<td>SR (NP Kopaonik, Vlasina, Goč), MN (NP Durmitor near Žabljak, area of Ivica)</td>
</tr>
<tr>
<td>Heterobasidion spp.</td>
<td>Heterobasidion Red Root Rot.</td>
<td>Pinus sylvestris</td>
<td>+ +</td>
<td>SR (Deliblato Sands)</td>
</tr>
<tr>
<td>Lophodermella sulcigena (Rostrup) Höhnel</td>
<td>Needles from the current vegetation.</td>
<td>Pinus sylvestris, Pinus mugo</td>
<td>+ +</td>
<td>BH (Romanija Mountain), SR (near Vlasina), MN (Durmitor Mountain)</td>
</tr>
<tr>
<td>Lophodermium pinastri (Schrad) Chév.</td>
<td>Needles in the litter, more rarely needles of the trees previously infected by other fungi.</td>
<td>Pinus nigra, Pinus sylvestris, Pinus heldreichii</td>
<td>+ +</td>
<td>CRO (Zadar, Benkovac, Šibenik), SR (Šargan, Suvobor, Maljen, Južni Kučaj, Goč, NP „Kopaonik“, Deliblato Sands), MN (Virpazar, Bar, Sutomore, Podgorica)</td>
</tr>
<tr>
<td>Lophodermium seditiosum Minter, Staley and Millar</td>
<td>On one and two-year old needles</td>
<td>Pinus nigra, Pinus sylvestris, Pinus heldreichii, Pinus halepensis</td>
<td>+ +</td>
<td>CRO (Pališin, Zadar, Benkovac, Šibenik), SR (Zlatibor, Šargan, Suvobor, Maljen, Južni Kučaj, Goč, NP „Kopaonik“, Deliblato Sands, Horogoško-Subotička Sands, NP „Durmitor”), MN (Virpazar, Podgorica, Sutomore and Bar)</td>
</tr>
<tr>
<td><strong>Melampsora pinitorqua</strong>&lt;br&gt;Rostrup</td>
<td>Rust diseases (shoots).</td>
<td><strong>Pinus sylvestris, Pinus nigra</strong></td>
<td>++</td>
<td>SR, BH (Romanija Mountain), CRO (Slavonija)</td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
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<td>---</td>
</tr>
<tr>
<td><strong>Mycosphaerella dearnessii</strong>&lt;br&gt;M. E. Barr</td>
<td>Needle blight</td>
<td><strong>Pinus halepensis, Pinus sylvestris, Pinus mugo</strong></td>
<td>+</td>
<td>CRO (Crvena Luka near Biograd). SLO (Bled and Ljubljana)</td>
</tr>
<tr>
<td><strong>Mycosphaerella pini</strong>&lt;br&gt;E. Rostrup ap. Munk</td>
<td>Anamorph <em>Dothistroma septosporum</em> on the needles from the previous vegetation (ten months old) more rarely also on needles from current vegetation. In the Austrian pine natural regeneration, it was isolated from the three-month old needle. The perfect stage <em>M. pini</em> is formed on the 2-year old needles.</td>
<td><strong>Pinus nigra, Pinus sylvestris</strong></td>
<td>+++</td>
<td>BH (Banja Luka), CRO (Kožino near Zadar, Benkovac), SLO, SR (Trgulan Bara near Ravna Reka, Deliblato sands, Pešter and Subotica-Horogš sands. Also, in Divčibare, Južni Kučaj, Goč, Fruška gora, Rudnik, near Belgrade, Loznica, Kučevo, Negotin, Priboj, Prijepolje, Tutin etc.), MN (Pljevlje, Cetinje, Virpazar, Podgorica, Sutomore)</td>
</tr>
<tr>
<td><strong>Phacidium infestans</strong>&lt;br&gt;Karst.</td>
<td>The fungus occurs on the needles of lower branches which were covered with snow during the winter.</td>
<td><strong>Pinus nigra, Pinus sylvestris</strong></td>
<td>+++</td>
<td>SR and MN (Durmitor, Prokletije, Golija, Kopaonik, Sinjaevina)</td>
</tr>
<tr>
<td><strong>Phellinus pini</strong>&lt;br&gt;(Thore. Ex Fr.) Pilát</td>
<td>Wood rot. Fruiting bodies on living trees.</td>
<td><strong>Pinus nigra, Pinus sylvestris, Pinus halepensis, Pinus pinea, Pinus pinaster</strong></td>
<td>+</td>
<td>SR, BH (near Ivanjica), CRO (Dalmatia), MN (Durmitor, Sutomore, Podgorica, Ulcinj)</td>
</tr>
</tbody>
</table>
**Sphaeropsis sapinea**  
(Fr.) Dyko et Sutton  
It causes drying of current vegetation shoots. Infection occurs immediately after the beginning of growth of the new shoot. The pycnidia are formed on the needles one year after shoot drying. Numerous pycnidia are also formed on cone scales.  

<table>
<thead>
<tr>
<th>Species</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pinus nigra</em></td>
<td>++</td>
</tr>
<tr>
<td><em>Pinus sylvestris</em></td>
<td></td>
</tr>
<tr>
<td><em>Pinus jeffrey</em></td>
<td></td>
</tr>
<tr>
<td><em>Pinus peuce</em></td>
<td></td>
</tr>
<tr>
<td><em>Pinus heldreichii</em></td>
<td></td>
</tr>
</tbody>
</table>

**Legend**: +++ highly significant; ++ moderately significant; + low significant

As it is shown in results, plenty of fungi attack pines in Western Balkan region. To control these fungi it is necessary and very important to apply appropriate treatments against these diseases. The most of the fungi are pathogens of weakness, i.e. attacking only trees which are under stress caused by insects, lacking of nutrients and water in soil, climate changes, human impact or other fungi.

The most common control treatments in Balkan region are chemical appliances with copper fungicides which are not harmful for environment and pine trees but only target is specific pathogen. For some fungi species it is necessary to remove alternative hosts to prevent spreading of disease. In case of high level of disease, radical treatments could be applied such as cutting of infected trees, removing from the area, burning etc. Similar treatments are used in other European countries as well. Main difference is that Balkan region lacking with more researches of biological and genetical treatment methods.

Our opinion for prevention of development and further spreading of fungi diseases is necessity to avoid monocultures and return species back to their autohtonic and natural habitats.
5. Conclusion

Based on the conducted research it was shown that:

✓ **Fungi on pine trees which are the most widespread in Balkan region are:**

   *Armillaria* spp., *Cyclaneusma niveum*, *Gremmeniella abietina*, *Lophodermium pinastri*, *Lophodermium seditiosum*, *Mycosphaerella pini* and *Sphaeropsis sapinea*

✓ **According to pathogens significance *in situ* we divided them into three categories:**

   - **high significance fungi:** *Armillaria* spp., *Gremmeniella abietina*, *Heterobasidion* spp., *Mycosphaerella pini*, *Phacidium infestans* and *Sphaeropsis sapinea*;

   - **fungi with middle significance:** *Cenangium ferruginosum*, *Coleosporium tussilaginis*, *Cronartium flaccidum*, *Cronartium ribicola*, *Cyclaneusma minus*, *Cyclaneusma niveum*, *Lophodermella sulcigena*, *Lophodermium pinastri*, *Lophodermium seditiosum*, *Melampsora pinitorqua*;

   - **fungi with low significance:** *Mycosphaerella dearnessii* and *Phellinus pini*.

✓ Parasitic pathogens attack all species of pine which are growing in Balkan region but the most damaged were *Pinus nigra* and *Pinus sylvestris*. Beside these species pathogens also damaged in high degree *Pinus mugo* and *Pinus heldreichii*. In coastal region of Croatia and Montenegro the most sensitive species to parasitic attack were *Pinus halepensis*, *Pinus pinea* and *Pinus pinaster*.

✓ Diseases have had a very substantial impact on pines in natural ecosystems as well as in plantations. We are gradually gaining an understanding of the complex and often subtle roles that pathogens play in natural forests ecosystems. The study of tree pathogens should be considerably enhanced in order to equip us with the wherewithal to deal with future disease problems. Efforts to exclude pathogens from new environments through more effective quarantine strategies should also be vigorously supported.
6. Summary

In history of tree development, diseases were a key factor for big forest loses in Balkan region. They are present in all phases of production - seed production, seedling nurseries, forest plantations and in natural forests.

Intensive afforestation of bare lands and deforested areas in the area of the former Yugoslavia was undertaken in the second half of the 20th century. The most frequent species in afforestation were *Pinus* species. The establishment of monocultures over large areas was followed by numerous problems already from the beginning. In pine plantations, among harmful biotic factors, especially important were pests and diseases caused by parasitic fungi (e.g. needle diseases, branch and shoot dying, root rot, etc.).

The aim of this study was to research distribution, life cycle and the control possibilities of the most important pine parasitic fungi in Western Balkan region i.e. Serbia, Bosnia and Herzegovina, Croatia, Slovenia and Montenegro.

In order to evaluate the effect of pine diseases and their distribution in Balkan countries, we collected the data and analysed them. General concept of these analysis was to assess all existing data of pathogen attacks using objective parameters and to put them together.

The pathogen species which appears in Balkan countries were described according to their hosts, symptoms, distribution and control treatments.

Sequence of the fungi species is shown according to colonized part of the pine plant order (needles, shoots, branch bark, stem or root).

Based on the conducted research it was shown that fungi on pine trees which are the most widespread in Balkan region are: *Armillaria* spp., *Cyclaneusma niveum*, *Gremmeniella abietina*, *Lophodermium pinastri*, *Lophodermium seditiosum*, *Mycosphaerella pini* and *Sphaeropsis sapinea*.

Parasitic pathogens attack all species of pine which are growing in Balkan region but the most damaged were *Pinus nigra* and *Pinus sylvestris*. Beside these species pathogens also damaged in high degree *Pinus mugo* and *Pinus heldreichii*. In coastal region of Croatia and Montenegro the most sensitive species to parasitic attack were *Pinus halepensis*, *Pinus pinea* and *Pinus pinaster*. 
As it is shown in results, plenty of fungi attack pines in Western Balkan region. To control these fungi it is necessary and very important to apply appropriate treatments against these diseases. The most of the fungi are pathogens of weakness, i.e. attacking only trees which are under stress caused by insects, lacking of nutrients and water in soil, climate changes, human impact or other fungi.

The most common control treatments in Balkan region are chemical appliances with copper fungicides which are not harmful for environment and pine trees but only target is specific pathogen.

Our opinion for prevention of development and further spreading of fungi diseases is necessity to avoid monocultures and return species back to their autohtonic and natural habitats.
7. References


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