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Dieback of Austrian pine – the epidemic occurrence of *Sphaeropsis sapinea* in southern Moravia

L. JANKOVSKÝ, D. PALOVČÍKOVÁ

Mendel University of Agriculture and Forestry, Faculty of Forestry and Wood Technology, Brno, Czech Republic

ABSTRACT: In the course of recent years, various cases of Austrian pine dieback of all age classes have occurred in a number of localities. At all localities, Sphaeropsis shoot – killing of pine caused by *Sphaeropsis sapinea* (Fr.) Dyko et Sutton syn. *Diplodia pinea* (Desm.) Kickx. was recorded on a mass scale in declining shoots. Fruit bodies of the fungus were found on twigs, at the base of needles being particularly abundant on cones. Generally, the fungus is considered to be an opportunist pathogen which spreads on damaged tissues of shoots accelerating their dying. In trees with the same symptoms of damage, *Brunchorstia pinea* (Karsten) Höhn was also detected at some localities. The occurrence of scales *Leucaspis pussila* (Loew.) can be considered to be the demonstration of stress load of trees suffering from drought. Feeding marks of *Pityophthorus pityographus* (Ratzeburg) and *Ips acuminatus* (Gyll.) were noticed. Annual shoots were damaged by species of the genus *Magdalis* at some localities. The impact of climatic extremes, particularly drought the effect of which is also manifested in increments is an important predisposition factor. The situation under study is rather the result of a chronic damage to pine and secondary activation of some pathogens particularly of *Sphaeropsis sapinea* and pests which can occur as mortality stressors.

Keywords: *Sphaeropsis sapinea*; dieback; *Pinus nigra; Magdalis*; drought

In recent five years, dieback of Austrian pine (*Pinus nigra* Arnold) occurred in a number of localities in southern Moravia. The first symptoms were recorded after winter 1997/1998 in plantings of Austrian pine in the town residential area of Brno. At the same time, it was possible to find individual dieback of Austrian pine even at other localities of southern Moravia. Manifestations of the decline are accompanied by the activation of a number of insect pests (URBAN 2000). About till 2000, dieback of individual trees occurred. After winter 2000/2001 and particularly 2001/2002, acceleration of damage occurred when the decline manifested markedly and groups of trees and even whole stands were affected. Similar symptoms are also known from northern Moravia, eastern Bohemia etc. In the majority of localities, it refers to extreme sites with marked impacts of drought. However, it is not a rule. Causes of damage are generally mentioned as manifestations of stress or results of short-term droughts (URBAN 2000). The same demonstrations of decline were found in Slovakia, Hungary (KOLTAY 1997), Austria (CECH, CAPRETTI 1995; CECH, TOMICZEK 1996), Italy (MARESI et al. 1999), Slovenia (JURC et al. 1998), Croatia (DIMINIC 1996), France (PIOU et al. 1991), the Netherlands (DAM, KAM 1984) etc. In the first half of the 90's, Austrian pine decline was observed in Central Bohemia accompanied by the occurrence of *Cenangium ferruginosum* Fr. (JANČAŘÍK oral commun.).

It is possible to suppose that the damage to Austrian pine is an example of global decline when predisposition generally abiotic stressors occur disturbing physiological processes of a host species. Fungal pathogens or insect pests respond to the impaired health condition as initiation or even mortality stressors. The objective of the paper is to evaluate the occurrence of fungal pathogens and some other harmful factors on Austrian pine and to assess their role in the process of decline and dieback.

MATERIAL AND METHODS

On sites with the occurrence of Austrian pine decline, both dead and green annual shoots were sampled to analyse the presence of fungal pathogens and other pests. Shoots were incubated in a moisture chamber. Samples were taken from green tissues for cultivation on malt-extract agar. Determination was carried out on the basis of usual macroscopic and microscopic determination procedures.

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From sample trees at localities Kobeřice (District Brno country), Miroslav (District Znojmo) and Brno-Soběšice (District Brno-City; Křtiny Training Forest Enterprise), discs were taken at b.h. for annual ring analyses with the aim to study changes in the increment of declining Austrian pine trees at localities under investigation.

RESULTS AND DISCUSSION

The characteristic manifestation of dieback is crown drying which initially affects particularly the lower part of crowns. Rusty crowns are conspicuous already at a distance. Affected trees survive for several years, however, the damage increases and the trees generally die after 2 to 3 years. In some trees, revitalization was observed, other trees survive even after 5 years of damage. Annual shoots die from ends buds being also damaged. The decline begins in the lower part of a crown which can be considered to be the manifestation of drought impacts when conifers saturate preferentially crown tops by water. Trees are affected individually, however, groups of pine trees are also affected. Needles dry from their base on dead shoots where they remain several months.

Infested trees are conspicuous due to their reddish needles. In twigs and buds, heavy resin exudation occurs. The buds are aborted. In some cases, the heavy resin exudation occurs even in stems.

In addition to *Pinus nigra* Arnold, the same symptoms of pine dieback were found in some relative species of pines, viz. *Pinus heldreichii* Christ cv. Smidt, *Pinus ponderosa* P. et C. Lawson, *Pinus jeffreyi* Grev. et Balf., *Pinus leucodermis* Ant., *Pinus aristata* Engelm. etc. Generally, it concerned similar dieback of shoots as in Austrian pine. In Scots pine *Pinus sylvestris* L., this type of decline was not observed. For the present, it is possible to state that this type of decline does not manifest markedly in Scots pine. The health condition of Scots pine on common sites with Austrian pine was markedly better in spite of dieback of individual trees. Generally, it referred to, however, the invasion of bark insect particularly *Ips acuminatus* (Gyll.).

Impacts of climatic extremes

A marked predisposition stressor are effects of abiotic factors particularly impacts of drought in early spring which was especially marked just in last three years. Austrian pine *Pinus nigra* as a species of southern Europe and the Mediterranean should tolerate summer droughts and higher temperatures. However, it poorly tolerates drought during early spring as well as sudden fluctuations of temperatures in winter months. Moreover, in case of older stands data are missing on the behaviour of older trees and stands of Austrian pine under conditions of the Czech Republic. In the past, Austrian pine was planted on extreme sites. Manifestations of Austrian pine decline were, however, observed even in plantings with other conifers such as Scots pine *Pinus sylvestris* L. and Norway spruce *Picea abies* (L.) Karsten which did not suffer from any visible symptoms of decline. In addition to drought it is possible to take into consideration also temperature extremes in winter months particularly sudden changes in temperature at the end of winter and in early spring. Increased nitrogen depositions resulting in the imperfect maturation of tissues and their increased susceptibility to frost appear to be a risk factor. Problems with water are also demonstrated by a fact that particularly lower parts of crowns dry up. In conifers unlike broadleaves, satura-

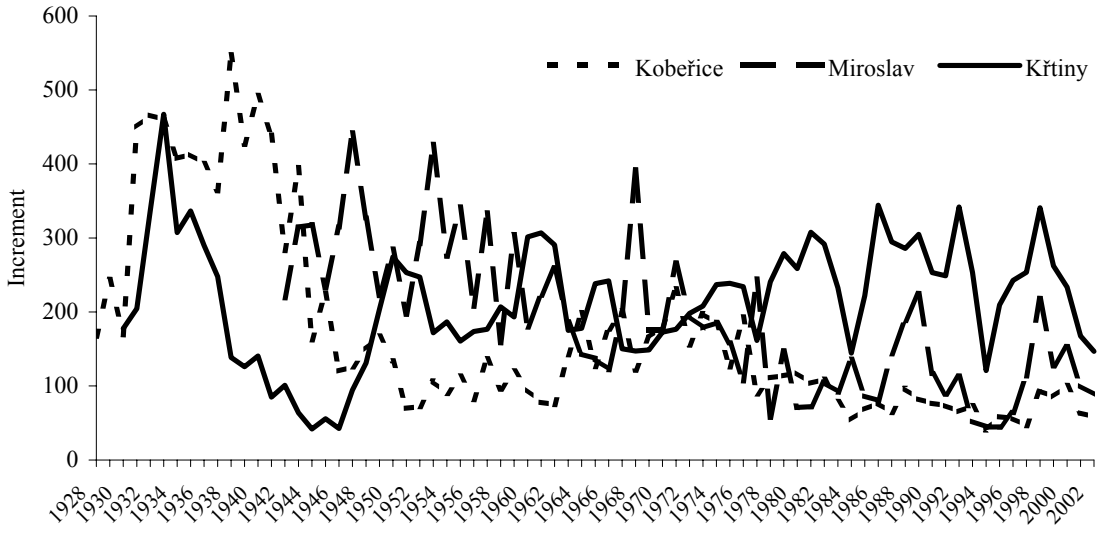

Fig. 1. Comparison of increments from annual rings taken from trees growing at localities showing decline of Austrian pine *Pinus nigra*. A sudden increase of increments in 1998 followed by a sudden decrease in next years appears to be a conspicuous event. This trend is evident at all localities. Moreover, at Miroslav and Kobeřice localities, there is a long-term increment depression in the last ca. 25 years with a turn in 1977/1978. Within the period, an increase in increments in studied trees is evident in 1990 and 1998. After the increase in 1998 decrease in increments occurred

tion of crowns occurs from the crown top which remains green for a long time. In broadleaves, on the other hand, primarily skeletal branches dry up.

Effects of abiotic factors were also corroborated by annual ring analyses which showed evident decrease in increments in the period of drought. The general trend of increments is also decreasing. The reason of the fact consists in the effect of climatic extremes which manifested first of all at Koběřice and Miroslav localities (Fig. 1). Samples from the Křtiny Training Forest Enterprise show evidently more favourable conditions for the growth of Austrian pine as compared with other localities under study.

Fungal pathogens

Biotic factors, mainly fungi and insect respond as so-called initiation stressors to increased predisposition of woody species. To a greater or smaller extent they can occur as mortality stressors. More or less marked linkages to abiotic factors are also of use. Simultaneously, biotic interactions occur particularly between insect and fungi.

At all localities, Sphaeropsis shoot – killing of pine caused by *Sphaeropsis sapinea* (Fr.) Dyko et Sutton syn. *Diplodia pinea* (Desm.) Kickx. was found on a mass scale on declining shoots. Fruit bodies of the fungus were found at the locality on twigs and bases of needles and they were particularly abundant on cones. Generally, the fungus is considered to be an opportunist pathogen which spreads on damaged tissues of shoots and accelerates their dying. Some authors regard the fungus as a saprophyte which responds to dying of tissues. Aborting the buds accompanied with resin exudation on bark of twigs and stems is typical of the fungus. Fruit bodies are black pycnids forming just on cones, twigs and at the base of needles. Typical conidia released from pycnidia are first hyalline, unicellular, finally dark-brown, two-celled, 25–40 × 10–15 µm in size.

With respect to the high frequency of *Sphaeropsis sapinea* on the studied samples when the fungus was detected virtually in all declining Austrian pine trees showing drying of crowns it is possible to regard the fungus an important and highly risk agent participating in the decline. The observed symptoms of damage to Austrian pine correspond to symptoms which are ascribed just to the fungus (PIOU et al. 1991). *Sphaeropsis sapinea* was also found in other species of pines with similar symptoms of damage, viz. *Pinus ponderosa*, *P. jeffreyi, P. heldreichii, P. leucodermis* and *P. aristata*. As a saprophyte, the fungus was detected on dead needles of *Pinus sylvestris*.

It is necessary to understand the occurrence of the fungus as a response to the tress load of a host by climatic stressors, particularly climatic extremes in the winter period and in early spring. Infection of another flowers (PETERSON 1977) often precedes infection of shoot tissues. CECH and CAPRETTI (1995) mention that heavy precipitation in summer 1989 and spring 1990 significantly contributed to the development of infection. *Sphaeropsis sapinea* occurs already in green tissues without visible manifestations of a disease (FLOWERS et al. 2001). Thus, there is a question to what extent its activity is caused by an increased stress load. For example BACHI and PETERSON (1985) demonstrated in increased susceptibility of Austrian pine plants stressed by drought to *Sphaeropsis sapinea* infection.

In samples from the Rožnov pod Radhoštěm locality and from foothill localities of the Orlické hory Mts., *Brunchorstia pinea* (Karsten) Höhn [teleomorph *Gremmeniella abietina* (Lagerb.) Morelet, syn. *Ascocalyx abietina* (Lagerb.) Schläpher-Bernhard] was also found. Declining Austrian pine trees showed the same symptoms of infection as dying pines in southern Moravia. Samples were already taken in spring. At the locality, a similar damage was also observed in *Pinus strobus* L., *P. aristata* Engelm. and *Picea pungens* (L.) Karst. Also there, *Sphaeropsis sapinea* was detected on cones.

Compared to expectation, the occurrence was not found of *Cenangium ferruginosum* which is together with *Sphaeropsis sapinea* mentioned as a causal agent in similar cases of Austrian pine decline (MARESI et al. 1999; DIMINIC 1995; CECH, TOMICZEK 1996).

Isolations from stems by a split billet method were largely negative and no important endophytic organism was found in tissues. In some discs which were taken for annual ring analyses from Kobeřice and Miroslav Hills localities, symptoms of blue-staining showed as the result of secondary infection by fungi of the genus *Ophiostoma* sp. Probably it concerned *Ophiostoma piceae* (Muench) H. & P. Syd. or *Ophiostoma minus* (Hedgc.) H. & P. Syd. This infection, however, should be considered to be secondary. On the discs, green colonies of *Trichoderma viride* Pers. grew also abundantly. However, this definitely refers to a fungus which does not show any connection with the decline under study. Thus, it is possible to exclude a suspicion to the presence of pathogens of vascular tissues as potential causal agents of the studied decline of *Pinus nigra*. As for saprophytic species, *Epicoccum nigrum* Link, *Fusarium* sp., *Verticillium* sp. etc. were detected by isolation.

On needles of Austrian pine with symptoms of shoot dying, *Cyclaneusma* needle cast caused by *Cyclaneusma minus* (Butin) Di Cosmo, Peredo et Minter and *C. niveum* (Pers.) Di Cosmo, Peredo et Minter generally considered a saprophyte on dead needles was usually present. Dothistroma needle blight *Mycosphaerella pini* E. Rostrup is a problem of young pines. The fungus, however, does not show any relationship with the dieback of generally premature and mature stands. At some localities, e.g. Březina by Svitavy, both types of damage occurred, i.e. Dothistroma nedle blight and dieback of shoots, however, it occurred in young pines here. In needles, other fungi were also detected, viz. *Sclerophoma pithyophilla* (Corda) Höhn, *Phoma* sp., *Lophodermium seditiosum* Minter, Staley et Millar, *L. pinastri* (Schrad.) Chev., *Sphaeropsis sapinea* etc.

The occurrence of *Armillaria* sp. was found only exceptionally and it concerned a response to the tree dieback.

Root rots as causal agents of the observed decline of Austrian pine *Pinus nigra* can be positively excluded.

Insect pests

In needles virtually at all localities, scales *Leucaspis pussila* (Loew.) occurred abundantly. The presence of sucking insect generally signalizes the stress load of a host, above all the deficiency of water which is manifested in the increased concentration of carbohydrates of cell juices so that tissues are attractive just for sucking insect. At the same time, nitrogen metabolism is affected. Other species of insect were also found. In samples taken in the Křtiny Training Forest Enterprise, feeding marks were noted of *Pityophthorus pityographus* (Ratzeburg). At the Kobeřice locality, *Ips acuminatus* (Gyll.) occurred as well.

In samples taken from the Miroslav locality, numerous marks were found after the maturation feeding of *Magdalis* sp. It was probably a species *Magdalis frontalis* (Gyll.). In the course of maturation feeding, *Magdalis* sp. eat up circular holes accompanied by resin exudation in the phloem and cambium of young shoots. They are mentioned as heliophilous and thermophilic beetles. *Magdalis* sp. are also mentioned as vectors of some fungal diseases particularly of vascular mycoses. They winter as imagoes, maturation feeding occurs from April to May–June. The time corresponds with the beginning of damage manifestations. It is necessary to consider *Magdalis* sp. as one of risk factors of the dieback of *Pinus nigra* at thermophilic localities. In case of the beetles it is, however, necessary to mention the stress load by drought as an important predisposition factor.

CONCLUSION

For the present, it is not possible to confirm positively that the damage under study is the result of a common gradation of a pathogen or pest. The decline of Austrian pine and some other introduced species is probably the result of chronic damage and secondary activation of some pathogens. The proportion of particular stressors in the decline is not evident yet. Particularly impacts of climatic extremes should be considered to be an important factor. Wilted or otherwise damaged tissues are predisposed to the colonization of fungal and insect pests. In case of Austrian pine, it concerns above all fungal infection by *Sphaeropsis sapinea* which (as the only potential pathogen) was found but some exceptions at all localities. In trees with the same symptoms *Brunchorstia pinea* was also detected. Austrian pine decline is also accompanied by the occurrence of some insect pests. For the future, it is possible to expect increased frequency of similar episodes of decline which recently affected some introduced pines. It is important that autochthonous Scots pine *Pinus sylvestris* is not affected for the present.

Manifestations of Austrian pine decline can be partly attributed to climatic extremes or climatic changes. Unfortunately, even species from southern regions of Europe respond to changes in environmental conditions similarly as domestic species being equally susceptible to diseases. On the other hand, for a number of pathogens the change in climatic conditions represents the removal or shift of a climatic barrier which hampered their further progress. The observed epidemic occurrence of *Sphaeropsis sapinea* can serve as an example.

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Chřadnutí borovice černé – masový výskyt *Sphaeropsis sapinea* na jižní Moravě

L. JANKOVSKÝ, D. PALOVČÍKOVÁ

Mendelova zemědělská a lesnická univerzita, Lesnická a dřevařská fakulta, Brno, Česká republika

ABSTRAKT: V posledních letech se na řadě lokalit projevují různé projevy chřadnutí borovice černé všech věkových tříd. Na všech lokalitách byla na chřadnoucích letorostech zaznamenána v masovém měřítku *Sphaeropsis sapinea* (Fr.) Dyko et Sutton, syn. *Diplodia pinea* (Desm.) Kickx. Plodnice houby byly na této lokalitě zjištěny na větvičkách, na bázích jehlic a zvláště hojné byly plodnice na šiškách. Obecně je tato houba považována za oportunního patogena, který se šíří na poškozených pletivech letorostů a urychluje jejich odumírání. Na stromech se stejnými symptomy poškození byla na některých lokalitách zaznamenána i *Brunchorstia pinea* (Karsten) Höhn. Výskyt štítenek *Leucaspis pussila* (Loew.) je možné považovat za projev stresové zátěže stromů suchem. Byly zaznamenány požerky *Pityophthorus pityographus* (Ratzeburg) a *Ips acuminatus* (Gyll.). Letorosty na některých lokalitách byly poškozeny křováky z rodu *Magdalis*. Významným predispozičním faktorem je dopad klimatických extrémů, zvláště pak sucha, jejichž vliv se projevuje mimo jiné i na přírůstech. Pozorovaná situace je spíše výsledkem chronického poškození borovice a sekundární aktivizace některých patogenů, především *Sphaeropsis sapinea,* a škůdců, kteří se mohou uplatňovat jako mortalitní stresory.

Klíčová slova: *Sphaeropsis sapinea*; chřadnutí; *Pinus nigra; Magdalis*; sucho

V posledních letech se na řadě lokalit projevují různé projevy chřadnutí borovice černé všech věkových tříd. U borovic černých asi do věku 20 let je častou příčinou *Mycosphaerella pini* E. Rostrup, která se v současnosti běžně vyskytuje především v oblasti Moravy a Slezska. Starší stromy od věku 60–80 let prosychají od spodních částí koruny. Symptomaticky jde o dieback, odumírání od konců letorostů. Stejné příznaky chřadnutí jsou známy ze Slovenska, Rakouska, Maďarska a Slovinska. Z hlediska dynamiky byly první případy poškození zaznamenány zhruba před pěti lety, poškozené stromy zpravidla několik let přežívají. Poškození se postupně šíří a v roce 2002 na řadě lokalit akcelerovalo.

Za predispoziční faktor je nutné považovat dopady abiotických faktorů, především pak sucha, které se v posledních letech projevuje zejména v předjaří, tedy v období, které je z hlediska potřeb vody borovice černé zásadní. Projevy nedostatku vody je možné sledovat na dokumentovaném snížení přírůstů letokruhů. Nejasné jsou rovněž dopady mrazu, zvláště pak náhlé střídání silných mrazových period s oblevou koncem zimního období.

Zavadlá či jinak poškozená pletiva jsou predisponována ke kolonizaci houbovými a hmyzími škůdci. V případě borovice černé jde především o houbovou infekci *Sphaeropsis sapinea,* která byla zjištěna jako jediný potenciální patogen na všech lokalitách. Projevy chřadnutí odpovídají symptomům, které jsou v případě tohoto patogena uváděny. Na stromech se stejnými symptomy poškození byla na lokalitě Rožnov pod Radhoštěm zaznamenána i *Brunchorstia pinea* (Karsten) Höhn., když *Sphaeropsis sapinea* (Fr.) Dyko et Sutton byla z odebraných vzorků zjištěna pouze na šiškách.

Dalším faktorem, který se na procesu chřadnutí podílí, je hmyz. Na jehlicích prakticky ze všech lokalit byly v hojné míře přítomny štítenky sosnové *Leucaspis pussila* (Loew.). Přítomnost savého hmyzu obecně signalizuje stresovou zátěž hostitele, především pak nedostatek vody, který se projevuje zvýšenou koncentrací cukrů buněčných šťáv, takže pletiva jsou atraktivní právě pro savý hmyz. Zároveň je ovlivněn metabolismus dusíku. Byly zjištěny i jiné druhy hmyzu. Na odebraných vzorcích ze ŠLP Křtiny byly zaznamenány požerky *Pityophthorus pityographus* (Ratzeburg), na lokalitě Kobeřice rovněž *Ips acuminatus* (Gyll.). Na lokalitě Miroslavské kopce bylo pozorováno silné poškození letorostů křováky z rodu *Magdalis*. Mezi biotickými škůdci je možné uvažovat úzké souvislosti, kdy *Sphaeropsis sapinea* může pronikat do pletiv právě žíry křováků, kteří mohou být zároveň i vektory této houby.

Prozatím nelze jednoznačně potvrdit, že pozorované poškození je důsledkem prostého přemnožení nějakého patogena či škůdce. Pozorovaná situace je spíše výsledkem chronického poškození borovice a sekundární aktivizace některých patogenů, především *Sphaeropsis sapinea,* a škůdců, kteří se mohou uplatňovat jako mortalitní stresory.

Pozorovaná situace je pravděpodobně výsledkem chronického poškození borovice a sekundární aktivizace některých patogenů. Dosud není zřejmý podíl jednotlivých stresorů na chřadnutí borovice černé *Pinus nigra* Arnold, případně některých dalších borovic. Za významný faktor je nutné považovat dopady klimatický extrémů. Zavadlá či jinak poškozená pletiva jsou predisponována ke kolonizaci houbovými a hmyzími škůdci. V případě borovice černé jde především o hou-

bovou infekci *Sphaeropsis sapinea*, která jako jediný potenciální patogen byla zjištěna až na výjimky na všech lokalitách. Na stromech se stejnými symptomy byla zaznamenána i *Brunchorstia pinea*. Do budoucna je možné očekávat zvýšenou četnost podobných epizod chřadnutí, které v současnosti postihlo některé introdukované borovice. Významnou skutečností je, že autochtonní borovice lesní *Pinus sylvestris* L. prozatím postižena není.

Corresponding author:

Dr. Ing. LIBOR JANKOVSKÝ, Mendelova zemědělská a lesnická univerzita, Lesnická a dřevařská fakulta, Lesnická 37, 613 00 Brno, Česká republika
tel.: + 420 545 134 116, fax: + 420 545 211 422, e-mail: jankov@mendelu.cz