Some aspects of alder decline along the Lužnice River

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ABSTRACT: Alder decline along watercourses is one of the marked manifestations of tree decline in the Czech Republic. Local decline of alder trees is documented in the Czech Republic for about 15 years. The aim of this paper is to evaluate causes of alder decline and assess health conditions of other species of riparian stands at 2 localities on the medium reach of the Lužnice River. Effects were studied of abiotic and biotic stressors on the health condition of tree species. No fungal pathogen was found in tissues of declining alders which would be present in all trees and which could be considered to be the main causal agent of the decline. Even an occurrence of the causal agent of alder decline named alder-*Phytophthora* has not been proved. Tree-ring analyses demonstrated decreasing trends of an increment in alders; however, an abiotic or biotic factor showing direct effects on the fluctuation of tree ring dimensions has not been positively determined. A marked role in the alder decline is demonstrated particularly by abiotic factors accompanied by the secondary activation of some pathogens. Generally, the phenomenon can be named as polyetiologic decline.

Keywords: *Alnus*; decline; tree-ring study; fungi; pathogens; environmental stress

Alder decline along watercourses is one of the marked manifestations of tree decline in the Czech Republic (CR) assuming locally the character of an epidemic. The local decline of alder is documented in the CR for about 15 years. Since 1993 when a new hybrid pathogen named alder-*Phytophthora* was isolated in Great Britain for the first time, alder decline is linked with the pathogen throughout western and Central Europe. Also in the CR, a number of present papers deal with alder decline caused by parasitic fungi particularly of the genus *Phytophthora.* However, none of recent papers regards the alder decline as a phenomenon caused by the whole complex of biotic and abiotic factors. Effects of floods on the health condition of alder and other species along watercourses have not been studied in detail. Although problems of the resistance of species of riparian stands to the long-term waterlogging of a locality and their suitability for planting along watercourses in the period of frequent floods are rather topical the problems have not been studied adequately yet.

On the medium reach of the Lužnice River, alder decline began to show more markedly in spring 2003, ie about 8 months after a disastrous flood in August 2002. Crowns of alders became dry, leaves were reduced and dark brown to black necrotic spots occurred on the lower part of stems. At the end of summer 2003, defoliation of some trees reached even 100%. However, there is a question if alder trees declined already before the flood which subsequently supported the process of decline or if the flood functioned as a trigger of the extensive die-back of alder along the Lužnice River.

Alder creates arbuscular endomycorrhiza with *Zygomycetes*, particularly with genera *Glomus* and *Gigaspora.* At the same time, it creates ectomycorrhiza. A number of ectomycorrhizal fungi is specific for alder, viz *Lactarius lilacinus* (Lasch: Fr.) Fr., *Lactarius obscuratus* (Lasch) Fr. and *Russula*

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pumila Rouzeau et Massart, *Paxillus rubicundulus* P.D.Orton. etc.

Alder is the only indigenous species creating symbiosis with actinomycetes of the genus *Frankia* spp. which, after the penetration into the alder root, stimulate cells of a primary bark to divide and colonize originating tissues of root nodules. *Frankia* is able to bind atmospheric nitrogen fixation values being comparable with values in *Rhizobium* spp. living in symbiosis with plants of the family *Fabaceae* (Struková 1997).

Attention was paid to the decline of alder in Europe already before 1900. However, causes and a detailed description of symptoms of the decline mostly do not occur and often only one factor of the decline is mentioned. During the first half of the 20th century, the symptoms began to be documented in more details and it was taken into account that the cause of the decline can consist in the whole complex of factors. These factors then act in synergy or, more frequently, subsequently. Alder decline caused by the number of pathogenic factors is manifested in the colour of leaves, dwarf growth of the whole crown and subsequent death of some main branches or of the whole tree (Cech, Hendry 2003).

In the 50s of the last century, a marked dieback of alder occurred in Tuscany (Moriondo 1958 in Cech, Hendry 2003). Symptoms in a crown were not noted; the main symptom of decline was thus the presence of delimited bark necroses on the alder stem. These necroses gradually developed in canker resulting in the formation of longitudinal cracks in bark. A bacterium *Erwinia alni* Surico et al. was identified (Surico et al. 1996 in Cech, Hendry 2003) in wounds.

Two species of fungi are often related to bark necroses: *Ophiovalsa suffusa* (Fr.) Petr. and *Valsa oxystoma* Rehm (Hartig 1894; Münch 1927; Nijpels 1900; Schwarz 1928; Truter 1947; von Tobeuf 1893 in Cech, Hendry 2003). But some exceptions (Appel 1904; Nijpels 1900; Schwarz 1928 in Cech, Hendry 2003) the authors treat the fungi as secondary parasites.

In central Poland, dieback of individual branches and whole crowns of alders occurred in 1991. A fungus *Melanconium apiocarpon* Link. (Kwasna 1993) was identified as a originator of the decline.

In 1997, a pathogen *Pseudomonas syringae* van Hall was isolated from twigs and leaves of black alder in Italy. This pathogen caused their necrotic injury (Scortichini 1997).

The main cause of disturbing buds is related to the attack of a fungus *Sporidesmium wroblewski* Bubák. The role of the fungus in the process of decline is, however, rather problematic.

In 1993, a fungus very similar to *Phytophthora cambivora* (Petri) Buisman was isolated from declining alders at some localities in Great Britain. In Europe, it is a rather frequent pathogen of roots of hard-wooded broadleaves (Brasier et al. 1995). Subsequently, it was found that it referred to a new hybrid of taxa *Phytophthora cambivora* and *P. fragariae* Hickman with a characteristic behaviour and morphological properties which was named alder-*Phytophthora* (Brasier et al. 1999 in Streito 2003). Symptoms of the attack were typical of the genus *Phytophthora* known from the decline of other broadleaved species. Crowns of trees dried, leaves were abnormally small and yellow. Dead roots were often without bark. The decline is accompanied with necroses of conductive tissues of roots and lower parts of a stem with dark effluxes from bark lesions.

The problem of alder decline linked with alder-*Phytophthora* is known from Great Britain, the Netherlands, Germany, Sweden, France, Austria, Belgium, Ireland, Poland and Hungary (Gibbs, van Dijk 2003; Claessens 2003; Lonsdale 2003). In 2001, the pathogen was detected in the Czech Republic (Gregorová et al. 2003). Alder-*Phytophthora* was detected in three European species of alder, viz *Alnus glutinosa*, *A. incana* and *A. cordata.* The majority of records refers to *Alnus glutinosa* which is most related to riparian stands (Streito 2003).

The only reliable evidence of the disease is isolation of the pathogen which is, however, rather problematic (Gregorová et al. 2003).

Drought in a summer period was considered to be the primary cause of alder decline since 1825 (Althann 1889 in Cech, Hendry 2003).

Records on damage to alder in Central Europe due to intense winter frosts are rare. On the other hand, it was found that abnormally mild winter could increase the sensibility of alder to early frosts (Augst 1903 in Cech, Hendry 2003).

Drainage and channelization of streams and rivers often resulted in the destruction of riparian alder stands in Europe. In 1891, floods on the Odra River in Poland destroyed extensive stands of black alder (Schmidt 1892 in Cech, Hendry 2003). Intense floods on the Danube River in 1892 caused depositions of the thick layer of mud at lower parts of stems of black alder which resulted in the rot of roots, decrease in increment and death of many trees (Eisenmenger 1894 in Cech, Hendry 2003). In northern Germany, the period between 1912 and 1932 was characterized by heavy rains, repeated floods and elevated groundwater table which resulted in the die-back of young alders due to the shortage of oxygen in soil (Gassert 1934 in Cech, Hendry 2003).

Alder decline affected black alder *Alnus glutinosa* (L.) Gaertn. already at the end of the 19th and at the beginning of the 20th century. It occurred also in artificially planted trees which grew well in the course of the first 10 to 12 years and soon began to produce fruits. Then, the growth markedly decreased between the 13th and 20th years and die-back of crowns occurred. From the crown towards the stem base, necroses of brown colour developed. On the basis of available data it was concluded that this disorder could be explained by known climatic, edaphic or biological factors. Planted alders were affected most markedly (Münch 1927, 1935, 1936, 1937 in Cech, Hendry 2003).

In the Czech Republic, attention is paid to the local decline of alder since the 60s of the last century. But only Jančařík (eg 1986, 1988, 1993) notices that it is necessary to see that the cause of alder decline consists in the whole spectrum of abiotic and subsequently biotic factors. As for wood-destroying fungi, alder decline is above all related to *Inonotus radiatus* (Sow.: Fr.) P. Karst. which colonizes dying stems. Infection of a root system by *Armillaria* spp. is not also marked. At present, *Armillaria* species are frequently found in trees infected by alder-*Phytophthora* (Cech, Hendry 2003).

Also some other wood destroying fungi can occur on alder such as *Fomitopsis pinicola* (Sw.: Fr) P. Karst., *Phellinus alni* (Bondartsev) Parmasto, *Daedaleopsis confragosa* (Bolton: Fr.) J. Schrot etc.

Notes on damage to alder stems by osier weevil *Cryptorrhynchus lapathi* L. are rather frequent in our country but none of authors ascribes to the insect pest a fundamental importance. Only Urošević (1963) concludes that *Cryptorrhynchus lapathi* and its larvae can be the potential causal agent of the spread of cancerous necroses caused probably by bacterial infections.

As for leaf-eating pests, at a number of localities *Agelastica alni* L. (Jančařík 1993) occurred rather frequently at the end of the 80s. At the end of the 80s, local gradations occurred of *Dryocoetes alni* Georg. developing under bark of alder (Jančařík 1993) in southern and northern Bohemia and in northern Moravia.

In the Czech Republic, alder decline began to occur on a larger scale in the mid-80s. One of the first notices came from the region of Jindřichův Hradec where alder decline was observed along the Hamerský stream and along the Nežárka River. Symptoms of the decline were very variable and heterogeneous. Terminal shoots of thin branches in crowns exhibited decreased increment and loss of foliage. Thus, marked thinning of crowns occurred. Small leaves often occurred in crowns of declining alders (Jančařík 1993).

At the end of the 90s, several foci of the new type of alder decline occurred in our country. Symptoms of damage were similar as in other regions of Europe. In September 2001 during the study of declining alder in the Ohře River watershed along the Chodovský potok stream near Karlovy Vary, a pathogen alder-*Phytophthora* was isolated for the first time. The fungus was detected in a substrate with damaged roots and in conductive tissues of dying individuals of *Alnus glutinosa* (Černý et al. 2003).

At present, there are several foci of the occurrence of alder decline in our country. It refers to the region of the Ohře River (where the invasion pathogen was detected first) and the region of the Labe River – Pardubice and Hradec Králové, Pojizeří, Poorličí and newly also Plzeňsko. A number of isolated foci has been also recorded (Gregorová et al. 2003).

The decline is also related to abiotic factors. In Silesia in 1914, alder decline occurred as a result of spring frosts. Frequent spring frosts during the development of annual shoots caused their damage (Rockstroh-Karmine 1915 in Cech, Hendry 2003).

In spring 1960, a more intense damage to about a 10-year-old alder plantation planted in a waterlogged grassy depression occurred in the Hlavenec Forest District near Brandýs nad Labem. Stems were not mostly foliated to a certain height being reddish and as if ringed at breast height. On the basis of sample analyses it was found that it referred to the first frost damage and heavy attack by semi-parasitic fungi. Similar damage was noticed at a windbreak near Podivín where about a 5-year-old planting of alder was (after damage by frost) attacked by a non specified fungus from the genus *Cytospora* spp. (Urošević 1963).

Gregorová et al. (2003) ranks water table fluctuation and long-term waterlogging of a locality among main abiotic causes of alder decline. According to the author, the long-term waterlogging of a locality is often the cause of death of part of the root system and weakening the trees. The flooding can also affect mycorrhizal and actinorrhizal relationships.

The aim of the paper is to evaluate causes of alder decline and to assess health conditions of other species of riparian stands at 2 localities on the medium reach of the river. Partial objectives are as follows: assessing the present situation, determination of the dynamics of worsening the health condition of alder, evaluation of the impact of floods in 2002 and other abiotic stressors on the health condition of alder, to cover the spectrum of fungal pathogens.

MATERIAL AND METHODS

Localities under study

Two localities where marked alder decline occurred were selected on the central and lower reach of the Lužnice River in August 2003. Each of the localities was formed by sections of various length of the left and right bank of the river with trees growing in the immediate vicinity of the water table.

The first locality occurs in Planá nad Lužnicí behind a road bridging the Lužnice River towards Sezimovo Ústí. On the left bank (upstream), it refers to a reach at a distance of 47.2–48.4 km from a place where the Lužnice River flows into the Vltava River. A reach on the right bank exhibit the following river log: 47.5–48.0 km. Geographical co-ordinates of the centre of the locality: 49°21´13´´N and 14°42´03´´E, altitude 394 m.

The second locality occurs in the vicinity of Dobronice near Bechyně. The river log of the locality on the left bank is 20.6–21.2 km, that on the right bank is 20.7–21.0 km. Geographical co-ordinates of the locality are roughly 49°20´26´´N and 14°30´04´´E, altitude 365 m.

By means of habitual diagnostics, the health condition of alder and other species was evaluated in August 2003 and 2004.

In April 2004, disks of wood were taken for tree-ring analyses. Sampling was carried out four-times from various parts of alders to isolate fungal pathogens in spring and in autumn 2004. In a dendrochronological laboratory, tree-ring analyses were carried out of delivered disks in May 2004. In a phytopathological laboratory, fungal pathogens were always isolated after sampling. On the basis of data of the Czech Hydrometeorological Institute (ČHMÚ) in České Budějovice climatic conditions were evaluated both in the period of floods and in years before and after the floods.

Evaluation of the health condition of alder and other species of riparian stands

In Planá nad Lužnicí, 200 alder trees and 43 other species were evaluated on a 1,200 m long section on the left bank of the Lužnice River in 2003 and 2004 (300 m were omitted due to inaccessible terrain), on a 500 m long section on the right bank, 80 alders and 10 others species. In Dobronice near Bechyně, on a 600 m long section 80 alders and 25 other species were evaluated on the left bank and on a 300 m long section on the opposite bank 80 alders and 32 other species.

The degree of damage to a tree was determined on the basis of crown defoliation in %. Notice No. 78/1996 on the determination of zones of damage to forests by air pollution on the basis of defoliation of crown in % distinguishes 6 degrees of damage to a tree (Table 1).

Within the evaluation of the health condition of trees roots of declining alders were also sampled. In some of them, the degree of their mechanical damage and damage to mycorrhizas were evaluated in a laboratory.

The spectrum of fungi

Sampling for the isolation of fungal pathogens was carried out only on the Planá nad Lužnicí locality. Twigs were selected with reduced leaves, sparse foliage or parts of branches on the interface between living and dead wood. Roots were sampled from the upper soil layer of 40 cm. Both thick and fine roots served as a tested material. Wood and bark were taken from the lower part of a stem from the proximity of dark necroses.

Twigs, roots, bark from the vicinity of necrosis and wood under necrosis were taken from declining alder trees – in total 4 various kinds of samples which were cultivated on wort agar – Malt Extract Agar (MEA) after surface sterilization by ethanol and sodium hypochlorite. After last sampling at the end of October 2004, other three kinds of substrates were used to compare the growth and for qualitative ana-

Table 1. The degree of damage to a tree according to Notice No. 78/1996

Degree of damage to a tree	Damage description	Crown defoliation (%)
0	undamaged tree	0
1	slightly damaged tree	1–25
2	medium-damaged tree	26–50
3	heavily damaged tree	51–75
4	dying tree	76–100
5	dead tree	100

lyses of microscopic fungi: Corn Meal Agar (CMA), V8 Juice Agar (V8JA), Potato Carrot Agar (PCA). The method "green apples" (Streito 2003) was applied for isolation of patogen from tissue as well.

Dendrochronological analysis

Samples for dendrochronological analyses can be taken as a cross section (disk) or as a bore. From the viewpoint of measurements, a cross section was more suitable because potential disorders in the tree growth could be better assessed. In autumn 2003, workers of the Povodí Vltavy – provoz Lužnice institution marked trees intended for felling at both localities. Disks were sampled from these stems. In Planá nad Lužnicí and Dobronice 16 and 15 disks, respectively were taken.

Samples for dendrochronological analyses were processed according to standard dendrochronological methods (Rybníček 2004). Measurements are carried out on cross sections. In order the tree ring width to be easily measurable the wood surface has to be sanded. For this operation, disk or belt sanders were used. Wood samples were measured on a special measuring table equipped with a sliding screw mechanism and an impulse-meter recording the interval of the table-board shift and thus also the annual ring width. From here, information is transferred directly to a computer. Samples were always measured from the centre (i.e. from the oldest annual ring) towards to stem girth and always perpendicular to the next annual ring. Annual increments were measured in one direction only with the accuracy of measurements amounting to 0.01 mm.

RESULTS

Weakening, damage to and decline of alder trees on the central and lower reaches of the Lužnice River began to appear more markedly after a disaster flood in 2002. Alders grow there together with other accompanying species closely in a row along the river. At localities under study in Planá nad Lužnicí and in Dobronice near Bechyně, there were marked differences in the vitality of particular trees, viz from visually quite healthy to totally dead trees.

The decline of alder at the locality manifests itself in drying crowns. In about half of the trees, reduced leaves occur. In 2003, creation of small branches on stems occurred only in 12% of all living alders. A year later, regeneration potential of alder occurred in more than half of living trees. Another symptom consists in necroses of the lower part of stems which were found in 15% of all living alders in 2003.

Table 2. Symptoms of the alder decline in 2003 and 2004 (from the total number of living trees)

Locality	Course and symptoms of the decline											
	Drying the whole crown		Drying particular branches		Creation of small branches on a stem		Reduced leaves		Yellowing of leaves		Bark necroses	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Planá n. L. – left bank	185	93	1	2	16	55	110	51	0	0	26	24
(in %)	100	100	0.5	2	9	58	59	54	0	0	14	25
Planá n. L. – right bank	70	52	0	0	20	36	28	20	5	5	18	14
(in %)	100	100	0	0	28	68	39	38	7	9	25	26
Dobronice – left bank	28	21	0	0	0	13	23	5	1	1	3	2
(in %)	100	100	0	0	0	62	82	24	4	5	11	10
Dobronice – right bank	73	63	0	0	7	26	42	35	2	1	7	10
(in %)	100	100	0	0	10	41	58	55	3	1	10	16
Total	356	229	1	2	43	130	203	111	8	7	54	50
(in %)	100	100	0.3	0.9	12	57	57	48	2	3	15	22

Table 3. Degrees of damage to alder in 2003 and 2004 and the development of health conditions on the left and right bank in Planá nad Lužnicí and Dobronice

Pieces	Mean dbh (cm)	
440	39.1	
Year	2003	2004
Degree of damage 0	11	5
Degree of damage 1	59	17
Degree of damage 2	53	33
Degree of damage 3	85	74
Degree of damage 4	151	103
Degree of damage 5	81	82
Felled	0	129
Mean degree of damage	3.3	3.6

A year later, their occurrence slightly increased. These necroses are accompanied by the efflux of dark exudates on the bark surface above the necrosis. Only in the negligible part of living alders, drying of particular branches and yellowing of leaves occurred (Table 2).

Damage to alders growing on the left alluvial bank of the river was substantially higher than that of alders growing on the opposite bank. In August 2003, some 68% of all alders growing on left banks were evaluated by the degree of damage 4 or 5 (dying or dead tree) whereas on the opposite bank, it was only about 27% of alders. Also felling of alders in February 2004 was particularly aimed at the left bank of the Lužnice River.

No relationship has been found between the degree of damage to alder and its dbh (diameter at breast height) or age or a distance from the river. It was possible to see side by side alders with dbh 15 and 42 cm, both with about 70% defoliation.

Mechanical damage to stem bases occurs sporadically on the left bank of the river. In Planá nad Lužnicí and in Dobronice, its presence was detected in 8 and 5 alders, respectively. In the majority of cases, it refers to trees which are used by fisher for tying up boats. These boats then wear off root swellings and bases of the trees during the fluctuation of water table and floods. These injuries have become a direct gate for the entrance of infections and wood-destroying fungi occur often on them.

Comparing the health condition in 2003–2004, it is necessary to note that the health condition of 210 alders (48%) from the studied set of 440 trees worsened since 2003. Some 129 dead alders (29%) growing predominantly on left banks of both localities were felled in February 2004. It resulted in an apparent decrease in the average degree of damage. In 20% alders, health conditions did not change since 2003; in 3% alders, health conditions have improved thanks to their regeneration potential (Table 3).

The development of health conditions of alder is depicted on left and right banks of particular localities, the development of health conditions of alder on left and right banks in total and the development of health conditions of alder separately in Planá nad Lužnicí and Dobronice. In leaves of all living alders, feeding of *Agelastica alni* (L.) was evident, however, their abundance did not indicate increased or even mass outbreak.

Dendrochronology

On the basis of analyses it is possible to state that growth responses of particular trees on vari-

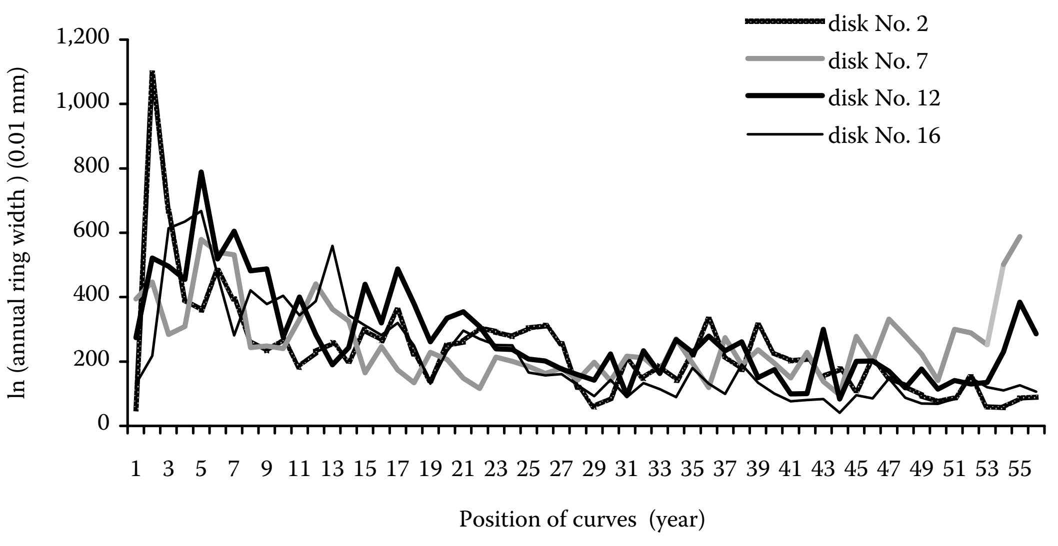

Fig. 1. Dynamics of the growth of four alders of the same age in Planá nad Lužnicí

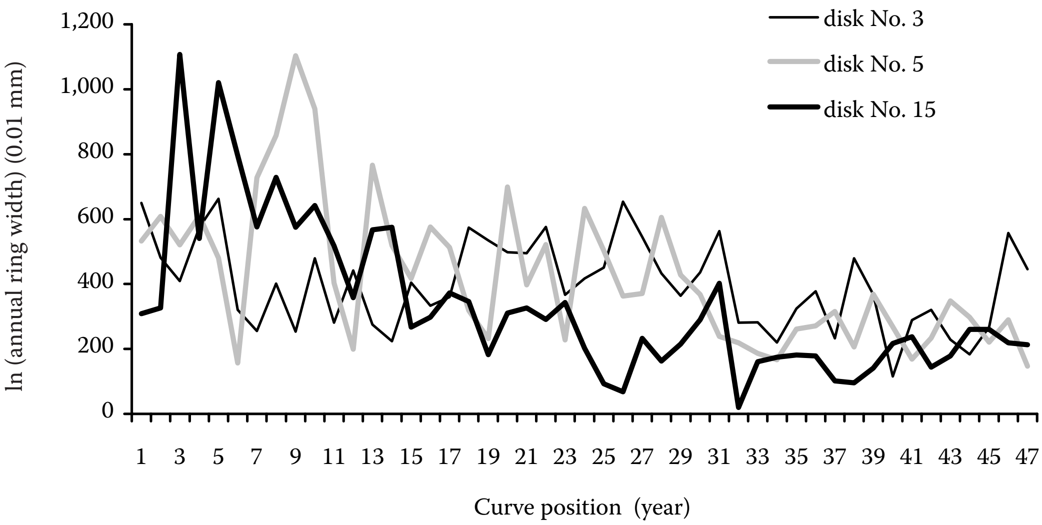

Fig. 2. Dynamics of the growth of three alders of the same age in Dobronice

ous climatic extremes were quite heterogeneous. A problematic point consisted in a fact that in measured disks sampled from dead trees dating the time of death was missing. If it occurred in the year of floods, in the day of their felling (winter 2004) or already before the flood. This problem was to be solved compiling tree-ring curves from particular disks. We supposed that these curves would be of the same trend. Shifting the curves along the horizontal axis in such a way statistical values of similarity (simultaneity, *t*-tests) to be as high as possible we wanted to obtain information on the year of the last wood increment.

However, this procedure cannot be realized due to the quite different trend of all curves, ie absolutely different response of particular trees. The response of trees to drought in 1992 can serve as an example. About in a half of trees, the annual ring width decreased as compared with the previous year, in the remaining trees an increment increased. The response of trees on the flood in 2002 was probably similar.

The fact can be best documented comparing the growth dynamics of alder trees of the same age which grew under the same edaphic and climatic conditions. At the Planá nad Lužnicí locality, the growth of four alders was compared (three alders 56 years old, one alder 55 years old). Disks Nos. 2, 7, 12 and 16 (Fig. 1) were cut off from the alders.

Moreover, the growth was compared of three alders of the same age (47 years) from the Dobronice locality from which disks Nos. 3, 5, 15 (Fig. 2) were sampled. Growth curves of these alders should exhibit a similar growth trend and after their potential shift within the *x* axis they should meet in the majority of extreme values. Moreover, in the optical comparison of curves in both diagrams no position is evident of their correlation.

By means of annual ring analyses, the age of felled trees corresponding to the number of measured annual rings on particular disks was determined (Table 4). However even there, a marked diversity is evident in the growth dynamics of particular trees.

On the basis of the annual ring analysis it is possible to conclude that:

1. Alder as a species with diffuse-porous wood ranks among the most complicated group of tree species from the viewpoint of tree-ring analysis. Annual ring boundaries are often very indistinct.
2. Increments of alders are markedly eccentric and the frequency of missing and double annual rings is rather high. Therefore, it is necessary the disks to be measured in more directions.
3. Each of the trees responded otherwise to various stimuli of the ambient environment. A growth trend has not been found which would be common for selected trees.

Table 4. Evaluation of changes in the health condition of alders in 2003–2004

Condition	Number of trees	Proportion (%)
Decrease in the degree of damage	11	3
Increase in the degree of damage	210	48
Steady condition	90	20
Felled	129	29

The spectrum of fungal pathogen in alder

In both studied localities, the occurrence of 7 species of wood-destroying fungi was found. In

Table 5. Age and dbh of trees disks were sampled from which for annual ring analyses

Locality **Planá nad Lužnicí**

Disk No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Mean
Age (years)	62	56	39	43	36	45	55	51	58	47	26	56	51	62	37	56	49
dbh (cm)	29	26	26	19	24	17	28	27	31	24	26	31	26	28	21	24	25

Locality **Dobronice near Bechyně**

Disk No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Mean
Age (years)	49	43	47	38	45	47	68	49	59	38	49	34	36	22	47	44
dbh (cm)	30	27	37	18	32	40	38	22	60	26	39	27	37	44	32	34

12 declining alders in Dobronice and Planá nad Lužnicí *Inonotus radiatus* (Sow.: Fr.) P. Karst. occurred, in 3 alders *Chondrostereum purpurem* (Pers.) Pouzar, in 2 alders *Pleurotus ostreatus* (Jacq.: Fr.) Kummer and on 4 alder stumps *Hypholoma fasciculare* (Huds.) Quél. All these species occurred in heavily damaged or even dead trees which corroborated a fact that it generally referred to secondary saprophytic pathogens attacking weakened trees. During a field survey of the vicinity of both localities, the occurrence of *Pholiota populnea* (Pers.: Fr.) Kuyper & Tjall.-Beukers was detected in alder wood on a wood stack in Katov near Soběslav. Papers do not mention the species on alder yet. It refers to one of the first documented finds. In addition to alder health conditions of other species were also monitored (*Quercus, Salix, Populus, Cerasus, Acer, Robinia*). Damage to these species ranged between degrees 0 and 1 which corresponded maximally to 25% defoliation.

Based on gradually taken samples the composition of particular species of microscopic fungi was determined. As yet, 6 genera of microscopic fungi have been identified during analyses; in two genera also a species has been determined. From dying roots, wood under necroses, twigs and hard rot taken from stumps *Fusarium* spp. was isolated. One isolate was classified as *Fusarium culmorum* (WG.Smith) Saccardo. Some other species as *Acremonium strictum* W. Gams., *Alternaria alternata* (Fr.: Fr.) Keissl. was identified as well. From living twigs, *Alternaria* sp., and *Epicoccum nigrum* Link. were isolated. From a hard rot sampled in April 2004 from an alder stump, genera *Sordaria* spp. and *Mucor* spp. were isolated. The isolate from bark was identified as *Gliocladium catenulatum* Gilman & Abbott. Fungi isolated using method "Green apples" was identified as *Fusarium* spp. only. Species from genus *Pytophthora* was not registered.

DISCUSSION AND CONCLUSION

In the course of monitoring the locality in 2003 to 2004, an unambiguous answer referring to causes of alder decline along the Lužnice River has not been obtained. On the basis of facts obtained it is possible to conclude that it refers to polyetiologic decline. A marked role is played particularly by biotic factors which are accompanied by the activation of some pathogens.

The decline can be explained by the set of following causes:

1. Mechanical effects of a flood in August 2002

The flood in August 2002 was characterized by a very fast course. The river water table rose during 12 hours by several meters which was reflected in the immense pressure and transporting force of water carrying away all what was in the way. Due to the pressure of water, layers of sediments coating the tree root system were washed. Thus, particular roots were uncovered and their susceptibility to mechanical damage increased. Particularly fine roots were broken and other roots were injured by transported material and undermined. This hypothesis is documented by substantially larger damage to alders (but also other species) growing on alluvial banks of the river as against those growing on opposite banks. In the period of the greatest stagnation when water reached up to a height of 3 m from the stem base stems of some trees were moreover heavily stressed by pressure. This could result in further damage to root systems of trees and in extreme cases even to windbreaks. This fact is caused by the death of mechanically stressed parts of roots. On the other hand the some symptoms of alder decline were observed prior to flood in August 2002. The flood accelerate alder decline in this locality.

2. Oxygen deficit – hypoxia

Black alder *Alnus glutinosa* is a characteristic species of riparian stands. In spite of this, it does not tolerate groundwater fluctuations and long-term flooding by stagnant water. Alders, however, tolerate spring increase in the river water table. Water is cold being quickly oxidized and contains thus sufficient amounts of oxygen. Moreover, leaves of trees are only in the stage of development and trees do not exhibit high requirements for transpiration or water uptake. On the other hand, summer floods represent considerable danger for trees. Water in a river is of higher temperature which is manifested by the higher kinetic energy of water molecules forcing out oxygen molecules. Moreover, the amount of oxygen in water is reduced by the flow rate deceleration which occurred several days after the water stagnation in the Lužnice River. According to local inhabitants, water stopped on some places even 4 weeks. Thus, roots were suffocated and their water uptake ceased. Overheating the alder leaves occurred because air temperatures immediately after the flood were relatively high. Because demands for transpiration increased and water uptake by roots decreased trees were subject to huge stress which manifested itself in their wilting.

3. Invasion of microorganisms to weakened trees

The occurrence of a pathogen alder-*Phytophthora* along the Lužnice River on the basis of laboratory analyses has not been proved yet, nevertheless, it is possible to suppose its invasion to trees weakened by floods. Together with other species of microscopic fungi it accelerates alder decline.

4. Trees in the stage of late maturity

Alder is ranked among short-lived species and, therefore, some alders naturally die out at an age of about 60 years. It also applies to the situation along the Lužnice River. Limited funds of institutions taking care of riparian stands can result in the gradual disintegration of the stands in consequence of high age. As a matter of fact, these stands were not regenerated for a long time and care of the stands was negligible. During the actual evaluation of the health condition of alders it was found that the age of trees was not related to the degree of damage – i.e. both old and young alders exhibit the same degree of decline.

Within actual monitoring the health condition of alder a number of risks factors has been found; however, none of them cannot be considered to be the only causal agent of the decline. It is possible to state the polyetiologic character of alder decline with significant effects of climatic factors as predisposition stressors.

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Některé aspekty chřadnutí olší na Lužnici

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ABSTRAKT: Chřadnutí olší podél vodotečí je jedním z výrazných projevů chřadnutí dřevin v České republice. Lokální chřadnutí olší je v České republice dokumentováno přibližně 15 let. Cílem příspěvku je zhodnotit příčiny chřadnutí olší a posoudit zdravotní stav ostatních dřevin břehových porostů na dvou lokalitách na středním toku řeky Lužnice. Sledovali jsme vliv abiotických a biotických stresorů na zdravotní stav dřevin. V pletivech chřadnoucích olší nebyl zjištěn žádný houbový patogen, který by byl přítomen na všech stromech a kterého by bylo možné považovat za hlavního původce chřadnutí. Neprokázal se ani výskyt původce chřadnutí olší označovaný jako alder-*Phytophthora*. Letokruhová analýza poukázala na klesající tendenci přírůstů u olší, nebyl však jednoznačně stanoven abiotický, případně biotický faktor, který by měl přímý vliv na zjištěné kolísání velikosti přírůstů. Výraznou úlohu v chřadnutí olší hrají především abiotické faktory, které jsou doprovázeny sekundární aktivizací některých patogenů. Celkově je možné tento jev označit jako polyetiologické chřadnutí.

Klíčová slova: olše; chřadnutí; letokruhová analýza; houby; patogeni; environmentální stres

Chřadnutí olší podél vodotečí je jedním z výrazných projevů chřadnutí dřevin v České republice, místně začíná mít charakter epidemie. Lokální chřadnutí olší je v České republice dokumentováno přibližně 15 let, zejména od roku 1993, kdy byl ve Velké Británii poprvé izolován nový hybridní patogen označovaný jako alder-*Phytophthora*. I u nás se celá řada současných prací věnuje chřadnutí olší způsobeným parazitickými houbami (zejména z rodu *Phytophthora*). Žádná z těchto prací poslední doby však nepohlíží na chřadnutí olší jako na jev způsobený celým komplexem biotických a abiotických faktorů, ani podrobně nesleduje vliv povodní na zdravotní stav olší a dalších dřevin podél vodních toků. Přestože je problematika odolnosti dřevin břehových porostů vůči dlouhodobému přemokření lokality a jejich vhodnosti k výsadbě kolem toků v době častých povodní poměrně aktuální, nebylo jí zatím věnováno mnoho pozornosti.

Na středním toku řeky Lužnice se chřadnutí olší začalo výrazněji projevovat na jaře roku 2003, tedy přibližně osm měsíců po katastrofální povodni v srpnu 2002. Koruny olší prosychaly, listy byly zmenšené, na spodních částech kmenů se objevovaly tmavě hnědé až černé nekrotické skvrny. Na konci léta 2003 dosáhla defoliace některých stromů až 100 %. Otázkou však zůstává, zda olše chřadly již před povodní, která následně podpořila proces chřadnutí, nebo zda povodeň působila jako spouštěcí mechanismus rozsáhlého odumírání olší na Lužnici.

Koncem 90. let 20. století se u nás objevilo několik ohnisek nového typu chřadnutí olší. Příznaky poškození byly podobné jako v jiných oblastech Evropy. V září roku 2001 byl během studií chřadnoucích olší v povodí Ohře na Chodovském potoce poblíž Karlových Varů poprvé izolován patogen alder-*Phytophthora*. Houba byla zjištěna v substrátu s poškozenými kořeny a ve vodivých pletivech hynoucích jedinců *Alnus glutinosa* (Černý et al. 2003). V současné době u nás existuje několik ohnisek výskytu chřadnutí olší. Jedná se o Poohří (kde byl invazní patogen zjištěn poprvé), dále střední Polabí v okolí Pardubic a Hradce Králové, Pojizeří, Poorličí a nově o Plzeňsko. Kromě nich je evidována řada izolovaných ohnisek (Gregorová et al. 2003).

Chřadnutí je možné vysvětlovat souborem následujících příčin:

Mechanický účinek povodně v srpnu 2002

Povodeň v srpnu 2002 byla charakteristická velice rychlým průběhem. Hladina vody v řece stoupla během 12 hodin o několik metrů, což se promítlo v obrovském tlaku a unášecí síle vody, která odnášela všechno, co jí stálo v cestě. Vlivem tlaku vody došlo k vymytí vrstvy sedimentů obalující kořenový systém stromů. Tím se jednotlivé kořeny obnažily a zvýšila se jejich citlivost k mechanickému poškození. Zejména jemné kořeny byly zpřetrhány, další byly poraněny unášeným materiálem a podemlety. Dokladem této hypotézy je podstatně větší poškození olší (ale i dalších druhů dřevin) rostoucích na náplavových březích řeky než na březích protějších.

Ve chvílích největší stagnace, kdy voda sahala až do výšky 3 m od báze kmene některých stromů, byly navíc kmeny silně namáhány v tlaku. To mohlo vést k dalšímu narušení kořenových systémů stromů, v krajních případech i k vývratům. K tomuto faktu vede odumření mechanicky namáhané části kořenů.

Nedostatek kyslíku – hypoxie

Olše lepkavá *Alnus glutinosa* je charakteristickou dřevinou břehových porostů. Přesto nesnáší kolísání hladiny spodní vody a dlouhotrvající zaplavení stojatou vodou. Jarní zvyšování hladiny vody v řece olším nevadí. Voda je totiž chladná, rychle se okysličuje a obsahuje tedy dostatek kyslíku. Listy stromů jsou navíc teprve v rozvoji a strom nemá vysoké požadavky ani na transpiraci, ani na příjem vody. Velké nebezpečí pro stromy představují naproti tomu letní záplavy. Voda v řece má vyšší teplotu, což se projevuje ve vyšší kinetické energii molekul vody, které vytlačují molekuly kyslíku. Množství kyslíku ve vodě se navíc snižuje se zpomalením toku vody, k čemuž došlo několik dní po stagnaci vody v Lužnici. Podle místních obyvatel zůstala na některých místech voda stát i čtyři týdny. Došlo tak k přidušení kořenů, které přestaly přijímat vodu. A protože teploty vzduchu bezprostředně po povodni byly poměrně vysoké, došlo navíc k přehřátí listů. Tím, že se zvyšovaly nároky na transpiraci a snižoval se příjem vody kořeny, byly stromy vystaveny obrovskému stresu, který se projevil jejich vadnutím.

Invaze mikroorganismů na oslabené stromy

Přítomnost patogena alder-*Phytophthora* na řece Lužnici zatím ještě na základě laboratorních analýz potvrzena nebyla, přesto lze předpokládat jeho invaze na povodní oslabené stromy. Spolu s dalšími druhy mikroskopických hub urychluje chřadnutí olší.

Stromy ve fázi pozdní dospělosti

Olši řadíme mezi krátkověké dřeviny, proto ve věku kolem 60 let již některé olše přirozeně odumírají. Na Lužnici tomu není jinak. Omezené finance subjektů, v jejichž kompetenci je péče o břehové porosty, mohou mít za následek postupný rozpad břehových porostů v důsledku vysokého věku. Porosty se totiž dlouhou dobu neobnovovaly, nepečovalo se o ně. Při vlastním hodnocení zdravotního stavu olší bylo zjištěno, že stáří stromů nesouvisí se stupněm poškození – tzn. staré i mladé olše chřadnou stejně.

V rámci konkrétního sledování bylo zjištěna řada rizikových faktorů, žádný z nich však nelze označit za jediného původce pozorovaného chřadnutí. Lze konstatovat polyetiologický charakter chřadnutí s významným vlivem klimatických faktorů jako predispozičních stresorů.

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