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Distribution and ecology of Armillaria species in some habitats of southern Moravia, Czech Republic

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In forest ecosystems of southern Moravia, five species of annulate *Armillaria* species and the exannulate species *Armillaria socialis* were observed. *Armillaria ostoyae* shows its ecological optimum in the forest type group *Querceto-Fagetum* where it represents an important parasite of spruce. *Armillaria gallica* is a dominant species of floodplain forests and thermophilic oak communities where *A. ostoyae* is lacking. *Armillaria mellea* occurs on broadleaved species and fruit trees. *Armillaria cepistipes* and *A. borealis* were detected in the Drahanská vrchovina Highlands only, *A. socialis* occurs rarely on stumps and bases of dead oak trees in a hard-wooded floodplain forest along the Dyje river. It is one of the northernmost localities in Europe. *Armillaria* spp. were identified in 79 hosts, 33 of which were coniferous species. The main role of *Armillaria* spp. consists in the decomposition of wood in soil (stumps, roots) and in the species spectrum regulation in the course of succession.

Key words: *Armillaria*, root rots, hosts, ecology

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V lesních ekosystémech jižní Moravy bylo zjištěno 5 druhů prstenatých václavek a bezprstenný druh *Armillaria socialis*. *Armillaria ostoyae* má ekologické optimum ve skupině lesních typů *Querceto-Fagetum*, kde je významným parazitem na smrku. Dominantním druhem lužních lesů a termofilních doubrav je *A. gallica*, kde naopak zcela scházela *A. ostoyae*, *A. mellea* se vyskytuje ohniskovitě na listnatých a ovocných dřevinách. Václavky *A. cepistipes* a *A. borealis* byly zjištěny pouze na Drahanské vrchovině. *Armillaria socialis* se vyskytuje vzácně na pařezech a bázích odumřelých dubů v tvrdém luhu podél Dyje. Jde o jednu z nejseverněji položených lokalit v Evropě. Václavky byly identifikovány na 79 hostitelích, z toho bylo 33 druhů jehličnanů. Hlavní funkce václavek spočívá v dekompozici dřevní hmoty v půdě (pařezy, kořeny) a v regulaci druhového spektra dřevin v průběhu sukcese.

INTRODUCTION

The species of the genus *Armillaria* are mentioned from all continents with the exception of the Antarctic. They are part of a number of ecosystems, from tundra across mixed forests of the temperate zone and tropical forests to sclerophyllous formations of semideserts. An overview of the present knowledge on the distribution of the *Armillaria* species in particular continents is given e. g. by Kile et al. (1994).

In Europe, on the basis of genetic studies and intersterility tests by Korhonen (1978) and other nomenclatural and taxonomic papers (e.g. Marxmüller 1982, 1987, 1992; Termorshuizen and Arnolds 1987), five species of annulate *Armillaria* species are distinguished: *Armillaria borealis* H. Marxmüller et Korhonen, *A. cepistipes* Velen., *A. ostoyae* (Romagn.) Herink, *A. mellea* (Vahl: Fr.) Kumm. and *Armillaria gallica* H. Marxmüller et Romagn. In addition, two exannulate *Armillaria* species occur in Europe, viz. *A. socialis* (DC.: Fr.) Fayod and *A. ectypa* (Fr.) Emel.

The geographical distribution of *Armillaria* spp. in particular countries of Europe is described in a number of papers (Guillaumin et al. 1993; Sicoli, Luisi and Manicone 1994; Tsopelas 1994; Źólciak 1989 etc.). The distribution of *Armillaria mellea* s. l. in the Czech Republic or Czechoslovakia is descibed in a number of papers concerning particularly forest pathology aspects (Málek 1966, 1973; Lazebníček 1973; Černý 1973, 1985; Jančařík and Jankovský 1999; Jankovský 1995 etc.). Ecology, distribution and host spectrum of *Armillaria mellea* (Vahl: Fr.) P. Kumm. is given by Antonín (1988).

Armillaria spp. were noticed in more than 600 woody species and herbs (Raab 1962, Guillaumin et al. 1985, Kile et al. 1991) from all climatic zones. Among the hosts, we can find representatives of trees, shrubs, herbs and grasses. *Armillaria* spp. attacks also fruit trees and in some cases even agricultural crops. There are also mycorrhizal associations of *Armillaria* spp. with some non-green orchids such as *Galeola septentrionalis* and *Gastrodia cunningamii* (Hamada 1940, Terashita and Chuman 1989, Cambell 1962). *Armillaria* spp. also cause damage to plantings of ornamental and fruit species and other agricultural crops. In Europe, *Armillaria mellea* is frequently mentioned as a causal agent of dying lemon-trees in the Mediterranean, almonds, apricot trees, peach trees and other stone fruits, grape-vine, walnuts etc. (Guillaumin and Lung-Escarmant 1985). As causal agents of diseases, *Armillaria* spp. are mentioned even in strawberry, prickly pear, cotton-plant and various species of vegetables. In the Czech Republic, *Armillaria* spp. cause occasionally damage to fruit orchards and gardens.

As primary parasites, *Armillaria* spp. occur in the Czech Republic mainly in secondary stands of conifers, particularly of Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*). The main predisposition factor is a disorder in the water regime of a host plant. There is a marked water deficit in secondary spruce stands at lower altitudes and highlands (Málek 1966, Jankovský 1995).

The aim of the paper is to determine the species spectrum, distribution and phytopathological aspects of *Armillaria* spp. in forest ecosystems of southern Moravia represented by forest stands in the hills in the vicinity of Brno, thermophilic oak communities and floodplain forests in the alluvia of the Dyje and Morava rivers.

Fig. 1 The monitored areas. I: The Křtiny Training Forest Enterprise (TFE), II: The Bobravská pahorkatina hilly country, III: The park plantings and gardens in Brno, IV: The Lednice-Valtice area.

MATERIAL AND METHODS

Distribution, species and host spectrum were studied in 4 areas:

I. The Křtiny Training Forest Enterprise (TFE), represented by the southern edge of the Drahanská vrchovina Highlands. The TFE region is situated at the northern edge of Brno. Autochthonous oak/beech, beech and fir/beech stands in the 3rd-4th forest vegetation zones (oak/beech and beech zones) were replaced here by secondary spruce stands in the past. The studied area is situated on the border between southern and central Moravia in the region of the Drahanská vrchovina Highlands geomorphological unit formed by highlands on monotonous sediments of culm. The biota belong to the 3rd oak/beech to the 5th fir/beech forest vegetation zone and only along edges, thermophilic elements occur more frequently. Potential vegetation consists of beech communities of the *Luzula* type, in broken relief floriferous beech communities. Biodiversity is increased by contact of the Drahanská vrchovina Highlands with the north-Pannonian and Carpathian subprovince. Considerable remnants of beech and cultivated spruce stands occur on slopes. The natural flora is markedly affected by anthropogenic activities particularly by extensive plantings of exotic woody species. These are then potential hosts of fungal parasites including *Armillaria* sp. The altitude of the region ranges between 350 and 600 m.

II. The Bobravská pahorkatina hilly country (the Bobrava Uplands), NW, W and SW of Brno separates the Drahanská vrchovina Highlands from the central Bohemian-Moravian Highlands. Forest communities are formed there similarly as in the Křtiny TFE by oak/beech and beech stands which are markedly affected by human activities. Particularly at higher altitudes, natural communities have been replaced by spruce plantations.

III. Park plantings and gardens in part of the built-up area of Brno include generally secondary park plantings aged 40 to 250 years. They represent only a fragment of the autochthonous flora and the occurrence of *Armillaria* sp. was monitored above all on a number of exotic species there. Urban alley plantings and gardens are also included.

IV. The ecosystems of a floodplain forest and thermophilic oak communities of the Lednice-Valtice area, including forest ecosystems of the Dolnomoravský úval ravine. Floodplain forests are represented by soft-wooded and hard-wooded floodplain stands along the Dyje and Morava rivers. Křivé jezero National Nature Reserve (NNR) near Bulhary as well as Randšpurk NNR and Cahnov NNR in Soutok game preserve can serve as examples of the locality. Thermophilic oak communities are natural forest ecosystems on gravel alluvia in the Dyje river floodplain represented for example by the locality Rendezvous. *Quercus cerris,* among others, appears to be a stand-forming species.

The results are presented as the summary of records from 1988–1999.

Species identification was carried out primarily according to morphology of fruitbodies. In problematic cases, the identification was verified by intersterility tests. The occurrence of infection by *Armillaria* spp. was also indicated according to symptoms of infection such as the presence of rot, mycelial fans (syrrocia), rhizomorphs etc. Species identification was in some cases only based on the morphology of vegetative mycelium in vitro. The mycelium was cultivated on malt-extract agar (MEA 3). For the purpose of physiological tests, also other media were used, e.g. Sabouraud's agar, Czapek-Dox agar and also other organic substrates.

Armillaria spp. was considered to be a parasite when its fruitbodies or direct symptoms of infection were found on a living individual.

Isolated strains (44) and specimens (86) are deposited in the collection of cultures of the Department of Forest Protection and Game Management, MUAF Brno.

RESULTS

In the studied regions of southern Moravia, five annulate species of *Armillaria* and the exannulate species *A. socialis* (Tab. 1) were found. *Armillaria* spp. were determined in 79 woody species, 44 of which were broadleaved species and 33

Table 1. Summary of frequencies of *Armillaria* records according to their relation to a host (1989–1997).

Region		*A. borealis*		*A. cepistipes*		*A. ostoyae*		*A. mellea*		*A. gallica*		*A. socialis*		*Armillaria* sp.		*Armillaria* total	
		sapr.	par.	sapr.	par.	sapr.	par.	sapr.	par.	sapr.	par.	sapr.	par.	sapr.	par.	**sapr.**	**par.**
Drahany Highlands	conif.	4	1	6	–	763	144	–	–	23	3	–	–	63	88	**859**	**236**
	broadl.	3	1	20	2	40	21	1	2	64	23	–	–	–	46	**128**	**95**
	total	7	2	26	2	803	165	1	2	87	26	–	–	63	129	**981**	**326**
Bobrava Uplands	conif.	–	–	2	–	157	39	–	–	14	6	–	–	16	24	**189**	**69**
	broadl.	–	–	–	–	11	8	28	4	26	4	–	–	–	33	**65**	**49**
	total	–	–	2	–	168	47	28	4	40	10	–	–	16	57	**254**	**118**
Park and garden plantings in Brno	conif.	–	–	–	–	3	13	–	–	2	5	–	–	1	7	**6**	**25**
	broadl.	–	–	–	–	–	–	1	5	4	25	–	–	–	8	**5**	**38**
	total	–	–	–	–	3	13	1	5	6	30	–	–	1	15	**11**	**63**
Lednice-Valtice area	conif.	–	–	–	–	–	–	–	–	5	13	–	–	–	–	**5**	**13**
	broadl.	–	–	–	–	–	–	1	2	48	26	1	–	2	1	**52**	**29**
	total	–	–	–	–	–	–	1	2	53	30	1	–	2	1	**57**	**33**
Total for all localities	conif.	4	1	8	–	923	196	–	–	44	20	–	–	80	131	**1059**	**348**
	broadl.	3	1	20	2	51	29	31	13	142	78	1	–	2	88	**250**	**211**
	total	**7**	**2**	**28**	**2**	**974**	**225**	**31**	**13**	**186**	**98**	**1**	–	**82**	**207**	**1309**	**547**

coniferous species (Tab. 2). Besides of woody species, *Armillaria* spp. were observed on two species of herbs – *Fragaria* sp. and *Pelargonium* sp. As for quantity, most finds came from conifers (about 70 % collections), particularly *Picea abies* (55 %). The majority of collections of fruitbodies originated from stumps, dead wood or dead standing trees (70 %) where *Armillaria* decomposes wood as a saprophyte. This stage generally follows a parasitic stage in which the species colonises particular parts of a host. After its death, the fungus quickly colonises wood.

Except for *Armillaria mellea* and *A. socialis*, all species were observed both in broadleaves and conifers. None of the species showed either a saprophyte or parasite character (Tab. 1). Only *Armillaria ostoyae* can be regarded a predominant parasite in secondary spruce plantations. The same observation is valid for *A. mellea* in the warmest regions. *Armillaria gallica* and *A. borealis* are mainly saprophytes and occasionally function as necrotrophic parasites. *Armillaria cepistipes* and *A. socialis* are mentioned as saprophytes. However, *A. cepistipes* was observed on root systems of dying trees in the same areas with beech decline as in the Bílé Karpaty Mts. In none of the species, it is possible to speak about an exclusive saprophyte or parasite.

Table 2. Survey of number of *Armillaria* hosts observed in southern Moravia

		Armillaria borealis	*Armillaria cepistipes*	*Armillaria ostoyae*	*Armillaria mellea*	*Armillaria gallica*	*Armillaria socialis*	*Armillaria* total
Number of hosts	Conifers	2	2	28	0	13	0	33
	Broadleaves and shrubs	2	4	8	9	37	1	44
	Herbs	–	–	–	–	–	–	2
	Total	4	6	36	9	50	1	79

Infection is primarily dependent on the predisposition of a host. Pathogenicity of particular species or virulence of strains are only secondary. The lower proportion of parasitism in *A. gallica* is caused by the fact that its ecological optimum occurs on wet sites of floodplain forests and on the bottoms of valleys along water courses. Generally, autochthonous stands are tolerant to infection by *Armillaria*. On the other hand, there exist plantings of some conifers in the Lednice park in SE Moravia which are heavily damaged by *Armillaria*. *Armillaria ostoyae* shows its ecological optimum in the nutrient-rich series of lower and medium altitudes (forest type group *Querceto-Fagetum*), i.e. in regions where the original species composition (*Fagus sylvatica*, *Quercus petraea*, *Abies alba* etc.) has been radically changed in favour of more vulnerable spruce plantations.

Survey of the host spectrum of Armillaria in Southern Moravia

Coniferous hosts of *Armillaria* species (records on the basis of vegetative traits without species identification are also included)

Abies alba, A. concolor, A. grandis, A. nordmanniana, Cryptomeria japonica, Chamaecyparis lawsoniana, Chamaecyparis sp., *Juniperus virginiana, J. chinensis, J. communis, Larix decidua, Picea abies, Picea glauca, P. mariana, P. omorica, P. orientalis, P. pungens, Pinus aristata, P. banksiana, P. koraiensis, P. contorta, P. monticola, P. nigra, P. mugo, P. flexilis, P. rotundata, P. strobus, P. sylvestris, P. wallichiana, Pseudotsuga menziesii, Taxus baccata, Thuja plicata, Thuja occidentalis, Tsuga* sp.

Broadleaved hosts *Armillaria* species

Acer campestre, A. platanoides, A. pseudoplatanus, A. saccharinum, Aesculus hippocastanum, Alnus glutinosa, Alnus incana, Armeniaca vulgaris, Betula sp., Carpinus betulus, Castanea sativa, Cerasus avium, Cornus mas, Corylus avellana, C. colurna, Fagus sylvatica, Fraxinus excelsior, F. angustifolia, Gleditschia triacanthos, Gymnocladus dioica, Juglans nigra, J. regia, Malus domestica, Padus serotina, Persica vulgaris, Populus sp., *Prunus domestica, Pyrus communis,*

P. domestica, Quercus cerris, Q. petraea, Q. pubescens, Q. robur, Q. rubra, Q. virgiliana, Robinia pseudacacia, Rosa sp., *Sambucus nigra, S. racemosa, Salix* sp., *Sorbus aucuparia, S. torminalis, Syringa vulgaris, Tilia* sp., *Ulmus* sp., *Vitis vinifera.*

Herbs as hosts of *Armillaria* species

Fragaria vesca, Pelargonium sp.

Hosts of *Armillaria borealis*

Picea abies, Pinus sylvestris, Betula sp., *Fagus sylvatica.*

Hosts of *Armillaria cepistipes*

Abies alba, Picea abies, Alnus glutinosa, A. incana, Betula sp., *Fagus sylvatica.*

Hosts of *Armillaria ostoyae*

Conifers: *Abies alba, A. grandis, A. concolor, A. nordmanniana, Cryptomeria japonica, Chamaecyparis lawsoniana, Juniperus chinensis, J. communis, Picea abies, P. glauca, P. mariana, P. omorica, P. pungens, Pinus contorta, P. flexilis, P. koraiensis, P. monticola, P. banksiana, P. nigra, P. mugo, P. aristata, P. rotundata, P. strobus, P. sylvestris, P. wallichiana, Pseudotsuga menziesii, Thuja plicata, T. occidentalis.*

Broadleaves: *Betula* sp., *Carpinus betulus, Fagus sylvatica, Castanea sativa, Quercus petraea, Q. robur, Q. rubra, Sorbus torminalis.*

Hosts of *Armillaria mellea*

Acer platanoides, Armeniaca vulgaris, Cerasus avium, Fraxinus excelsior, Juglans regia, Malus domestica, Persica vulgaris, Quercus cerris, Quercus petraea.

Hosts of *Armillaria gallica*

Conifers: *Abies alba, Juniperus virginiana, J. chinensis, J. communis, Larix decidua, Picea abies, Picea omorica, Picea orientalis, Picea pungens, Pinus contorta, Pinus sylvestris, Pseudotsuga menziesii, Thuja plicata.*

Broadleaves and shrubs: *Acer campestre, A. platanoides, A. pseudoplatanus, A. saccharinum, Aesculus hippocastanum, Alnus glutinosa, Armeniaca vulgaris, Betula* sp., *Carpinus betulus, Cerasus avium, Cornus mas, Corylus*

avellana, C. colurna, Fagus sylvatica, Fraxinus excelsior, F. angustifolia, Gleditschia triacanthos, Malus domestica, Padus serotina, Pelargonium sp., *Populus* sp., *Prunus domestica, Quercus cerris, Q. petraea, Q. pubescens, Q. robur, Q. rubra, Q. virgiliana, Robinia pseudoacacia, Rosa* sp., *Salix* sp., *Sambucus nigra, S. racemosa, Sorbus aucuparia, Syringa vulgaris, Tilia* sp., *Ulmus* sp.

Distribution and pathology of Armillaria species

Secondary spruce stands growing on *Querceto-Fagetum* nutrient-rich forest sites in the Drahanská vrchovina Highlands, represented especially by the Křtiny TFE, are seriously damaged by *Armillaria ostoyae*. The main reason is a precipitation deficit: the total amount of annual precipitation is only about 600 mm and above all summer droughts act as an initiational stressor (Manion 1991). It occurs as an opportunist parasite in declining firs, oaks and other autochthonous tree species there. *Armillaria* species participate significantly in the decomposition of stumps and dead roots. *Armillaria gallica* is predominantly a saprophyte of decomposed wood in moist habitats of the alluvia of streams and slope bases. As a parasite, it occurs occasionally both in broadleaves and conifers. *Armillaria cepistipes* and *A. borealis* are relatively rare species being of no major economic importance. *Armillaria mellea* was found in *Fraxinus excelsior* and on stumps of *Acer platanoides* in the lowest part (alt. 280 m) of the Křtiny TFE on the border of Brno. In this area, *Armillaria* species were found in 43 host species, twenty of which are coniferous species.

In predominatly broadleaved oak/beech stands of the Brno Uplands, *Armillaria* spp. occasionally parasitise in coppices. The following species were noticed: *Armillaria ostoyae*, *A. mellea* and *A. gallica*. In secondary spruce stands, the situation is similar as in the Drahanská vrchovina Highlands, where the stands are stressed by low altitude. Moreover, a number of the stands were established on loess. *Armillaria mellea* occurs in focuses and causes locally also damages to pole stands of *Quercus petraea*. *Armillaria ostoyae* parasitise in oak trees only occasionally at higher altitudes (alt. 300–450 m). In the region, *Armillaria* species were found in 12 host species, six of which are coniferous species.

In park plantings and gardens in Brno, *Armillaria* spp. are quite common. Fruit trees are particularly damaged by *A. mellea* but also by *A. gallica*, which is commonly distributed in Brno parks in a number of broadleaves and exotic conifers. *Armillaria ostoyae* occurs only at higher situated border parts in conifers, broadleaves and fruit trees. In addition to fruit trees *A. mellea* was recorded in *Quercus robur* and *Quercus petraea* only. The occurrence of mycelial fans in grapevine (*Vitis vinifera*) is also of interest. From 30 host species 13 are conifers.

The prevailing *Armillaria* species of floodplain forests and thermophilic oak stands in the Lednice-Valtice area including the Lednice park is *A. gallica*. In the

Lednice park, it infects also conifers predisposed to wilting in the period of summer droughts. It was found there in *Abies alba, Picea abies, P. orientalis, P. pungens, Taxus baccata, Thuja plicata* and other species. *Armillaria mellea* occurs as an opportunist parasite in oak (*Quercus petraea, Q. robur, Q. cerris*). Other species of *Armillaria* were not found. *Armillaria* spp. were identified in 10 broadleaved species and 5 coniferous species.

Notes to the ecology of particular species of Armillaria in the region

Armillaria gallica occurs as the only *Armillaria* species in all regions under study. It is an absolutely dominant species in floodplain forest ecosystems and in lowland oak communities of the Lednice-Valtice area. As a saprophyte, it is common particularly on broadleaves of lower-altitude regions. In impaired individuals, however, it changes into a parasite. In conifers, it parasitise in park plantings in the Lednice park and also in alluvia along streams of the Drahanská vrchovina Highlands. Symptoms of damage to conifers are similar as in *A. ostoyae*, however, long strand-like rhizomorphs form abundantly under bark and in soil. In broadleaves, it is the causal agent of closed and open stem cavities, where it moves up to a height of 3–6 m. It was detected in 30 broadleaved species. The spectrum of hosts of the fungus was the largest of all *Armillaria* species (50 host species.). A record on *Syringa vulgaris* and *Pelargonium* sp. is also of interest.

Armillaria mellea is a thermophilic species which occurs in the region of southern Moravia on various species of broadleaves. Right in the Brno agglomeration, it is a frequent parasite on fruit trees in gardens (e.g. *Cerasus avium, Armeniaca vulgaris, Persica vulgaris, Juglans regia, Malus domestica, Pyrus communis*). It was detected in 10 broadleaved species. Its occurrence is also mentioned on *Thuja* sp. in Brno gardens (Antonín 1988). This corresponds to the ecology of the fungus in southern Europe (Guillaumin et al. 1985).

Armillaria ostoyae is the most important species of *Armillaria* causing considerable economic damage in secondary spruce stands. It absolutely predominates particularly in upland regions and, on the contrary, at the lowest altitudes it was not found. The majority of records originate from spruce (55 %). In total, it was identified in 36 tree species, 3 of which are broadleaved species. In addition to native species, it was noticed in most of exotic conifers in glades and arboreta in the region of the Křtiny TFE. It is of interest that the ecological optimum of *A. ostoyae* is in many respects quite identical with the ecological optimum of silver fir (*Abies alba*). Also its southern boundary distribution in Europe corresponds to the range of silver fir (Greece, SW France, Corsica, the Apennines). In remnants of natural stands in the Křtiny TFE, *A. ostoyae* is primarily a saprophyte. It goes over to parasitism in silver fir (*Abies alba*) and oak (*Quercus petraea*). However, it never causes such damage as in spruce, and infection by *Armillaria* is limited

only to peripheral parts of the root system. The cause of infection of living trees is again their predisposition due to drought stress (particularly summer droughts). Oak trees are infected mainly at higher elevations (about 400–500 m alt.) where they grow on the margin of the ecological optimum.

Armillaria cepistipes was detected particularly as a saprophyte on buried wood of broadleaves and more rarely also conifers. It is rather problematic to distinguish this species from *A. gallica*. A simple identification according to the morphology of fruitbodies and cultures is not reliable. To a certain extent, it differs ecologically because *A. cepistipes* is distributed and replaces *A. gallica* at higher altitudes and in the north. Fruitbodies corresponding to *A. cepistipes* f. *pseudobulbosa* Romagn. et H. Marxmüller (1983) were also found on damaged stems of living alders (Křtiny TFE, Forest District Řečkovice). *A. cepistipes* was noticed on roots of declining or dead beech trees at the localities of Radějov (White Carpathians), Tetčice (Bobrava Upland) and the Drahanská vrchovina Highlands. In this case, identification was verified by PCR tests. The status of the species in the conditions of the Czech Republic requires further research. *Armillaria cepistipes* appears to be more abundant than previously expected. It is more frequent particularly in beech stands at medium altitudes.

Armillaria borealis is probably a less frequent *Armillaria* species in the Czech Republic so far. In the vicinity of Brno, it was noticed in pine, birch and also spruce. Similarly as *A. ostoyae*, it can be a causal agent of root rots of spruce. Unlike that species, *A. borealis* pervades into sapwood soon after the host's death, forming fruitbodies on the stem at a height of 2–5 m. The formation of rhizomorphs is not abundant as compared with *A. gallica* and *A. cepistipes*. The fungus was detected only in the Drahanská vrchovina Highlands.

Armillaria socialis was found only on stumps of oak trees and on bases of dead standing trees of *Quercus robur* in the floodplain of the Lanžhot virgin forest and National Nature Reserve (NNR) Cahnov. It occurs also in the Ranšpurk NNR and in the Křivé jezero NNR (Antonín, personal communication). It is a markedly thermophilic species.

DISCUSSION

Although *Armillaria* species are intensively studied in many aspects, more detailed data on the distribution of particular species in the Czech Republic have not been published so far. Černý (1989) mentioned a differentiation of species based on their ecological requirements. The occurrence and ecology of *Armillaria* species in the region of southern Moravia generally correspond to these characteristics.

As for European species, the broadest spectrum of hosts is given for *Armillaria mellea*. Based on data from France, England and Italy, Guillaumin et al. (1993) mention 142 host species from 30 families. The list includes also introduced

species. An absolute majority is formed by broadleaved trees and shrubs, as for conifers 14 representatives of *Pinaceae* are mentioned, 2 representatives of *Taxodiaceae* (*Cryptomeria japonica*, *Sequiadendron giganteum*) and 10 representatives of *Cupressaceae*. It is also of interest that some monocotyledonous plants are mentioned as hosts of *Armillaria mellea*, e.g. *Arundo donax*, *Strelitzia reginae*, *Musa chinensis*. *Armillaria socialis* is mentioned from 12 host species of 4 families, however, not even in one case a find from conifers is mentioned. *Armillaria ostoyae* was found in 38 plant species of 9 families, 21 of which are coniferous species (*Pinaceae* and *Cupressaceae* families). *Armillaria gallica* was observed on 40 host species of 14 families, 10 of which were coniferous species (*Pinaceae* and *Cupressaceae* families). *Armillaria borealis* is given from two hosts only and *Armillaria cepistipes* from *Tilia platyphyllos* only.

From the Czech Republic, Lazebníček (1973) mentions 26 host species of 23 genera on which fruitbodies of *Armillaria mellea* s. l. were recorded. The greatest proportion belongs to *Picea abies*, followed by *Fagus sylvatica*, *Quercus* sp. div., *Abies alba*, *Carpinus betulus*, *Betula* sp. div. and *Alnus* sp. div. In living hosts, fruitbodies were found only in 5 % of finds. As for fruit trees, only apple (*Malus domestica*) and cherry (*Cerasus avium*) are mentioned.

Antonín (1988) mentions 15 host species (14 broadleaves, 1 conifer – *Thuja* sp.) of *Armillaria mellea* from the Czech Republic.

A great number of host species also comes from agricultural crops, particularly various fruit trees and grapevine. Damage caused by *Armillaria* species are of significant economic importance particularly to stone fruits like almonds (*Amygdalus communis*), plums (*Prunus domestica*), cherries (*Cerasus avium*), apricots (*Armeniaca vulgaris*) and grapevine (*Vitis vinifera*) in the southern part of Europe (Guillaumin 1985). In the tropics, *Armillaria* species parasitise even on banana trees (*Musa* sp.), cacao trees (*Theobroma cacao*) and rubber trees (*Hevea brasilensis*).

At present, a significant increase in *Armillaria* spp. as a mortality stressor can be observed in some localities of the Czech Republic. The fungus reacts primarily to an increased predisposition of spruce due to climatic extremes (Holuša and Liška 2002). *Armillaria* spp. can occur as an important biotic agent destabilising spruce stands under the impact of climatic changes (Jankovský et al. 2003, Jankovský 2003).

CONCLUSIONS

The diversity of ecological conditions of forests in southern Moravia is also confirmed by observation of the complete species spectrum of annulate *Armillaria* species. The occurrence of *A. mellea* and particularly the exannulate *A. socialis* represents the northern boundary of their distribution in the region. The vicinity

of Brno is also important for its plantings of exotic species in neighbouring arboreta and urban parks. A number of them was quite commonly attacked by *Armillaria* spp.

In total, 5 species of annulate *Armillaria* and the exannulate *A. socialis* were found. *Armillaria ostoyae* shows its ecological optimum in the forest type group *Querceto-Fagetum* where it is an important parasite of spruce. It also attacks *Abies alba*, *Quercus petraea* and other species. *Armillaria gallica* is a dominant species of floodplain forests and thermophilic oak communities. On the contrary, *A. ostoyae* was almost missing there. *Armillaria mellea* occurs on broadleaves and fruit trees. *Armillaria cepistipes* and *A. borealis* were found only in the Křtiny TFE. *Armillaria socialis* occurs rarely on stumps and bases of dead oak trees in a floodplain forest along the Dyje river (NNR Cahnov, Ranšpurk and Křivé jezero). It is one of its northernmost localities. Such a complete *Armillaria* species spectrum in the relatively small area of southern Moravia particularly in the Drahanská vrchovina Highlands is not common in Europe.

The main role of *Armillaria* spp. consists in the decomposition of wood in soil such as stumps and roots. In case of any physiological weakening of host species, *Armillaria* spp. begin to fulfil this role already on living trees such as in the case of spruce which is grown under conditions at the margin of its ecological optimum.

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