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Species of *Armillaria* in the Wielkopolsko-Pomorski Forest Region (NW Poland)

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Fungi belonging to the genus *Armillaria* were identified in forests situated in the Wielkopolsko-Pomorski Forest Region. The occurrence of each species in various habitats, stands and hosts was determined. Mating tests as well as morphological studies of fruit-bodies were made for species identification.

Key words: *Armillaria*, mating test, intersterile group, Wielkopolsko-Pomorski Forest Region.

INTRODUCTION

Among root disease fungi, *Armillaria* species are the most prominent killers and decayers of deciduous and coniferous trees and shrubs.

Effects of their activity can be observed in forest stands in the whole territory of Poland. In 1998 damages were registered in deciduous and coniferous stands of all age classes in the area of more than 150 000 hectares (Sierota et al. 1999).

In 1998 the *Armillaria* root rot was recorded in the area of 18 186 hectares (young forests – 4 006 ha, older stands – 14 180 ha) in forest stands situated in the Wielkopolsko-Pomorski Forest Region (data were obtained from individual forest districts – signal charts).

Until 1978 (Korhonen 1978) and 1988 (Żółciak 1990) the root rot of *Armillaria* was attributed to *Armillaria mellea* (Vahl: Fr.) Kummer in Europe and Poland, respectively. This species was considered to be very polymorphic. Korhonen (1978) found five intersterile groups (A, B, C, D and E) within this species.

The current nomenclature for the five groups is as follows (Guillaumin et al. 1993):

– group A – *Armillaria borealis* Marxmüller et Korhonen,
– group B – *Armillaria cepistipes* Velenovský,

– group C – *Armillaria ostoyae* (Romagn.) Herink [synonyms *A. obscura* (Schaeffer) Herink and *A. polymyces* (Pers.: S. F. Gray) Singer et Clemençon]
– group D – *Armillaria mellea* sensu stricto (Vahl: Fr.) Kummer,
– group E – *Armillaria gallica* Marxmüller et Romagnesi [synonyms *A. bulbosa* (Barla) Kile et Watling and *A. lutea* Gillet].

The objectives of the present study were to:
– identify the fungi from the genus *Armillaria* in the forests situated in the Wielkopolsko-Pomorski Forest Region,
– analyse the occurrence of *Armillaria* species considering forest habitat (fresh coniferous forest, fresh mixed coniferous forest, fresh broad-leaved forest, fresh mixed broad-leaved forest), type of stand (coniferous, deciduous and mixed stands), stand age classes (10) and host species.

MATERIAL AND METHODS

Fifty-nine experimental one-time-sampled plots of 500 m^2 each (20 × 25 m) were established in forest stands situated within the territory of 18 forest districts in the Wielkopolsko-Pomorski Forest Region (between latitudes 51°24′N and 54°30′N and between longitudes 14°53′N and 19°94′N, Fig. 1).

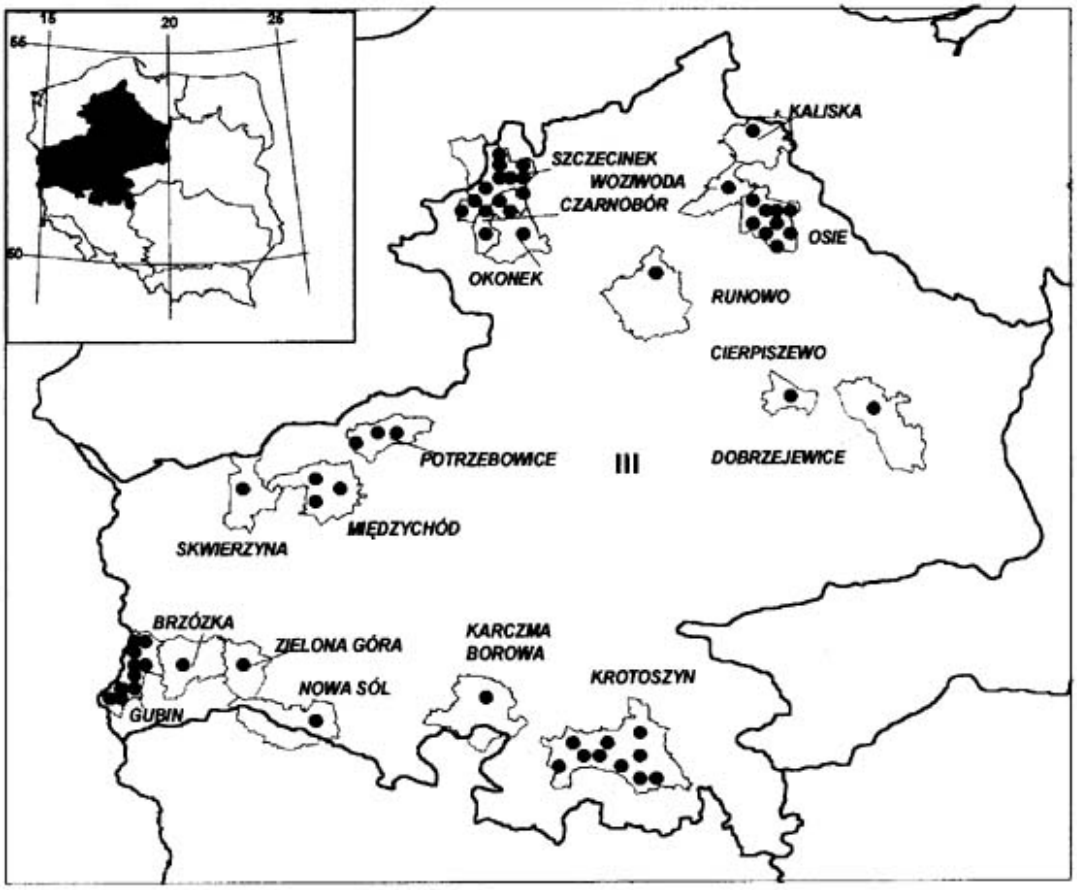

Fig. 1. Distribution of experimental plots in the Wielkopolsko-Pomorski Forest Region

In each plot 1 to 10 samples were taken in autumn 1997 and 1998. The samples consisted of fruit-bodies of *Armillaria* (142 samples), fragments of wood colonized by mycelium of *Armillaria* (17 samples) and rhizomorphs (7 samples). In some cases samples were collected outside the forest stands.

In the present study the stands were chosen on the basis of data obtained from questionnaires of the annual forest state assessments informing about the area of stands infested by root rot of *Armillaria*, inventory documents and the author's own observations.

The identification of *Armillaria* isolates was performed by using mating tests (K o r h o n e n 1978). In total eighty-nine samples were identified. An unknown diploid or haploid isolate was paired with haploid tester strains representative of each of the European species (*Armillaria borealis*, *Armillaria cepistipes*, *Armillaria ostoyae*, *Armillaria mellea*, *Armillaria gallica*). The mating reactions were scored after 3 weeks. Compatible matings were characterized by a change of haploid tester strains from fluffy to crustose.

Fruit-bodies of *Armillaria* were identified on the basis of the macro- and microscopic features (R o m a g n e s i and M a r x m ü l l e r 1983). Seventy-seven samples were identified in that way. The colour, shape and size of pileus were analysed as well as the shape of stipe, the colour of annulus, the colour and distribution of scales on the pileus. The following microscopic features of fruit-bodies were analysed: the occurrence of clamp connections at the bases of basidia, the properties of epidermal cells of scales of pileus and the size of spores.

RESULTS

A total of 166 samples were collected in the forest area situated in the Wielkopolsko-Pomorski Forest Region.

The proportion of samples found in each type of forest habitat and stand, and in ten stand age classes were calculated. They were as follows:

1. Forest habitats: fresh coniferous forest – 13.2% of the samples, fresh mixed coniferous forest – 19.9%, fresh broad-leaved forest – 45.8%, fresh mixed broad-leaved forest – 15.7%, undetermined – 5.4%.

2. Stand types: coniferous stand – 35.5% of the samples, deciduous stand – 41%, mixed stand – 19.3% and undetermined stand – 4.2%.

3. Stand age classes: 1–20 – 33.1%, 21–40 – 12.7%, 41–60 – 16.9%, 61–80 – 3%, 81–100 – 2.4%, 101–120 – 3%, 121–140 – 11.4%, 141–160 – 14.5%, 161–180 – 1.8%, 181–200 – 1.2% of the samples.

The distribution of *Armillaria* species identified in forests in the Wielkopolsko-Pomorski Forest Region is presented in Figure 2.

Among the identified isolates and fruit-bodies belonging to the genus *Armillaria*, *Armillaria ostoyae* occurred most frequently – 75.3%. The remaining species were less common: *A. gallica* – 16.3%, *Armillaria cepistipes* – 4.8%, *Armillaria mellea* – 2.4% and *Armillaria borealis* – 1.2%.

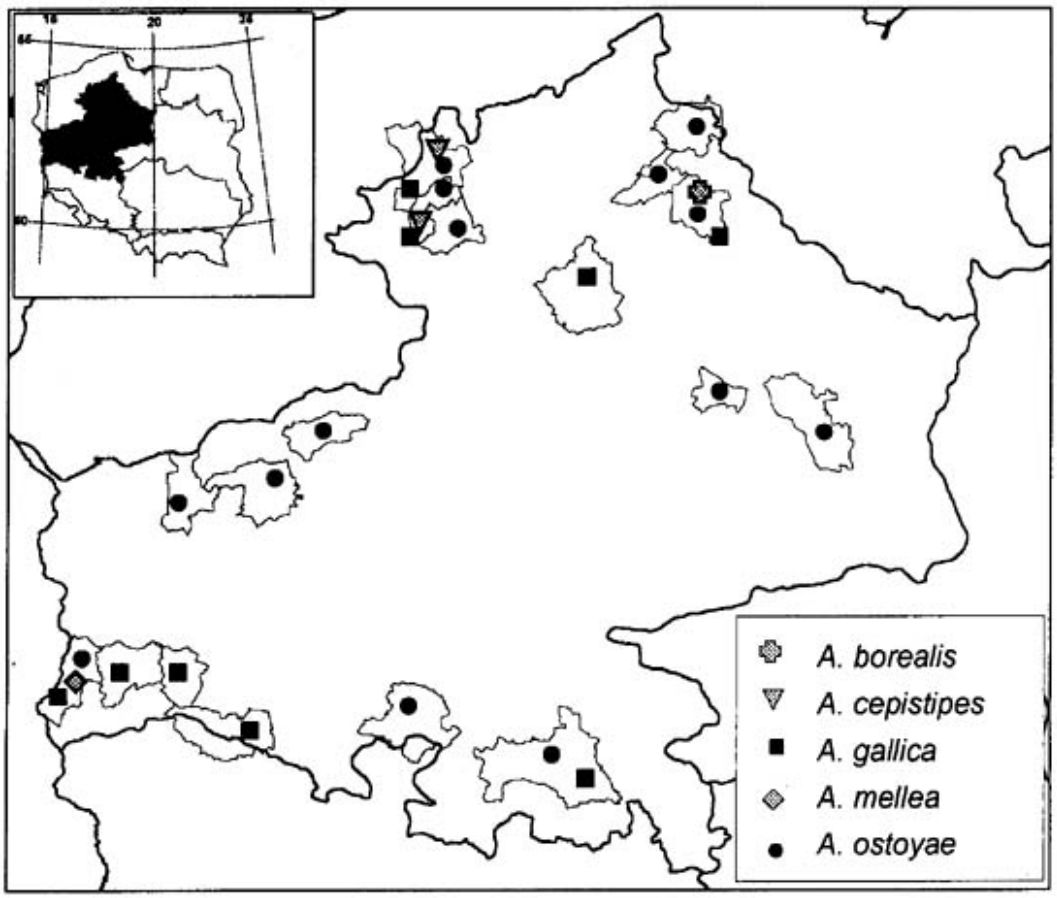

Fig. 2. Distribution of *Armillaria* species in the Wielkopolsko-Pomorski Forest Region

Table 1

Percentage of particular *Armillaria* species in samples from different types of forest habitats in the Wielkopolsko-Pomorski Forest Region

Type of forest habitat	Species of *Armillaria*				
	A. borealis (%)	*A. cepistipes* (%)	*A. gallica* (%)	*A. mellea* (%)	*A. ostoyae* (%)
Fresh coniferous forest	–	–	–	–	100.0
	–	–	–	–	17.6
Fresh mixed coniferous forest	–	–	–	–	100.0
	–	–	–	–	26.4
Fresh broad-leaved forest	1.3	10.5	27.6	–	60.5
	50.0	100.0	77.8	–	36.8
Fresh mixed broad-leaved forest	3.8	–	15.4	–	80.0
	50.0	–	14.8	–	–
Not determined	–	–	22.2	44.4	33.3
	–	–	7.4	100.0	2.4

Armillaria borealis and *Armillaria gallica* were found in fresh broad-leaved – and fresh mixed broad-leaved forests (Table 1). *Armillaria cepistipes* was recorded in fresh broad-leaved forests. *Armillaria ostoyae* was found in all the types of forest habitats, most frequently in fresh broad-leaved forests. *Armillaria mellea* occurred only outside the forest studied. That is why the type of forest habitat was not determined for this species.

Armillaria borealis and *Armillaria gallica* were found in deciduous and mixed stands, whereas *Armillaria cepistipes* and *Armillaria mellea* occurred in deciduous forests (Table 2). *Armillaria ostoyae* was observed in coniferous, deciduous and mixed stands.

Table 2

Percentage of particular *Armillaria* species in samples from different stands in the Wielkopolsko-Pomorski Forest Region

Stand	Species of *Armillaria*				
	A. borealis (%)	*A. cepistipes* (%)	*A. gallica* (%)	*A. mellea* (%)	*A. ostoyae* (%)
Coniferous	–	–	–	–	100.0
	–	–	–	–	47.2
Deciduous	1.5	11.8	27.9	2.9	55.9
	50.0	100.0	70.4	50.0	30.4
Mixed	3.1	–	21.9	–	75.0
	50.0	–	25.9	–	19.2
Not determined	–	–	14.3	28.6	57.1
	–	–	3.7	50.0	3.2

As far as the age of the stand is concerned *Armillaria borealis* was noticed in the 1–20-year-old forests (Table 3). *Armillaria cepistipes* was found in the 21–40 and 121–140-year-old stands, *Armillaria gallica* – in the 21–40, 41–60, 121–140, 141–160 and 181–200-year-old ones, and *Armillaria mellea* – in the 21–40 and 41–60-year-old stands. *Armillaria ostoyae* was observed in all the stand age classes.

Armillaria borealis was found on *Picea abies* (Table 4), *Armillaria cepistipes* was recorded on *Fagus sylvatica* and *Fraxinus excelsior*, *Armillaria gallica* was identified on *Fagus*, *Quercus* spp., *Carpinus betulus*, *Juglans regia* and *Robinia pseudoacacia*. *Armillaria mellea* occurred *Malus domestica*, *Populus tremula* and *Vitis vinifera*. *Armillaria ostoyae* was found on *Betula pendula*, *Fagus*, *Prunus avium*, *Quercus*, *Carpinus*, *Pyrus communis*, *Larix decidua*, *Pinus sylvestris* and *Picea*.

Table 3

Percentage of particular *Armillaria* species in samples from different stand age classes in the Wielkopolsko-Pomorski Forest Region

Stand age classes	Species of *Armillaria*				
	A. borealis (%)	*A. cepistipes* (%)	*A. gallica* (%)	*A. mellea* (%)	*A. ostoyae* (%)
1–20	1.8 50.0	– –	– –	– –	98.1 43.2
21–40	– –	9.5 25.0	9.5 7.4	9.5 50.0	71.4 12.0
41–60	– –	– –	46.4 48.1	7.1 50.0	46.4 10.4
61–80	– –	– –	– –	– –	100.0 4.0
81–100	– –	– –	– –	– –	100.0 3.2
101–120	– –	– –	– –	– –	100.0 4.0
121–140	5.3 50.0	26.3 62.5	5.3 3.7	– –	63.1 9.6
141–160	– –	41.6 37.0	41.6 37.0	– –	54.2 10.4
161–180	– –	– –	– –	– –	100.0 2.4
181–200	– –	50.0 3.7	50.0 3.7	– –	50.0 0.8

Table 4

Fungi from the genus *Armillaria* on different hosts in the Wielkopolsko-Pomorski Forest Region

L.p.	Stand age classes	*Armillaria* species				
		A. borealis (%)	*A. cepistipes* (%)	*A. gallica* (%)	*A. mellea* (%)	*A. ostoyae* (%)
1.	*Betula pendula*	–	–	–	–	1.2
2.	*Carpinus betulus*	–	–	1.2	–	4.2
3.	*Fagus sylvatica*	–	1.8	1.2	–	9.0
4.	*Fraxinus excelsior*	–	0.6	–	–	–
5.	*Juglans regia*	–	–	0.6	–	–
6.	*Larix decidua*	–	–	–	–	0.6
7.	*Malus domestica*	–	–	–	0.6	–
8.	*Picea abies*	0.6	–	–	–	3.6
9.	*Pinus sylvestris*	–	–	–	–	34.3
10.	*Populus tremula*	–	–	–	0.6	–
11.	*Prunus avium*	–	–	–	–	0.6
12.	*Pyrus communi*	–	–	–	–	0.6
13.	*Quercus* spp.	–	–	4.2	–	13.25
14.	*Robinia pseudoacacia*	–	–	0.6	–	–
15.	*Vitis vinifera*	–	–	–	0.6	–
16.	Not determined	0.6	2.4	8.4	0.6	7.8

DISCUSSION

The results of the present study are of preliminary character. It is evident that *Armillaria* species are characterized by different requirements with respect to climatic and natural conditions (Guillaumin et al. 1993). According to Guillaumin et al. (1993) *A. borealis* is a species of northern and continental distribution. It has not been found anywhere except for Europe and Western Siberia. The northern limit of distribution of this species is connected with the limited range of woody vegetation, reaching 69° of latitude (Korhonen 1978). The species extends south to 55°N in Britain, 49°30'N in France and 47°N in Central Europe (Guillaumin et al. 1993). The northern limit of distribution of *A. cepistipes* is near the arctic circle around 66°N (Korhonen 1978). The species extends southward to 42°30'N (Guillaumin et al. 1993). *A. ostoyae* is present in the north of Europe but not so far north as *A. borealis* and *A. cepistipes*. The species may be found in many regions in Europe with a continental or Atlantic climate (Guillaumin et al. 1993). In the Mediterranean region, e.g. in south-east France and Italy, *A. ostoyae* is found at high altitudes only. *A. gallica* is absent from areas of extremely cold climate (Finland, Norway). *A. mellea* is a thermophiluos species of Atlantic-Mediterranean distribution.

All *Armillaria* species, including *Armillaria mellea* sensu stricto, were found in the Wielkopolsko-Pomorski Forest Region. The occurrence of *A. mellea* was observed in the westernmost part of the Wielkopolsko-Pomorski Forest Region which is characterized with its mild microclimatic conditions. Guillaumin et al. (1993) suggest that *A. mellea* is rare in the region of continental climate unless there is a microclimate with mild winter temperatures.

The occurrence of *Armillaria* species is mainly connected with forest areas (except for *A. mellea* which is found outside forests).

A. ostoyae is the only species that has been noted hitherto in fresh coniferous forests (Żółciak 1999). *A. cepistipes* and *A. gallica* show preference for fertile broad-leaved forests.

Armillaria ostoyae seems to be the most frequent species of *Armillaria* in forests situated in the Wielkopolsko-Pomorski Forest Region. It was found in all the types of forests investigated, i.e. in coniferous, deciduous and mixed stands. *Armillaria ostoyae* was also observed in all stand age classes as well as in most of the host species.

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Grzyby z rodzaju *Armillaria* w Wielkopolsko-Pomorskiej Krainie Przyrodniczoleśnej

Streszczenie

Materiał badawczy (owocniki, fragmenty drewna przerośniętego grzybnią, ryzomorfy) pobierano jesienią 1997 i 1998 roku na jednorazowych powierzchniach w kompleksach leśnych położonych w Wielkopolsko-Pomorskiej Krainie Przyrodniczoleśnej. Izolaty z 166 prób identyfikowano metodą Korhonena – testów łączenia grzybni w kulturach. Owocniki identyfikowano na podstawie cech makroskopowych i mikroskopowych.

Zidentyfikowano pięć intersterylnych grup biologicznych i tyleż odpowiadających im gatunków. Przedstawiono występowanie zidentyfikowanych grzybów w odniesieniu do typu siedliskowego lasu (Bśw, BMśw, Lśw i LMśw), typu drzewostanu (iglaste, liściaste, mieszane), dziesięciu klas wieku drzewostanu oraz gatunku rośliny-gospodarza.

Armillaria ostoyae wydaje się być gatunkiem najczęstszym w kompleksach leśnych położonych na terenie Krainy Wielkopolsko-Pomorskiej. Grzyb ten stwierdzono we wszystkich badanych siedliskach i drzewostanach, we wszystkich klasach wieku oraz na większości roślin–gospodarzy.