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Dedicated to Professor Alina Skirgiełło on the occasion of her ninety-fifth birthday

Armillaria species in coniferous stands

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Identification of the *Armillaria* species in selected coniferous stands (Scots pine stands, Norway spruce stands and fir stands) was the aim of the work carried out on the basis of mating tests and consideration of macroscopic traits of fruit bodies. One species of *Armillaria* [*A. ostoyae* (Romagnesi) Herink] was found in Scots pine stands, three species [*A. ostoyae, A. cepistipes* Velenovský and *A. borealis* Marxmüller et Korhonen] were found in Norway spruce stands and two species [*A. ostoyae* and *A. cepistipes*] were found in fir stands.

Key words: coniferous stands, *Armillaria ostoyae*, *A. cepistipes*, *A. borealis*

INTRODUCTION

Armillaria root infection is the most important disease affecting mainly young Scots pines (*Pinus sylvestris* L.) planted often in/after mixed stands in the north-east part of Poland and Norway spruce (*Picea abies* Karst.) stands in the south part of the country (Mańka 1953, 1998; Twarowski, Twarowska 1959; Twarowska 1965; Rykowski 1985; Capecki 1994, 1997; Sierota 2001; Lech 2003; Mańka et al. 2003). It is caused by *Armillaria* species. From seven European *Armillaria* species, five were identified in Poland: *A. borealis* Marxmüller et Korhonen, *A. cepistipes* Velenovský, *A. ostoyae* (Romagn.) Herink, *A. mellea* (Vahl: Fr.) Kummer and *A. gallica* Marxmüller et Romagnesi (Żółciak 1999).

The objectives of the present study were to identify *Armillaria* species in selected coniferous stands: Scots pine stands, Norway spruce stands and fir stands in Poland and to determine the occurrence of *Armillaria* species considering forest habitat (according to Polish forest site typology) and stand age classes.

MATERIALS AND METHODS

Material (samples) consisted of fruit bodies of *Armillaria*, fragments of wood colonized by mycelium of *Armillaria* and rhizomorphs. Samples were taken from experimental one-time-sampled plots of 500 m^2 each (20x25 m) established in production stands: Scots pine stands, Norway spruce stands and fir stands. 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.

One hundred and five plots were established in the Scots pine stands, situated within the territory of 52 Forest Districts (Fig. 1A). On each plot 1 to 10 samples were taken in 1985, 1989-94 and 1996-1998. Fifty plots were established in the Norway spruce stands, situated within the territory of 17 Forest Districts, 1 - in Gorce National Park and 1 - in Krynica Experimental Forest. On each plot 1 to 15 samples were taken in 1981, 1989, 1991, 1994, 1996-98 and 2001-03. Fifteen plots were establish in the fir stands, situated within the territory of 5 Forest District, 1 – in Gorce National Park and 1 – in Rotocze National Park. On each plot 1-12 samples were taken in 1991, 1994, 1996 and 1998. Characterization of the stands and samples is presented in table 1.

The identification of *Armillaria* isolates was performed by using mating tests (Korhonen 1978). Fruit bodies of *Armillaria* were identified on the basis of the macro- and microscopic features (Romagnesi, Marxmüller 1983).

Table 1
Characterization of stands, from which samples of *Armillaria* were taken

Stands	Age of stands	Type of forest habitat*	Proportion of main species (%)	Number of the			
				experimental plots	samples	obtained isolates (fruit bodies/ colonized wood/ rhizomorphs) identified using mating tests	samples (fruit bodies) identified of the macro- and microscopic features
Scots pine	1-160	FCF, FMCF, FMBF, MMCF, MMBF	100 (Scots pine)	105	356	176 (71/105/-)	180
Norway spruce	1-120	FMCF, FBF, FMBF, MUF, MMF, MF	60-100 Norway spruce	50	228	114 (86/27/1)	114
fir	41-140	FBF, UF, MMF, MF	50-100 (fir)	15	53	25 (23/2/-)	28
Total				170	637	315 (180/134/1)	322

Explanations: fresh coniferous forest (FCF), fresh mixed coniferous forest (FMCF), moist mixed coniferous forest (MMCF), fresh broadleaved forest (FBF), fresh mixed broadleaved forest (FMBF), upland forest (UF), mixed upland forest (MUF), moist mixed broadleaved forest (MMBF), mountain forest (MF), mixed mountain forest (MMF).

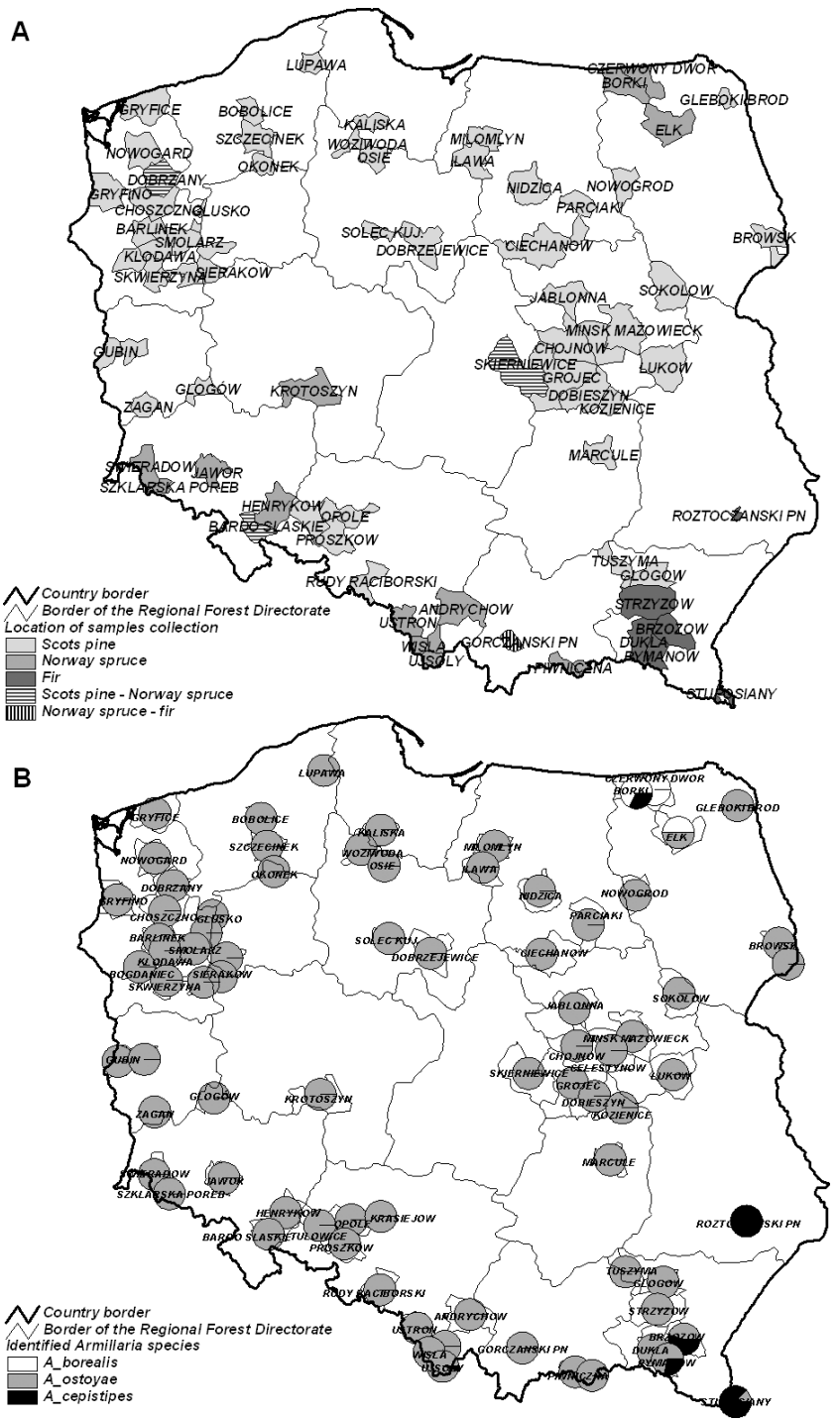

Fig. 1. A) Distribution of experimental plots. B) Distribution of *Armillaria* species in Scots pine stands, Norway spruce stands and fir stands.

RESULTS

A total of 637 samples were collected in the investigated coniferous stands (356 samples - in Scots pine stands, 228 samples - in Norway spruce stands and 53 samples – in fir stands). The proportions of *Armillaria* samples found in the coniferous stands were calculated (Tabs 2 and 3).

Table 2
Percentage of samples of *Armillaria* from coniferous stands: Scots pine, Norway spruce and fir considering different types of forest habitat

Stands	Type of forest habitat									
	FCF (%)	FMCF (%)	MMCF (%)	FBF (%)	FMBF (%)	MMBF (%)	UF (%)	MUF (%)	MMF (%)	MF (%)
Scots pine	9,3	78,4	5,6	0,8	4,8	1,1	-	-	-	-
Norway spruce	0,9	-	-	2,6	12,7	-	-	13,6	36,4	33,8
Fir	-	-	-	3,8	-	-	45,3	-	3,8	47,1

Table 3
Percentage of samples of *Armillaria* from coniferous stands: Scots pine stands, Norway spruce stands and fir stands considering different stand age classes

Stands	Stand age classes							
	1-20 (%)	21-40 (%)	41-60 (%)	61-80 (%)	81-100 (%)	101-120 (%)	121-140 (%)	141-160 (%)
Scots pine	84,8	0,6	1,7	7,0	2,2	2,8	0,6	0,3
Norway spruce	2,2	1,3	38,6	45,6	11,4	0,9	-	-
Fir	-	-	5,7	7,5	26,4	37,7	22,6	-

Only one species of *Armillaria* – *A. ostoyae* was found in the Scots pine stands, three species: *A. ostoyae, A. cepistipes* and *A. borealis* were found in the Norway spruce stands and two species: *A. ostoyae* and *A. cepistipes* were found in the fir stands (Fig. 1B). In the Norway spruce stands, among the identified isolates and fruit bodies belonging to genus *Armillaria*, the species *A. ostoyae* attained the highest proportion – 85,5%. The remaining ones were less frequent: *A. borealis* – 11,4% and *A. cepistipes* – 3,1%. In the fir stands share of *A. ostoyae* was 51,2% and share of *A. cepistipes* was 48,8%. In the Scots pine stands the species *A. ostoyae* was found in six forest site types, mainly in fresh mixed coniferous forest (Tab. 4). In the Norway spruce stands all the three identified species were found in fresh mixed broadleaved forest site type. The species *A. ostoyae* was recorded in six investigated site types. *A. borealis* was found in fresh broadleaved forest site type and fresh mixed broadleaved forest site type. *A. cepistipes* was found in fresh mixed broadleaved forest site type, mixed mountain forest site type, and mountain forest site type. In the fir stands *A. ostoyae* was noticed on three forest site types: upland forest, mountain forest and mixed mountain forest, *A. cepistipes* – in fresh broadleaved forest, upland forest, and mountain forest.

Table 4
Percentage of particular *Armillaria* species in samples from coniferous stands from different types of forest habitat

Type of forest habitat	Species of *Armillaria*		
	A. borealis (%)	*A. cepistipes* (%)	*A. ostoyae* (%)
Scots pine stands			
FCF	-	-	9,3
FMCF	-	-	78,4
MMCF	-	-	5,6
FBF	-	-	0,8
FMBF	-	-	4,8
MMBF	-	-	1,1
Norway spruce stands			
FMCF	-	28,6	0,9
FBF	3,8	-	2,6
FMBF	96,2	-	12,7
MUF	-	-	13,6
MMF	-	57,1	36,4
MF	-	14,3	33,8
fir stands			
FBF	-	9,5	-
UF	-	38,1	50,0
MMF	-	-	6,2
MF`	-	52,4	43,8

Table 5
Percentage of particular *Armillaria* species in samples from coniferous stands of different stand age classes

Stand age classes	Species of *Armillaria*		
	A. borealis (%)	*A. cepistipes* (%)	*A. ostoyae* (%)
Scots pine stands			
1-20	-	-	84,8
21-40	-	-	0,6
41-60	-	-	1,7
61-80	-	-	7,0
81-100	-	-	2,2
101-120	-	-	2,8
121-140	-	-	0,6
141-160	-	-	0,3
Norway spruce stands			
1-20	-	-	2,2
21-40	-	-	0,9
41-60	88,5	57,1	8,8
61-80	3,8	14,3	75,4
81-100	7,7	28,6	8,3
101-120	-	-	4,4
fir stands			
41-60	-	-	9,4
61-80	-	9,5	6,2
81-100	-	23,8	28,1
101-120	-	42,9	31,3
121-140	-	23,8	25,0

A. ostoyae was found most frequently in the 1-20-year-old Scots pine stands (84,8%), in the 61-80-year-old Norway spruce stands (75,4%) and in the 101-120-year-old fir stands (31,3%; Tab. 5). *A. borealis* and *A. cepistipes* were noticed mainly in the 41-60-year-old Norway spruce stands. *A. cepistipes* was collected particularly in the 101-120-year-old fir stands.

CONCLUSIONS

A. ostoyae seems to be the most frequent species of *Armillaria* in coniferous stands in Poland. It was found in the all investigated stands (100% in pine, 85,5% in Norway spruce and 51,2% in fir stands), in all types of forest habitat and in all stand age classes. It is in concordance with findings of many authors that *A. ostoyae* is responsible for most cases of *Armillaria* attacks in conifers (Guillaumin, Berthelay 1981; Rishbeth 1982; Roll-Hansen 1985; Guillaumin et al 1985; Rykowski 1990; Guillaumin et al 1993).

A. borealis was found only in the older (41-100-years-old) Norway spruce stands in fertile forest site types (FBF, FMBF). *A. cepistipes* was noticed in the older Norway spruce and fir stands and in many forest site types except for weak coniferous ones. Over 50% of samples of that species were collected in the mountain sites.

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Opieńki w drzewostanach iglastych

Streszczenie

Materiał badawczy (owocniki, fragmenty drewna przerośniętego grzybnią, ryzomorfy) pobierano w różnych latach, na jednorazowych powierzchniach w wybranych drzewostanach iglastych: sosnowych, świerkowych i jodłowych. Izolaty identyfikowano za pomocą testów intersterylności. Owocniki identyfikowano na podstawie cech makroskopowych i mikroskopowych. Wśród badanych próbek stwierdzono trzy gatunki opieniek. Stwierdzono w drzewostanach: sosnowych – *A. ostoyae*, świerkowych – *A. ostoyae, A. borealis* i *A. cepistipes*, jodłowych – *A. ostoyae* i *A. cepistipes*. *A. ostoyae* wydaje się być jednym z najczęściej występujących gatunków opieniek w drzewostanach iglastych w Polsce. Stwierdzono ten gatunek we wszystkich badanych drzewostanach iglastych. Jego udział stanowił 100% prób zebranych w drzewostanach sosnowych, 85,5% – w drzewostanach świerkowych oraz 51,5% – w drzewostanach jodłowych. *A. ostoyae* stwierdzono na wszystkich typach siedliskowych lasu i w drzewostanach we wszystkich klasach wieku. *A. borealis* stwierdzono tylko w drzewostanach świerkowych, w wieku 41-100 lat, na bogatych siedliskach. *A. cepistipes* stwierdzono w drzewostanach świerkowych i jodłowych, w starszym wieku, na większości badanych siedlisk.