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# BIODIVERSITY OF MACROFUNGI OF SELECTED FIELD AFFORESTATIONS IN THE AGROECOLOGICAL LANDSCAPE PARK NEAR TUREW (CENTRAL WIELKOPOLSKA)

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**Abstract**: The paper presents the results of mycological observations on the diversity of macrofungi in selected field afforestations in the Agroecological Landscape Park. The occurrence of 139 species, mainly Agaricales, was recorded during studies of three permanent plots between 1998 and 2000. The participation of macrofungi in the field afforestations was analyzed in bioecological groups of mycorrhizal, saprotrophic and parasitic fungi.

**Key words**: Bioecological groups of macrofungi, field afforestations, Agroecological Landscape Park, Central Wielkopolska

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## INTRODUCTION

The Dezydery Chłapowski Agroecological Landscape Park has been of interest to scientists for many years. Most studies have addressed the influence of field afforestations on the agricultural landscape, especially the water cycle, plant production and the microclimate of adjacent fields (e.g., Wilusz & Jaworski 1960; Ryszkowski 1975; Karg & Karlik 1993). Several studies assessed the economic value of the afforestations (e.g., Jastrzębski 1959; Siwek 1962; Ryszkowski 1996). A relatively small number of studies focused on the biocoenotic role of the afforestations (Ryszkowski *et al.* 1990; Szwed & Ratyńska 1991; Karg 1995; Kędziora 1996). Floristic and phytosociological research has been conducted by Gołdyn (1977), Bałazy and Ratyńska-Nowak (1988), Bałazy *et al.* (1990), Ratyńska-Nowak (1990, and unpubl.), Arczyńska-Chudy and Gołdyn (1998) and Gołdyn and Arczyńska-Chudy (1998).

Detailed mycological studies of the Agroecological Landscape Park have not been done yet. Kujawa and Karg (1997) was an exception, but it supplied only preliminary data on the occurrence in the park of macromycete species protected or endangered in the whole of Poland. Bujakiewicz and Kujawa (2000) recently summarized the results of studies in a manorial park in Turew between 1997 and 1999, on the species composition of macromycetes and the role of the park as a refuge habitat in the agricultural landscape.

This paper presents the results of three years' observations (1998–2000) on the diversity of macromycetes in selected field afforestations in relation to their floristic composition and habitat conditions in the Dezydery Chłapowski Agroecological Landscape Park.

## STUDY AREA

The Dezydery Chłapowski Agroecological Landscape Park, established on 1 Dec. 1992, comprises 17,200 ha, 65% of which is arable land, 9% green areas (meadows and pastures), and only 15% forests.

It is situated in the Nizina Wielkopolska lowland, with the Pagórki Dolskie hills in its eastern part and the Równina Kościańska plain, part of the Wysoczyzna Leszczyńska plateau, in its western part (Krygowski 1961). The majority of the park is located within the NE part of the Równina Kościańska plain, which was formed as a moraine. It

is situated *ca* 80 m above sea level and its relief is flat (Bartoszewicz 1998).

Nearly 90% of the park is covered by formations of direct glacial and aqua-glacial accumulation. These are loams, boulder sands and glacial sands. Boulder clays on which usually a sand layer is deposited are the parent rock in the area studied. The plastic consistency of loams may become hardened during long periods of low rainfall (Bartoszewicz 1998).

The climate of the area is temperate, and mean monthly temperatures in winter are relatively high (a few degrees below zero) and in summer relatively low, 17°C–18°C (Kędziora & Palusiński 1998). Mean maximum air temperatures are 0.1°C in January and 23.7°C in July, while mean minimum temperatures range from –5.4°C in January to 12.5°C in July. As the mean annual temperature amplitude is 20°C, the park is situated in the transition zone between maritime and continental climates. The vegetative period lasts 225 days, from the beginning of the third decade of March until the end of October (Woś 1994).

Winds from the west prevail. Wind velocity is average for Poland and ranges between 1 and 4 m/s (mean 2.5 m/s). The highest wind velocities occur in late autumn and also in winter and spring (Kędziora & Palusiński 1998; Kędziora 1990).

Precipitation levels in the park are some of the lowest in Poland and in Europe. Annual rainfall reaches 590 mm, seldom exceeds 650 mm and falls below 400 mm in particularly dry years. Thus the study area is characterized by a considerable deficit of precipitation and a poor surface water network covering *ca* 0.15% of the area. Nearly all the park is in the catchment basin of the Górna Obra; the section of it in this part is called the Kościański Kanał channel.

Oak-hornbeam forest (*Galio sylvatici-Carpinetum*) is the potential plant community in the greater part of the Agroecological Landscape Park. Carrs (*Ribo nigri-Alnetum*) and alluvial forests (*Circaeo-Alnetum* and *Ficario-Ulmetum*) can be found in local depressions and near watercourses. Coniferous habitats occurring on local elevations occupy the smallest area.

The absence of high moor peats and the small share of low moor peats are a distinct characteristic of the park. A very high degree of deforestation and changes in the plant cover brought about by human activity are negative floristic features of the area (Czubiński 1947).

For many centuries the whole park has been subjected to the impact of economic activity, and the majority of plant communities developed here are anthropogenic. However, since large parts of communities not used for farming are preserved – such as field afforestations, balks, ponds, watercourses, enclaves of meadows and forests or village parks – the area has retained its natural floristic richness, evidenced by the presence of species rare or protected in Poland.

The Agroecological Landscape Park has a rich network of field afforestations that act as wind barriers. The ratio of forested to arable land in the vicinity of Turew is 1.19 ha/100 ha. Some of the afforestations date to the time of Dezydery Chłapowski, who managed these lands in the 1830's. Currently all planting zones are protected by law.

Field afforestations are shrubs developing spontaneously or deliberately planted, or small areas of communities of arborescent vegetation that are not, however, differentiated from forest areas. Due to the anthropogenic origin of these communities, ongoing human activities in adjacent areas, the absence of preservation efforts, and most frequently inappropriate management, the afforestations show varying degrees of deformation (Bałazy & Ratyńska-Nowak 1988; Kasprzak 1993).

## METHODS

Mycological studies were conducted between 28 July 1998 and 17 December 2000. Permanent study plots were established within field afforestations in different localities whose floristic composition varied (Table 1). Dr. Andrzej Brzeg of Adam Mickiewicz University classified them phytosociologically (nomenclature follows Mirek *et al*. 1995).

Three plots *ca* 500 $m^2$ each were established on 28 July 1998. In each plot, 31 mycological observations were made approximately every 14 days within successive vegetative seasons (Strakulska 2001).

**Table 1.** Floristic-phytocoenological differentiation of permanent plots in the Agroecological Landscape Park.

| Plot number | | | I | II | III |
|---|---|---|---|---|---|
| Date | | | 08.07.2000 | 08.07.2000 | 08.07.2000 |
| Density of tree layer | a1 | [%] | – | – | 55 |
| Density of tree layer | a2 | [%] | – | – | 15 |
| Density of shrub layer | b | [%] | 60 | 90 | 20 |
| Cover of herb layer | c | [%] | 75 | 60 | 90 |
| Cover of moss layer | d | [%] | 20 | + | + |
| Plot size | [$m^2$] | | 600 | 500 | 500 |
| Number of species | | | 78 | 48 | 34 |
| I. Ch. D* *Epilobio-Salicetum capreae* | | | | | |
| **Betula pendula* | b | | 2.2 | . | . |
| *Betula pendula* | c | | 1.2 | . | . |
| **Sorbus aucuparia* | b/c | | +/+ | . | . |
| *Salix caprea* | b | | + | . | . |
| **Populus tremula* | b | | + | . | . |
| II. Ch. *Epilobietea angustifolii* | | | | | , |
| *Chamaenerion angustifolium* | | | 1.2 | . | . |
| *Cirsium vulgare* fo. | | | +.2 | . | . |
| *Calamagrostis epigejos* | | | +.2 | +.2 | . |
| *Rubus gracilis* | | | +.2 | . | +.2 |
| *Gnaphalium sylvaticum* | | | + | . | . |
| III. Introduced trees | | | | | |
| *Pinus sylvestris* | b | | 2.3 | . | . |
| *Pinus sylvestris* | c | | r | . | . |
| *Populus × canadensis* | b | | 2.3 | . | . |
| *Larix decidua* | b | | 2.3 | . | . |
| *Sorbus intermedia* | b | | 1.2 | . | . |
| *Picea abies* | b | | 1.2 | . | . |
| *Acer pseudoplatanus* | b | | +.2 | . | . |
| *Ulmus laevis* | b | | +.2 | . | . |
| *Populus balsamifera* | b | | + | . | . |
| *Padus serotina* | b/c | | +/+ | . | /+ |
| IV. Ch. *Koelerio-Corynephoretea* | | | | | |
| *Ceratodon pupureus* | d | | 2.2 | . | . |
| *Brachythecium albicans* | d | | 1.2 | . | . |
| *Rumex acetosella* | | | + | . | . |
| *Hypochoeris radicata* | | | + | . | . |
| *Festuca ovina* | | | + | . | . |
| V. Ch. *Stellarietea mediae* and agricultural relicts | | | | | |
| *Apera spica-venti* | | | 2.2 | . | . |
| *Lactuca serriola* | | | + | . | . |
| *Viola arvensis* | | | + | . | . |
| *Myosotis arvensis* | | | + | . | . |

*(cont.)*

**Table 1**. *Continued.*

| Plot number | I | II | III |
|---|---|---|---|
| *Myosotis stricta* | + | . | . |
| *Veronica arvensis* | + | . | . |
| *Centaurea cyanus* | + | . | . |
| *Triticum aestivum* | r | . | . |
| *Conyza canadensis* | +.2 | r | . |
| *Chenopodium album* | r | + | . |
| *Stellaria media* | + | 1.2 | . |
| *Fallopia convolvulus* | + | + | 1.1 |
| *Bromus sterilis* | . | 2.3 | 3.3 |
| *Atriplex patula* | . | r | . |
| *Hordeum vulgare* | . | r | . |
| VI. Ch. *Artemisietea vulgaris* | | | |
| *Cynoglossum officinale* | 1.2 | . | . |
| *Rumex obtusifolius* | +.2 | . | . |
| *Carduus crispus* | +.2 | . | . |
| *Epilobium montanum* | + | . | . |
| *Equisetum arvense* | + | . | . |
| *Convolvulus arvensis* | + | . | . |
| *Arctium tomentosum* | + | . | . |
| *Cirsium arvense* | 2.3 | + | . |
| *Torilis japonica* | 2.2 | + | . |
| *Urtica dioica* | 1.2 | 1.2 | . |
| *Geum urbanum* | + | + | . |
| *Galium aparine* | + | 1.1 | 2.2 |
| *Rubus caesius* | + | 2.2 | +.2 |
| *Agropyron repens* | 2.3 | 2.2 | 2.2 |
| *Chaerophyllum temulum* | . | 1.2 | . |
| *Glechoma hederacea* | . | +.2 | . |
| *Bromus inermis* | . | +.2 | . |
| *Alliaria petiolata* | . | + | . |
| *Artemisia vulgaris* | . | + | . |
| *Impatiens parviflora* | . | + | . |
| *Galeopsis pubescens* | . | 1.2 | 1.2 |
| *Fallopia dumetorum* | . | 1.1 | 1.1 |
| *Veronica sublobata* | . | 1.1 | + |
| *Ballota nigra* | . | 1.2 | +.2 |
| *Geranium robertianum* | . | 1.2 | + |
| *Moehringia trinervia* | . | + | + |
| *Chelidonium majus* | . | . | 2.3 |
| *Humulus lupulus* | . | . | 1.2 |
| VII. Ch. *Molinio-Arrhenatheretea* | | | , |
| *Plantago major* | 1.1 | . | . |
| *Rumex acetosa* | 1.2 | . | . |
| *Rumex thyrsiflorus* | + | . | . |

**Table 1**. *Continued.*

| Plot number | | I | II | III |
|---|---|---|---|---|
| *Deschampsia caespitosa* | | +.2 | . | . |
| *Achillea millefolium* | | +.2 | . | . |
| *Poa palustris* | | +.2 | . | . |
| *Veronica chamaedrys* | | +.2 | . | . |
| *Trifolium repens* | | + | . | . |
| *Crepis biennis* | | + | . | . |
| *Alopecurus pratensis* | | + | . | . |
| *Cerastium holosteoides* | | + | . | . |
| *Taraxacum officinale* | | 2.1 | . | r |
| *Poa trivialis* | | +.2 | +.2 | . |
| *Festuca rubra* | | +.2 | + | +.2 |
| *Agrostis gigantea* | | 1.2 | . | 1.2 |
| *Dactylis glomerata* | | . | 2.2 | 1.2 |
| *Arrhenatherum elatius* | | +.2 | . | 3.4 |
| *Poa pratensis* | | . | . | +.2 |
| VIII. Ch. *Rhamno-Prunetea* | | | | |
| *Crataegus monogyna* | b | . | 5.4 | . |
| *Crataegus monogyna* | c | . | + | . |
| *Sambucus nigra* | b | . | 2.2 | 1.2 |
| *Sambucus nigra* | c | . | + | + |
| *Rosa canina* | b | . | 1.2 | . |
| *Rosa canina* | c | . | + | . |
| *Rhamnus catharticus* | b | . | +.2 | . |
| *Pyrus pyraster* | b | . | + | + |
| IX. Ch. *Chelidonio-Robinietum* | | | | |
| *Robinia pseudacacia* | a[1] | . | . | 4.1 |
| *Robinia pseudacacia* | a[2] | . | . | 2.1 |
| *Robinia pseudacacia* | b | . | . | 2.1 |
| *Robinia pseudacacia* | c | . | . | + |
| X. Ch. *Querco-Fagetea* | | | | |
| *Acer platanoides* | b | . | 1.1 | + |
| *Acer platanoides* | c | . | 2.1 | . |
| *Poa nemoralis* | | +.2 | 2.2 | +.2 |
| *Dryopteris filix-mas* | | + | . | . |
| *Fraxinus excelsior* | c | + | . | . |
| *Ribes uva-crispa* | b | . | +.2 | . |
| *Atrichum undulatum* | d | . | +.2 | . |
| *Ribes spicatum* | b | . | . | +.2 |
| XI. Others | | | | |
| *Quercus robur* | b | 1.1 | . | + |
| *Quercus robur* | c | 1.1 | + | 1.1 |
| *Phascum cuspidatum* | d | 1.2 | +.2 | +.2 |
| *Brachythecium rutabulum* | d | +.2 | +.2 | +.2 |

*(cont.)*

**Table 1**. *Continued.*

| Plot number | | I | II | III |
|---|---|---|---|---|
| *Agrostis capillaris* | | 2.2 | . | 2.2 |
| *Poa compressa* | | + | . | + |
| *Brachythecium curtum* | d | 1.2 | . | . |
| *Veronica officinalis* | | +.2 | . | . |
| *Senecio jacobea* | | + | . | . |
| *Bidens frondosa* | | + | . | . |
| *Hypericum perforatum* | | +.2 | + | . |
| *Galium verum* | | . | +.2 | . |
| *Brachythecium velutinum* | d | . | +.2 | . |
| *Pohlia nutans* | d | . | +.2 | . |
| *Dicranella heteromalla* | d | . | +.2 | . |
| *Euphorbia cyparissias* | | . | + | . |
| *Anthoxanthum odoratum* | | . | . | 1.2 |
| *Holcus mollis* | | . | . | +.2 |

The collected and identified material was deposited in the Department of Plant Ecology and Environment Protection at the Adam Mickiewicz University in Poznań (POZM).

A combined table (Table 2) illustrating the variety of mycota in individual plots was prepared on the basis of observations of the macromycetes' participation in the Agroecological Landscape Park. Fungal species were divided into bioecological groups (Lisiewska 2000).

The first set of digits refers to the number of occurrences of a given species throughout the observations, and the next set shows the abundance range of fruitbodies according to Nespiak's (1959) scale. The nomenclature of fungal taxa was adopted chiefly from Moser (1983) and Jülich (1984), supplemented in keeping with Breitenbach and Kränzlin (1984, 1991, 1995).

## FLORISTIC AND PHYTOSOCIOLOGICAL DESCRIPTION OF PERMANENT PLOTS

PLOT I. WYSKOĆ FIELD AFFORESTATION. The Wyskoć tree line field afforestation was established in 1993 in a field in the vicinity of Gołębin Stary village in Czempiń municipality. The permanent plot covers *ca* 600 $m^2$ (Fig. 1), on cryptic podzol soils formed on light loamy sand deposited on light loam. These soils constitute a good rye complex on the farming utility scale.

The plot vegetation is related to the *Epilobio-Salicetum capreae* Oberd. 1957 community with high shares of grassland, segetal, herbaceous and meadow species within acidophilous oak *Calamagrostio-Quercetum petraeae* forest habitat. As many as 78 plant species were recorded in one phytosociological relevé (Table 1).

Trees introduced artificially in the post-agricultural area were planted in eleven rows, and the density of external rows was additionally increased with poplar to emphasize the tree stand borders. Altogether 3093 trees of thirteen species were planted. Oak (24.6%) and larch (18.8%)

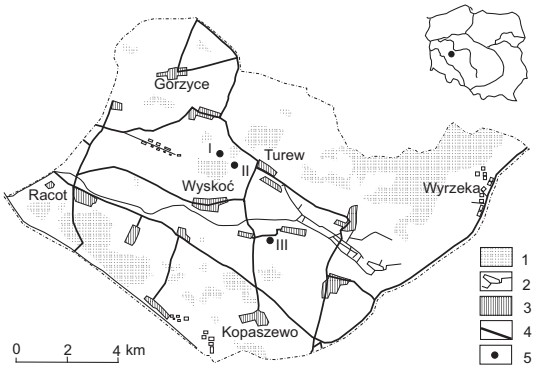


**Fig. 1**. Location of permanent plots in the Agroecological Landscape Park. 1 – forests, 2 – water-courses, 3 – vilages and buildings, 4 – main roads, 5 – permanent plot.

**Table 2**. Macrofungi on permanent plots in selected field afforestations.

| Plot number | I | II | III |
|---|---|---|---|
| Number of observations | 31 | 31 | 31 |
| Total number of species | 62 | 72 | 59 |
| MYCORRHIZAL FUNGI | | | |
| Number of species | 23 | 2 | 3 |
| *Thelephora terrestris* | 14/1–5 | . | . |
| *Laccaria proxima* | 11/1–5 | . | . |
| *Suillus grevillei* | 10/1–4 | . | . |
| *Inocybe lanuginella* | 7/1–2 | . | . |
| *Xerocomus chrysenteron* | 6/+–2 | . | . |
| *Paxillus involutus* | 6/1–2 | . | . |
| *Xerocomus rubellus* | 4/1 | . | . |
| *Laccaria laccata* | 4/2–5 | . | . |
| *Laccaria tortilis* | 3/1–5 | . | . |
| *Lactarius glyciosmus* | 2/+ | . | . |
| *Inocybe napipes* | 2/1 | . | . |
| *Inocybe grammata* | 2/1–2 | . | . |
| *Hebeloma longicaudum* | 2/1–2 | . | . |
| *Hebeloma crustiliniforme* | 2/1 | . | . |
| *Xerocomus subtomentosus* | 1/+ | . | . |
| *Lactarius necator* | 1/1 | . | . |
| *Amanita muscaria* | 1/1 | . | . |
| *Laccaria bicolor* | 1/1 | . | . |
| *Inocybe bongardii* | 1/2 | . | . |
| *Inocybe petiginosa* | 1/2 | . | . |
| *Lactarius deliciosus* | 1/2 | . | . |
| *Hebeloma sacchariolens* | 1/2 | . | . |
| *Russula foetens* | . | 1/+ | . |
| *Tricholoma inamoenum* | . | . | 1/+ |
| *Russula cyanoxantha* | . | . | 1/+ |
| *Lactarius quietus* | 2/1 | 1/+ | 3/+–2 |
| SAPROTROPHIC FUNGI | | | |
| Total number of species | 39 | 69 | 56 |
| a) on humus | | | |
| number of species | 10 | 26 | 23 |
| *Peziza vesiculosa* | 4/+–1 | . | . |
| *Volvariella gloiocephala* | 1/+ | 1/+ | . |
| *Coprinus comatus* | . | 4/1–2 | . |
| *Agaricus xanthoderma* | . | 3/+–1 | . |
| *Bovista pusilla* | . | 3/+–1 | . |
| *Bolbitius vitellinus* | . | 3/1–2 | . |
| *Entoloma sericeum* | . | 1/+ | . |
| *Lepiota subgracilis* | . | 1/+ | . |
| *Agrocybe sphaleromorpha* | . | 1/+ | . |
| *Melanoleuca melaleuca* | . | 1/+ | . |
| *Entoloma excentricum* | . | 1/1 | . |
| *Panaeolus fimicola* | . | 1/1 | . |
| *Psathyrella canoceps* | . | 1/1 | . |
| *Hygrophoropsis aurantiaca* | . | 1/2 | . |
| *Lepiota subincarnata* | . | 1/2 | . |
| *Bovista plumbea* | . | 2/2 | 2/+–1 |
| *Lepista nuda* | . | 2/1–2 | 2/+–2 |
| *Agaricus silvicola* | . | 1/1 | 3/+–1 |
| *Agaricus campester* | . | 1/1 | 3/+–2 |
| *Agaricus abruptibulbus* | . | . | 2/+ |
| *Agaricus arvensis* | . | . | 2/+–2 |
| *Phallus impudicus* | . | . | 1/2 |
| *Calvatia utriformis* | . | . | 1/+ |
| *Melanoleuca brevipes* | . | . | 1/+ |
| *Melanoleuca excissa* | . | . | 1/+ |
| *Panaeolina foenisecii* | . | . | 1/1 |
| *Marasmius collinus* | . | . | 1/1 |
| *Leucoagaricus pudicus* | . | . | 1/1 |
| *Agrocybe arvalis* | . | . | 1/1 |
| *Melanoleuca cinerascens* | . | . | 1/2 |
| *Macrolepiota procera* | 3/+ | 2/+–2 | 2/1 |
| *Lycoperdon perlatum* | 2/1–2 | 5/1–2 | 1/1 |
| *Agrocybe praecox* | 1/1 | 1/+ | 1/1 |
| *Marasmius oreades* | 1/2 | 1/2 | 5/+–2 |
| *Conocybe tenera* | 1/1 | 1/1 | 2/+ |
| *Calvatia excipuliformis* | 1/+ | 3/+ | 2/+–1 |
| *Macrolepiota rhacodes* var. *hortensis* | 1/1 | 4/+–2 | 6/1–3 |
| *Lepista nebularis* | 1/1 | 1/1 | 3/2–3 |
| b) on litter | | | |
| number of species | 22 | 23 | 20 |
| *Clitocybe rivulosa* | 3/2–4 | . | . |
| *Mycena rosea* | 2/+–1 | . | . |
| *Clitocybe candicans* | 2/+–2 | . | . |
| *Clitocybe metachroa* | 2/+–2 | . | . |
| *Tubaria pellucida* | 1/+ | . | . |
| *Stropharia semiglobata* | 1/+ | . | . |
| *Pholiota lenta* | 1/1 | . | . |
| *Mycena tenella* | 1/1 | . | . |
| *Marasmius androsaceus* | 1/2 | . | . |
| *Mycena stylobates* | 1/2 | . | . |

*(cont.)*

**Table 2**. *Continued.*

| Plot number | I | II | III |
|---|---|---|---|
| *Clitocybe vermicularis* | 1/2 | . | . |
| *Clitocybe angustissima* | 1/4 | . | . |
| *Cyathus olla* | 4/1–5 | 1/1 | . |
| *Tubaria hiemalis* | 1/2 | 2/1 | . |
| *Clitocybe dealbata* | 5/1–3 | . | 3/+–1 |
| *Clitocybe fragrans* | 4/1–2 | . | 2/+–2 |
| *Clitocybe gibba* | 1/2 | . | 2/1 |
| *Stropharia aeruginosa* | . | 6/1 | . |
| *Coprinus xanthothrix* | . | 4/+–2 | . |
| *Tubaria furfuracea* | . | 2/2 | . |
| *Coprinus hemerobius* | . | 1/+ | . |
| *Mycena galopoda* | . | 1/+ | . |
| *Clitocybe clavipes* | . | 1/+ | . |
| *Tubaria romagnesiana* | . | 1/1 | . |
| *Psathyrella marcescibilis* | . | 1/1 | . |
| *Psathyrella subnuda* | . | 1/1 | . |
| *Mycena sanguinolenta* | . | 1/2 | . |
| *Clitocybe cerussata* | . | 1/2 | . |
| *Collybia peronata* | . | 5/+–2 | 1/1 |
| *Psathyrella prona* | . | 2/1–2 | 1/1 |
| *Clitocybe odora* | . | 1/1 | 1/1 |
| *Mycena filopes* | . | 1/2 | 1/1 |
| *Clitocybe inversa* | . | 1/2 | 2/1–3 |
| *Clitocybe suaveolens* | . | . | 2/1–2 |
| *Coprinus plicatilis* | . | . | 1/+ |
| *Clitocybe vibecina* | . | . | 1/+ |
| *Psathyrella spadiceo–grisea* | . | . | 1/1 |
| *Psathyrella gyroflexa* | . | . | 1/1 |
| *Collybia confluens* | . | . | 1/2 |
| *Collybia hybrida* | . | . | 1/2 |
| *Collybia dryophila* | 5/1 | 7/+–2 | 7/1–2 |
| *Mycena pura* | 3/+ | 3/1–2 | 2/+–2 |
| *Collybia butyracea* var. *asema* | 3/+–1 | 1/3 | 1/1 |
| *Stropharia cyanea* | 1/1 | 3/1–2 | 5/+–1 |
| *Clitocybe flaccida* | 1/1 | 2/1–2 | 5/+–3 |
| c) on wood | | | |
| number of species | 7 | 20 | 13 |
| *Daedalea quercina* | 1/1 | . | . |
| *Exidia glandulosa* | 1/2 | . | . |
| *Psathyrella hydrophila* | 1/2 | . | . |
| *Pluteus cervinus* | 1/+ | 1/+ | . |
| *Mycena vitilis* | 2/+–1 | . | 4/+–1 |
| *Marasmius rotula* | . | 5/2–3 | . |
| *Trametes versicolor* | . | 2/+–3 | . |
| *Lycoperdon pyriforme* | . | 2/2 | . |
| *Pleurotus ostreatus* | . | 1/+ | . |
| *Crucibulum laeve* | . | 1/+ | . |
| *Collybia marasmioides* | . | 1/+ | . |
| *Pluteus salicinus* | . | 1/+ | . |
| *Psathyrella obtusata* | . | 1/+ | . |
| *Mycena niveipes* | . | 1/1 | . |
| *Bjerkandera adusta* | . | 1/2 | . |
| *Stereum hirsutum* | . | 1/3 | . |
| *Coprinus disseminatus* | . | 1/3 | . |
| *Coprinus micaceus* | . | 4/1–2 | 1/3 |
| *Psathyrella candolleana* | . | 2/1–3 | 4/1– 3 |
| *Coprinus domesticus* | . | 1/+ | 1/+ |
| *Flammulina velutipes* | . | 1/+ | 1/1 |
| *Psathyrella pseudocasca* | . | 1/1 | 1/1 |
| *Auricularia auricula-judae* | . | . | 6/+– 2 |
| *Ramaria stricta* | . | . | 2/1 |
| *Mycena erubescens* | . | . | 1/+ |
| *Mycena polygramma* | . | . | 1/+ |
| *Polyporus brumalis* | . | . | 1/1 |
| *Mycena galericulata* | 2/+–1 | 8/+–2 | 14/1– 3 |
| *Hypholoma fasciculare* | 1/3 | 1/3 | 1/2 |
| PARASITIC FUNGI | | | |
| Number of species | 0 | 1 | 0 |
| *Polyporus squamosus* | . | 3/1 | . |

were the dominant species. The share of poplar was 12.3%, fir 10.7%, beech 7.8%, elm, birch and rowan *ca* 5% each, and other species (linden, pine, sycamore and mountain ash) between 2% and 3% (Karg 1999).

The shrub layer (b), with 60% density, is very well developed. The undergrowth is mainly *Betula pendula, Pinus sylvestris, Populus* × *canadensis, Larix decidua, Sorbus intermedia, Pica abies* and *Quercus robur*, with a few representatives of *Sorbus aucuparia, Acer pseudoplatanus, Ulmus laevis* and *Padus serotina*, as well as single individuals of *Salix caprea, Populus tremula* and *Populus balsamifera.* Some species such as *Salix*

*caprea* are self-sown. Most trees of *Ulmus laevis* were attacked by elm disease.

The grassland-type herb layer is very rich, with 75% cover. Nitrophilous plants of the class *Artemisietea vulgaris* prevail. The share of *Urtica dioica* is relatively high. Synanthropic species such as *Agropyron repens, Galium aparine, Convolvulus arvense* occur. *Plantago major, Rumex acetosa, Achillea millefolium, Poa palustris, Veronica chamaedrys, Taraxacum officinale* are some of the meadow species characteristic of the class *Molinio-Arrhenatheretea*. Seedlings of *Betula pendula, Pinus sylvestris, Padus serotina, Fraxinus excelsior* and *Quercus robur* occur in the herb layer.

The share of *Ceratodon purpureus, Phascum cuspidatum* and three species of *Brachythecium* (*B. albicans, B. rutabulum* and *B. curtum*) is significant in a somewhat poor moss layer. The coverage of the moss layer is small (20%). However, mosses forming clusters do not play a major role in this area.

PLOT II. HAWTHORN SHRUB LINE. Plot II (500 $m^2$) was established within Kościan municipality in a hawthorn shrub line 1125 m long and *ca* 4 m wide, occupying 2.25 ha.

The soils in the plot discussed can be classified as leached brown soils deposited on light loamy sands. This type of soil constitutes a poor rye complex on the farming utility scale.

Although the plot is very littered, it is the most natural of the plots examined. It occupies a shaded, very moist and fertile habitat related to the *Galio sylvatici-Carpinetum*. Decomposing deciduous litter is abundant. Decaying wood at different stages of decomposition is especially plentiful. Stumps, fallen logs and twigs or branches are found. Trees may have grown in the area earlier, though only the shrub layer (individuals up to one hundred years old) and a less developed herb layer occur there now. Hawthorns are regularly trimmed. Moss clusters are formed under some stumps.

The phytocoenosis bears a resemblance to that of the thicket community of *Pruno-Crataegetum* Hueck 1931. Forty-eight plant species were recorded in the relevé (Table 1).

*Crataegus monogyna* with the participation of *Sambucus nigra, Rhamnus catharticus* and *Rosa canina* dominates in the shrub layer, the density of which is quite high (90%). Other components are *Pyrus pyraster, Acer platanoides* and *Ribes uva-crispa*, which occur rarely. Seedlings of *Crataegus monogyna, Rosa canina, Quercus robur* and *Acer platanoides* were recorded in the herb layer.

The herb layer, with 60% cover, consists of nitrophilous plants of the class *Artemisietea vulgaris* typical of forest edge, such as *Urtica dioica, Galium aparine, Rubus caesius, Agropyron repens, Chaerophyllum temulum, Glechoma hederacea, Bromus inermis, Galeopsis pubescens, Fallopia dumetorum, Veronica sublobata, Ballota nigra* and *Geranium robertianum*, accompanied by *Poa nemoralis*, a species of the class *Querco-Fagetea*. The class *Molinio-Arrhenatheretea* is represented by three meadow species: *Dactylis glomerata, Poa trivialis* and rarely *Festuca ovina*. Segetal plants of the class *Stellarietea mediae* occur sporadically and do not play an important role. These are *Stellaria media, Bromus sterilis, Conyza canadensis, Chenopodium album, Fallopia convolvulus, Atriplex patula* and *Hordeum vulgare*. *Calamagrostis epigejos* is a species typical of clear-cuts.

The moss layer is poorly defined. *Phascum cuspidatum, Brachythecium rutabulum, B. velutinum, Pohlia nutans* and *Dicranella heteromalla* occur in it.

PLOT III. *ROBINIA* AFFORESTATION. The plot was established in Krzywiń municipality. The robinia afforestation, 1430 m long (N-S) and 30 m wide, totals 5 ha, 500 $m^2$ of which is occupied by the plot. The area, well insolated obliquely, belongs to the potential oak-hornbeam forest habitat.

*Robinia pseudacacia* 150 years old, introduced by Dezydery Chłapowski, prevails in the tree stand. Spontaneous regeneration of oak has been observed. The shrub layer is significantly less developed, while *Chelidonium majus*, next to grasses such as *Festuca rubra, Agrostis gigantea* and *Agropyron repens*, dominates in the herb layer. There are numerous decaying stumps and fallen old branches of *Robinia pseudacacia* or less frequently *Sambucus nigra*, at different stages of decomposition. Grass litter in the form of hay is deposited abundantly. Due to relatively quick decomposition, deciduous litter of robinia and oak origin is sparse.

The third plot was established on typical brown soils. The surface layer of the soil is formed of weak loamy sands deposited on loose sands. The robinia zone is a very poor rye complex on the agricultural utility scale.

A slightly hilly area below the old robinia planting creates a characteristic microrelief and separates the field from the road. Phytosociologically the phytocoenosis resembles the *Chelidonio-Robinietum* Jurko 1969 community. Only 34 plant species were recorded in the relevé (Table 1).

*Robinia pseudacacia* forms the upper part of the tree layer ($a_1$), with 55% density. *Robinia* also prevails in layer $a_2$, but with only 15% density.

The shrub layer (b) is poorly developed (density 20%). Prevailing are *Sambucus nigra, Ribes spicatum* and *Padus serotina* as well as undergrowth of *Robinia pseudacacia, Acer platanoides* and *Quercus robur*.

The herb layer (c), grassy in nature, is highly developed (cover 90%). It is dominated by species of nitrophilous plants of the class *Artemisietea vulgaris*, such as *Chelidonium majus, Galium aparine, Agropyron repens, Galeopsis pubescens, Humulus lupulus* and *Fallopia dumetorum*. There are numerous representatives of some meadow plants of the class *Molinio-Arrhenatheretea*, such as *Arrhenatherum elatius, Dactylis glomerata, Agrostis gigantea, Festuca rubra* and *Poa pratensis*. Occurring sporadically are synanthropic plants of the class *Stellarietea mediae* and field relicts including *Bromus sterilis* and *Fallopia convolvulus*. The herb layer also contains seedlings of *Quercus robur, Robinia pseudacacia, Sambucus nigra* and *Padus serotina*.

The moss layer is very sparse. It is represented only by species with low coverage, such as *Brachythecium rutabulum* and *Phascum cuspidatum*.

## MYCOLOGICAL ANALYSIS OF THE EXAMINED AFFORESTATIONS

PLOT I. WYSKOĆ FIELD AFFORESTATION. Habitat conditions and floristic composition are the main factors influencing the characteristic mycota, which either forms mycorrhizal associations with the introduced trees or develops as saprobes on fallen decomposing leaves and wood fragments.

Altogether 62 species of macromycetes were recorded. Epigeic mycorrhizal fungi were represented by 23 species, which constituted 37% of the mycobiota of the plot. Saprobic fungi (39 species, i.e., 63% of the mycobiota of the phytocoenosis) occurred significantly more often. Ten species (16% of the mycobiota) were humicolous saprobes, 22 species (36%) litter-inhabiting saprobes, and only 7 species (11%) lignicolous saprobes. No parasitic fungi were recorded (Table 2; Fig. 2).

Development conditions were good for epigeic mycorrhizal fungi that often fruit collectively, for example *Thelephora terrestris* and *Laccaria proxima*, great numbers of which were also recorded on the Smolnica recultivated coal mine dump in the vicinity of Gliwice (Lisiewska 1987), or *Laccaria laccata* and *L. tortilis*. The latter species is encountered especially on forest roads and in well-lit parks on loamy substrates (Kreisel 1987). For several species, only one or a few individuals were recorded in the plot, for example *Laccaria bicolor, Hebeloma sacchariolens* and *Inocybe bongardii*. In this plot, single fruitbodies of *Lactarius glyciosmus, L. necator* and *Amanita muscaria* were found under birches, and of *Lactarius deliciosus* near pine plantings. Edible fungi such as *Suillus grevillei, Xerocomus chrysenteron, X. rubellus* and *X. subtomentosus* were also found.

The percentage share of ubiquitous species was high in the group of humicolous saprobes (Table 2).

*Volvariella gloiocephala*, a species not found frequently and known from only a few localities in gardens and on roadsides in the lowland part of Poland (Skirgiełło 1999), deserves special attention. *Marasmius oreades*, which may be considered a parasite of grass roots (Kreisel 1987), is another interesting humicolous saprobe associated with meadows and grassy roadsides through its habitat.

The majority of saprobes were litter-inhabiting fungi, and species of the genera *Clitocybe, Collybia, Mycena, Stropharia* and *Tubaria* in particular. *Clitocybe dealbata* occurred on fallen leaves. *Clitocybe rivulosa* was numerous and *Marasmius androsaceus* was sporadic on coniferous litter.

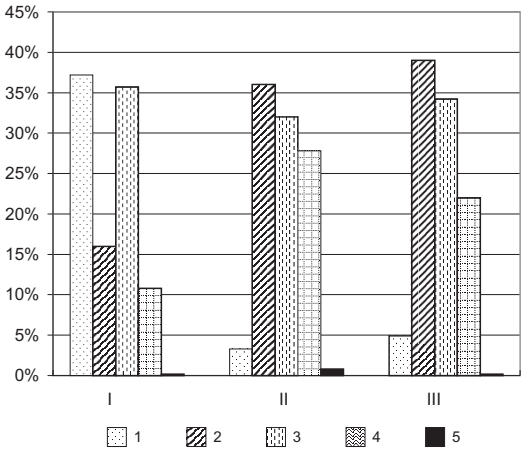


**Fig. 2**. Proportion of bioecological groups of macrofungi on permanent plots. 1 – mycorrhizal, 2 – saprotrophs on humus, 3 – saprotrophs on litter, 4 – saprotrophs on wood, 5 – parasites. I–III – plots.

Species of the genus *Clitocybe* such as *Clitocybe flaccida, C. gibba, C. vermicularis, C. metachroa, C. candicans* and *C. angustissima* prevailed in the group of litter-inhabiting fungi. The latter two fungi were recorded on recultivated brown coal mining dumps (Lisiewska *et al.* 1986). Few representatives of *Tubaria pellucida, Stropharia semiglobata, Pholiota lenta, Mycena pura, M. rosea* and *M. tenella* were found. The synanthropic species *Cyathus olla*, also found in orchards near Poznań (Lisiewska & Balcerkiewicz 1991), often fruited numerously on remnants of herbaceous plants.

Wood was scarce in the plot, no decomposing stumps, logs or branches were noted. Only a few species of lignicolous macromycetes were found. *Hypholoma fasciculare* was most numerous, while *Daedalea quercina* occurred singly on an oak stump. *Exidia glandulosa* and *Mycena vitilis* occurred on fallen twigs, and *Psathyrella hydrophila* fruited on deciduous wood.

PLOT II. HAWTHORN SHRUB LINE. Mycological richness is the greatest in this plot; 72 species of macromycetes were found throughout the three years of observations, and only two species were epigeic mycorrhizal fungi (3% of the mycobiota of this phytocoenosis). Saprobic fungi were represented by 68 species (96%), including 26 species of humicolous saprobes (36%), 23 species of litter-inhabiting saprobes (32%) and 20 species of lignicolous saprobes (28%). One parasitic fungus was recorded (Fig. 2).

The mycorrhizal species *Russula foetens* occurred exclusively in this phytocoenosis. *Lactarius quietus*, associated with oak forests, was also found in other afforestations in which oak trees occurred.

Saprobic fungi were the most numerous bioecological group. Fruitbodies of *Marasmius rotula, Mycena galericulata, Stropharia aeruginosa, Collybia dryophila, Lycoperdon perlatum* and *Coprinus micaceus* were found most frequently. The majority of these species were observed in the other plots. *Entoloma excentricum*, which is on the Polish 'red list' of fungi in the category of extinct and lost species (Wojewoda & Ławrynowicz 1992), was also found.

The presence of synanthropic humicolous saprobes such as *Coprinus comatus, Agrocybe sphaleromorpha, Bolbitius vitellinus* and *Panaeolus fimicola* is conditioned by considerable anthropogenic impacts (refuse, organic fertilization of adjacent fields). Particularly notable is the humicolous saprobe *Bovista pusilla*, which fruits in insolated areas among xerothermic vegetation on forest edges (Kreisel 1987; Rudnicka-Jezierska 1991). As in the Wyskoć afforestation (Plot I) and the robinia afforestation (Plot III), the inedible *Macrolepiota rhacodes* var. *hortensis* as well as edible fruitbodies of *Macrolepiota procera* occurred. The habitats of these taxa differ, as *Macrolepiota rhacodes* var. *hortensis* occurs in gardens, parks, meadows, on humus- and nutrient-rich soils and compost heaps (Breitenbach & Kränzlin 1995), while *M. procera* is observed especially on the margins of deciduous and mixed forests, near fields. Due to the anthropogenic nature of the field afforestations, the two fungi taxa occur there alternately. Fruitbodies of *Agaricus xanthoderma, A. silvicola, A. abruptibulbus, Hygrophoropsis aurantica* and *Marasmius oreades* were also recorded in this plot.

Litter-inhabiting saprobes constitute a fairly considerable group; synanthropic species occurring only in this plot, such as *Coprinus hemero-*

*bius, Psathyrella subnuda* and *Coprinus xanthotrix*, are among them. They have been observed as well in Wielkopolska in orchards in which herbicides were used (Lisiewska & Balcerkiewicz 1991). Apart from species of anthropogenic habitats, also recorded were macrofungi of forest communities, for example species of deciduous forests such as *Mycena sanguinolenta, Mycena filopes* and *Collybia peronata*.

This plot was rich in lignicolous fungi, of which 12 species occurred exclusively in the hawthorn shrub line. Individuals of *Coprinus micaceus, C. disseminatus, C. domesticus* and *Mycena niveipes* were found near hawthorn stumps. Fruitbodies of *Mycena galericulata* occurring numerously on trunks of *Sambucus nigra* were rather frequent. *Stereum hirsutum* and *Trametes versicolor* fruited fairly numerously on pieces of bark, while *Marasmius rotula* was observed on fallen twigs.

Parasitic fungi were represented exclusively by *Polyporus squamosus*, which occurs annually.

PLOT III. *ROBINIA* AFFORESTATION. The occurrence of macromycetes was the least in this plot. As few as 59 species, including three species of epigeic mycorrhizal fungi (5% of the mycobiota) and 56 species of saprobic fungi (95%) were recorded.

Of the three species of epigeic mycorrhizal fungi, only *Lactarius quietus*, which fruited more abundantly in the robinia afforestation, occurred in all permanent plots. The other two, *Russula cyanoxantha* and *Tricholoma inamoenum*, recorded sporadically, were observed only in this plot.

Species associated with fields, meadows, gardens and grassy roadsides, such as *Agaricus arvensis, A. campester, Leucoagaricus pudicus, Panaeolina foenisecii, Agrocybe arvalis* and *Marasmius oreades*, as well as *Marasmius collinus*, usually not distinguished from it, prevailed among the saprobic humicolous fungi found exclusively in this plot. Infrequent specimens of *Agaricus silvicola, A. abruptibulbus* and other species associated with deciduous and mixed forests were found at the borders of the plot, on loamy soils. Some of the macrofungi listed are also recorded in the *Chelidonio-Robinietum* community in Niestachowski Park in Poznań (Lisiewska & Celka 1995). Species of the genus *Melanoleuca*, such as *M. excissa* and *M. cinerascens*, found only in this plot, as well as *Melanoleuca brevipes*, are also recorded in a robinia afforestation on the Kazimierz brown coal mining dump (Lisiewska et al. 1986), deserve special attention.

Species of the genera *Clitocybe* and *Collybia* dominated among the litter-inhabiting fungi (Table 2).

The group of lignicolous saprobes is relatively small. The exclusive species were *Mycena erubescens, M. polygramma, Polyporus brumalis, Ramaria stricta* and *Auricularia auricula-judae*, which can also be considered a weak parasite of *Sambucus nigra* (Wojewoda 1977). These species were also recorded in the *Chelidonio-Robinietum* community in Golęciński Park in Poznań (Lisiewska & Celka 1995). *Mycena galericulata*, recorded as many as 14 times (between 15 and 100 specimens), fruited most abundantly in Plot III.

A small number of macrofungi, especially epigeic mycorrhizal species, may be a result of excessive cover of the plot by a dense, grassy herb layer preventing the development of fruitbodies.

## RESULTS AND CONCLUSIONS

Between 1998 and 2000 the occurrence of 139 species of macromycetes was recorded during 31 mycological observations in permanent plots. The fungi belong to basidiomycetes (138 species). The order Agaricales was represented most numerously (107 species).

Three bioecological groups of macrofungi were differentiated on the basis of their life forms and type of substrate: epigeic mycorrhizal, saprobic (humicolous, litter-inhabiting and lignicolous) and parasitic.

Listed by bioecological group, the share of macromycetes in all mycota in the plots was as follows:

Epigeic mycorrhizal fungi (26 species) – 19%
Saprobic (saprotrophic) fungi:
- humicolous (38 species) – 27%
- litter-inhabiting (45 species) – 32%
- lignicolous (29 species) – 21%

Parasitic fungi (1 species) – 1%

Increased anthropopressure has brought about the occurrence of synanthropic fungi such as *Bolbitius vitellinus, Cyathus olla, Coprinus plicatilis, C. comatus, Agaricus campester, A. xanthoderma* and *Melanoleucca brevipes*. Strong winds, especially in autumn and winter, undoubtedly have contributed to this, as they blow off particles of dry soil together with fertilizer from the fields, which are then stopped at the margins of field afforestations.

Species typical of coniferous communities, such as *Laccaria proxima, Paxillus involutus, Suillus grevillei, Xerocomus subtomentosus, X. rubellus, Amanita muscaria* and *Lactarius deliciosus*, were observed in coniferous plantings. Fungi known from deciduous forest communities, such as *Lactarius quietus, Lepista nebularis, Xerocomus chrysenteron, Russula cyanoxantha, Collybia dryophila, C. peronata, C. butyracea* var. *asema* and *Mycena filopes*, were recorded in deciduous afforestations.

The mycorrhizal fungi were represented by 26 species, the majority of which belonged to the genera *Hebeloma, Inocybe, Laccaria, Lactarius* and *Xerocomus*. Apart from one species (*Lactarius quietus*), all mycorrhizal fungi occurred exclusively in single permanent plots.

The greatest share of mycorrhizal species was recorded in the Wyskoć afforestation, where the mosaic-like tree stand is formed of different tree species (Table 2).

Saprobes were the bioecological group represented most numerously in the mycota of the studied field afforestations. The greatest number of exclusive species in the subgroup of humicolous saprobes occurred in Plot II, where, for example, *Agaricus xanthoderma, Bovista pusilla, Coprinus comatus, Entoloma sericeum, Hygrophoropsis aurantiaca, Lepiota subgracilis, Panaeolus fimicola*, and *Psathyrella canoceps* were found. *Coprinus comatus* was encountered most frequently and fruited most abundantly. The other species occurred sporadically and in small numbers.

Litter-inhabiting saprobic fungi constituted the majority of the mycota of all afforestations. Similar numbers of species of macromycetes fruiting on litter were found in Plots I and II, but abundance was definitely the highest in the Wyskoć afforestation. Twelve exclusive species were recorded in this afforestation, including *Clitocybe angustissima, Clitocybe rivulosa, Marasmius androsaceus, Mycena rosea, Stropharia semiglobata* and *Tubaria pellucida*.

*Pleurotus ostreatus, Trametes versicolor, Stereum hirsutum, Flammulina velutipes* and *Coprinus micaceus* are lignicolous saprobes, the greatest number of which was recorded in Plot II. *Polyporus squamosus*, fruiting on an oak trunk, was the only parasite recorded.

Some of the edible mushrooms recorded in the plots studied were *Suillus grevillei, Xercomus chrysenteron, Marasmius oreades, Macrolepiota procera, Lactarius deliciosus* and *Agaricus campester*; poisonous fungi were represented by *Mycena rosea, Amanita muscaria, Agaricus xanthoderma, Paxillus involutus, Russula foetens* and *Macrolepiota rhacodes* var. *hortensis*.

Field afforestations are a refuge for endangered and rare species in Poland (Wojewoda & Ławrynowicz 1992). These are *Entoloma excentricum* (Extinct), *Inocybe grammata* (Vulnerable), *Lactarius deliciosus* (Vulnerable), *Agaricus xanthoderma* (Rare), *Clitocybe angustissima* (Rare), *Clitocybe candicans* (Indeterminate), *Psathyrella canoceps* (Indeterminate) and *Macrolepiota procera* (Indeterminate). *Phallus impudicus*, recorded twice, is a species protected by law.

In terms of species composition the mycobiota of the studied field afforestations bear some resemblance the macromycetes recorded in the manorial park in Turew (Bujakiewicz & Kujawa 2000), with 42 species occurred in both.

Our continuous mycosociological observations between 28 July 1998 and 17 December 2000 made it possible to examine seasonal occurrences and the influence of environmental patterns (e.g., temperature, precipitation, snow cover, wind, habitat) on the fruiting of macromycetes.

Precipitation and temperature changes influenced the intensity of fruiting of fungal species in particular. In this study, three periods of the greatest fructification can be differentiated in the annual cycle of fruiting. The first slight increase in fruiting took place in the spring in May. The sec-

ond peak, in the summer, was in July. The maximum autumn peak was at the end of September and the beginning of October. Only in 1999 did the peak of autumn fruiting take place at the end of October and the beginning of November, perhaps due to a prolonged drought and relatively high ambient temperatures.

Field afforestations form an anthropogenic agricultural landscape in forest-deficient Wielkopolska, and enhance the recreational value of the area. They provide a refuge for plant, animal and macrofungi species that are rare or endangered in Poland. Increased water retention in the soil, diminished air erosion, and intensification of environmental self-regulation and self-restoration mechanisms are benefits of their influence on the microclimatic conditions of adjacent arable fields.

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