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FAGUS IN THE FOREST HISTORY OF POLAND

Buk w historii lasów Polski

ABSTRACT. An analysis of the occurrence of fossil remains of the genus *Fagus* in 69 localities of Neogene floras and 50 localities of the Middle and Upper Pleistocene floras has been carried out. It permits the statement that *Fagus* played an important role in the composition of the Neogene forest associations, whereas in the part of the Pleistocene covered by the analysis the range of this tree did not include the territory of Poland. Traces of beech pollen in Pleistocene profiles come, above all, from glacial sediments contaminated on an enormous scale with Tertiary material. An attempt has also been made to grasp the causes of the lack of the beech in the European area north of the Alps and Northern Carpathians in the Middle and Upper Pleistocene.

INTRODUCTION

The beginnings of the history of the genus *Fagus* go back to the Cretaceous, but its taxonomic differentiation, involving modern species, is based on fossil materials of Tertiary age. According to Takhtajan (1981, p. 153), "*Fagus*, that typical representative of the temperate flora of the northern hemisphere, is almost certainly eastern Asian in origin. It is in east Asia that the most primitive and basic types of beech are centred, while the Euro-Caucasian and North American species are derivative in character".

In Poland fossilized pollen grains, leaves, fruits and wood of beech were recorded many times from the localities of Tertiary and Quaternary floras. In the beech history its wide-spread occurrence in forest associations is marked twice: once in the Upper Tertiary (Neogene) and then as late as the Holocene. In the Pleistocene, separating these two periods, the role of the beech and even its presence in the European areas north of the Alps and Northern Carpathians has been a keenly discussed problem for many years. The characteristic feature of the history of this tree is also its rapid expansion in the Late Holocene.

Table 1

Localities of micro- and macrofossils of the genus *Fagus* found in Neogene deposist in Poland

No.	Sites	Fruits	Leaves	Pollen	Authors
1	2	3	4	5	6
1.	Babina			+	Doktorowicz-Hrebnicka 1957
2.	Bełchatów			+	Raniecka-Bobrowska 1970
3.	Brzeg Dolny		+		after Hummel 1983
4.	Chrościna			+	Sadowska 1977
5.	Chyżne	+		+	Łańcucka-Środoniowa 1963; Tran Dinh Nghia 1974
6.	Czarny Dunajec			+	Oszast 1973
7.	Czerna			+	Romanowicz 1961
8.	Domański Wierch	+	+	+	Łańcucka-Środoniowa 1966; Zastawniak 1972; Oszast 1973
9.	Frydman			+	Środoń 1973
10.	Gierlachowo			+	Ziembińska-Tworzydło 1974
11.	Gołębin Stary			+	Ziembińska-Tworzydło 1974
12.	Gosławice-Niesłusz			+	Mamczar 1960
13.	Gozdnica	+		+	Stachurska et al. 1971; Sadowska 1977
14.	Huba	+		+	Szafer 1954; Oszast 1973
15.	Jaroszów			+	Sadowska 1977
16.	Jawor			+	Raniecka-Bobrowska 1970
17.	Jaworzyna			+	Sadowska 1977
18.	Jerzmanowa			+	Sadowska 1977
19.	Kłaj I			+	Kita 1963
20.	Kokoszyce		+		after Hummel 1983
21.	Koniówka	+		+	Oszast & Stuchlik 1977; Białobrzeska & Truchanowiczówna 1983
22.	Kotlina Sądecka			+	Oszczypko & Stuchlik 1972
23.	Krosinko			+	Ziembińska-Tworzydło 1974
24.	Krościenko	+		+	Szafer 1946—1947; Oszast 1973
25.	Kruszyn			+	Romanowicz 1961
26.	Kuławsk			+	Romanowicz 1961
27.	Legnica			+	Sadowska 1977
28.	Lipnica Wielka			+	Tran Dinh Nghia 1974
29.	Łaziska			+	Romanowicz 1961
30.	Łojowice			+	Sadowska 1977
31.	Milików			+	Sadowska 1977
32.	Mirostowice			+	Sadowska 1977
33.	Mizerna	+		+	Szafer 1954; Szafer & Oszast 1964
34.	Młyny		+		Zastawniak 1980
35.	Mosina			+	Ziembińska-Tworzydło 1974
36.	Nowa Wieś			+	Ziembińska-Tworzydło 1974
37.	Nowe Czaple			+	Sadowska 1977
38.	Nysa			+	Sadowska 1977
39.	Oczkowice			+	Ziembińska-Tworzydło 1974
40.	Olsztyn			+	Doktorowicz-Hrebnicka 1957
41.	Opole			+	Sadowska 1977

1	2	3	4	5	6
42.	Paczków			+	Sadowska 1977
43.	Parzyce			+	Romanowicz 1961
44.	Piaseczno			+	Oszast 1967
45.	Przeworno			+	Sadowska 1977
46.	Rogoźno			+	Mamczar 1961
47.	Rudy			+	Sadowska 1977
48.	Ruszów	+	+	+	Sadowska 1977; Hummel 1983
49.	Rypin			+	Stuchlik 1964
50.	Smogorzówek		+		after Hummel 1983
51.	Snicz			+	Biernat 1964
52.	Sośnica		+	+	Stachurska et al. 1973; after Hummel 1983
53.	Stare Gliwice	+	+	+	Oszast 1960; Szafer 1961
54.	Stawiany		+		Zastawniak 1980
55.	Straszów			+	Sadowska 1977
56.	Suchoraba	+			Łańcucka-Środoniowa 1966
57.	Swoszowice		+		after Łańcucka-Środoniowa 1966
58.	Ślepuchowo			+	Ziembińska-Tworzydło 1974
59.	Tarpno			+	Sadowska 1977
60.	Trzebnica		+		after Hummel 1983
61.	Tuplice			+	Sadowska 1977
62.	Ustronie			+	Ziembińska-Tworzydło 1974
63.	Wieliczka	+			Zabłocki 1928; Łańcucka-Środoniowa 1966
64.	Wielowieś			+	Sadowska 1977
65.	Wołów			+	Sadowska 1977
66.	Wrocław			+	Sadowska 1977
67.	Zielona Góra			+	Sadowska 1977
68.	Żarów			+	Sadowska 1977
69.	Żary			+	Doktorowicz-Hrebnicka 1954

FAGUS IN THE UPPER TERTIARY

The long list of the Neogene localities of the genus *Fagus* found in the territory of Europe shows that this tree was a frequent component of the forest associations of those times (Tralau 1962). Neither was it rare in the Neogene of Poland (Table 1, Fig. 1), as indicated by its numerous localities distributed over the extensive area of the so-called central depression of the Polish Lowlands, which abound in brown coal deposits, and also in the Subcarpathian foredeep and mountainous basins (Nowy Targ — Orawa and Nowy Sącz).

The occurrence of *Fagus* pollen has been noted at 61 localities of Neogene deposits (Table 1). Its frequency ranges from the most commonly encountered sporadic pollen grains to their continuous participation in pollen diagrams, their maximum values exceeding 20 and even 40 %. A particularly abundant frequency characterizes the localities in the Nowy Targ-Orawa Basin (Czarny Dunajec — 24 %, Domański Wierch — 31 %, Huba — 16 % and Krościenko — 42 %), in Lower Silesia (Gozdnica—

20 %, Sośnica — 39 % and Tuplice — 15 %) and in the profiles at Stare Gliwice (30 %), Bełchatów (15 %) and Rypin (7 %). Higher frequences were usually recorded from profiles referred to the Upper Miocene and Pliocene.

Determination of macroscopic remains of the genus *Fagus* from the European Tertiary, begun nearly 150 years ago, resulted in the distinction of a large number

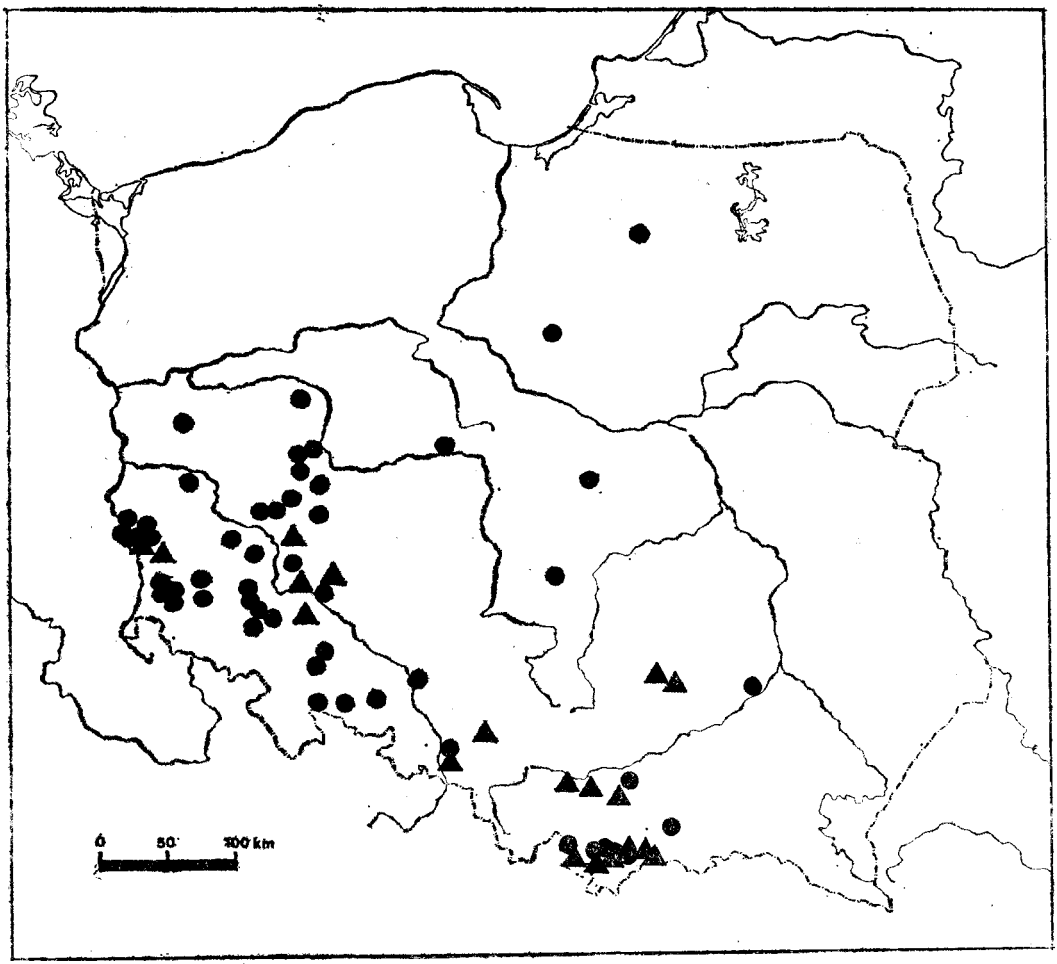

Fig. 1. Distribution of the localities of micro- and macrofossils (dots and triangles, respectively) of the genus *Fagus* in Neogene deposits in Poland

of taxons specified by Tralau (1962). Their variety was due, above all, to the well-known morphological variability of beech leaves. Tralau divided the taxons described into two groups. In one of them he numbered those resembling the type *F. sylvatica* L. and the related Euro-Asiatic species and in the other the taxons similar to the North-American species *F. grandifolia* Ehrh. (= *F. ferruginea* Ait.), differentiated according to the situation of localities. This division resolves itself into the distinction

Table 2

Taxons of the genus *Fagus* distinguished in Neogene deposits in Poland

Sites / Name of plants	f — fruits, l — leaves	Brzeg Dolny (after Hummel 1983)	Chyżne (Łańcucka-Środoniowa 1963)	Domański Wierch (Łańcucka-Środoniowa 1966; Zastawniak 1972)	Gozdnica (Stachurska et al. 1971)	Huba (Szafer 1954)	Kokoszyce (after Hummel 1983)	Koniówka (Białobrzeska & Truchanowiczówna 1983)	Krościenko (Szafer 1946—47)	Mizerna (Szafer 1954)	Młyny (Zastawniak (1980)	Ruszów (Hummel 1983)	Smogorzówek (after Hummel 1983)	Sośnica (Łańcucka-Środoniowa et al. 1981)	Stare Gliwice (Szafer 1961)	Stawiany (Zastawniak 1980)	Suchoraba (Łańcucka-Środoniowa 1966)	Swoszowice (after Łańcucka-Środoniowa 1966)	Trzebnica (after Hummel 1983)	Wieliczka (Zabłocki 1928; Łańcucka-Środoniowa 1966)
F. attenuata Goepp.	l	+					+					+	+	+					+	
F. ferruginea Ait. foss.	f							+	+			+			+					+
F. haidingeri Kov.	l			+																
F. decurrens Reid	f		?			+			+	+					+					
F. orientalis Lipsky foss. Palibin	f			+													+			+
F. orientalis Lipsky foss. Palibin	l										+					+		+		
F. sylvatica L.	f								+	+										
Fagus sp.	f, l				+									+	+					

of two polymorphic taxons in the European Neogene. Zagwijn (1960, p. 62) also gives two types of pollen grains of *Fagus* from the Dutch Pliocene, "a bigger one corresponding with the pollen of recent *Fagus sylvatica*, and a smaller, rather thick-walled form, which resembles the pollen of *Fagus ferruginea*. The former type occurs in the Miocene and Early Tiglian also".

Nowadays 19 localities of macroscopic beech remains are known from Poland, the remains being numbered in 6 taxons belonging to two groups distinguished by Tralau (Table 2). Some of these localities are rich in fossil leaves (Ruszów), whereas others abound in fruits (Gozdnica, Koniówka); there are also deposits in which both leaves and fruits occur (Domański Wierch, Ruszów). Their coincidence increases the accuracy of the determination of leaves, because well-preserved fruits provide more reliable criteria for the estimation of their systematic position.

This information about the occurrence of fossil remains of *Fagus* in Neogene deposits indicates the important role of this tree in the composition of forests of those times. Its presence in pollen diagrams and in the form of macroscopic remains seems to suggest that in some habitats the species of this genus occurred as if in dispersion, while in others they grew thicker. This difference may have resulted from somewhat different requirements of various species as regards soil quality. Recent *F. grandifolia* is characterized in this respect by its distinct predisposition to moist habitats (Harlow & Harrar 1958), such localities being as a rule avoided by *F. sylvatica*.

The European history of the genus *Fagus* in the Quaternary deserves special attention. The views of the authors of *The Floral Record of the Late Cenozoic of Europe* (Hammen et al. 1971) on this matter are quite clear. In the table illustrating the successive extinction of a number of taxons of the Tertiary flora, starting from the Miocene, the occurrence of *Fagus* ends in the Tiglian Interglacial in the Lower Pleistocene. This opinion, preceded by doubts of other authors as to the occurrence of the beech in the Central and North European interglacial floras (Jessen & Milthers 1928; Averdieck 1962; Andersen 1964, and others), induces us to estimate the fossil localities of this tree in the Pleistocene of Poland.

TRACES OF THE GENUS *FAGUS* IN THE PLEISTOCENE OF POLAND

Problem of redeposited pollen

The gradual cooling of the climate that had begun in the Neogene increased in the long-lasting Lower Pleistocene. At that time repeated periodical oscillations of the cold and moderately warm climate brought about the processes of erosion and sedimentation on an enormous scale, to which the deposits of Neogene formations, containing fossil remains of the then dominant world of plants and animals, were exposed. The rest of work, enriching the Quaternary cover in remains of the

Neogene flora, was done by the Scandinavian ice sheet, which encroached on the territory of Poland several times, extending to the Carpathians and Sudetes at the time of its maximum expansion. Those processes resulted in the heavy contamination of Quaternary deposits with Tertiary and older material, found chiefly in the course

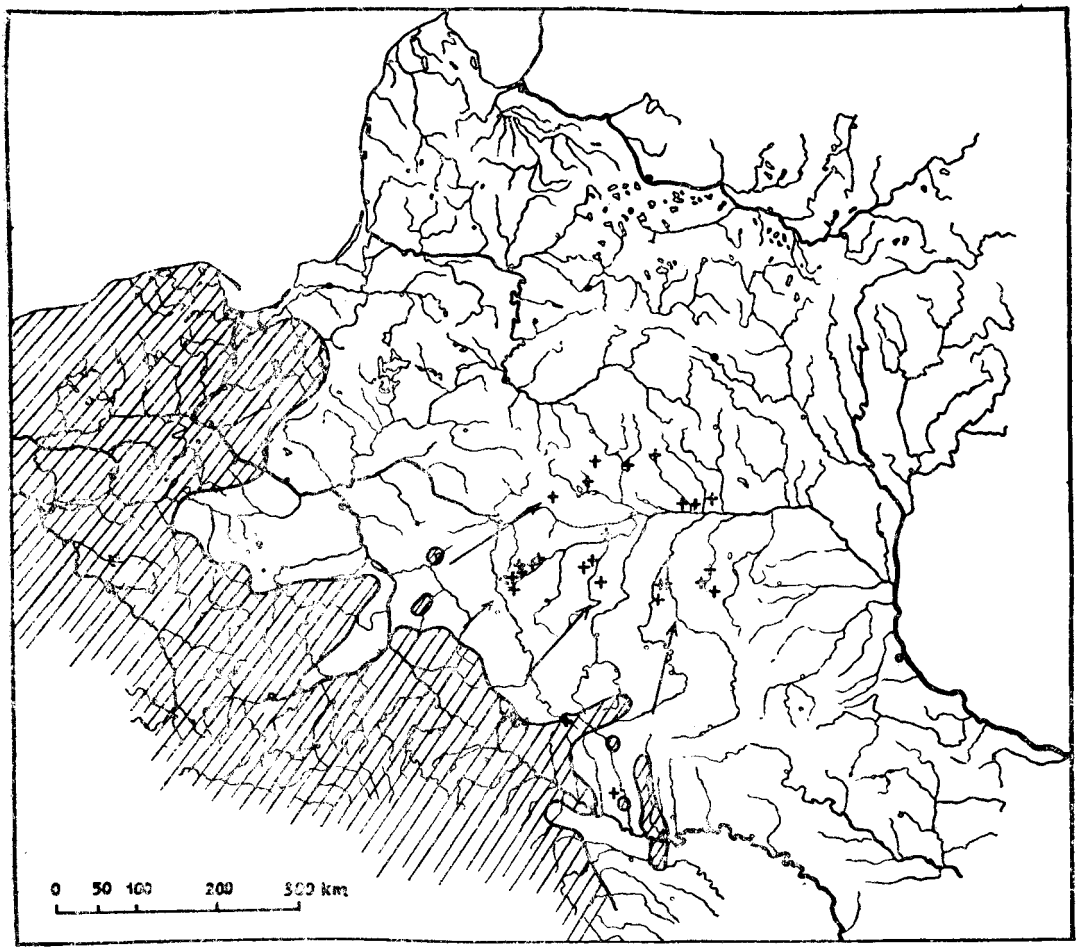

Fig. 2. The modern range of *Fagus sylvatica* and its fossil localities in the peatbogs of Polesie (Pripet Marshes) (Kulczyński 1935)

of studies conducted by the method of palinological analysis. I have written elsewhere (Środoń 1962) in more detail on the importance of this problem to the studies of the Quaternary vegetation history, emphasizing the merits of Iversen (1936), who was the first to pay attention to the occurrence of Tertiary sporomorphs in Danish moraine clays and proposed a method for dealing with them in relation to the sporomorphs in primary deposits. Traces of redeposited pollen in the diagrams of Quaternary floras, especially those published earlier, may also be represented in the curves of indeterminate sporomorphs or those referred to as "varia". Palinolo-

Table 3

The occurrence of *Fagus* pollen traces in the Middle and Upper Pleistocene floras in the territory of Poland. Contamination of the profiles with sporomorphs of Tertiary plants is also shown

No.	Age	Localities	Number of samples with *Fagus*	Absolute or percentage share of *Fagus* pollen	The presence of sporomorphs of Tertiary plants	Authors
		Late Glacial				
1		Bocian	1	1		Tobolski 1966
2		Bryjarka	1	1	+	Pawlikowa 1965
3		Czajków 1	3	1—2		Szczepanek 1971
4		Dębica 2	1	1	+	Środoń 1965
5		Golejów 1	2	1—2		Szczepanek 1971
6		Grel	20	1—3		Koperowa 1962
7		Kraków-Rondo	1	1	++	Mamakowa 1970
8		Mikołajki	4	1—2	+	Ralska-Jasiewiczowa 1966
9		Obary	5	1—2	+	Mamakowa 1962
10		Podbukowina	1	0.2	+	Mamakowa 1962
11		Puścizna Rękowiańska	11	1—3		Koperowa 1962
12	Vistulian	Słopiec	3	3×1		Szczepanek 1982
13		Tarnawa Wyżna	2	2×1		Ralska-Jasiewiczowa 1980
14		Witów	2	0.35;0.08	+	Wasylikowa 1964
15		Wolbrom	1	1	+	Latałowa 1976
16		Żuchowo	1	0.1		Oszast 1957
		Pleniglacial				
17		Białka Tatrzańska	1	1		Sobolewska & Środoń 1961
18		Łążek	1	1	+	Mamakowa 1968
19		Zator	3	3×1	+	Koperowa & Środoń 1965
		Early Glacial				
20		Brzeziny	1	1		Birkenmajer & Środoń 1960
21		Kąty	3	3×1	+	Mamakowa et al. 1975
22		Ściejowice	2	0.5;1.0	+	Mądalski 1935; Dyakowska 1939
23		Ustroń	1	1		Szczepanek 1965
24		Wadowice	2	2 × 0.1		Sobolewska et al. 1964

25	Eemian	Bażantaria	2	0.5;1.0		Halicki & Brodniewicz 1961
26		Białka	1	1	+	Makowska 1979
27		Główczyn G2	5	5 × 0.1	+	Niklewski 1968
28		Gołków	1	1	+	Janczyk-Kopikowa 1966
29		Góra Kalwaria	1	1	+	Sobolewska 1961
30		Józefów	8	8 × 1	+	Sobolewska 1966
31		Nakło	8	8 × 1—2	+	Noryśkiewicz 1978
32		Raki	1	1		Kuszell 1980
33		Warszawa 1b	4	4 × 1 ?		Raniecka-Bobrowska 1954
34		Wołów I—72	16	16 × 1		Kuszell 1980
35		Żyrardów 2/69	2	2 × 0.1	+	Krupiński 1978
36	Saalian	Góra Kalwaria	3	1—2	++	Środoń 1974
37		Koniecpol	2	1—2	++	Niklewski 1966
38		Łabędy	1	0.5		Ralska-Jasiewiczowa 1958
39		Zabłocie	17	1—2	++	Ralska-Jasiewiczowa 1960
40	Mazovian	Aleksandrów Łódzki	1	0.5		Różycki F. 1956
41		Barkowice Mokre	5	0.5—1.5		Sobolewska 1952
42		Boczów	4	0.3—2.1	++	Janczyk-Kopikowa 1977
43		Gościęcin	1	4.0	+	Środoń 1957
44		Nowiny Żukowskie	1	0.2		Dyakowska 1952
45		Olszewice	13	0.4—0.8		Sobolewska 1956
46		Stanowice 1	2	2 × 0.1	+	Sobolewska 1977
47		Węgorzewo	5	1—4	++	Sobolewska 1975
48	Cracovian vel Saalian	Cieplice	36	1—5	+++	Dyjor & Sadowska 1968; Jahn 1976
49		Wadowice	10	5—28	+++	Oszast & Środoń 1968
50		Szaflary	7	1—25	+++	Birkenmajer & Stuchlik 1975; Środoń 1982

gists find the occurrence of the same genera of trees, e.g. *Pinus*, *Picea*, *Abies*, *Tilia*, *Quercus* etc. in the Neogene and Quaternary floras, and among them also the genus *Fagus*, with which we are concerned here, particularly troublesome. This concurrence, increased by difficulties in discriminating the pollen of particular species of a given genus, is responsible for many misinterpretations of pollen diagrams concerning Quaternary vegetation. The contamination of profiles can also be caused by the drilling equipment used for taking samples from the deposits. Recently this hazard has been decreased owing to the use of samplers of a different type, collecting samples starting from the bottom of deposits. There are also cases in which the pollen occurring in Quaternary profiles has been blown from exposed Neogene formations. Finally, another origin of foreign pollen may be its long-distance transport. Kulczycki's (1935) map of the present-day range of the beech in Poland, enriched with its fossil sites in the Late Holocene and surface pollen spectra from the peatbogs of Polesie (Fig. 2), proves a great significance of this factor. Kulczyński referred the origin of these localities of 1—4 % frequencies to the Littorina migration of the beech towards the north east, which however has not been confirmed by the results of more recent studies. Here we are concerned with fossil traces of the long-range transport of beech pollen over a distance approximating in this case to at least 350 km. This fact deserves close attention in the course of interpretation of the isopollen maps of this tree, especially in the border-regions of its distribution.

Beech in pollen diagrams of Pleistocene deposits

Table 3 informs about the occurrence of mainly sporadic pollen grains of the beech at 50 fossil flora localities of Middle and Upper Pleistocene age in Poland. An analysis of this table shows the following: In 29 cases the probable source of the beech pollen is the material found in these profiles but redeposited from the Tertiary. The authors of papers on the diagrams from the remaining 21 localities do not report any exotic pollen. In 6 of them, of Late Glacial age, the beech pollen may have been brought on the drill from the Holocene layers (profiles 3, 5, 6 and 11—13). Another 6 localities are referable to climatic periods not favouring the occurrence of beech (profiles 1, 16, 17, 20, 23 and 24). At the remaining 9 localities of this group, representing interglacial floras, the slight frequencies of beech pollen also suggest contamination with Tertiary material (profiles 25, 32—34, 38, 40, 41, 44 and 45). This is confirmed by sandy, clayey and silty sediments occurring in these localities and containing pollen of *Fagus*, i.e. sediments which as a rule accompany contaminations with foreign material. Wasylikowa (1964, p. 365) exemplifies this phenomenon well with a number of Late Glacial flora localities. It should finally be stated that the authors of the profile analyses in question often treat those sporadic pollen grains as contaminations.

It is noteworthy that Table 3 does not include localities of interglacial floras from Szeląg (Szafer & Trela 1928), Hamernia (Szafer 1931, anal. J. Trela) and Bedlno (Szafer et al. 1931), characterized, notably as regards Szeląg and Ha-

mernia by high frequencies of *Fagus* pollen. A re-examination of the deposits from Szeląg (Środoń 1956) and original samples, i.e. those obtained in 1931, from Hamernia (Środoń 1984, anal. K. Mamakowa), showed that pollen of this genus was missing from both these profiles. Neither has its presence been proved in a repeated analysis of the profile at Bedlno (Środoń & Gołąbowa 1956). The table does not comprise fossil flora localities of the Lower Pleistocene, the period so far little known in Poland. In the pollen diagram of the flora of that age from Ponurzyca in the Otwock region *Fagus* is not represented (Stuchlik 1975).

MACROSCOPIC BEECH REMAINS OF INTERGLACIAL AGE

Beech macroremains occur fairly frequently in Neogene deposits (Tables 1 and 2) but very rarely in interglacial floras, and they are not always accurately determined. Leaves described from Eemian deposits at Samostrzelniki on the River Neman and from the Holsteinian (= Mazovian) interglacial in Germany (Bilshausen, Tönisberg) can be quoted by way of example. It has appeared with time that these leaves were wrongly determined (Szafer 1926, 1953; Chanda 1962; Kempf 1966).

Fragments of cupules (5 specimens) found in deposits derived from the decline of the Hoxnian (= Mazovian) interglacial at Gort in western Ireland and identified as *Fagus sylvatica*, while there was no pollen of that genus at all in the profile in question (Jessen et al. 1959), are particularly intriguing. At a few other localities of floras of that age studied in the territory of Ireland, *Fagus* has not been recorded (Watts 1970) *.

BEECH MIGRATIONS IN THE PLEISTOCENE

An analysis of the occurrence of beech traces in Middle and Upper Pleistocene deposits suggests that this tree did not grow in the territory of Poland at that time. This opinion agrees with the results of the above-mentioned investigations in the west of Europe. A really important question arises, namely, why the beech did not cross the northern Carpathians nor, probably, the Alps during the last two interglacials. It will be very difficult to answer this question univocally, for the fate of this tree in the course of successive glaciations is little known.

The genus *Fagus* may have survived the most extensive glaciations (Cracovian and Saalian) in mountain refuges in the Near East, which can be inferred from the

* The results of the estimation of fossil beech traces in the Pleistocene of Poland incline us to take critical glance at the usually sporadic occurrence of pollen of the genus *Pterocarya* in integlacial deposits, i.e. the tree now regarded as the distinguishing taxon of the Mazovian interglacial. Doubt is caused by the substantial role of this tree in the composition of the Neogene vegetation, its modern distribution and considerable requirements of humidity (Browicz 1982) as well as the very essential in this case and often observed contamination of interglacial profiles containing *Pterocarya* with sporomorphs redeposited from the Tertiary.

data presented in Frenzel's (1968) work. As the climatic conditions improved, this heavy-seeded tree, which has fairly great requirements as regards habitat and climate, began its migration to the north, pushing forward through the forest associations composed of trees which advanced faster than did the beech. The distance between the beech refuges and the Central European mountain ranges was at least 1000 km and probably the Mazovian and Eemian interglacials did not last long enough — as Szafer (1953, p. 35) suggests — for the beech to cover that distance and to cross the Alps and Northern Carpathians. We shall have still to wait some time for the evaluation of this view, for our information about the occurrence of the beech in the South European deposits of the above-mentioned interglacials is as yet very scanty, especially in regard to the older of them (Follieri 1962; Šercelj 1966; Opravil 1969; Hammen et al. 1971; Ambrosetti et al. 1972; Bottema 1974; Božilova & Djankova 1976; Cârciumaru 1980; Grüger 1983). The Eemian flora of the travertines from Ganovec at the foot of the Tatra Mts. in Slovakia contains no traces of the beech (Kneblová 1960).

At the time of the better known and least extensive Vistulian glaciation the beech refuges were situated nearer than during the older glaciations. This is evidenced by the interstadial and late glacial localities of fossil floras, often with a high proportion of beech, described from Calabria in the south of Italy (Grüger 1977), Yugoslavia (Šercelj 1966), Greece (Hammen et al. 1971; Bottema 1974, 1979), Bulgaria (Božilova 1975) and Romania (Cârciumaru 1980). The isopollen maps, presenting the history of the beech in Europe over a space of the last 13 000 years (Huntley & Birks 1983), are also a valuable source of information.

BEECH EXPANSION IN THE HOLOCENE

The centres of spread of the beech in the Holocene were its South-European glacial refuges mentioned above. In all probability the time factor assumed in the picture of the migration of this tree in the interglacials was also responsible for its late appearance in the Holocene of Central and West Europe. The beech did not reach the territory of Poland until about 5000 years ago (Ralska-Jasiewiczowa 1983) and 2000 years later it came to a spontaneous formation of beech-dominant forest association in suitable climatic conditions and under the highly favourable influence of the increasing economic activity of prehistoric man.

The isopollen maps, showing the stages of the spread of the beech in Poland, were made twice (Szafer 1935a; Ralska-Jasiewiczowa 1983). Although the period intervening between these maps is long, the results obtained in them are concurrent in essence. It can be seen from their substance that the beech reached Poland from the south-east and by the lowerings in the Carpathians and Sudetes, arriving latest in Pomerania. In course of time it spread over the southern and western areas of the country, extending to the border of its present north-eastern range in Europe.

Fifty years ago Szafer (1935b) formed his opinion that the beech had first came into our territory from the south-east, whereas Ralska-Jasiewiczowa (1983) thinks that there is no evidence for that. It should be reminded that Szafer's opinion is based in great measure on the results of studies on the Podolian beech, which studies led to the distinction of specimens at many localities here, such that the characters of their leaves and fruits were intermediate between those of *F. sylvatica* and *F. orientalis* (Wiśniewski 1932; Czeczottowa 1933, 1935; Szafer 1935b; Mądalski 1938, 1947, 1951). This intermediate form, referred to as *F. moesiaca* (K. Maly) Czecz., occurs not unfrequently in the southern part of the Balkan Peninsula, in the zone where the ranges of *F. sylvatica* and *F. orientalis* border on each other (Browicz 1982). According to Szafer, the "Podolian beech" outdistanced the common beech considerably in its migration to the north and "...its 'insular' localities in western Podolia, in the southern parts of eastern Podolia and in Bessarabia... are relics of that period" (Szafer l.c., p. 46). This route of migration of the beech, extending along the outer side of the curve of the Carpathians, was probably the shortest and, at the same time, most suitable in respect of climate and configuration of the land. The isopollen maps made for the genus *Fagus* and covering the whole territory of Europe seem to confirm this supposition (Huntley & Birks 1983).

The late appearance of the beech in Central and Western Europe was due not only to the remote situation of its glacial refuges but also to the barrier of primary forests built up of shade-loving trees and leaving no gaps on the soils fit for the penetration of the beech, which barrier hindered the shift of its range to the north (Iversen 1973). It was only the neolithic colonization, with its extensive pasturage, fire clearance and rotation of crops and fallow, that created a particular chance for this tree, as evidenced by the striking coincidence of the development of neolithic settlement and a rapid rise in the proportion of beech in the pollen diagrams representing the transition from the Atlantic to the Subboreal. This rise is as a rule accompanied by a decrease in the proportions of the components of mixed deciduous forests, varying with the changing fates of settlement, and by the symptomatic occurrence of the pollen of cereals, weeds and synanthropic plants connected with the economic activity of man (Iversen 1941). Probably it was not before then that it came to the formation of the Central-European beech association bearing signs of its origin connected with human actiivty.

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REFERENCES

Ambrosetti S. P., Azzaroli A., Bonadonna F. P. & Follieri M. 1972. A scheme of Pleistocene chronology for the Tyrrhenian side of Central Italy. Boll. Soc. Geol. It., 91:169—184.

Andersen S. Th. 1964. Interglacial plant successions in the light of environmental changes. Report of the VIth INQUA, Warsaw 1961, II:359—368.

Averdieck F. R. 1962. Das Interglazial von Fahrenkrug in Holstein. Ein Beitrag zur Frage des Buchenvorkommens im Jungpleistozän. Eiszeitalter u. Gegenwart, 13:5—14.

Białobrzeska M. & Truchanowiczówna J. 1983. Fruits of the genus *Fagus* from the Neogene of the Western Carpathians — biometrical study. Acta Palaeobot., 23, 3:103—120.

Biernat S. 1964. Trzeciorzęd okolic Korfantowa (Śląsk Opolski) (summary: The Tertiary in the Korfantów vicinities). Kwart. Geol., 8, 2:297—305.

Birkenmajer K & Środoń A. 1960. Interstadiał oryniacki w Karpatach (summary: Aurignacian Interstadial in the Carpathians). Biul. Inst. Geol., 150:9—70.

— & Stuchlik L. 1975. Early Pleistocene pollen-bearing sediments at Szaflary, West Carpathians, Poland. Acta Palaeobot., 16, 2:113—144.

Bottema S. 1974. Late Quaternary vegetation history of northwestern Greece. Thesis, Groningen.

— 1979. Pollen analytical investigation in Thessaly (Greece). Palaeohistoria, 21:19—40.

Božilova E. 1975. Correlation of the vegetational development and climatic changes in the Rila and Pirin Mountains during the Late Glacial and Post Glacial time compared to other areas. In: Problems of Balkan Flora and Vegetation. Sofia.

— & Djankova M. 1976. Vegetation development during the Eemian in the North Black Sea Region. Bulg. Acad. of Sc., Phytology, 4:25—33.

Browicz K. 1982. Chorology of trees and shrubs in South-West Asia and adjacent regions. PWN, Warszawa-Poznań.

Cârciumaru M. 1980. Mediul geografic în pleistocenul superior şi culturile paleolitice din România. Bucuresti.

Chanda S. 1962. Untersuchungen zur pliozänen und pleistozänen Floren- und Vegetationsgeschichte im Leinetal und im südwestlichen Harzvorland (Untereichsfeld). Geol. Jb., 79:783—844.

Czeczottowa H. 1933, 1935. Studium nad zmiennością liści buków: *F. orientalis* Lipsky, *F. silvatica* L. i form przejściowych (summary: A study on the variability of the leaves of beeches: *F. orientalis* Lipsky, *F. silvatica* L., and intermediate forms). Rocz. Polsk. Tow. Dendrol., V, VI: 45—121, 1—68.

Doktorowicz-Hrebnicka J. 1954. Analiza pyłkowa węgla brunatnego z okolic Żar na Dolnym Śląsku (summary: Pollen analysis of brown coal from the region of Żary (Lower Silesia). Biul. Inst. Geol., 71:41—108.

— 1957a. Wzorcowe spektra pyłkowe plioceńskich osadów węglonośnych (summary: Index pollen spectra of Pliocene coal-bearing sediments). Prace Inst. Geol., 15:87—165.

— 1975b. Wiek węgla brunatnego z terenu Babiny na Dolnym Śląsku w świetle analizy pyłkowej (summary: The age of brown coal from the area of Babina (Lower Silesia) in the light of pollen analysis). Prace Inst. Geol., 15:187—200.

— 1960. Paralelizacja pokładów węgla brunatnego województwa bydgoskiego i poznańskiego (summary: Correlation of brown coal seams from the provinces of Poznań and Bydgoszcz). Biul. Inst. Geol., 157:69—133.

Dyakowska J. 1939. Interglacjał w Ściejowicach pod Krakowem (summary: Interglacial in Ściejowice near Cracow). Starunia, 17:1—15.

— 1952. Roślinność plejstoceńska w Nowinach Żukowskich (summary: Pleistocene flora of Nowiny Żukowskie on the Lublin Upland). Biul. Inst. Geol., 67:115—181.

Dyjor S. & Sadowska A. 1968. Górnomioceńskie osady ilaste Sudetów (summary: Upper Miocene clay deposits of the Sudetes). Przegl. Geol., 12:545—550.

Firbas F. 1958. Über das *Fagus*-Vorkommen im "Interglazial" von Wasserburg am Inn (Oberbayern). Geobot. Inst. Rübel in Zürich, Veröff., 33:81—90.

Follieri M. 1962. La foresta colchica fossile di Riano Romano. II. Analisi polliniche. Annali. di Bot., 27, 2:245—280.

Frenzel B. 1968. The Pleistocene vegetation of Northern Eurasia. Science, 161:637—649.

Grüger E. 1977. Pollenanalytische Untersuchung zur würmzeitlichen Vegetationsgeschichte von Kalabrien (Süditalien). Flora, 166:475—489.

— 1983. Untersuchungen zur Gliederung und Vegetationsgeschichte des Mittelpleistozäns am Samerberg in Oberbayern. Geol. Bavarica, 84:21—40.

Halicki B. & Brodniewicz I. 1961. La stratigraphie du Pléistocène supérieur dans région péribaltique méridionale. Bull. l'Acad. Polon. Sc., Sér. Sci. Géol. Géogr., 9, 3:163—169.

Hammen T., Wijmstra T. A. & Zagwijn W. H. 1971. The floral record of the Late Cenozoic of Europe. In: Turekian K. K. (ed.) Late Cenozoic Glacial Ages. Yale Univ. Press.

Harlow W. M. & Harrar E. S. 1958. Textbook of Dendrology. McGraw-Hill Book Company.

Hummel A. 1983. The Pliocene leaf flora from Ruszów near Żary in Lower Silesia, SW Poland. Prace Muzeum Ziemi, 36:9—104.

Huntley B. & Birks J. H. B. 1983. An atlas of past and present pollen maps for Europe: 0—13 000 years ago. Cambridge Univ. Press.

Iversen J. 1936. Sekundäres Pollen als Fehlerquelle. Danm. Geol., Unders., IV, II, 15:1—24.

— 1941. Land occupation in Denmark's Stone Age. Danm. Geol. Unders., II, 66:1—68.

— 1973. The development of Denmark's nature since the Last Glacial. Danm. Geol. Unders., 5, 7C: 1—126.

Jahn A. 1976. "Dobowe" iły warwowe w Jeleniej Górze (summary: "Diurnal" varved clays from Jelenia Góra). Przegl. Geol., 24, 9:517—520.

Janczyk-Kopikowa Z. 1966. Interglacjał eemski w Gołkowie koło Warszawy (summary: Eemian Interglacial at Gołków near Warsaw). Kwart. Geol., 10, 2:453—461.

— 1977. Osady interglacjalne w Boczowie koło Rzepina (Polska Zachodnia) (summary: Interglacial deposits from Boczów near Rzepin, W. Poland). Kwart. Geol., 21, 4:789—801.

Jessen K. & Milthers V. 1928. Stratigraphical and paleontological studies of interglacial fresh-water deposits in Jutland and Northwest Germany. Danm. Geol. Unders., II, R., 48:1—379.

— Andersen S. Th. & Farrington A. 1959. The interglacial deposits near Gort, co. Galway, Ireland. Proc. Roy. Irish Acad., 60B: 1—77.

Katalog skamieniałości, 3a i 3b. In: Budowa Geologiczna Polski II. Wyd. Geol. Warszawa 1977.

Kempf E. K. 1966. Das Holstein-Interglazial von Tönisberg im Rahmen des niederrheinischen Pleistozäns. Eiszeitalter u. Gegenwart, 7:5—60.

Kita Z. 1963. Analiza palinologiczna osadów mioceńskich odwiertu Kłaj I (summary: Palynological analysis of Tortonian deposits from the bore-hole Kłaj I, east of Kraków). Rocz. Polsk. Tow. Geol., 33, 4:517—526.

Kneblová V. 1960. Paleobotanický výzkum interglaciálnich travertinů v Gánovcich. Biol. Práce, 6, 4: 1—42.

Koperowa W. 1962. Późnoglacjalna i holoceńska historia roślinności Kotliny Nowotarskiej (summary: The history of the Late Glacial and Holocene vegetation in Nowy Targ Basin). Acta Palaeobot., 2, 3:1—57.

— & Środoń A. 1965. Pleniglacial deposits of the last glaciation at Zator (West of Kraków). Acta Palaeobot., 6, 1:1—31.

Krupiński K. M. 1978. Historia, dynamika rozwoju i zaniku zbiornika interglacjalnego w Żyrardowie (summary: History and dynamics of the development and disappearance of the interglacial basin in Żyrardów). Biul. Inst. Geol., 300:153—178.

Kulczyński S. 1930. Stratygrafia torfowisk Polesia (Zusammenfassung: Stratigraphie der Moore von Polesie). Prace Biura Melioracji Polesia, I, 2:1—84.

Kuszell T. 1980. Trzy nowe stanowiska flory z interglacjału eemskiego na Dolnym Śląsku (summary: Three new localities of Eemian flora in Lower Silesia). Geol. Sudetica, 15, 1:143—167.

Latałowa M. 1976. Diagram pyłkowy osadów późnoglacjalnych i holoceńskich z torfowiska w Wolbromiu (summary: Pollen diagram of the Late Glacial and Holocene peat deposits from Wolbrom, S. Poland). Acta Palaeobot., 17, 1:55—80.

Łańcucka-Środoniowa M. 1963. Stan badań paleobotanicznych nad miocenem Polski południowej (summary: Palaeobotanical investigations on the Miocene of southern Poland). Rocz. Polsk. Tow. Geol., 33, 2:129—158.

— 1966. Tortonian flora from the "Gdów Bay" in the south of Poland. Acta Palaeobot., 7, 1:135.

— Walther H. & Zastawniak E. 1981. A preliminary report on a new study of the Neogene flora

from Sośnica near Wrocław in Lower Silesia, West Poland (leaf and fruit-seed floras). Acta Palaeobot., 21, 2:101—114.

Makowska A. 1979. Interglacjał eemski w dolinie Dolnej Wisły (summary: Eemian Interglacial in valley of lower Vistula River). Stud. Geol. Polon., 63:1—90.

Mamakowa K. 1962. Roślinność Kotliny Sandomierskiej w późnym glacjale i holocenie (summary: The vegetation of the Basin of Sandomierz in the Late Glacial and Holocene). Acta Palaeobot., 3, 2:1—57.

— 1968. Flora z interstadiału Paudorf w Łążku koło Zaklikowa (summary: Flora from the Paudorf Interstadial at Łążek near Zaklików, SE Poland.) Acta Palaeobot., 9, 1:29—44.

— 1970. Late Glacial and Early Holocene vegetation from the territory of Kraków, Paoland. Acta Palaeobot., 11, 1:3—12.

— Mook W. G. & Środoń A. 1975. Late Pleistocene flora at Kąty (Pieniny Mts., West Carpathians). Acta Palaeobot., 16, 2:147—172.

Mamczar J. 1960. Wzorcowy profil środkowego miocenu Polski środkowej (summary: Standard section of the Middle Miocene for central Poland). Biul. Inst. Geol., 157:13—69.

— 1961. Wzorcowy profil sporowo-pyłkowy z górnomioceńskiego węgla brunatnego z Polski środkowej, złoże Rogóźno (summary: Standard spore-pollen section of the Upper Miocene brown coal in central Poland (Rogóźno brown coal deposits). Biul. Inst. Geol., 158:305—323.

Mądalski J. 1935. Plejstoceńska flora ze Ściejowic koło Krakowa (Zusammenfassung: Pleistocene Flora von Ściejowice bei Kraków). Starunia, 10:1—12.

— 1938. O nowym dla Polski buku z zakresu form *Fagus orientalis* Lipsky (summary: On a new beech in Poland belonging to the forms of *Fagus orientalis* Lipsky). Sylwan, A, 56, 1:1—7.

— 1947. Z badań nad *Fagus silvatica* L. i *F. moesiaca* (Maly, Domin) Czeczott (summary: Studies on *Fagus silvatica* L. and *Fagus moesiaca* (Maly, Domin) Czeczott). Acta Soc. Bot. Pol., 18, 2:129—154.

— 1951. Jeszcze słów parę o odkryciu *Fagus orientalis* Lipsky na północnej krawędzi Podola (summary: Supplementary note on the discovery of *Fagus orientalis* Lipsky on the northern border of Podolia). Rocz. Sekcji Dendrol. P. T. B., 7:115—122.

Niklewski J. 1966. Plejstoceński profil pyłkowy z okolic Koniecpola nad Pilicą (summary: The Pleistocene pollen profile from the vicinity of Koniecpol on the Pilica). Acta Geol. Polon., 16, 3:401—412.

— 1968. Interglacjał eemski w Główczynie koło Wyszogrodu (summary: The Eemian Interglacial at Główczyn near Wyszogród). Monogr. Bot., 27:125—192.

Noryśkiewicz B. 1978. Interglacjał eemski w Nakle nad Notecią (summary: The Eemian Interglacial at Nakło on the River Noteć, N Poland). Acta Palaeobot., 19, 1:67—112.

Opravil E. 1969. O rozšíření buku (*Fagus silvatica* L.) v československém kvartéru. Práce Odboru Přírod. Věd. Vlastivěd. Ústavu v Olomouci, 15:1—57.

Oszast J. 1957. Historia klimatu i flory Ziemi Dobrzyńskiej późnym glacjale i holocenie (summary: History of the climate and flora of the Dobrzyń Region (N Poland) in the Late Glacial and Holocene). Biul. Inst. Geol., 118:179—232.

— 1960. Analiza pyłkowa iłów tortońskich ze Starych Gliwic (summary: Pollen analysis of Tortonian clays from Stare Gliwice in Upper Silesia, Poland). Monogr. Bot., 9, 1:1—47.

— 1967. Mioceńska roślinność złoża siarkowego w Piasecznie koło Tarnobrzega (summary: The Miocene vegetation of a sulphur bed at Piaseczno near Tarnobrzeg (S Poland). Acta Palaeobot., 8, 1:1—29.

— 1973. The Pliocene profile of Domański Wierch near Czarny Dunajec in the light of palynological investigations (Western Carpathians, Poland). Acta Palaeobot., 14, 1:1—42.

— & Środoń A. 1968. Wyniki badań palinologicznych nad iłami zastoiskowymi z Wadowic (summary: Results of palynological examinations of ice-dammed clays from Wadowice). Przegl. Geogr., 40, 2: 343—350.

— & Stuchlik L. 1977. Roślinność Podhala w neogenie (summary: The Neogene vegetation of the Podhale (West Carpathians, Poland). Acta Palaeobot., 18, 1:45—86.

Oszczypko N. & Stuchlik L. 1972. Miocen słodkowodny Kotliny Sądeckiej. Wyniki badań geologicznych i palinologicznych (summary: The fresh-water Miocene of the Nowy Sącz Basin. Results of the geological and palynological investigations). Acta Palaeobot., 13, 2:137—156.

Pawlikowa B. 1965. Materiały do postglacjalnej historii roślinności Karpat Zachodnich. Torfowisko na Bryjarce (summary: Materials for the post-glacial history of vegetation of the West Carpathians. Peat-bog on the Bryjarka). Folia Quatern., 18: 1—9.

Ralska-Jasiewiczowa M. 1958. Interstadiał zlodowacenia środkowopolskiego na Górnym Śląsku (summary: The Riss-interstadial at Łabędy in the Upper Silesia). Monogr. Bot., 7:95—105.

— 1960. Plejstoceńska flora z Zabłocia nad Bugiem (summary: Pleistocene flora from Zabłocie on the River Bug). Folia Quatern., 2:1—9.

— 1966. Osady denne Jeziora Mikołajskiego na Pojezierzu Mazurskim w świetle badań paleobotanicznych (summary: Bottom sediments of the Mikołajki Lake (Masurian Lake District) in the light of Palaeobotanical investigations). Acta Palaeobot., 7, 2:1—118.

— 1980. Late Glacial and Holocene vegetation of the Bieszczady Mts. (Polish Eastern Carpathians). Instytut Botaniki PAN, PWN, Warszawa—Kraków.

— 1983. Isopollen maps for Poland: 0—11000 years B. P. New Phytol., 94:133—175.

Raniecka-Bobrowska J. 1954. Analiza pyłkowa profilów czwartorzędowych Woli i Żoliborza w Warszawie (summary: Pollen analysis of Quaternary profiles at Wola and Żoliborz, Warsaw). Biul. Inst. Geol., 69:107—140.

— 1970. Stratygrafia młodszego trzeciorzędu Polski na podstawie badań paleobotanicznych (summary: Stratigraphy of Late Tertiary in Poland on the basis of palaeobotanical research). Kwart. Geol., 14, 4:728—753.

Romanowicz I. 1961. Analiza sporowo-pyłkowa osadów trzeciorzędowych z okolic Bolesławca i Zebrzydowej (summary: Spore and pollen analysis of Tertiary sediments from the vicinity of Bolesławiec and Zebrzydowa). Biul. Inst. Geol., 158:325—409.

Różycki F. 1956. Interglacjał na terenie Aleksandrowa Łódzkiego (summary: Interglacial from Aleksandrów Łódzki). Przegl. Geol., 3:130—131.

Sadowska A. 1977. Roślinność i stratygrafia górnomioceńskich pokładów węgla Polski południowo-zachodniej (summary: Vegetation and stratigraphy of Upper Miocene coal seams of the south-western Poland). Acta Palaeobot., 18, 1:87—122.

Šercelj A. 1966. Pelodne analize pleistocenskih in holocenskih sedimentov Ljubljanskega barja. Diss. IV, Cl. Acad. Sci. Slov., 9:1—44

Sobolewska M. 1952. Interglacjał w Barkowicach Mokrych pod Sulejowem (summary: Interglacial at Barkowice Mokre near Sulejów). Biul. Państw. Inst. Geol., 66:245—284.

— 1956. Wyniki analizy pyłkowej osadów interglacjalnych z Olszewic (summary: Pollen analysis of the interglacial deposits of Olszewice on the Pilica River). Biul. Inst. Geol., 100:271—289.

— 1961. Flora interglacjału eemskiego z Góry Kalwarii (summary: Flora of the Eemian Interglacial from Góra Kalwaria (Central Poland). Biul. Inst. Geol., 169:73—90.

— 1966. Wyniki badań paleobotanicznych nad eemskimi osadami z Józefowa na Wyżynie Łódzkiej (summary: Results of palaeobotanic researches of Eemian deposits from Józefów, Łódź Upland). Biul. Perygl., 15:303—312.

— 1975. Analiza palinologiczna osadów interglacjalnych z Węgorzewa (summary: A palynological analysis of the interglacial deposits at Węgorzewo). Biul. Inst. Geol., 288:137—165.

— 1977. Roślinność interglacjalna ze Stanowic koło Rybnika na Górnym Śląsku (summary: Interglacial vegetation of Stanowice near Rybnik (Upper Silesia). Acta Palaeobot., 18, 2:3—14.

— & Środoń A. 1961. Late Pleistocene deposits at Białka Tatrzańska (West Carpathians). Folia Quatern., 7:1—16.

— Starkel L. & Środoń A. 1964. Młodoplejstoceńskie osady z florą kopalną w Wadowicach (summary: Late Pleistocene deposits with fossil flora at Wadowice (West Carpathians). Folia Quatern., 16:1—64.

Stachurska A., Dyjor S. & Sadowska A. 1971. Charakterystyka paleobotaniczna młodotrzeciorzędowych osadów w Gozdnicy na Dolnym Śląsku (summary: Palaeobotanic characteristics of Late Tertiary sediments at Gozdnica (Lower Silesia). Roczn. Polsk. Tow. Geol., 41, 2:359—386.

— Sadowska A. & Dyjor S. 1973. The Neogene flora at Sośnica near Wrocław in the light of geological and palynological investigations. Acta Palaeobot., 14, 3:147—176.

Stuchlik L. 1964. Pollen analysis of the Miocene deposits at Rypin. Acta Palaeobot., 5, 2:1—111.

— 1975. Charakterystyka palinologiczna osadów preglacjalnych z Ponurzycy (rejon Otwocka) (summary: Palynological characteristics of the preglacial sediments of Ponurzyca (Otwock area). Kwart. Geol., 19, 3:667—678.
Szafer W. 1926. O florze i klimacie okresu międzylodowcowego pod Grodnem (Zusammenfassung: Über den Charakter der Flora und des Klimas der letzten Interglazialzeit bei Grodno in Polen). Spraw. Kom. Fizjogr. PAU, 60:1—40.
— 1931. The oldest interglacial in Poland. Bull. l'Acad. Pol. Sc. et Lett., B I, 19—50.
— 1935a. The significance of isopollen lines for the investigation of the geographical distribution of trees in the Post-glacial period. Bull. l'Acad. Pol. Sc. et Lett., B:235—239.
— 1935b. Las i step na zachodnim Podolu (summary: The forest and the steppe in west Podolia). Rozprawy Wydz. Mat.-Przyr. PAU, 71, B, III, 31:1—123.
— 1946—1947. Flora plioceńska z Krościenka nad Dunajcem (summary: The Pliocene flora of Krościenko in Poland). Rozprawy Wydz. Mat.-Przyr. PAU, B, 72 nr 1, 2:1—375.
— 1953. Stratygrafia plejstocenu w Polsce na podstawie florystycznej (summary: Pleistocene stratigraphy of Poland from the floristical point of view). Rocz. Polsk. Tow. Geol., 22:1—99.
— 1954. Plioceńska flora okolic Czorsztyna i jej stosunek do plejstocenu (summary: Pliocene flora from the vicinity of Czorsztyn (West Carpathians) and its relationship to the Pleistocene). Prace Inst. Geol., 11:1—238.
— 1961. Mioceńska flora ze Starych Gliwic na Śląsku (summary: Miocene flora from Stare Gliwice in Upper Silesia). Prace Inst. Geol., 33:1—205.
— & Trela J. 1928. Interglacjał w Szelągu pod Poznaniem (Zusammenfassung: Interglazial in Szeląg (Schilling) bei Posen). Spraw. Kom. Fizjogr. PAU, 63:71—82.
— Trela J. & Ziembianka M. 1931. Flora interglacjalna z Bedlna koło Końskich (Zusammenfassung: Die interglaziale Flora in Bedlno bei Końskie). Rocz. Polsk. Tow. Geol., 7:402—414.
— & Oszast J. 1964. The decline of Tertiary plants before the maximal glaciation of the West Carpathians. Report of the INQUA Congress, Warsaw 1961, II:479—482.
Szczepanek K. 1965. Młodoplejstoceńska flora z Ustronia nad górną Wisłą (summary: The Late Pleistocene flora from Ustroń on the upper Vistula). Kwart. Geol., 12:173—182.
— 1971. Kras Staszowski w świetle badań paleobotanicznych (summary: The Staszów karst in the light of palaeobotanical studies (S Poland). Acta Palaeobot., 12, 2:1—140.
— 1982. Development of the peat-bog at Słopiec and the vegetational history of the Świętokrzyskie (Holy Cross) Mts. in the last 10 000 years. Acta Palaeobot., 22, 1:117—130.
Środoń A. 1956. W sprawie interglacjału w Szelągu pod Poznaniem (summary: Interglacial in Szeląg near Poznań). Biul. Inst. Geol., 100:45—60.
— 1957. Flora interglacjalna z Gościęcina koło Koźla (summary: Interglacial flora from Gościęcin near Koźle (Sudeten Foreland). Biul. Inst. Geol., 118:7—60.
— 1962. O niektórych zagadnieniach dotyczących paleobotaniki i stratygrafii czwartorzędu w Polsce (summary: On some problems of Quaternary palaeobotany and stratigraphy in Poland). Kwart. Geol., 6: 679—694.
— 1965. O florach kopalnych w terasach dolin karpackich (summary: On fossil floras in the terraces of Carpathian valleys). Folia Quatern., 21:1—27.
— 1973. O utworach z florą plioceńską w Kotlinie Nowotarskiej i w Krościenku nad Dunajcem (summary: Remarks on the deposits with Pliocene flora in the east part of the Nowy Targ Basin and at Krościenko on the Dunajec River (Western Carpathians). Rocz. Polsk. Tow. Geol., 43, 2:301—313.
— 1974. The glacial flora of the Saalian age from Góra Kalwaria near Warsaw. Acta Palaeobot., 15, 1:17—41.
— 1982. Pieniny w historii szaty roślinnej Podhala. In: Zarzycki K. (ed.), Przyroda Pienin w obliczu zmian. PWN, Warszawa—Kraków.
— 1984. Uwagi o florze interglacjalnej z Hamerni nad Lubaczówką (summary: Some remarks on the interglacial flora from Hamernia, SE Poland). Acta Palaeobot., 24, 1—2:55—68.
— & Gołąbowa M. 1956. Plejstoceńska flora z Bedlna (summary: Pleistocene flora of Bedlno, Central Poland). Biul. Inst. Geol., 100:7—44.

Takhtajan A. 1981. Flowering plants origin and dispersal. Oliver and Boyd, Edinburgh.

Tobolski K. 1966. Późnoglacjalna i holoceńska historia roślinności na obszarze wydmowym w dolinie środkowej Prosny (summary: The Late Glacial and Holocene history of vegetation in the dune area of the middle Prosna valley). Prace Kom. Biol. Pozn. Tow. Przyj. Nauk, 32, 1:1—69.

Tralau H. 1962. Die spättertiären *Fagus*-Arten Europas. Bot. Not., 115, 2:147—176.

Tran Dinh Nghia. 1974. Palynological investigation of Neogene deposits in the Nowy Targ-Orawa Basin (West Carpathians, Poland). Acta Palaeobot., 15, 2:45—81.

Wasylikowa K. 1964. Roślinność i klimat późnego glacjału w środkowej Polsce na podstawie badań w Witowie koło Łęczycy (summary: Vegetation and climate of the Late Glacial in central Poland based on investigations made at Witów near Łęczyca). Biul. Perygl., 13:261—417.

Watts W. A. 1970. Tertiary and interglacial floras in Ireland. Irish Geograph. Stud., Belfast.

Wiśniewski T. 1932. Studia biometryczne nad zmiennością buka (*Fagus silvatica*) w Polsce I (Zusammenfassung: Biometrische Untersuchungen über die Variabilität der Rotbuche (*Fagus silvatica*) in Polen I). Sylwan, 50, 6:1—27.

Zabłocki J. 1928. Tertiäre Flora des Salzlagers von Wieliczka. I. Acta Soc. Bot. Polon., 5, 2:174—208.

Zagwijn W. H. 1960. Aspects of the Pliocene and Early Pleistocene vegetation in the Netherlands. Mededel. Geol. Sticht., Ser. C-III, no. 5:1—78.

Zastawniak E. 1972. Pliocene leaf flora from Domański Wierch near Czarny Dunajec (Western Carpathians, Poland). Acta Palaeobot., 13, 1:1—73.

— 1980. Sarmatian leaf flora from the southern margin of the Holy Cross Mts. (South Poland). Prace Muzeum Ziemi, 33: 39—107.

Ziembińska-Tworzydło M. 1974. Palynological characteristic of the Neogene of Western Poland. Acta Palaeont. Polon., 19, 3:309—432.