Significance of *Hippophae rhamnoides* L. in evolution of the Eemian Interglacial¹ flora in Warsaw area

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Abstract

Palynologic studies of sediments from Warsaw-Wawrzyszew and other sites in the Warsaw Basin enabled to analyze main occurrence phases of *Hippophae rhamnoides* during the widely understood Lake Pleistocene interglacial warming. In initial phases of the Eemian Interglacial (late glacial of a preceding glaciation) the area of Warsaw-Wawrzyszew indicated especially favourable conditions for such rich development of sea-buckthorn. Analysis of occurrence phases of this bush proves that besides climatic conditions, great influence on more abundant occurrence of sea-buckthorn in its late glacial (pre-interglacial) part could be played by edaphic conditions, mainly contents of basic compounds (CaCO_3) in a substrate.

Key words: Quaternary biostratigraphy, palaeoecology, palaeoclimatology, palaeogeography

INTRODUCTION

Hippophae rhamnoides L. belongs to typical heliophyllic and xeromorphic shrubs (Zalewska 1955, Gorczyński 1968), and has particular significance in analysis of plant evolution as a good index of climatic conditions in previous times. Description of main occurrence phases of this shrub and its role in development of Quaternary vegetation in Poland was presented by Śródón (1970). Most frequently and most abundant pollen of *Hippophaë* is noted in sediments of the Late Glacial of the Vistulian (Wisła) Glaciation (Śródón 1970, Krupiński 1973). Abundant pollen grains of this taxon (about 20% of the total AN+NAP) were only seldom recorded from sediments of this age, coming mainly from the Wielkopolska National Park (lakes Budzyńskie and Skrzynka, peatbogs Krosinko-Górka and Stęszew; after Ołtuszewski 1957)

¹ *sensu lato*

and from Chojna about 50 km to the south from Szczecin (about 30% after Krupiński 1991). In sections from other parts of Poland, pollen of this bush is considerably more rare. Its similar quantities (20.6%) were noted only in sediments of the Older Dryas from the Mikołajki Lake (Ralska-Jasiewiczowa 1966). In other sites in which considerable (but decidedly lower than afore-mentioned) quantities were noted, there are the lakes: Dymaszewskie (Ołtuszewski 1957) and Budzyńskie (Zafranski 1973), and peatbogs: Gorzewo, Kępno, Lututów and Węglewice (Tobolski 1966), Nart and Łack (Borówko-Dłużakowa 1961a, b), and Witów near Łęczyca (Wasylkowa 1964). In most sites maximum occurrence of *Hippophaë rhamnoides* is noted at the turn of the Older Dryas and the Alleröd.

In sediments of the Eemian Interglacial *sensu lato*, sea-buckthorn is considerably more rare, and its quantities are decidedly lower. The main period of its occurrence is also connected with the late glacial of the glaciation that precedes this interglacial (Krupiński 1973). In sediments from decline of this interglacial no *Hippophaë* pollen is noted or it occurs occasionally only and in insignificant quantities (Śrdoń 1970, Krupiński 1973, 1978).

In sediments of the Mazovian Interglacial with Krępiec (Janczyk-Kopikowa 1981) or Biała Podlaska floristic successions, the main occurrence phase of sea-buckthorn coincides with late glacial flora of a preceding glaciation (Sobolewska 1956, Śrdoń 1970, Krupiński 1984/85, Krupiński et al. 1986, 1988, Krupiński and Lindner 1991). At Gościęcín-Koźle (Śrdoń 1957) pollen of *Hippophaë* was noted in phases IV and V i.e. during a final part of the interglacial.

Considerable contents of pollen grains of *Hippophaë rhamnoides* in two sections from Warsaw-Wawrzyszew with undoubted flora of the Eemian Interglacial made occurrence and development of this shrub during the interglacial particularly interesting. The paper presents a full pollen diagram of sediments in the section Warsaw-Wawrzyszew VI (WW-VI), and a shortened and simplified pollen diagram with enlarged vertical scale from bottom part of the section Warsaw-Wawrzyszew XV (WW-XV). Application of enlarged vertical scale is due to quick floristic changes in this part of a pollen diagram, resulting presumably from very slow sedimentation rate and high sediment compaction.

LOCAL POLLEN STRATIGRAPHY

Palynologically-examined organic sediments are underlain by lake silts, sands and clays, whereas lake bottom is composed of till, over 20 m thick. Organic sediments start with bituminous shales in the bottom, passing gradually into varying morphologically and genetically limy gyttjas. In top of organic sediments there are fissured peats, containing also other vertical frost structures. Peats are occasionally overlain with sands, thinly laminated with peaty deposits of brown-beige humus silts, or by several metre thick sands, passing upwards into

entropogenic ambankments. In top the sands are of aeolian and fluvial origin, and contain locally gravel and pebble horizons (Morawski 1975, 1976, Krupiński and Morawski 1990).

In sections Warsaw-Wawrzyszew XV and VI floristic development reflects climatic-floristic transformations during initial part of the Eemian Interglacial. In each section six local pollen zones were distinguished (Table 1). They correspond to phytophases *b-d* in a scheme of flora evolution during the Eemian

T a b l e 1
Warsaw-Wawrzyszew — local pollen zones and their
determination thickness and sample numbers

Phytophases after Ś r o d o Ń (1967)	Local pollen zones*	
	Warsaw-Wawrzy- rzew IV	Warsaw-Wawrzy- szew XV
<i>Ef</i>	<i>Corylus, Taxus</i> (<i>Alnus, Tilia</i>) WW-7 1-3 485-520	<i>Corylus, Taxus</i> (<i>Alnus, Tilia</i>) WW-7 ...65-68 ...475-497
<i>Ee</i>	<i>Quercus, Pinus,</i> <i>Fraxinus (Corylus)</i> WW-6 4-5 520-535	<i>Quercus, Pinus</i> <i>Fraxinus (Corylus)</i> WW-6 69-78 497-542
<i>Ed</i>	<i>Pinus, Betula, Ul-</i> <i>mus (Quercus)</i> WW-5 6-7 535-550	<i>Pinus, Betula, Ul-</i> <i>mus (Quercus)</i> WW-5 79 542-548
	<i>Betula, Pinus</i> WW-4 8-9 550-563	<i>Betula, Pinus</i> WW-4 80 548-550
<i>Eb + Ec</i>	<i>Pinus, Hippophaë</i> WW-3 10-12/13 563-575	<i>Pinus, Betula, Ul-</i> <i>mus</i> WW-3 81-88 550-578
	<i>Hippophaë (Betu-</i> <i>la)</i> WW-2 13 575-580	<i>Betula (Hippop-</i> <i>haë)</i> WW-2 89-90 578-585
	<i>Hippophaë, NAP</i> WW-1 14 580-590	<i>Hippophaë, NAP</i> WW-1 90 585-587
	NAP + secondary deposit 15-17 590-660	NAP + secondary deposit 92-95 587-605

* Name o pollen zone, determination, sample nos, depth (cm).

Interglacial after Jessen and Milthers (1928), or to phytophases *Eb* to *Ed* after Šrodoń (1967).

The bed with secondary pollen (NAP + secondary bed) is preserved in both sections. It corresponds with initial deposition of sediments with sporomorphs of local plants. Rare and patchy-like plant communities produced insignificant pollen material making transport of even rare sporomorphs from further areas and derived from older deposits very distinct in pollen spectrum. Participation of sporomorphs of Tertiary or older plants increased to over 30% if referred to the total AP + NAP of Quaternary plants (some of them can be however of Tertiary origin). Loose vegetation or even its absence favoured erosive processes, supplying a water reservoir with sediments and sporomorphs from older deposits. Material in secondary bed included sporomorphs of exotic plants and of trees with greater climatic demands. For this reason evaluation of this elements is not complete as it does not comprise pollen of trees with smaller climatic demands (*Pinus*, *Betula*, *Salix*) that can be either of Tertiary or Quaternary age. The bed NAP + secondary deposit should be considered as a layer in a geological sense.

Main components of poor in number but rich in genera vegetation included shrubs and herbaceous plants, firstly representatives of *Gramineae*, *Cyperaceae*, *Artemisia*, *Rosaceae* and *Juniperus*. There are plants of high light demands, among others *Ephedra distachya* type, *Empetrum*, *Helianthemum*, *Polemonium*, *Armeria*, *Polygonum bistorta/viviparum* type and *Selaginella selaginoides*. Pollen of mesocratic and telocratic (= oligocratic) plants as *Quercus*, *Corylus*, *Alnus*, *Tilia*, *Fraxinus*, *Carpinus*, *Ulmus* and *Picea* should be considered to have occurred in secondary bed. It can be of Tertiary age as proved by numerous sporomorphs of Tertiary plants and of the *Hystrichosphaeridium* plankton. Plankton of the genus *Botryococcus* was abundant. Quantitative evaluation of material in secondary bed is not complete as it does not comprise pollen of *Betula*, *Pinus* and *Salix*, that can be at least partly of Tertiary origin.

The pollen zone Warsaw-Wawrzyszew WW-1 — *Hippophaë*, NAP (Table 1), reflects progressive vegetation evolution, mainly of shrubs and herbs, and to a considerable smaller degree of trees. Sea-buckthorn was the main component of local plant communities. Amongst trees gained more significance and considerably less — tree species of birch. Increased influence of local vegetation on pollen rain acts as significant element of floristic transformations in this area. Pollen spectra indicate distinct drop in participation of material from far transport, firstly of pollen from washed older sediments. Pollen material is less destructed and significance of *Botryococcus* decreased. In pollen diagrams of sediments from both sections from Warsaw-Wawrzyszew an outstanding feature is formed by distinct correlation of curves of *Botryococcus* and of sporomorphs of Tertiary plants, as well as periods of their occurrence.

The pollen zone WW-2 — *Betula*, *Hippophaë* or *Hippophaë (Betula)* (Table 1), makes difference between both sections. It can be due to rare sampling of

sediments in the section Warsaw-Wawrzyszew XV and for this reason, the first maximum of *Betula* could not be distinguished, although it is very distinct in the section WW-VI. However increasing values of *Betula* in the section WW-XV are also distinguishable (Figs. 1 and 2).

The pollen zone WW-3 — *Pinus*, *Hippophaë* or *Pinus*, NAP (*Hippophaë*) (Table 1), reflects also a certain differentiation in sediments of the sections. It is mainly expressed in curves of NAP, and to a smaller degree of *Hippophaë*. In both sections there is increased significance of sporomorphs of Tertiary plants, of destructed sporomorphs of *Botryococcus* colonies. Considerable participation of *Pediastrum* algae was noted, particularly in sediments of the section WW-XV, reaching the first maximum.

The curve *Hippophaë* indicates that this plant distinctly failed in competition for light with forest vegetation. It is undoubted that considerable influence was played here by the substrate, already impoverished in basic compounds and transformed by soil processes. This zone is the final one in occurrence of sea-buckthorn and of other plants with greater light demands.

The pollen zone WW-4 — *Betula*, *Pinus* (Table 1), forms the first phase in development of compact or relatively compact forest communities. In areas that are less edaphically favourable, the forest communities, although many a time could not keep up with retreating ice sheet (Iversen 1954, Śrdoń 1954, Mamakowa 1962), had park-like character. The latter enabled survival of already rare plants with greater or slightly greater light demands from previous evolution phases, among others of *Hippophaë*, *Artemisia*, *Juniperus*, *Helianthemum* and *Selaginella selaginoides* (section WW-VI), *Juniperus* and *Artemisia* (section WW-XV).

The pollen zone WW-5 — *Pinus*, *Betula*, *Ulmus* (*Quercus*) (Table 1), forms introduction to development of rich multi-species and compact forests of the Eemian Interglacial. *Pinus* reaches the third i.e. last maximum of its occurrence during this interglacial. This zone is also expressed by the second maximum of *Betula* (cf. Niklewski 1969). Significance of shrubs and herbaceous plants has also decreased, and heliophytic elements have almost completely disappeared.

The pollen zone WW-6 — *Quercus*, *Pinus*, *Fraxinus* (*Corylus*), referred to the phytophase Ee of Śrdoń (1967), proves development of compact mixed forests and beginning of development of rich multi-species deciduous forests, typical for climatic optimum of this interglacial. Plants with higher climatic demands appeared, among others *Hedera*, *Viscum* and *Humulus*.

The pollen zone WW-7 — *Corylus*, *Taxus* (*Alnus*, *Tilia*), referred to the phytophase Ef of Śrdoń (1967) constitutes a very important, either from diagnostic or from stratigraphic points of views, horizon for floristic successions considered for the Eemian ones. Detailed description of floristic development during the Eemian Interglacial, indicated in this and in other sections from Warsaw-Wawrzyszew, is the subject of a separate paper (Krupiński and

Morawski 1992) and for this reason characteristic features of this succession have been here only very roughly described and do not comprise the whole diagrams. Indicating in the table and in pollen diagrams of the post late-glacial vegetation phases results from diagnostic features for the Eemian age of the flora from the site Warsaw-Wawrzyszew.

OCCURRENCE OF *HIPPOPHAE* *RHAMNOIDES* L. IN FLORA OF THE EEMIAN INTERGLACIAL *SENSU LATO* IN WARSAW AREA

The Warsaw area, particularly its western part and adjacent region, is rich in floristic sites of the Eemian Interglacial age. Not in all of them, particularly the ones that have been previously palynologically elaborated, vegetative or generative remains of *Hippophaë* were noted. Reasons for this can be quite different. In newer studies, pollen of sea-buckthorn was more frequently noted and its quantities are usually very low. These are single specimens, samples or sites.

Results of the last author's examinations, including sediments of the Eemian Interglacial in two sections from Warsaw-Wawrzyszew, one from Warsaw-Wola (Krupiński 1988), three sections from Komorów, 20 km to the west of Warsaw (Krupiński unpubl.), indicate that in western part of the Warsaw Basin during preliminary vegetation phases of this interglacial (i.e. during the late glacial of the Saalian Glaciation) a sea-buckthorn was quite abundant, although occurred in varying quantities in individual sites. It constitutes the predominant element (over 45% of the total AP + NAP) in pollen spectra of sediments of the Eemian Interglacial age from the site Warsaw-Wawrzyszew. Basing on preliminary recognition and pollen analysis of the new section from Warsaw-Wawrzyszew (received from Morawski, State Geological Institute, Warsaw), participation of its pollen in spectra can be still higher. They are the sandy sediments, overlain with limy lake deposits (gyttjas) that contain remains of Eemian Flora. Agglomerations of pollen grains in analyzed materials formed an undoubted evidence of *Hippophaë in situ*. Participation of *Hippophaë* could be still greater if each pollen agglomeration was not treated as a single sporomorph what trees with principles of pollen analysis.

First appearance in pollen spectra of pollen grains of *Hippophaë rhamnoides* agrees with predominance of shrubs and herbs (NAP), heliophytic inclusive, in time it should be referred to the late glacial of the preceding glaciation. Considerable participation of Tertiary or older sporomorphs was caused by intensive erosive processes (absence of compact vegetation cover) that destructed surficial sediments containing sporomorphs of Tertiary plants.

The end of the evolution phase of *Hippophaë* in history of floristic transformations of these sections agrees with the second maximum of *Pinus*, just before the second, younger maximum of *Betula* and preceding appearance of the first, still rare deciduous trees (*Ulmus*, *Quercus*, *Fraxinus*). Forest communities in

this part of the section were of compact character; trees decidedly predominated in pollen spectra. No sporomorphs of plants of higher light demands occur. There are first plants of slightly higher climatic demands a.o. *Hedera* and *Viscum*, whereas in marshy meadows ash and elm were frequently accompanied by nitrophilous hop (*Humulus*). Full occupation of surface sediments by plant communities stopped erosion and supplying lake sediments with Tertiary sporomorphs.

In light of palynologic investigations of sediments of the section Warsaw-Wawrzyszew VI, predominant significance of *Hippophaë* in development of local plant communities corresponds to the phase with abundant development of shrubs and herbs (pollen zones WW-1, partly WW-2). During this phase, AP is insignificantly predominated by *Pinus* over *Betula*: pollen zone WW-1 — *Hippophaë*, NAP, and WW-2 — *Hippophaë* (*Betula*) (Table 1). It corresponds to the older part of the phytophase *c*. Noted in these sediments pollen grains of meso- and oligocratic trees should be considered for the ones in secondary bed.

In the section Warsaw-Wawrzyszew XV maximum values of *Hippophaë* pollen are indicated also in the phase with insignificant predominance of *Pinus* over *Betula*, just before rapid rise in *Betula* contents (pollen zone WW-1 — *Hippophaë*, NAP, older part of the phytophase *c* (Table 1, Figs. 1 and 2). Participation of NAP in this section is very similar to the section WW-VI or is slightly lower, reaching 75%.

During abundant occurrence of *Hippophaë rhamnoides* in sediments of both sections the presence of important index plants of open areas was noted i.e. *Ephedra distachya* type, *Empetrum*, *Helianthemum*, *Saxifraga*, *Pleurospermum austriacum*, *Armeria*, *Geranium* and *Selaginella selaginoides*. There were abundant *Artemisia* and *Juniperus* as well as representatives of the families: *Gramineae*, *Cyperaceae*, *Chenopodiaceae*, *Caryophyllaceae*, *Rosaceae* and others.

Constant presence of pollen of *Hippophaë rhamnoides* was also noted in the early Eemian sediments of the section in Warsaw-Wola (K r u p i ń s k i 1988) but its number does not exceed in any bottom sample the value of 2% if related to the total pollen of AP + NAP. Relatively small quantities of pollen of this taxon can be due to omitting the sediments from earlier phases of the late glacial that preceded this glaciation. Sands are the oldest sediments examined palynologically in this section and their deposition is to be connected with the phytophase *c* after Jessen and Milthers (1928) i.e. with decline of main occurrence of *Hippophaë* in sections from Warsaw-Wawrzyszew. The curve of *Hippophaë* from sediments of this section is of rational type, runs continuously and comprises 5 successive samples from bottom part of the section. Occurrence of *Hippophaë* in this section corresponds to considerable content of NAP (about 30-35%), whereas AP were insignificantly predominated by *Pinus* over *Betula*. There is numerous *Salix* and quite numerous sporomorphs of Tertiary or older plants. Amongst NAP there are very abundant *Artemisia* (to 14%), *Juniperus* and representatives of *Gramineae*, *Cyperaceae*, *Chenopodiaceae*, *Rosaceae* and

others. There were still heliophyllous plants of open areas i.e. *Helianthemum*, *Ephedra distachya* type, *Empetrum*, *Gentiana*, *Saxifraga*, *Polygonum bistorta/viviparum*, *Plantago major/media* type, *Sanguisorba officinalis*, *Chamaenerion/Epilobium* and *Selaginella selaginoides*.

Similar phase of the late glacial development before the Eemian Interglacial is reflected by rare pollen of *Hippophaë* (5 grains i.e. about 0.5%) in lake sediments of the occasionally sampled section from the western part of Warsaw-Wola, namely Odolany (Krupiński 1989/90).

Considerable contents of pollen of *Hippophaë rhamnoides* (about 9%) was noted in a single sample (no. 34) from the section from Gólków to the south of Warsaw (Janczyk-Kopikowa 1966). Main phase of its occurrence corresponds there to the phytophase *c*, with loose pine-birch or birch-pine communities with abundant shrubs and herbs. After Janczyk-Kopikowa (1966) vegetation of this time formed loose park pine-birch forests with patches of probable meadow vegetation with considerable participation of *Cyperaceae*, *Gramineae* and *Artemisia*. Presence of abundant *Artemisia* is connected by the authoress with a poor soil rather than with climatic conditions of the time. In the section there are also rare pollen grains of shrub, noted in two samples from the top. It corresponds to the first maximum of *Betula* within the older Vistulian. From a biostratigraphical point of view it was referred to the phytophase *i* in the scheme of Jessen and Milthers (1928).

Decidedly less pollen grains of sea-buckthorn were noted in the bottom sediments of the site Komorów near Pruszków (Krupiński unpubl.). In any of these sections its quantities are over 1.5%. Main phase of occurrence of this shrub occurs also during development of loose or patchy-like pine-birch or birch-pine communities with abundant shrubs and herbs, the ones of open areas inclusive.

Rare pollen grains of *Hippophaë* are noted in sediments of the section Żyrardów (Krupiński 1973, 1978). Flora in bottom part of the section Żyrardów 2/69, ascribed to the phytophase *b-c* in the scheme of Jessen and Milthers (1928), contains no more than 0.5% of sea-buckthorn pollen. Only in the lowermost sample (no. 230) it reaches 2%. In sediments of the Eemian Interglacial (phytophases *d* and *e*) or of the Early Vistulian (phytophases *j* and *k*) pollen of *Hippophaë* is noted only sporadically. In sediments of the Vistulian Glaciation age, coming from another section of this site (section Żyrardów 5/69; Krupiński 1986) no single pollen of *Hippophaë* was noted in any of several dozen analyzed samples, although climatic conditions and vegetation in that time made occurrence of this plant quite possible.

Presence of rare pollen grains of *Hippophaë* was noted also in sediments of the Eemian Interglacial in the section Zgierz-Rudunki II (Jastrzębska-Mamęłka 1985) in sediments related to the late glacial of the Saalian Glaciation (zones 1 and 2) a curve of this pollen runs continuously (to 0.5%). A single pollen of this shrub was noted also in a sample from upper part of the zone 12, ascribed

to the Amersfoort Interstadial (Jastrzębska-Mamełka 1985). But in the neighbouring section Zgierz-Rudniki I (Jastrzębska-Mamełka 1985) no pollen of sea-buckthorn was noted in well preserved sediments of the Amersfoort *b*. A single pollen of *Hippophaë* was found in sediments of the initial part of the phytophase *d* in the section from Główny near Wyszogród (Niklewski 1968).

In sediments of other sections with Eemian flora from the Warsaw area (Raniecka-Bobrowska 1954, Borówko-Dłużakowa 1960) or from Central Poland (Horoski: Bitner 1954, Bedno: Śrdoń and Gołbowa 1956, Sławno near Radom: Tołpa 1961, Góra Kalwaria and Józefów: Sobolewska 1961, 1966, Widawka drainage basin, Grodzisk Mazowiecki, Błonie and Rogów: Janczyk-Kopikowa 1971, 1973, 1974, 1985, Bobrówka valley: Klajnert and Piechocki 1972, Łomżyca basin: Krupiński 1992, and Niklewski and Krupiński 1992) even single pollen of *Hippophaë* was found, although in these sections sediments from primary phases of this interglacial warming were noted.

Analysis of regions and main phases of occurrence of *Hippophaë rhamnoides* L. during the Eemian Interglacial and the late glacial of the preceding glaciation in Central Poland indicates that the present area of Warsaw, especially its western and northern part represented particularly favourable conditions for development of the shrub. Sea-buckthorn gained there exceptionally great importance. Maximum participation of the pollen *Hippophaë* in pollen grain corresponds with older part of the phytophase *c* in vegetation evolution during the Eemian Interglacial after Jessen and Milthers (1928). Analysis of sections, bottom parts of which contained numerous pollen grains of *Hippophaë*, indicates that their remaining parts either do not contain this taxon or it occurs occasionally in a few cases and insignificant quantities only, in spite of the fact that the enclosed flora could take such possibility into account. Climatic factor was important but it was not the only one that decided about occurrence or absence of this shrub at the beginning and the end of the Eemian Interglacial. It deals also with other warmings during the Quaternary in the territory of Poland. Reasons are to be looked for in biological factors, especially in the edaphic one. Drawing such conclusion is possible on the basis of observation of habitat conditions in which this genus is noted at present.

Present climatic-geographical occurrence of *Hippophaë rhamnoides* L. is very extensive. It comprises areas of temperate and cool climate of Europe and Asia, between 30 and 67° of northern latitude (Mensel 1943). Within this area there are two zones (*a*) a narrow northern one along seashores of the Baltic and the North Sea to southern England, and (*b*) a wide southern inland one, comprising areas from the Pyrenees across the Alpine and Mediterranean countries, Asia Minor, Armenia, Persia, Turkestan, as far as mountains and uplands of Central Asia, Mongolia and southern Siberia. In Europe there is only a single species of *Hippophaë rhamnoides* L. (sea-buckthorn) and two species in Asia (*Hippophaë*

rhamnoides L. and two endemic forms: *Hippophaë salicifolia* D. Don. and *Hippophaë thibetana* Schlecht.). In the mountains it occurs up to 2000 m a.s.l. (Europe) and 5000 m a.s.l. (Himalayas).

Hippophaë rhamnoides belongs to the plants with geographic South-European and South-Siberian occurrence (Hultén 1950). Its main occurrence along seashores is a secondary phenomenon (Palmgren 1912: p. 188). It has strongly developed root system, composed of a top-root and numerous side roots, from which new shoots can grow. In spite of rare inflorescences of both sexes on a single specimen, it belongs to typical wind-pollinated dioecious species (Palmgren 1912). It is scattered mainly by wind, water and birds (Servettaz 1909, de Vries 1947). Occurrence of sea-buckthorn inland, far from seashores, is connected by Servettaz with migration routes of birds. On dune shores of the Netherlands and particularly on the Frisian Islands, it has been brought by starlings (de Vries 1947).

Young seedlings of sea-buckthorn demand much light for their development; they die if it is not available (Zalewska 1955). Particular case of vitality of sea-buckthorn was noted by Gorczyński (1968) at Cetniewo on a seashore where seedlings went through an asphalt path. In natural state a sea-buckthorn develops well on extremely barren soils or on sandy and gravel soils if they are rich in basic (mainly Ca) salts and particularly in slightly deeper and quite wet layers (Zalewska 1955).

Hippophaë rhamnoides L. is considered to be typical for psammophilous communities (group *Trifolio-Anthyllidetum maritimae*), growing on steep seashore cliffs. It occurs if a substrate is rich in CaCO_3 (Kornaś 1972). Szafer (1972) considers *Hippophaë rhamnoides* to be typical for marly cliffs. On sandy cliffs of Wolin Island sea-buckthorn in this community (*Trifolio-Anthyllidetum maritimae*) does not appear if a substrate is poor in calcium soils.

Hippophaë rhamnoides dislikes a substrate prepared and transformed by soil processes, rich in humus substances but devoid of calcium compounds. This fact explains not only a present location of sea-buckthorn along seashores and sandy shores of larger rivers in Central Poland (e.g. of the Vistula), but also considerably more common cases when its abundant generative and vegetative remains are noted in late glacial sediments, coming from initial phases of interglacial or interstadial warmings (Śröder 1970, Krupiński 1973) when a substrate was still rich in calcium carbonate. Connected with development of interglacial or interstadial flora and with climatic conditions of that time, a substrate has been considerably transformed due to soil processes, with reduction in basic (mainly CaCO_3) and enrichment in humus compounds. It made unfavourable conditions for development of sea-buckthorn during final phases of the Quaternary warmings in the territory of Poland.

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Fig. 2. Pollen diagram of sediments in the section Warsaw-Wawrzyszew VI. For explanations see Fig. 1. Taxons which are not marked in the pollen diagram (sample no./%): *Arctostaphylos* (17/5), *Vaccinium* (14/+), *Hypericum* (16/0.3), *Iridaceae* (14/0.1, 12/0.1), *Ligustrum* (5/x), *Polygonum persicaria* type (12/x), *Rumex* sec. *acetosa* (3/0.1), *Caltha* (15/0.3), *Parnassia* (14/0.1), *Myriophorum spicatum* (13/0.3), *Nuphar* (3/0.1), *Nymphaea* (3/0.1)

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Znaczenie *Hippophaë rhamnoides* L. w rozwoju flory interglacjału eemskiego obszaru Warszawy

Streszczenie

W osadach organogenicznych wieku eemskiego licznie występujących na obszarze zachodniej części Warszawy natrafiono na obfite występowanie ziarn pyłku *Hippophaë rhamnoides*. Wyniki badań palinologicznych osadów w dwóch profilach pochodzących z Warszawy Wawrzyszewa dowiodły, że na tym terenie w fazie początkowej rozwoju flory interglacjału eemskiego, rokitnik był elementem dominującym w miejscowych zbiorowiskach roślinnych. Osiągnął on w spektrach pyłkowych ponad 45 % udziału sumy AP + NAP.

Pierwsze sygnały dowodzące pojawienia się *Hippophaë rhamnoides* w rozwoju miejscowych zbiorowisk roślinnych przypadają na okres dominowania flory krzewiastej i zielnej, w tym terenów otwartych, początku ocieplenia interglacialnego (późnego glacjału zlodowacenia środkowopolskiego). Dominujące znaczenie rokitnika w spektrach pyłkowych przypada na fazę rozwoju zbiorowisk krzewiastych i zielnych. Wśród AP w deszczu pyłkowym nieznacznie przeważał ilościowo pyłek *Pinus* nad *Betula* — poziom pyłkowy *Hippophaë*, NAP oraz *Hippophaë* (*Betula*) (patrz tab. 1). Wraz z dominującym *Hippophaë* licznie występowały inne ważne wskaźnikowo elementy flory krzewiastej i zielnej, w tym terenów otwartych m.in. *Ephedra distachya* typ, *Empetrum*, *Helianthemum*, *Saxifraga*, *Pleurospermum austriacum*, *Armeria*, *Geranium*, *Selaginella selaginoides*, *Juniperus*, *Artemisia*. Kres fazy rozwojowej *Hippophaë* przypada na drugie maksimum występowania *Pinus*, tuż przed drugą, młodszą kulminacją *Betula*, poprzedzającą pojawienie się nielicznych ilościowo drzew liściastych (*Ulmus*, *Qureus*, *Fraxinus*). Zbiorowiska leśne tego okresu miały charakter zwarty, elementy heliofilne wycofały się.

Zdecydowanie mniejsze ilości pyłku *Hippophaë* stwierdzono w spągowych odcinkach profili z florą eemską w Warszawie przy ul. Kasprzaka (2 % — Krupiński 1988), Gołkowie (9 % — Janczyk-Kopikowa 1966), Warszawie Odolanach (0,5 % — Krupiński 1990),

Komorowie (do 1,5 % — Krupiński 1974-1986 msc.), Żyrardowie (do 2 % — Krupiński 1973, 1978), Zgierzu-Rudunkach (do 0,5 % — Jastrzębska-Mamełka 1985), Głównie (Niklewski 1968). W częściach stropowych tych profili (z wyjątkiem Gołkowa, Żyrardowa i Zgierza-Rudunkach) obecności ziarn pyłku tego taksonu nie odnotowano, pomimo że charakter flory mógłby wskazywać na możliwość pojawienia się tego krzewu.

W innych profilach tego wieku pochodzących z obszaru Polski Środkowej nie stwierdzono nawet pojedynczych przypadków obecności tego taksonu, pomimo że występują w nich osady pochodzące z faz początkowych i schyłkowych tego ocieplenia interglacjalnego. Obszar Warszawy Wawrzyszewa charakteryzował się więc wyjątkowo korzystnymi warunkami dla masowego pojawienia się tego krzewu.

Jakie więc czynniki mogły decydować o takiej historii i geografii występowania *Hippophaë* w czwartorzędzie Polski? Przyczyn takiego występowania zdaniem autora należy się doszukiwać w czynnikach natury biologicznej, a przede wszystkim edaficznej. Do wyciągnięcia takiego wniosku upoważniają obserwacje warunków siedliskowych w jakich on występuje współcześnie.

Hippophaë rhamnoides L. uważany jest za gatunek charakterystyczny dla zbiorowisk psamofilnych, zasiedlający strome klify nadmorskie, zespołu *Trifolio-Anthyllidetum maritimae*. Jednak warunkiem jego występowania jest zasobność podłoża w CaCO_3 (Kornaś 1972), a w przypadku braku tego związku w zespole tym nie pojawia się (Szafer 1972).

Hippophaë rhamnoides nie lubi podłoża przygotowanego i zmienionego przez procesy glebotwórcze i glebowe, zasobnego w związki próchniczne, lecz pozbawionego związków wapnia, a więc warunków siedliskowych jakie panowały w fazach schyłkowych ociepleń interglacjalnych. Zdecydowanie częstsze przypadki jego obecności na początku ociepleń interglacjalnych uwarunkowane były zasobnością podłoża w CaCO_3 .