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The phytogeographical character of the north-western part of the Eastern Carpathians (S.E. Poland)

Bogdan ZEMANEK

1. INTRODUCTION

The vast areas of the Eastern Carpathians and the striking distinctiveness of their flora and vegetation have attracted for a long time the attention of botanists but the investigations were focused rather on the ranges far to the south-east, such as the Rodna Mts., the Marmaros Mts., the Czywczyn Mts., the Czarnohora Mts., etc. Only a small part of the Eastern Carpathians is enclosed within the territory of Poland, namely the Western Bieszczady Mts. (Bieszczady Zachodnie) together with the adjacent foothills (Fig. 1). The flora of vascular and lower plants and the vegetation of higher parts of the Bieszczady Mts. were investigated by PALCZYNSKI (1962), ZARZYCKI (1963), JASIEWICZ (1965) (for further references see PARTYKA 1977). The history of vegetation in this territory was given by RALSKA-JASIEWICZOWA (1980, 1989, 1992). The lower ranges of the Bieszczady Mts., northwards and eastwards of the river San, were less studied (cf. ZEMANEK 1991a). There have also been many faunological investigations on various groups of animals (cf. PARTYKA 1977). From the point of view of natural history, the Western Bieszczady Mts. are among the best studied parts of the Polish Carpathians.

The character of the flora and vegetation, as well as a new concept of phytogeographical division of the northwestern part of the Eastern Carpathians, based on the recent studies are given in the present paper.

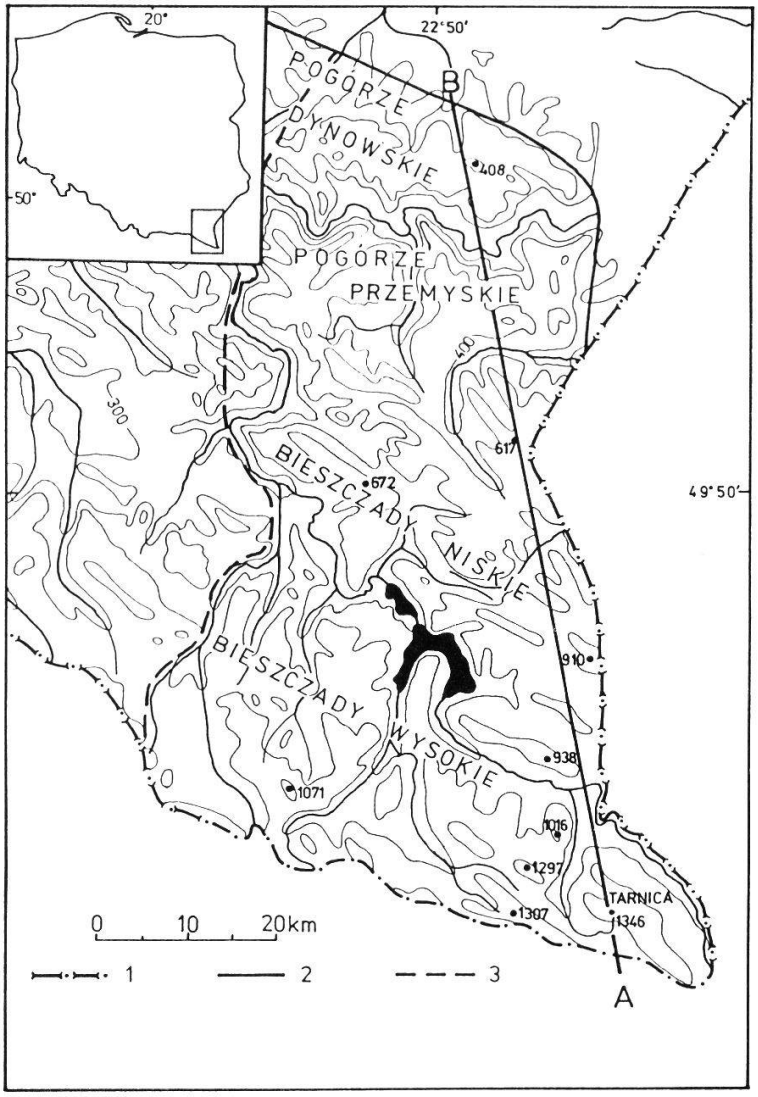

Fig. 1. The Polish Eastern Carpathians.
1 = state boundary, 2 = northern limit of the Carpathians, 3 = western boundary of the territory studied (phytogeographical boundary of the Eastern Carpathians according to PAWLOWSKI 1972); A-B = line of the section shown in Fig. 3.

2. PHYSIOGRAPHY OF THE POLISH EASTERN CARPATHIANS

The geomorphological division of of the Polish Eastern Carpathians (in a phytogeographical approach, according to PAWLOWSKI 1972) is shown in Fig. 2. The so-called ridge and valley pattern of land morphology is typical of the Eastern Carpathians. The parallel mountain ridges are separated by deep and broad river valleys and occasionally, at right angle, by deep ravines. In the southnorthern direction the relief changes gradually from typically medium

mountainous to low mountainous and at last to foothills (Fig. 3).
The geological structure of the territory investigated is rather simple. The Polish Eastern Carpathians are situated mainly within three tectonic units: the Skole Nappe in the north, the Silesian Nappe in the centre, and the Dukla Nappe in the south. The Silesian unit consists mainly of Krosno sandstone

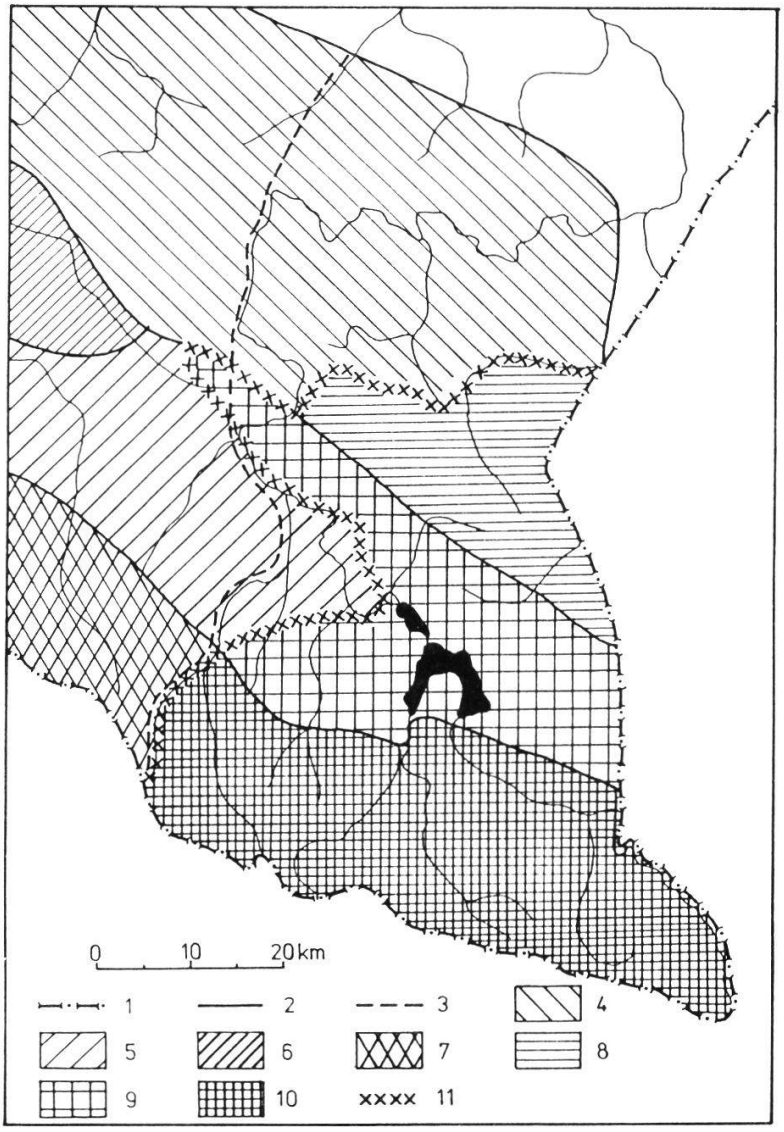

Fig. 2. Geomorphological division of the Polish Eastern Carpathians and adjacent territories (KLIMASZEWSKI and STARKEL 1972).
1 = state frontier, 2 = northern limit of the Carpathians, 3 = western boundary of the territory studied (phytogeographical boundary of the Eastern Carpathians according to PAWLOWSKI 1972), 4 = Dynow Foothills (Pogorze Dynowskie), 5 = Jaslo-Sanok Depression (Doly Jasielsko-Sanockie), 6 = Strzyzow Foothills (Pogorze Strzyzowskie), 7 = Low Beskids (Beskid Niski), 8 = Wankowa Upland (Wyzyna Wankowej), 9 = Low Bieszczady Mts. (Bieszczady Niskie), 10 = High Bieszczady Mts. (Bieszczady Wysokie), 11 = geomorphological boundary of the Eastern Carpathians.

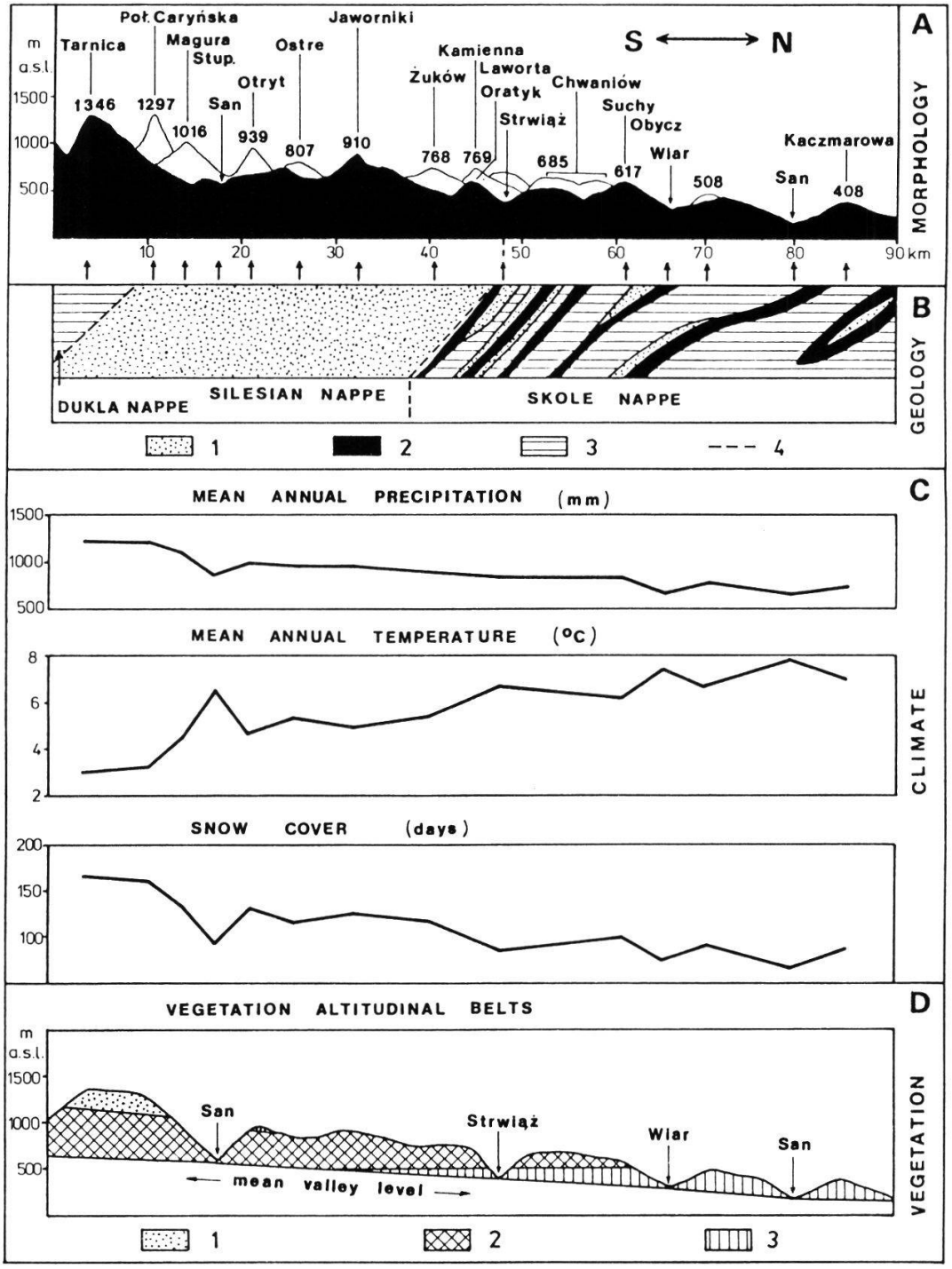

Fig. 3. Physiographical characterization of the Polish Eastern Carpathians.
A. Section of the Polish Eastern Carpathians along the line Mt. Tarnica - Mt. Jaworniki - Mt. Suchy Obycz. Arrows indicate places for which climatic data (C, below) have been calculated. B. Geological structure along the line of the section: 1 = Krosno layers, 2 = Menilitic layers, 3 = Inoceramus layers, 4 = boundaries between tectonic units. C. Changes of some climatic parameters along the line of the section: values for points shown above (A) by arrows are calculated after formulas by MICHNA and PACZOS 1972. D. Distribution of altitudinal vegetation belts along the line of the section: 1 = subalpine belt, 2 = montane belt, 3 = submontane belt.

rich in $CaCO_3$. Within the Skole unit they are replaced by Menilitic shale, Hieroglyphic layer, and Inoceramus sandstone. The Dukla unit consists of Krosno shale, Menilitic shale with Cergowa sandstone, and Inoceramus layer. In the vicinity of Przemysl the Jurassic Shtramberk limestone appears on the surface (cf. KLIMASZEWSKI and STARKEL 1972) (Fig. 2).

The soil originating from this rather uniform substratum does not differ much. Forest brown soil and leached brown soil predominate. The acid brown soil is rarer. On steep slopes with rock outcrops the brown pararendzinas are rarely found. Hydrogenic soil, i.e. alluvial soil and muck-gley soil, occur in the river valleys. There are also some peat bogs with peat mucky soil (ADAMCZYK and ZARZYCKI 1963, MAREK and PALCZYNSKI 1964, DZWONKO and ZEMANEK 1976, DZWONKO 1977).

The geological structure and land morphology of this territory are reflected in the water net. The parallel course of the main river valleys with perpendicular smaller tributaries and the occurrence of deep river ravines are typical of this area.

The territory studied lies within three climatic units: the northern unit with the foothills, the central unit with the lower parts of the Bieszczady Mts., and the southern unit with the higher ranges of the Bieszczady Mts. (OKOLOWICZ 1978) (Table 1).

Three vertical climatic zones which are of basic importance to the vegetation may be distinguished:

- the moderately warm zone with mean annual temperature above 6°C, up to about 500 m a.s.l.
- the moderately cool zone with mean annual temperature lower than 6°C, 500-1100 m a.s.l.
- the cool zone with mean annual temperature lower than 4°C, above 1100 m a.s.l. (MICHNA and PACZOS 1972).

Table 1. Mean values typical of climatic units in the Polish Eastern Carpathians (OKOLOWICZ 1978).

Climatic units	Mean monthly temperature (°C)		Duration of		Precipitation (mm)	Snow cover (days)
	I	VII	winter days	summer days		
northern	-3.5	17.9	90	99	780	85
central	-5.0	17.5	100	80	750	85
southern	-7.0	16.0	110	50	>900	100

3. VEGETATION

There are three altitudinal vegetation belts in the Polish Eastern Carpathians: the submontane, montane and subalpine belt. The boundaries between them run at 500-550 m a.s.l. and 1050-1150 m a.s.l. (ZARZYCKI 1963, JASIEWICZ 1965, DZWONKO 1976). In the northern ranges the montane zone is limited rather to small areas while the submontane belt is more important; in the southern parts their position is reversed. The subalpine belt appears only in the highest mountains (above 1100 m a.s.l.) in the southeastern corner of the Polish Eastern Carpathians (Figs. 1 and 3). It should be stressed that because of the lack of the high montane belt (spruce forest belt) the subalpine belt lies extremely low in comparison with other Carpathian ranges. This is a unique feature of the Bieszczady Mts.

In the southern part of this territory the *Dentario glandulosae-Fagetum* (= *Fagetum carpaticum*) is the dominating forest community. The beech forest occurs mainly above 500(-550) m a.s.l. but it goes down fairly low on the northern slopes and along shady, moist valleys. The occurrence of the *Phyllitido-Aceretum* forest on rocky slopes has been discovered. A typical acidophilous beech forest, *Luzulo-Fagetum*, is found in places as are fir-spruce forests of the *Vaccinio-Piceetalia* order. The lower parts of the mountains are covered by *Tilio-Carpinetum* forests with several habitat variants. Among the moist forest communities the most common along the rivers and streams is the *Alnetum incanae* forest. *Caltho-Alnetum* and *Circaeo-Alnetum* forests are rather rare. Along running waters the *Salicetum triandro-viminalis* osier community is very frequent. Vast areas are covered with artificial pine forests and secondary alder thickets with *Alnus incana* and *A. viridis*, growing in abandoned fields.

The plant communities of the subalpine belt are not yet well recognized. There are tall grass communities of the order *Calamagrostetalia villosae* (Fig. 4), e.g. *Poo-Deschampsietum*, and short grass communities of *Nardetalia* (but with the participation of alpine taxa). The *Trollio-Centaureetum* association with great percentage of subalpine and Eastern Carpathian tall forbs is very interesting. A fairly large area is covered by the shrub community *Pulmonario-Alnetum* with *Alnus viridis*.

The hay meadows of the order *Arrhenatheretalia* occurring in lower altitudes are rather altered by husbandry, which sometimes leads to grass monocultures. Moist meadows of *Molinietalia* are very rare. Pasture communities (mainly *Lolio-Cynosuretum* association) are very frequent in the sur-

roundings of villages, while the poor *Nardetalia*-grasslands are rather rare.
The raised peat bogs, occurring in some places in river valleys, represent the associations of *Sphagnetalia magellanici*. The *Valeriano-Caricetum flavae* low sedge association (*Caricetalia davallianae*) is the main community of eutrophic sedge mires; fragments of the *Carici canescentis-Agrostietum caninae* community are rarely found. Large areas in river valleys and flooded places are covered by reed communities (*Phragmition*) and high sedge communities (*Magnocaricion*). Along the streams low reed swamp communities of *Glycerio-Sparganion* and tall herb communities of *Filipendulo-Petasition* occur. The *Cirsietum rivularis* association (*Calthion*) is also very frequent. The aquatic associations are rather rare as suitable habitats are missing.
The patches of xerothermic communities occurring on steep slopes in the river valleys and in the northern and western parts of the region are mainly from the *Festuco-Brometea* class. They usually border warm shrub communities of the order *Prunetalia* and thermophilous variants of the *Tilio-Carpinetum* forest.

Fig. 4. *Veratrum album*, a component of subalpine meadows (poloninas) typical of the Polish Eastern Carpathians. Photo S. Michalik.

The anthropogenic communities may be divided into two groups: rather common field communities of *Secali-Violetalia* and ruderal communities of *Onopordetalia* around towns and villages.
Large clear-cut areas within forests are covered with nitrophilous clearing communities of the order *Atropetalia* (PALCZYNSKI 1962, ZARZYCKI 1963, MAREK and PALCZYNSKI 1964, JASIEWICZ 1965, DZWONKO and ZEMANEK 1976, DZWONKO 1977, WINNICKI and ZEMANEK 1987).
Only the southern ranges, where the subalpine plant communities occur, have their unique features. The difference among lower mountain groups are rather quantitative, i.e. the role played by mountain communities decreases and that by non-mountain increases northwards.

4. FLORA (VASCULAR PLANTS)

The flora of the Polish Eastern Carpathians amounts to about 1150 taxa (anthropogenic plants included). The flora of higher mountain parts is poorer than that of the ranges in contact with the lowlands, where many taxa alien to the mountains appear. The local diversity of geomorphology, the contact with rivers creating many habitats and allowing the migration of many plants, and the degree of anthropogenic disturbance of the environment distinctly affects the number of taxa.
The number of mountain taxa decreases from the south (more than 160) to the north (less than 50), while the number of xerothermic taxa amounts from less than 20 to more than 140, respectively (ZEMANEK 1991b). This is connected with the decrease in the altitudes of mountains. All quantitative floristic indices change in the same direction (ZEMANEK 1991a).
Some parts of the territory analyzed have taxa confined to a given range or mountain group. In the high southern ranges, these taxa are represented mainly by mountain plants, while in the low northern parts the mountain taxa are replaced by xerothermic taxa. The intermediate mountain groups have no or a few unique taxa.
The taxa representing the eastern and western elements are given in Table 2. Detailed distribution of many eastern and western taxa was presented in the many papers (cf. JASIEWICZ 1965, ZEMANEK 1991a). The occurrence of the eastern taxa, an indicatory element of the Eastern Carpathians, very prominent in the south-eastern ranges, diminishes to the north and to the west. In the foothills and along the river Oslawa the eastern and western elements are balanced (Fig. 5).

Table 2. Eastern and western plant taxa in the flora of the Polish Eastern Carpathians.

	High ranges	Low ranges	Foothills
Eastern Carpathian endemic taxa			
Aconitum lasiocarpum	+	+	-
Aconitum tauricum ssp. *nanum*	+	-	-
Dianthus carthusianorum var. *saxigenus*	+	-	-
Euphorbia carpatica	+	-	-
Melampyrum saxosum	+	-	-
Eastern Carpathian non-endemic taxa			
Aconitum paniculatum	+	+	-
Alchemilla turkulensis	+	+	-
Alnus viridis	+	+	-
Aposeris foetida	+	+	+
Arnica montana	+	-	-
Campanula patula ssp. *abietina*	+	+	-
Carex dacica	+	-	-
Carex transsilvanica (?)	+	+	+
Centaurea kotschyana	+	-	-
Cirsium waldsteinii	+	+	-
Dianthus compactus	+	+	-
Helleborus purpurascens	+	-	-
Lapsana intermedia	+	+	+
Laserpitium alpinum	+	-	-
Lathyrus laevigatus	+	+	-
Leucojum vernum var. carpaticum	+	+	-
Scopolia carniolica	+	+	-
Scorzonera rosea	+	-	-
Senecio papposus	+	-	-
Sesleria coerulea	+	-	-
Symphytum cordatum (?)	+	+	+
Telekia speciosa	+	+	-
Veratrum album ssp. *album*	+	-	-
Viola dacica	+	+	-
Eastern non-mountain taxa			
Cerastium sylvaticum	-	+	+
Glechoma hirsuta (?)	+	+	+
Western Carpathian taxa			
Aconitum variegatum ssp. *kotulae*	+	-	-
Galium rotundifolium	+	+	-
Luzula luzulina	+	+	-
Potentilla pusilla	+	+	-
Senecio rivularis	+	+	-
Veratrum album ssp. *lobelianum*	+	+	+
Western non-mountain taxa			
Hypericum humifusum	+	+	+
Hypochoeris glabra	-	+	-
Polygala oxyptera	+	+	-
Sarothamnus scoparius	+	+	+

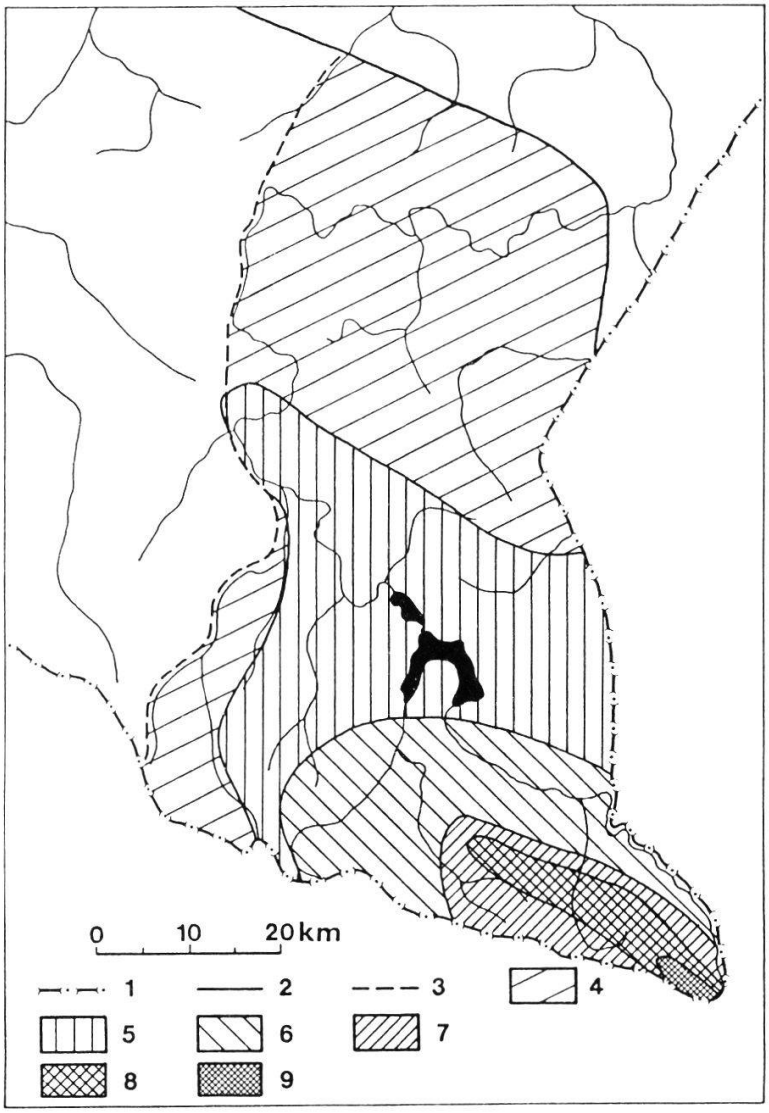

Fig. 5. Distribution of Eastern Carpathian taxa in the Polish Eastern Carpathians.
1 = state frontier, 2 = northern limit of the Carpathians, 3 = boundary of the Eastern Carpathians, 4 = less than 5 taxa, 5 = 5-10 taxa, 6 = 11-15 taxa, 7 = 16-20 taxa, 8 = 21-25 taxa, 9 = more than 25 taxa.

5. THE PHYTOGEOGRAPHICAL BOUNDARY BETWEEN THE EASTERN AND WESTERN CARPATHIANS

The question where to place the boundary between the Western and Eastern Carpathians is one of the oldest and most important phytogeographical problems of the Carpathians (for references see JASIEWICZ 1965 and ZEMANEK 1991c). The most important proposals of this boundary were as follows (from west to east): the Tylicz Pass (TACIK et al. 1957, ZARZYCKI 1963), the Dukla Pass (KOTULA 1881), the Lupkow Pass (WOLOSZCZAK 1895, PAX 1908), the

Uzok Pass (DOMIN 1938), the Jablonica Pass (ZAPALOWICZ 1909) (Fig. 6). PAWLOWSKI (1959, 1972) drew the boundary between the Eastern and Western Carpathians from the Lupkow Pass to the north along the river Oslawa and the river San. Investigations in the Bieszczady Mts. (JASIEWICZ 1965) and in adjacent territories of the Low Beskids (GRODZINSKA 1968) rather supported this idea.

The number of Eastern Carpathian plants distinctly decreases between Mt. Tarnica (30 taxa) and the river Oslawa (5 taxa) (distance of about 45 km) (Fig. 6). The next taxon disappears 60 km farther to the west, near the Dukla Pass (*Aconitum paniculatum*), and another two (*Scopolia carniolica* and *Aposeris foetida*) disappear in the Pieniny Mts. (about 100 km to the west from the Dukla Pass). Hence, the boundary of the Eastern Carpathian flora should be sought rather in the vicinity of the Oslawa valley (cf. ZEMANEK 1991c). The Slovak botanists (HENDRYCH and HENDRYCHOVA 1979, HADAC 1989) drew the boundary of the Eastern Carpathian flora a little farther east-

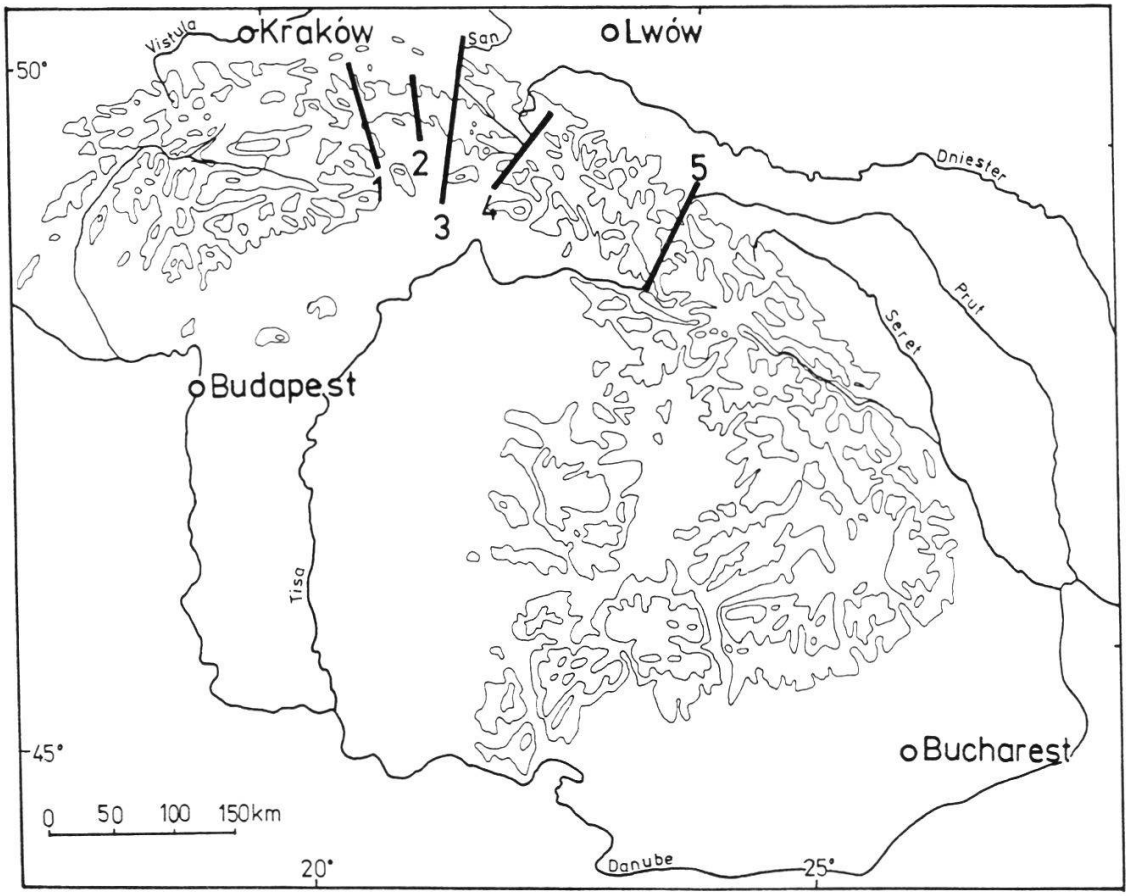

Fig. 6. Some proposals of the phytogeographic boundary between the Western and Eastern Carpathians.
1 = Tylicz Pass, 2 = Dukla Pass, 3 = Lupkow Pass, 4 = Uzok Pass, 5 = Jablonica Pass.

wards (at the Ruske Sedlo Pass or Mt. Cerniny, 15-20 km from the Lupkow Pass) but still in the same region.
There is also a marked disappearance of the Eastern Carpathian taxa in the northern direction as the altitudes of the ranges decrease (Fig. 5, Table 2). The territories of the foothills were included provisionally in the Eastern Carpathians by PAWLOWSKI (1972). Based on recent investigations (TOWPASZ 1990, ZEMANEK 1991a) they should be included rather in the Western Carpathians.
The boundary proposed between the Western and Eastern Carpathians would run from the Lupkow Pass region along the Oslawa and San valleys down to the northwestern end of the Slonne Gory Mts. and from there eastwards to the river Wiar valley and the edge of the Carpathians (Fig. 7).

6. PHYTOGEOGRAPHICAL DIVISION OF THE POLISH EASTERN CARPATHIANS

The phytogeographical division of this part of the Eastern Carpathians was proposed by many authors, e.g. KOTULA (1881), BATKO (1934), PAWLOWSKI (1959, 1972), JASIEWICZ (1965). The results of recent analysis of the flora of the Polish Eastern Carpathians (ZEMANEK 1991a) show that

- there is a distinct floristic separation of the subalpine ranges because of the great proportion of high mountain taxa and the absence of xerothermic taxa in their flora,
- a distinct group of intermediate mountain groups, characterized by a proportional decrease of mountain elements as the altitudes of the ranges diminish, may be separated,
- the foothills distinctly differ from other ranges.

In the light of a new concept of the western and northern boundaries of the Eastern Carpathians and taking the analysis of flora as a basis the following division of the territory studied might be proposed (Fig. 7):

Province: Central European, Mountain
  Subprovince: Carpathian
    Division: East Carpathians
      District: Forest Carpathians (or East Beskidy Mts.)
        Subdistrict: High Bieszczady Mts.
          (Subalpine section)
          (Montane section) (names of sections are provisional)
        Subdistrict: Low Bieszczady Mts.

The new division of the Polish Eastern Carpathians should be brought into

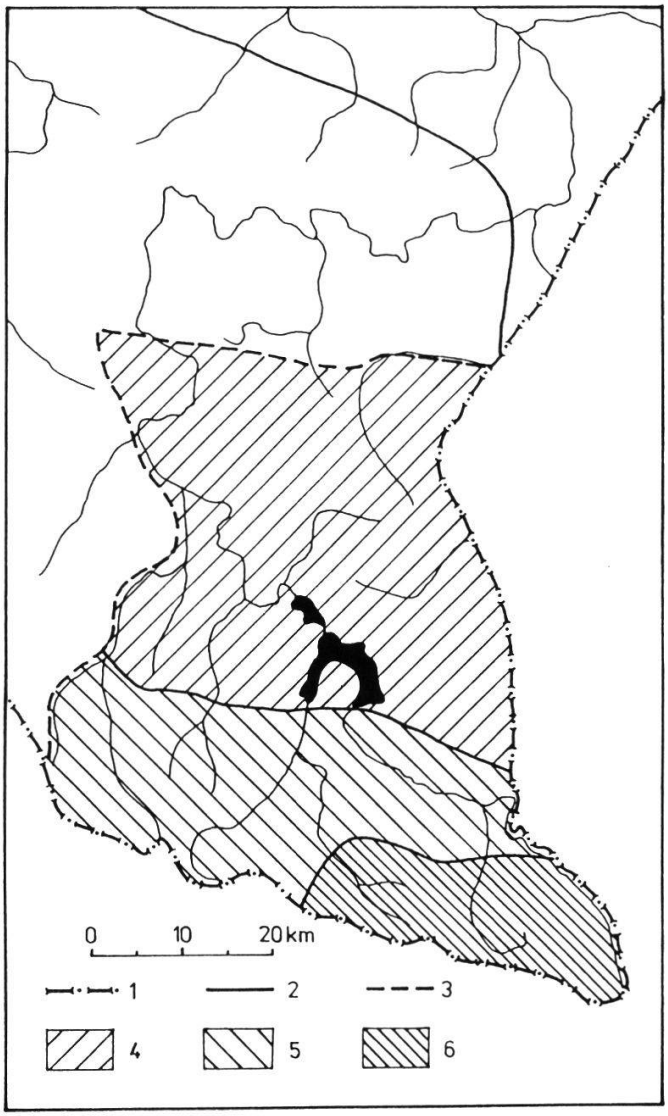

Fig. 7. Phytogeographical division of the Polish Eastern Carpathians.
1 = state frontier, 2 = northern limit of the Carpathians, 3 = boundary of the Eastern Carpathians, 4 = Lower Bieszczady Mts., 5 = High Bieszczady Mts., 'montane' section, 6 = High Bieszczady Mts., 'subalpine' section.

line with the division of the Ukrainian Carpathians. The division proposed by PAWLOWSKI (1948) was considerably changed by the Ukrainian botanists (cf. COPIK 1969).

It may be supposed that in spite of some floristic differences (cf. JASIEWICZ 1965), the Polish High Bieszczady Mts. might be combined with the adjacent mountain groups in the Ukrainian Carpathians (Mt. Pikuj, the Mt. Paraszka group, the Polonina Rowna and Polonina Borzawa Ranges) into one phytogeographical unit (cf. PAWLOWSKI 1948). The solution of this problem on the ba-

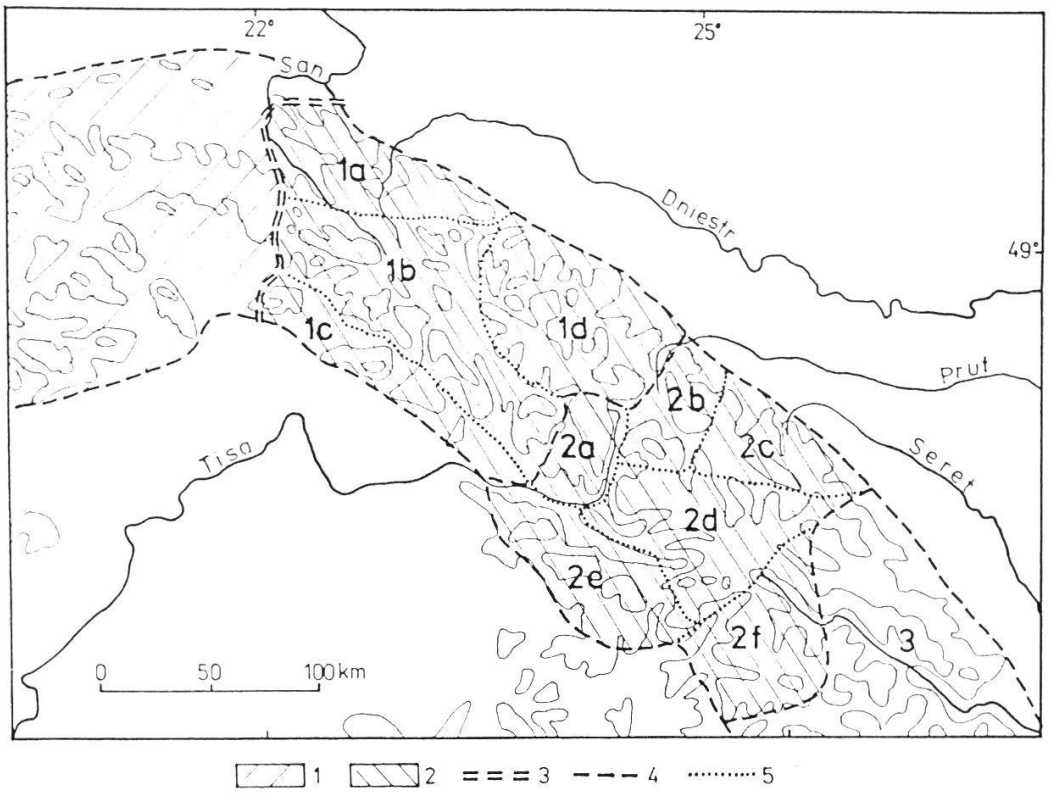

Fig. 8. Phytogeographical division of the northwestern part of the Eastern Carpathians. (PAWLOWSKI 1948, modified).
1 = Western Carpathians, 2 = Eastern Carpathians, 3 = boundary between the Eastern and Western Carpathians, 4 = boundaries of districts, 5 = boundaries of subdistricts.
The following units are shown: 1 = district of the Forest Carpathians: 1a = the Low Bieszczady Mts., 1b = the High Bieszczady Mts. and Poloniny, 1c = the Volcanic Carpathians, 1d = the Gorgany Mts.; 2 = district of the Pokucie-Marmaros Mts.: 2a = Swidowiec group, 2b = the Czarnohora Mts., 2c = the Czywczyn Mts., 2d = the Rodna Mts., 2e = the Lapos Mts., 2f = the Kelemen Mts.; 3 = district of the Bistritza and the Moldavian Mts.

sis of recent floristic data, as well as the connections between the Low Bieszczady Mts. and the Upper Dniestr Beskidy Mts. needs further international studies. The new division concept of the northwestern part of the Eastern Carpathians is given in Fig. 8.

SUMMARY

The paper deals with recent botanical investigations in the Polish Eastern Carpathians which enabled to accomplish a modern analysis of flora and vegetation (based on the distribution of Eastern Carpathian taxa). A new concept of the phytogeographical boundary between the Western and Eastern Carpathians was proposed and a new division of the Polish Eastern Carpathians on the background of the phytogeographical division of the north-western part of the Eastern Carpathians was discussed.

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