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Autor(en): **Mirek, Zbigniew / Piko-Mirkowa, Halina**

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Zbigniew MIREK and Halina PIĘKOŚ-MIRKOWA

1. INTRODUCTION

The Tatra Mountains form the highest chain in the Carpathians. They cover a comparatively small area, 750 km^2, but because of their fairly high altitudes (2655 m a.s.l.) they show the typical features of an alpine massif. Considerable differentiation of climatic conditions on the altitudinal gradient, rich relief, various geological substrata and soils contribute to a great diversity of habitats, resulting in a wealth, diversity and distinction of the flora and plant communities in the Tatra Mts.

From the geobotanical point of view, the Tatra Mts. constitute a separate district within the Carpathian Division and the West-Carpathian Subdivision (PAWLOWSKI 1972). The Tatras themselves have been divided into four geobotanical subdistricts: The Siwy Wierch massif, the Western Tatras, the High Tatras and the Bielskie Tatras (Fig. 1). The Polish Tatra Mts. include only a part of the Western Tatras and High Tatras. In 1954, the whole Polish Tatras (220 km^2) were proclaimed a National Park.

In spite of their small area, the Tatras belong to the most interesting areas of Poland. This is the reason why flora of the Tatras has aroused the keen interest of botanists for 180 years. Botanical literature concerning the Polish Tatras is very rich and consists of about 2000 publications.

Acknowledgements
We are greatly indebted to M.Sc. Hanna Kuciel for drawings and to M.Sc. Joanna Sucharska for her technical assistance.

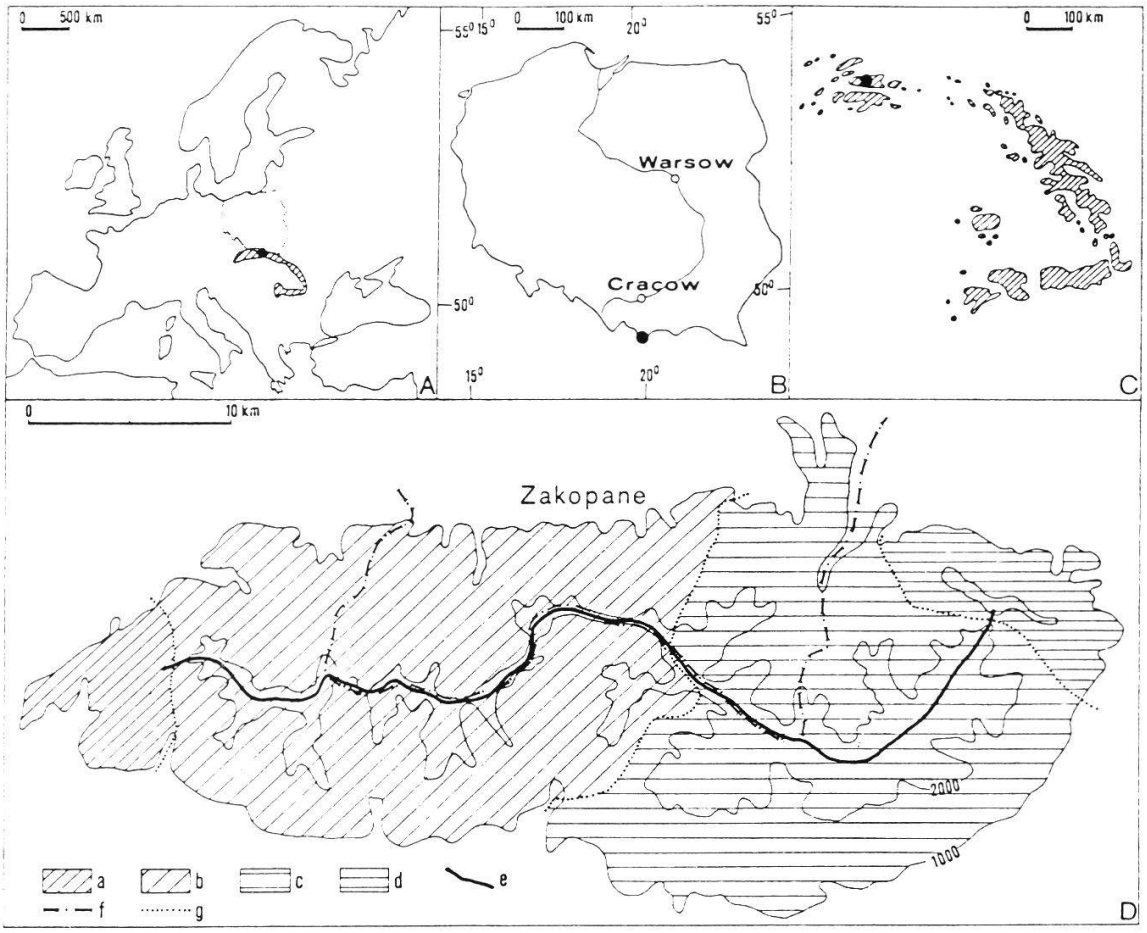

Fig. 1. Situation of the Tatra Mts. on the map of Europe (A), Poland (B) and the Carpathians (C).
Geobotanical division of the Tatras (D): the Siwy Wierch massif (a), the Western Tatras (b), the High Tatras (c), the Bielskie Tatras (d), main ridge of the Tatras (e), state boundary (f), boundaries between geobotanical subdistricts (g).

2. VEGETATION BELTS

In the Tatras, five vegetation belts (Fig. 2) are distinguishable: lower montane belt, upper montane belt, dwarf pine (= subalpine) belt, alpine belt and subnival belt. In the Carpathians, the latter developed only in the Tatra Mts. These are well characterized both by changes in the climate, plant formations and dominating associations as well as by altitudinal ranges of index species. In the lower forest belt the largest areas are occupied by the Carpathian beech forest, *Dentario glandulosae-Fagetum* (= *Fagetum carpaticum*). In the tree layer, *Fagus silvatica* usually dominates and *Abies alba* occurs quite abun-

dantly. *Picea abies* and *Acer pseudoplatanus* appear as an admixture. The *Dentario glandulosae-Fagetum* in the Tatras can be recognized by the characteristic species of the association, e.g. *Dentaria glandulosa* (Pan-Carpathian subendemic), *Polystichum braunii* and *Cardamine trifolia*, as well as numerous representatives of the alliance *Fagion* and the order *Fagetalia* (e.g. *Polystichum lobatum*, *Dentaria enneaphyllos*, *D. bulbifera*, *Viola reichenbachiana*, *Symphytum tuberosum*, *Sanicula europaea*, *Galeobdolon luteum*, *Pulmonaria obscura*, *Mercurialis perennis*, *Veronica montana*, *Adoxa moschatellina*, *Daphne mezereum*). The upper forest belt is occupied by spruce forest. The edaphic factor is responsible for the differentiation of the spruce forest into two associations of the order *Vaccinio-Piceetalia*. They are: *Polysticho-Piceetum* on calcareous rocks and *Plagiothecio-Piceetum* on siliceous rocks. In the tree layer, *Picea abies* dominates; near the timberline *Pinus cembra* appears locally. In the herb layer, the most often dominant is *Vaccinium myrtillus*. Moreover, *Vaccinium vitis-idaea*, *Homogyne alpina*, *Deschampsia flexuosa* and *Dryopteris expansa* are very frequent. Among the characteristic species, *Listera cordata*, *Polystichum lonchitis*, *Corallorrhiza trifida*, *Moneses uniflora* and mosses, *Rhytidiadelphus loreus* and *Plagiothecium undulatum*, can be numbered.

Two forest belts, the lower and upper montane belts, have fully developed on

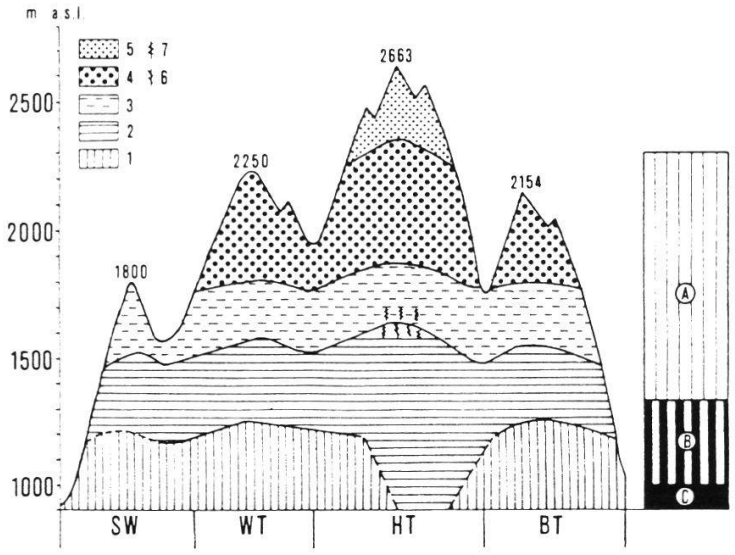

Fig. 2. Natural vegetation belts (after PAWLOWSKI 1972, slightly modified).
1 - lower montane belt, 2 - upper montane belt, 3 - dwarf pine belt (= subalpine belt), 4 - alpine belt, 5 - subnival belt, 6 - *Larix decidua*, 7 - *Pinus cembra*; belts of cultivated vegetation: A - oats and potato, B - manured meadows and pastures, C - non-utilized areas.
SW - the Siwy Wierch massif, WT - the Western Tatras, HT - the High Tatras, BT - the Bielskie Tatras.

limestone alone. On poor siliceous rock and moraines (in the High Tatras) there is a lack of beechwood, pure spruce forest extends from the foot up to the timberline (Fig. 2). Contrary to the phytosociological uniformity of the spruce forest both at lower and higher altitudes, tree stand vary significantly depending on the elevation. Distinct changes in the silhouettes of trees are especially obvious when approaching the upper forest limit (Figs. 3 and 4).
The climatic timberline in the Tatras averages at 1550 m a.s.l., but it is significantly modified by local climate conditions occurring at various slopes (Fig.

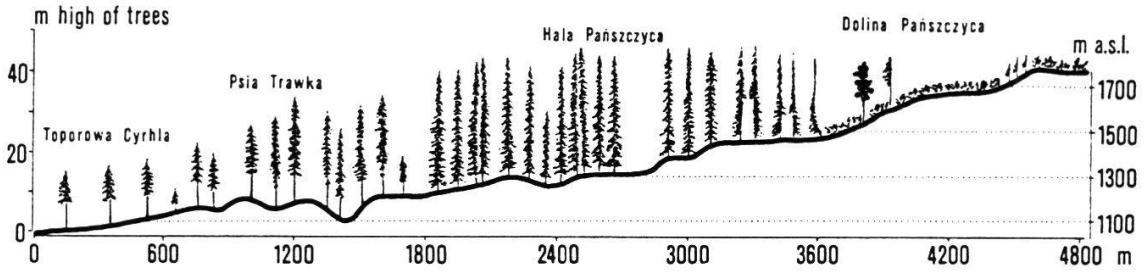

Fig. 3. Silhouette of *Picea abies* trees in lower and upper montane belt forest on poor granite moraine between Toporowa Cyrhla and Dolina Panszczyca valley in the High Tatra Mts. (MYCZKOWSKI 1955, modified).

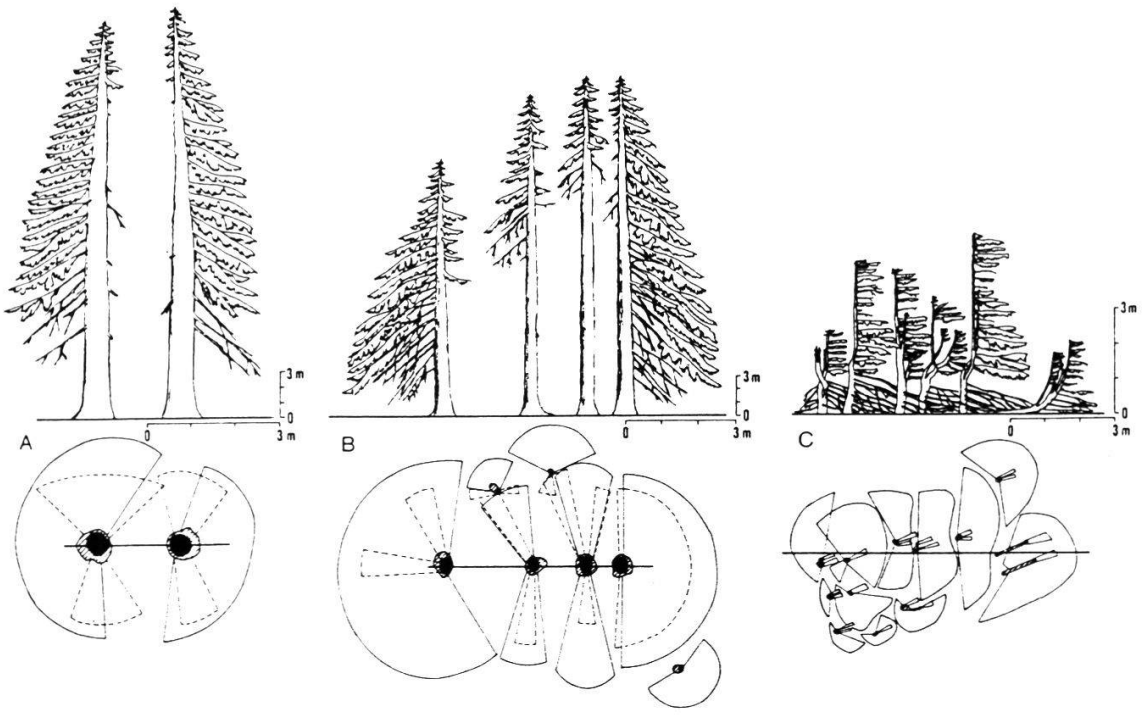

Fig. 4. Vertical and horizontal projections of *Picea abies* biogroups typical of: dense forest in fully stocked stands of upper montane belt (A), loose forest at the upper forest limit (B), subalpine (= dwarf pine) belt (C). (MYCZKOWSKI 1972).

5). It is also modified by the elevation of the massif (Figs. 3 and 5).
At present, only about one third of the timberline is of a natural character (Fig. 6) while the rest has been significantly lowered through prior anthropogenic activity (SOKOLOWSKI 1928, MYCZKOWSKI 1972, PIEKOS-MIRKOWA 1981, 1986). It has also been lowered by the already mentioned edaphic or orographic factors as well as by extra-climatic anomalies, as it may be the case with the so-called "phenomenon of Sarnia Skala Mt.", where the natural timberline lies at 1300-1340 m a.s.l. (PIEKOS 1968). The highest forest stand (timberline) is at 1650 m a.s.l. (Zabie Mt. in the Polish High Tatras). Above the

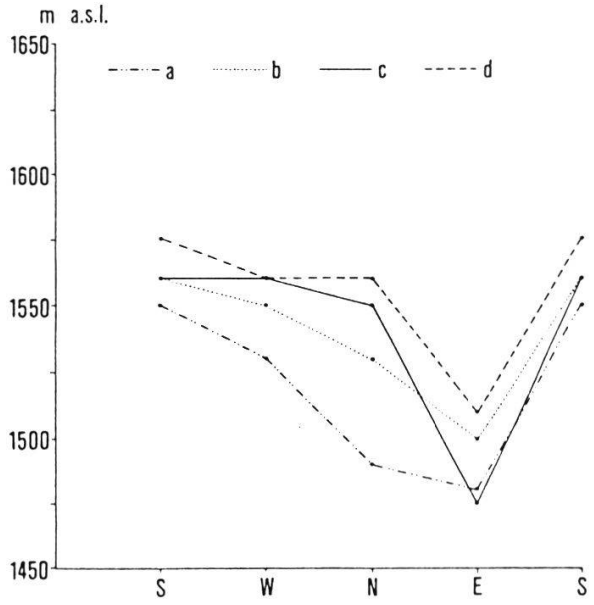

Fig. 5. Altitudinal differentiation of the mean upper forest limit in relation to various aspects (S, W, N, E slopes). (Compiled from SOKOLOWSKI 1928).
a - the Siwy Wierch massif, b - the Western Tatras, c - the High Tatras, d - the Bielskie Tatras.

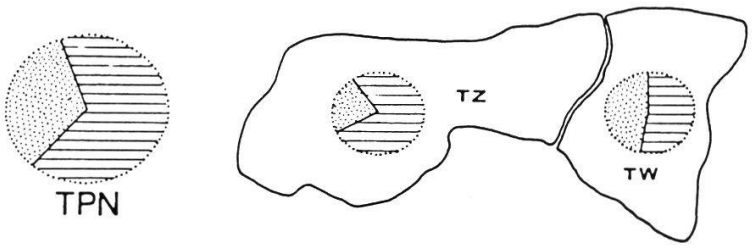

Fig. 6. Relationship between natural (dotted) and lowered (hatched) upper forest limit in the Tatra National Park (TPN).
TZ - the Western Tatra Mts., TW - the High Tatra Mts.

timberline, the subalpine belt extends from 1550 m to 1800 m a.s.l. and is occupied by the *Pinetum mughi carpaticum* association. In the shrub layer, besides *Pinus mugo*, the following species occur: *Sorbus aucuparia* var. *glabrata, Ribes petraeum* var. *carpaticum, Betula carpatica* and *Sorbus chamaemespilus*. Numerous tall-herbs (e.g. *Athyrium distentifolium, Leucanthemum waldsteinii, Doronicum austriacum, Cicerbita alpina*) thrive well in this belt.

High mountain grasslands become dominant in the alpine belt at an altitude of 1800 m to 2300 m a.s.l. There are two most important grassland associations widely distributed in the Tatras: *Oreochloo distichae-Juncetum trifidi* (= *Trifido-Distichetum*) of the *Caricetalia curvulae* order and *Festuco versicoloris-Seslerietum tatrae* (= *Versicoloretum tatricum*) of the *Seslerietalia variae* order. In the former community, confined to the siliceous rock, the dominance is assumed by *Juncus trifidus*. *Oreochloa disticha, Festuca supina* and *Agrostis rupestris* are locally abundant. Species which occur throughout the association include *Pulsatilla alpina, Campanula alpina, Primula minima* and *Hieracium alpinum.*

The *Festuco versicoloris-Seslerietum tatrae* association, occurring on calcareous rock, belongs to the floristically richest communities in the Tatra Mts. It is dominated by *Festuca varia* (= *F. versicolor*) and locally by *Sesleria tatrae*. Other frequent species are: *Androsace chamaejasme, Hedysarum hedysaroides* and *Carex sempervirens* ssp. *tatrorum.*

The subnival belt, ranging from 2300 m a.s.l. to the top of the highest Tatra peaks, lies above the alpine belt. It is characterized by bare rocks and very

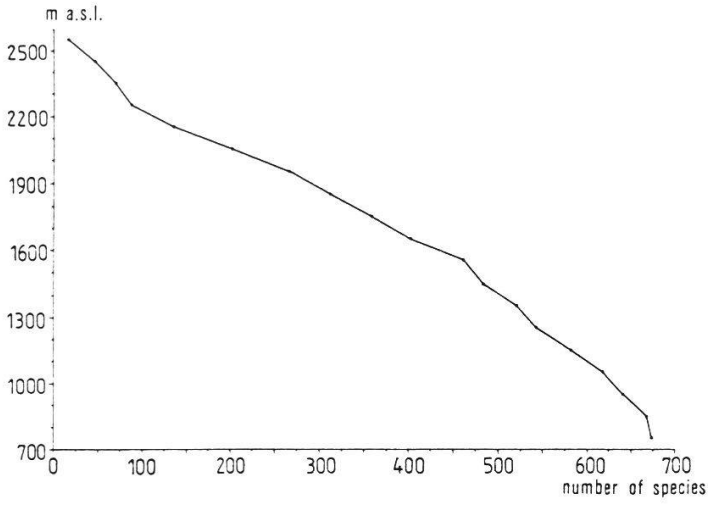

Fig. 7. Relationship between number of vascular plant species and altitude above sea level in the Tatra Mts. (KOTULA 1889-1890).

poor vegetation composed especially by lichens (e.g. *Rhizocarpon geographicum*). Not more than 120 vascular plant species may be found there (Fig. 7). *Oreochloetum distichae subnivale* (= *Distichetum subnivale*) of the order *Caricetalia curvulae* has developed as the climax association in this belt. *Oreochloa disticha* and *Festuca supina* play the dominant role. Characteristic species include *Gentiana frigida, Senecio carniolicus, Luzula spicata*, and cushion-plants, e.g. *Minuartia sedoides* and *Silene acaulis* ssp. *norica*.

3. STATISTICS OF THE FLORA

The flora of the Polish Tatras comprises over 1000 vascular plants (PIEKOS-MIRKOWA and MIREK 1992), c. 450 mosses and c. 200 liverworts (CZUBINSKI 1962), c. 700 lichens (TOBOLEWSKI 1992), c. 900 fungi (WOJEWODA 1992), c. 70 myxomycetes (KOMOROWSKA and DROZDOWICZ 1992) and c. 1000 algae species (KAWECKA 1992). The number of species decreases with altitude. Fig-

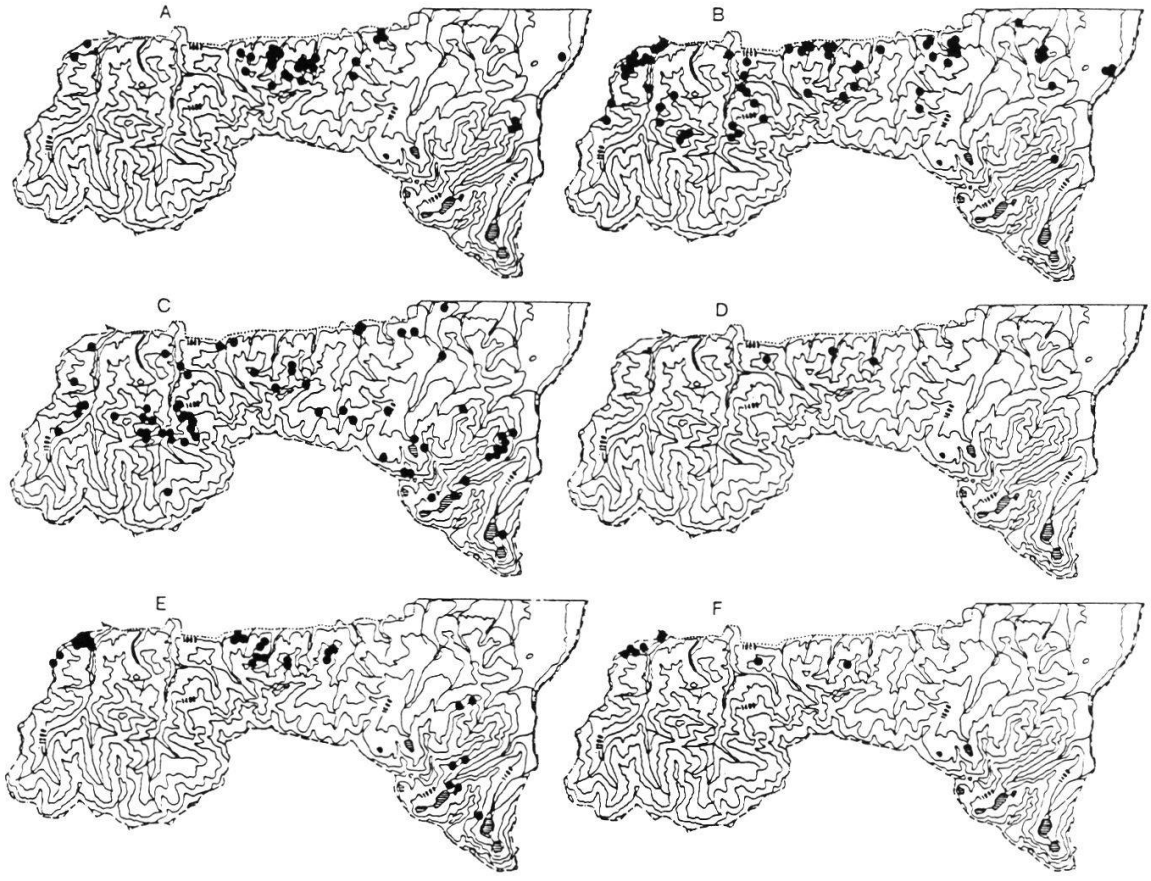

Fig. 8. Localities of some relic tree and shrub species in the Tatra National Park.
A - *Taxus baccata*, B - *Pinus silvestris*, C - *Larix decidua*, D - *Cotoneaster nebrodensis*, E - *Sorbus chamaemespilus*, F - *Arctostaphylos uva-ursi*.

ure 7 shows the relationship between the number of species and altitude. Among the vascular plants, one fourth consist of mountain species. At lower altitudes, lowland species prevail and high mountain species predominate from the timberline upwards.

Vascular plants are represented by 77 families and 341 genera. To the most rich families belong: *Compositae, Rosaceae, Gramineae, Cyperaceae, Orchidaceae, Ranunculaceae*. Well represented are also typical mountain genera like *Saxifraga* (14 species) and *Gentiana* (12 species).

Over 80 vascular plant species occurring in the Polish Tatras are under protection of the law.

The tree flora of the Polish Tatras is comparatively poor, but it is particularly important for the biocoenotic role it plays in forest formations. Trees, shrubs and shrublets comprise 67 species in the Polish Tatras. At least one third of them are very rare and mostly relic species (Fig. 8).

4. LIFE FORMS AND ADAPTATIONS

In the Tatras, as in other high mountains of the northern hemisphere, vascular plants have adapted to numerous stress factors imposed by severe conditions of high altitude. These adaptations are manifested in various growth forms, life strategies, physiological processes etc. One of the most significant adaptations is the dwarfing of plants which grow above the timberline. Many plants form rosettes (e.g. *Sempervivum montanum, Primula auricula*) and cushions (e.g. *Silene acaulis, Minuartia sedoides, Saxifraga caesia, Saxifraga baumgartenii*). Mat-forming plants (e.g. *Minuartia kitaibelii, Cerastium tatrae, Cerastium lanatum, Saxifraga aizoides*) and creeping shrublets (e.g. *Dryas octopetala, Salix herbacea, Salix reticulata, Salix kitaibeliana*) are also common.

Many plants show xeromorphic adaptations (e.g. hairness, waxy leaf covering and inrolled leaves, etc.) which reduce transpiration. The Raunkiaer biological spectrum of the Tatra flora differs markedly from that of the lowland. With increasing altitude, the hemicryptophytes and chamaephytes become entirely dominant. The former make up more than half of the total number of the Tatra species. In contrast to the hemicryptophytes, the therophytes play a small part. Their participation decreases from 16% at the foot of the Tatras to 2% at the altitudes ranging from 2000 to 2300 m a.s.l.; they do not occur at all above 2300 m a.s.l.

As a result of the decreasing number of insects at higher altitudes, many spe-

cies tend to produce relatively large and brightly coloured flowers. Simultaneously, wind pollinated plants (e.g. *Juncus trifidus*, grasses and sedges) appear to be abundant. In response to a shortened growth season, numerous plants have adopted self-fertilization, apogamy (e.g. *Alchemilla, Hieracium* and *Taraxacum* species) and various modes of vegetative reproduction. Several high mountain plants have evolved a viviparous or pseudoviviparous mode of reproduction. They produce bulbils (e.g. *Polygonum viviparum, Saxifraga cernua*) or small plantlets (e.g. *Poa granitica, Poa alpina* f. *vivipara, Festuca supina* f. *vivipara*) in place of flowers.

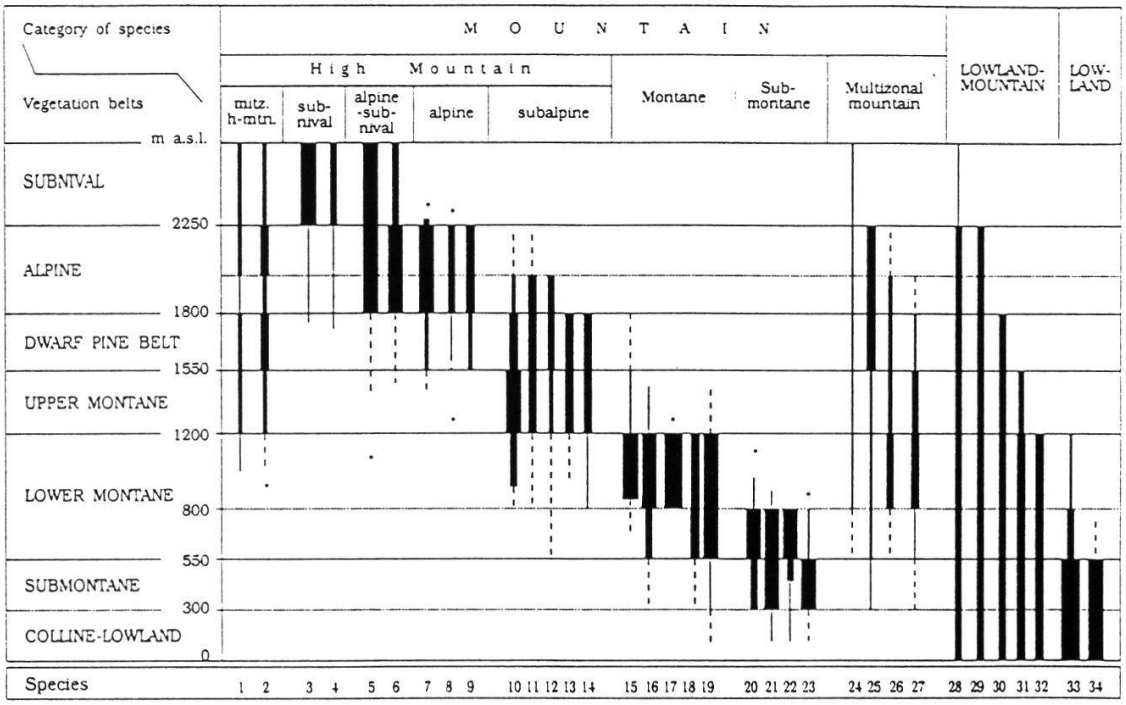

Fig. 9. Categories of altitudinal ranges of species and their representatives in Polish flora shown against a background of vegetation belts (MIREK 1990).
1 - *Potentilla crantzii*, 2 - *Geum montanum*, 3 - *Cerastium uniflorum*, 4 - *Gentiana frigida*, 5 - *Salix herbacea*, 6 - *Lloydia serotina*, 7 - *Myosotis alpestris*, 8 - *Pulsatilla alpina*, 9 - *Viola alpina*, 10 - *Polystichum lonchitis*, 11 - *Linum extraaxillare*, 12 - *Pinus mugo*, 13 - *Pinus cembra*, 14 - *Hieracium prenanthoides*, 15 - *Listera cordata*, 16 - *Luzula luzulina*, 17 - *Moehringia muscosa*, 18 - *Trifolium spadiceum*, 19 - *Dentaria glandulosa*, 20 - *Myricaria germanica*, 21 - *Calamagrostis pseudophragmites*, 22 - *Matteucia struthiopteris*, 23 - *Epilobium dodonaei*, 24 - *Soldanella carpatica*, 25 - *Huperzia selago*, 26 - *Carduus defloratus* ssp. *glaucus*, 27 - *Gentiana asclepiadea*, 28 - *Vaccinium vitis-idaea*, 29 - *Nardus stricta*, 30 - *Rubus idaeus*, 31 - *Campanula trachelium*, 32 - *Moehringia trinervia*, 33 - *Calamagrostis epigeios*, 34 - *Medicago falcata*; mltz.h.mtn. = multizonal high mountain species.

5. ALTITUDINAL ELEMENTS

Recognition, description and accurate classification of the altitudinal ranges of species is of great importance for any geobotanical descriptions and analyses.

Examples of various altitudinal ranges in the Tatra vascular plant flora are given in Fig. 9.

The presence of subnival species (Fig. 10) in the flora of the Tatras gives rise to the distinction of a subnival belt which in the Carpathians, is peculiar to the Tatra Mts.

Markedly different and often disjunctive altitudinal ranges represented by several closely related taxa (species or subspecies) resulted in the distinction of altitudinal vicariants. Examples of such pairs of vicariants and their altitudinal ranges in the Tatras are given in Table 1.

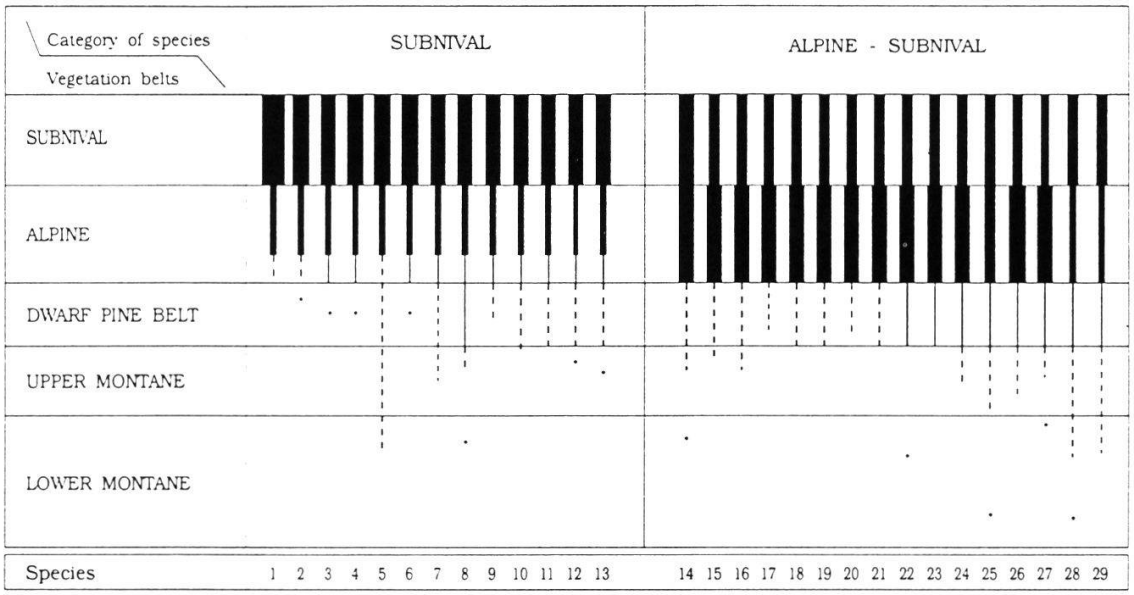

Fig. 10. Representatives of subnival and alpine-subnival species in the flora of the Tatra Mts. (MIREK 1990).

Subnival species: 1 - *Cerastium uniflorum*, 2 - *Ranunculus glacialis*, 3 - *Saxifraga bryoides*, 4 - *Saxifraga baumgartenii*, 5 - *Senecio carniolicus*, 6 - *Cochlearia tatrae*, 7 - *Poa laxa*, 8 - *Minuartia sedoides*, 9 - *Gentiana frigida*, 10 - *Luzula spicata*, 11 - *Silene acaulis* ssp. *norica*, 12 - *Geum reptans* 13 - *Saxifraga carpatica*.

Alpine-subnival species: 14 - *Salix herbacea*, 15 - *Lloydia serotina*, 16 - *Doronicum clusii*, 17 - *Carex fuliginosa*, 18 - *Senecio carpaticus*, 19 - *Androsace obtusifolia*, 20 - *Ligusticum mutellinoides*, 21 - *Campanula alpina*, 22 - *Saxifraga oppositifolia*, 23 - *Primula minima*, 24 - *Oreochloa disticha*, 25 - *Oxyria digyna*, 26 - *Tanacetum alpinum*, 27 - *Saxifraga hieracifolia*, 28 - *Saxifraga wahlenbergii*, 29 - *Cardaminopsis neglecta*.

Table 1. Examples of the altitudinal vicariants in closely related taxa occurring in the Tatra Mts.

Species	Vegetation belts			
	lower montane	upper montane	sub alpine	alpine
Rumex acetosa	———	— •		
R. alpestris	·····	———	———	———
Caltha palustris	·····	···-		
C. laeta	———	———	———	——— •
Cardamine amara	———	·····	···- •	
C. opizii	·····	———	———	····· •
Empetrum nigrum	·····	·····	···-	
E. hermaphroditum	·····	·····	———	———
Vaccinium uliginosum	·····	·····	···-	
V. gaultherioides			———	———
Petasites hybridus	····· •			
P. kablikianus	———	———	····· •	
Anthoxanthum odoratum	———	———		
A. alpinum		·····	———	———
Juniperus communis	———	····· •		
J. communis ssp. *nana*	• ·····	———	———	———
Sorbus aucuparia	———	——— ····· •		
S. aucuparia var. *glabrata*	• ·····	———	———	——— •
Swertia perennis	····· •			
S.perennis ssp. *alpestris*	·····	———	———	———
Solidago virgaurea	———	———		
S. virgaurea ssp. *alpestris*		·····	———	———

6. GEOGRAPHICAL ELEMENTS

In the Tatra flora, several geographical elements are represented. Among the lowland and lowland-mountain species occurring there, four geographical elements can be distinguished:

1. Central-European element. This large group consists of species which are widespread in Central Europe (e.g. *Phyteuma spicatum, Dentaria bulbifera*; Fig. 11).
2. Euro-Siberian element. This element is represented by numerous common

species occurring throughout the Euro-Siberian lowlands (e.g. *Polygonum bistorta, Paris quadrifolia, Daphne mezereum, Oxalis acetosella, Antennaria dioica, Vaccinium myrtillus*; Fig. 11).

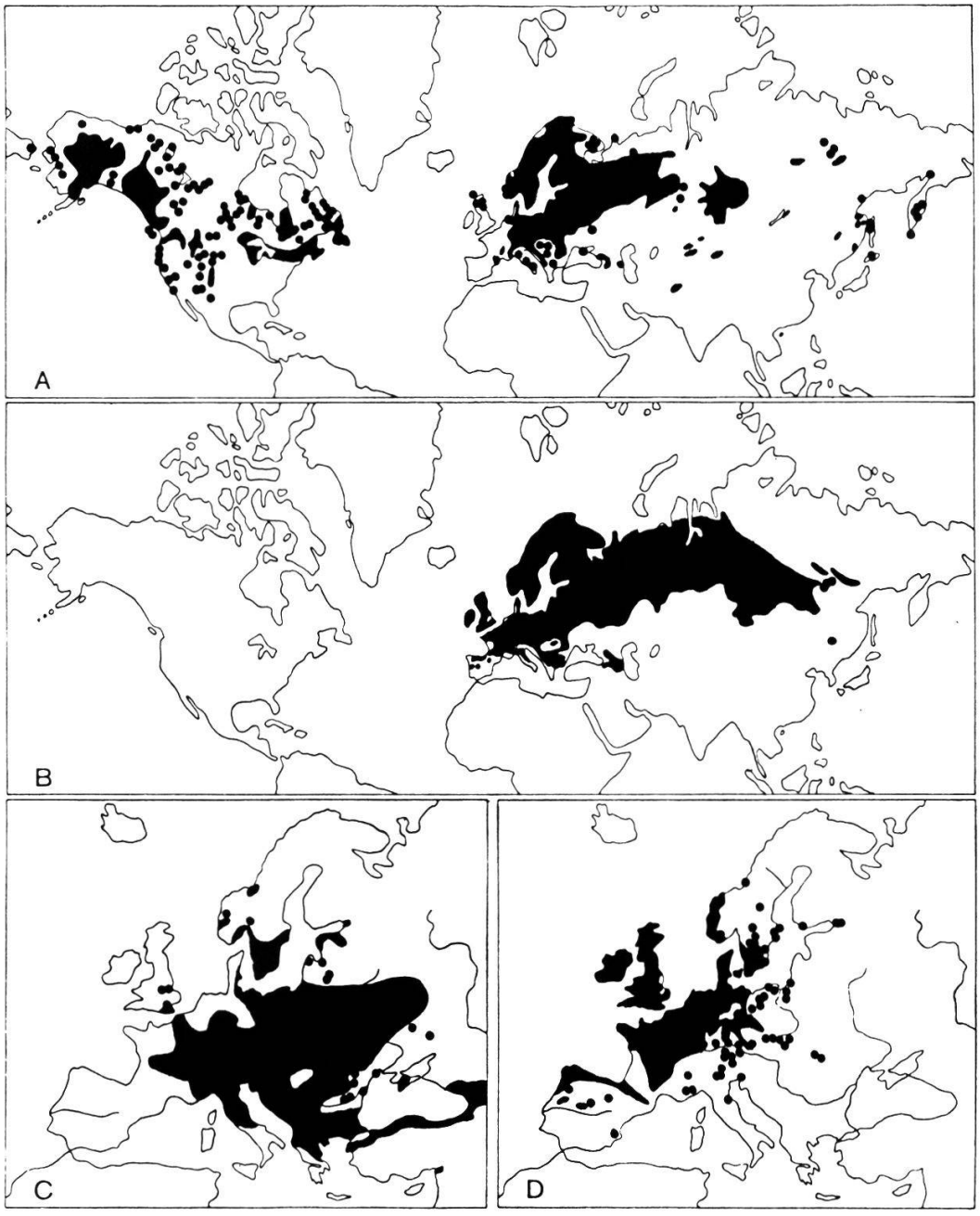

Fig. 11. World distribution of some lowland-mountain species representing four geographical elements (from various sources, modified).
A - *Moneses uniflora*, a Circum-Boreal species; B - *Vaccinium myrtillus*, an Euro-Siberian species; C - *Dentaria bulbifera*, a Central-Europaean species; D - *Galium saxatile*, a Sub-Atlantic species.

3. Circum-Boreal element. Species whose centre of distribution lies in the boreal zone of Eurasia and North America (e.g. *Adoxa moschatellina, Pirola minor, Orthilia secunda, Moneses uniflora*; Fig. 11) belong to this group.
4. Sub-Atlantic element. This component of the Tatra flora contains only a few species whose main centre of distribution is in West Europe (e.g. *Juncus squarrosus, Galium saxatile*; Fig. 11).

The presence of three geographical elements within the mountain flora of the Tatras is the result of history and migrations of plants in the Pleistocene.

1. Arctic-alpine and boreal-montane element. This group includes species

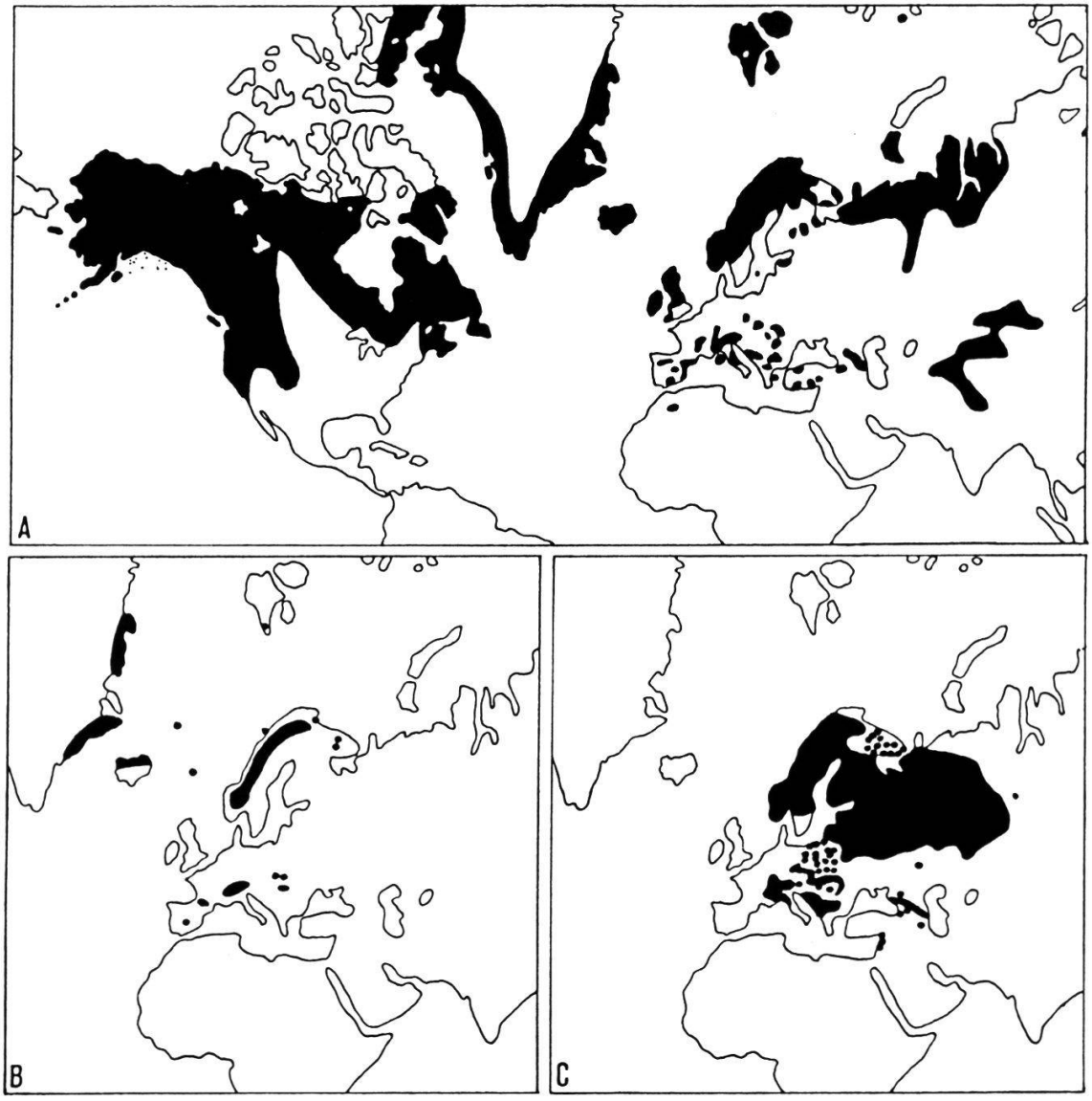

Fig. 12. World distribution of mountain species representing arctic-alpine and boreal-montane element. A - *Poa alpina*, B - *Ranunculus glacialis*, C - *Alnus incana*. (A and B according to PAWLOWSKI 1929, modified).

occurring in the Arctic or Boreal region, on the one hand, and on the other, after a more or less considerable disjunction, in the mountains of the Alpine system within Holarctis. Numerous high mountain and mountain species, respectively, display this type of distribution (e.g. *Poa alpina, Diphasium alpinum, Polygonum viviparum, Cerastium trigynum, Woodsia alpina, Ranunculus glacialis, Alnus incana*; Fig. 12).

2. Central-European element. This appears to be the most fundamental component of the Tatra flora. Species whose principal centre of occurrence is in the Central European mountains belong in this element (e.g. *Abies alba, Dentaria enneaphyllos, Gentiana punctata, Geum montanum, Primula minima, Potentilla aurea, Pinus mugo*; Fig. 13).

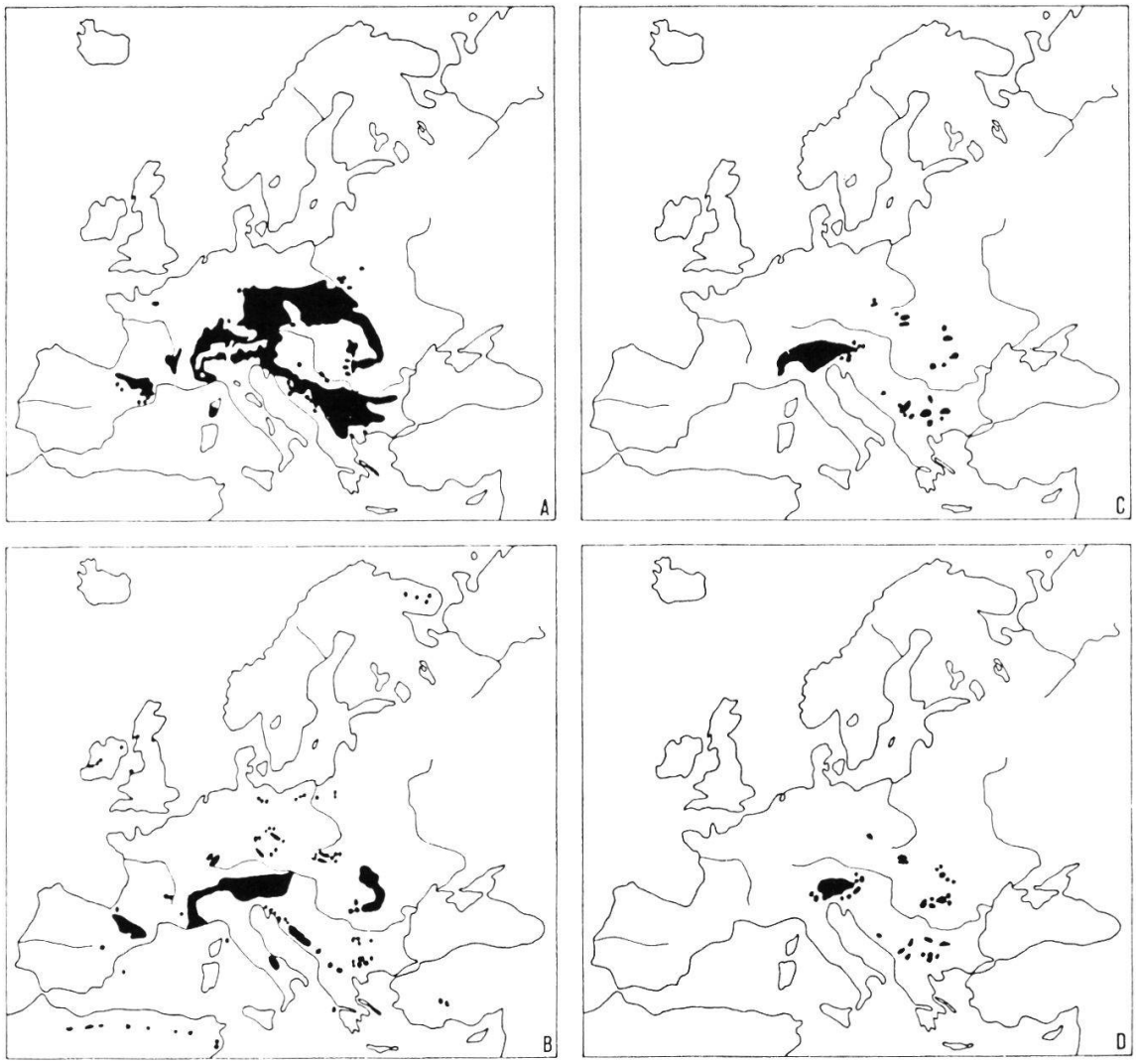

Fig. 13. World distribution of mountain species representing Central-European element (from various sources, modified).
A - *Abies alba*, B - *Pinus mugo*, C - *Gentiana punctata*, D - *Primula minima*.

One of the characteristic features of the Tatra flora is its close affinity to the flora of the Alps. There are numerous plants restricted in their distribution to the Alps and the Carpathians (mostly to the Tatras). Such is the case for the distribution patterns of *Viola alpina, Dianthus glacialis, Cerastium latifolium*, and others.

3. Altaic-Alpine element. This component of the Tatra flora is restricted to a few species or subspecies occurring both in the European mountains and in the mountains of Central Asia. An example is *Anemone narcissiflora.*

7. ENDEMISM

The flora and vegetation of the Tatras were strongly influenced during the Pleistocene and were significantly changed during the Holocene. For this reason the Tatras, being the centre of West Carpathian endemism (PAWLOWSKI 1970a, 1972), are comparatively very poor both in old and young endemic species (Fig. 14). Two more important West Carpathian endemic species occur in the Polish Tatras: *Saxifraga wahlenbergii* Ball (= *S. perdurans* Kit.) and *Delphinium oxysepalum* Borb. et Pax, both palaeo-endemics. Their isolated systematic position indicates their Tertiary age. Moreover, the following

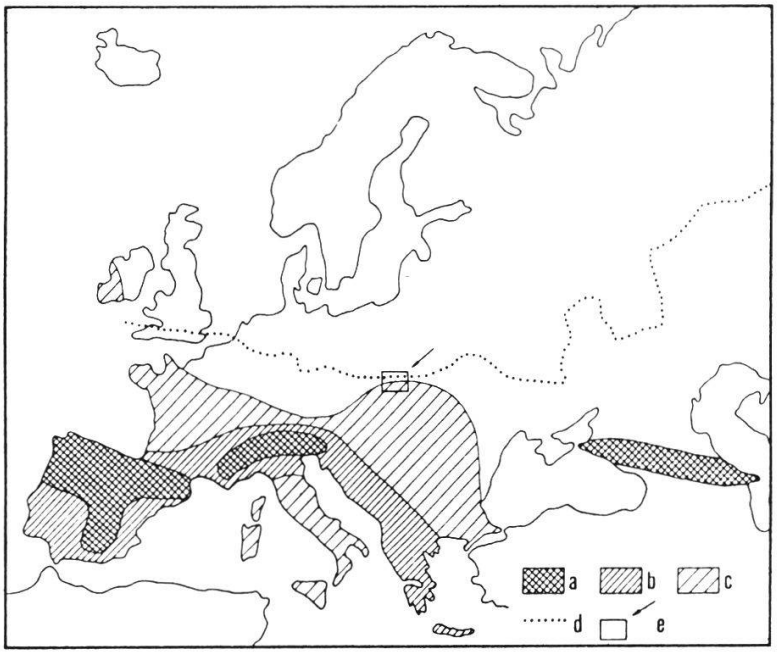

Fig. 14. Dislocation and quantitative representation of the European endemic genera having only relatively small distribution areas (HENDRYCH 1982, slightly modified).
a = 14-7, b = 6-4, c = 3-1 genera, d - S limit of the greatest glaciation, e - the Tatra Mts.

taxa are regarded as Tatra or West Carpathian endemics and subendemics: e.g., *Cochlearia tatrae* Borb., *Poa nobilis* Skalinska, *Soldanella carpatica* Vierh. (Fig. 15), *Festuca tatrae* (Czako) Degen, *Pulsatilla slavica* G. Reuss, *Dianthus plumarius* L. ssp. *praecox* (Kit.) Domin, *Carex sempervirens* Vill. ssp. *tatrorum* (Zapal.) Pawlowski, *Cerastium tatrae* Borbas (= *C. glandulosum* [Kit.] Soó), *Thymus carpaticus* Cel. and *Knautia kitaibelii* (Schult.) Borb. Moreover, ten of twelve Pan-Carpathian endemic species occur in the Tatra Mts.: *Cardaminopsis neglecta* (Schult.) Hay, *Erigeron nanus* Schur (= *E. hungaricus* [Vierh.] Pawl.), *Erysimum wittmannii* Zaw., *Festuca carpatica* Dietr., (Fig. 15), *Leontodon pseudotaraxaci* Schur, *Oxytropis carpatica* Uechtr., *Poa granitica* Br.-Bl. (ssp. *granitica*), *Salix kitaibeliana* Willd., *Thymus pulcherrimus* Schur, *Trisetum fuscum* Kit. Twelve of fifteen Pan-Carpathian subendemic species occur also in the Tatra Mts.: *Campanula polymorpha* Witasek, *Campanula serrata* (Kit.) Hendrych, *Centaurea mollis* W. et K., *Dentaria glandulosa* W. et K., *Erigeron macrophyllus* Herb., *Euphrasia tatrae* Wettst., *Festuca varia* Haenke (= *F. versicolor* Tausch em. Kraj.), *Leucanthemum waldsteinii* (Schultz Bip.) Pouzar (= *L. rotundifolium* [W. et K.] DC.), *Melampyrum herbichii* Wol., *Petasites kablikianus* Tausch., *Saxifraga carpatica* Rchb., *Symphytum cordatum* W. et K.
The distribution of some endemic species in the Tatra National Park is shown in Fig. 16.

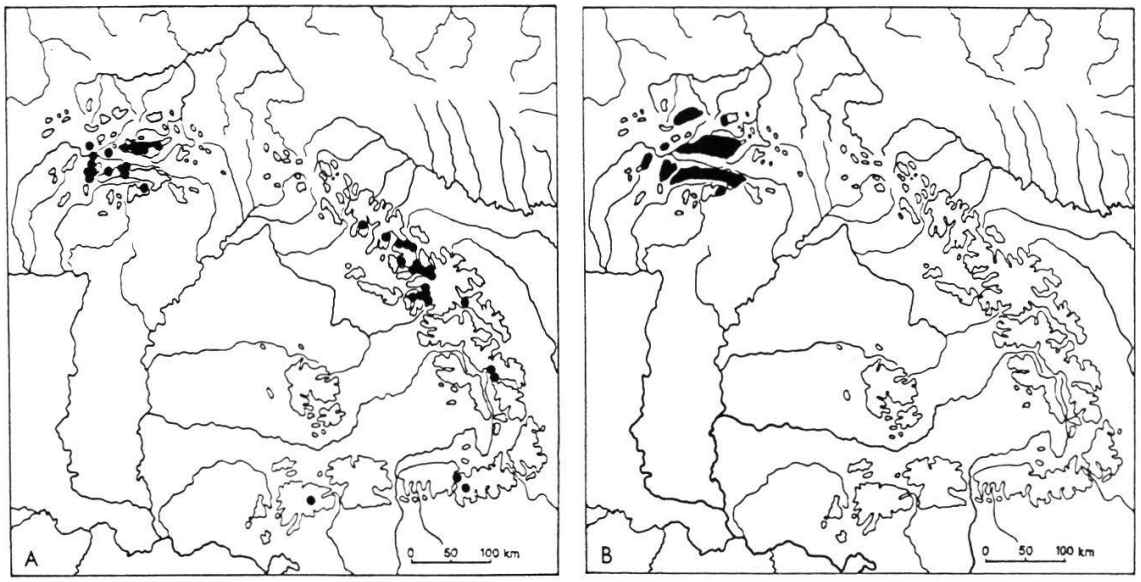

Fig. 15. Distribution of Pan-Carpathian endemic *Festuca carpatica* (A) and West-Carpathian endemic *Soldanella carpatica* (B). (PAWLOWSKA 1963 and PAWLOWSKI 1970b).

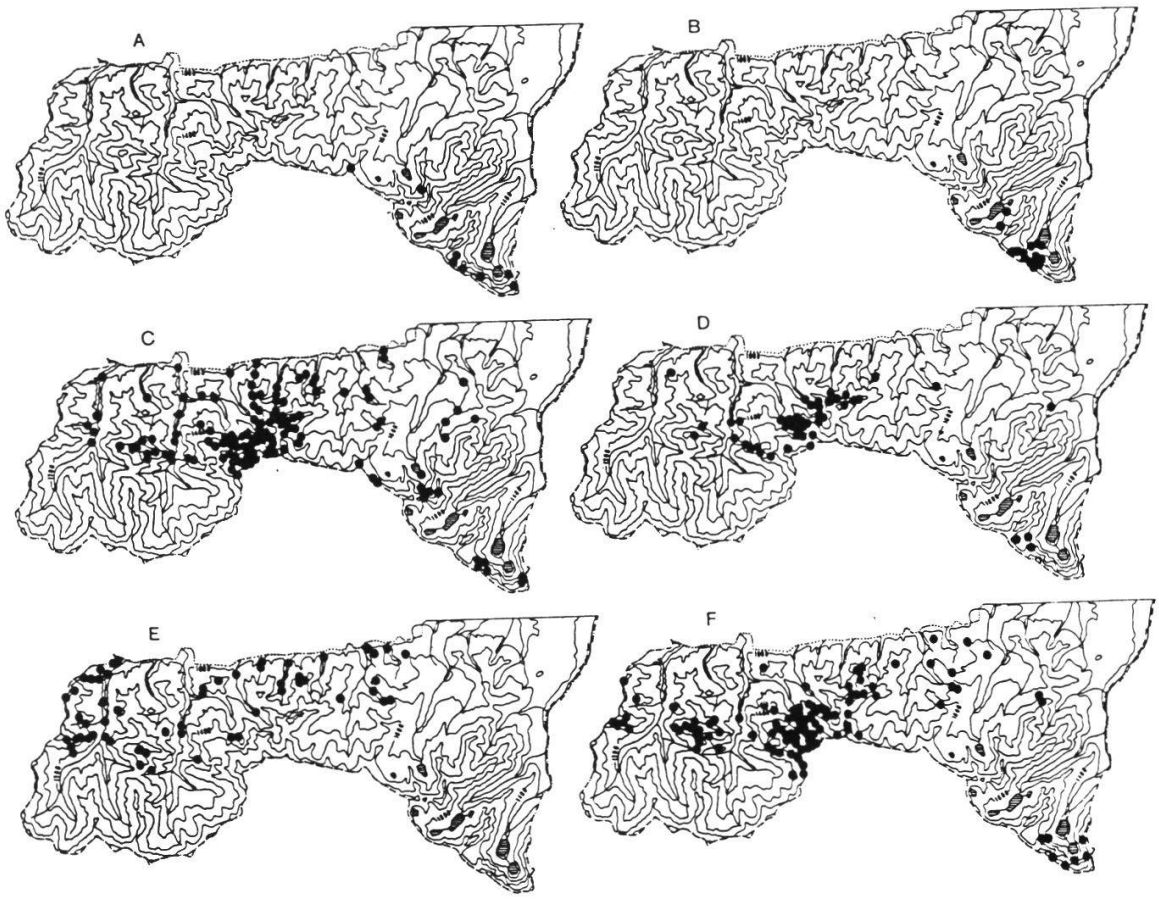

Fig. 16. Distribution of six endemic species in the Tatra National Park.
A - *Poa nobilis*, B - *Cochlearia tatrae*, C - *Saxifraga wahlenbergii*, D - *Delphinium oxysepalum*, E - *Festuca tatrae*, F - *Festuca varia*.

8. ORIGIN AND AGE OF THE FLORA

A thorough taxonomic-geographical analysis of the Tatra flora made by PAWLOWSKI (1929) showed that 3/4 to 4/5 of high mountain vascular plants are of Alpine-Central European origin. In contrast to the vascular flora, high mountain bryophytes appear to be mostly of Arctic origin. The majority of the species occurring in the Tatras could have migrated there during glacial times from the Arctic region and from other mountains of Europe, Asia and North America. There was a very intensive exchange of the floras between various areas.

The Old Tertiary flora of the Tatras was almost completely destroyed during glacial time. There is a small number of species which has survived in situ in the Tatra Mts. since the Tertiary. Among vascular plants, *Saxifraga wahlenbergii* (PAWLOWSKA 1966), *Delphinium oxysepalum* (PAWLOWSKI 1934) and

probably *Soldanella carpatica* (PAWLOWSKI 1972) may serve as examples. Some high mountain mosses (e.g. *Geheebia gigantea*, *Tetrodontium repandium*) and liverworts (e.g. *Bucegia romanica*) are also regarded as being Tertiary relicts.

A number of species have survived in the Tatras possibly since the older Pleistocene and they represent glacial relicts. An example is *Salix herbacea* restricted in Poland to the Tatras. However, fossils show its presence in the Polish lowlands in older glacial times. Apart from the vascular plants, numerous moss species and almost all high mountain liverworts represent glacial relicts.

9. RARE PLANTS

About 18% of the vascular plant flora in the Polish Tatra National Park consists of very rare species (PIEKOS-MIRKOWA 1982). The localities of some of the most interesting ones, especially mountain species, tend to concentrate in two regions: 1) calcareous massif of the Czerwone Wierchy, and 2) valley of lake Morskie Oko consisting of very poor non-calcareous rock (Fig. 17). Some of them appear to be extremely rare, their only localities in the Carpathians being in the Tatra Mts. A typical example is the high mountain fern *Dryopteris villarsii* (Bell.) Woynar ex Schinz et Thell. (Fig. 18) (PIEKOS-MIRKOWA and MIREK 1988, 1989).

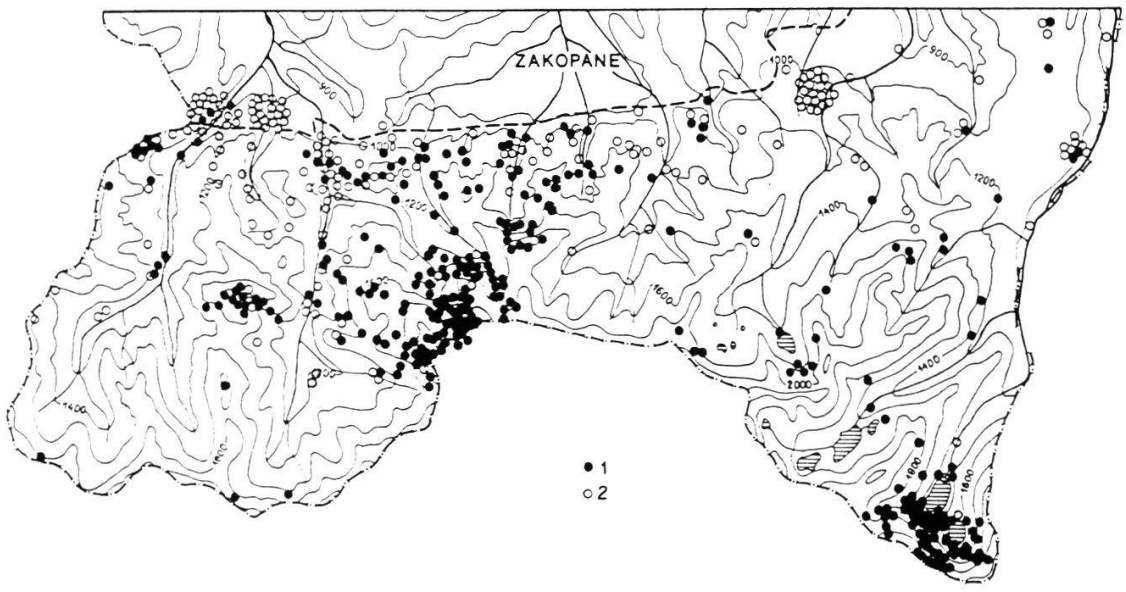

Fig. 17. Localities of rare mountain (1) and non-mountain (2) species in the Tatra National Park (PIEKOS-MIRKOWA 1982).

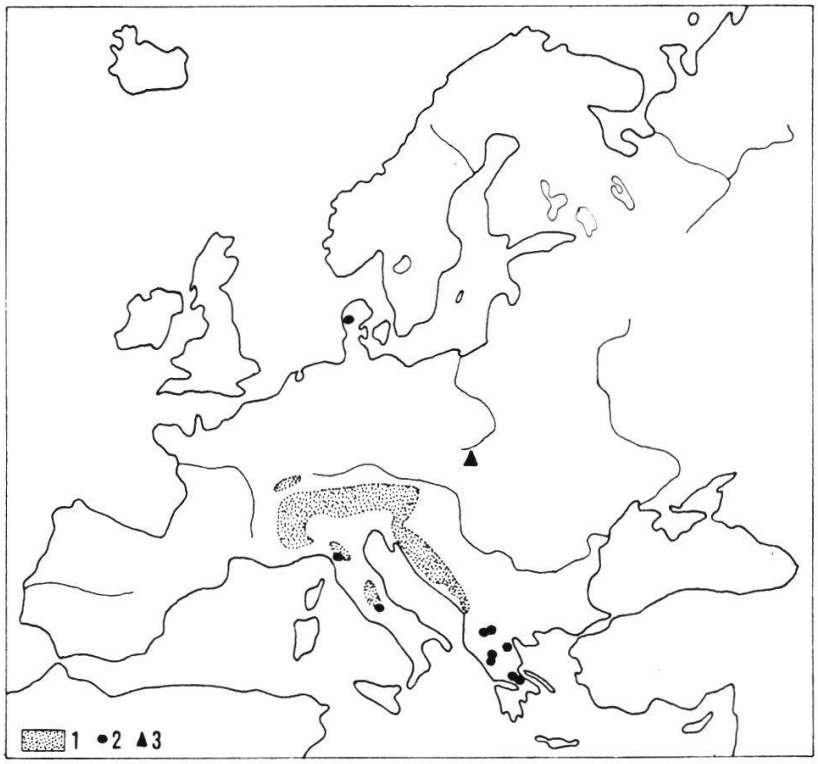

Fig. 18. Distribution of *Dryopteris villarsii* (PIEKOS-MIRKOWA and MIREK 1989).
1 - main area, 2 - single localities, 3 - locality in the Tatra Mts.

10. EDAPHIC ELEMENTS

There are species which are indifferent in regard to the substratum, and there are many others which exhibit a well-marked affinity to calcareous or non-calcareous rocks. This allows the distinction between calcifilous and calcifuge species. Among calcifilous species there are numerous vascular plants (e.g. *Leontopodium alpinum, Chamorchis alpina, Gentiana clusii*), mosses (e.g. *Gymnostomum calcareum*), liverworts (e.g. *Scapania calcicola*) and lichens (e.g. *Xanthoria elegans*). As examples of calcifuge species, *Cochlearia tatrae, Salix herbacea, Andreaea nivalis* and *Rhizocarpon geographicum* can be mentioned. In reference to very closely related taxa (species and subspecies) one speaks of edaphic vicariants. One example (*Galium anisophyllum - G. saxatile*) is presented on the map (Fig. 19).
On the other hand, numerous species with no clear affinity to any substratum do exist (e.g. *Soldanella carpatica, Huperzia selago, Doronicum austriacum, Anemone narcissiflora, Tortella tortuosa, Thamnolia vermicularis*).

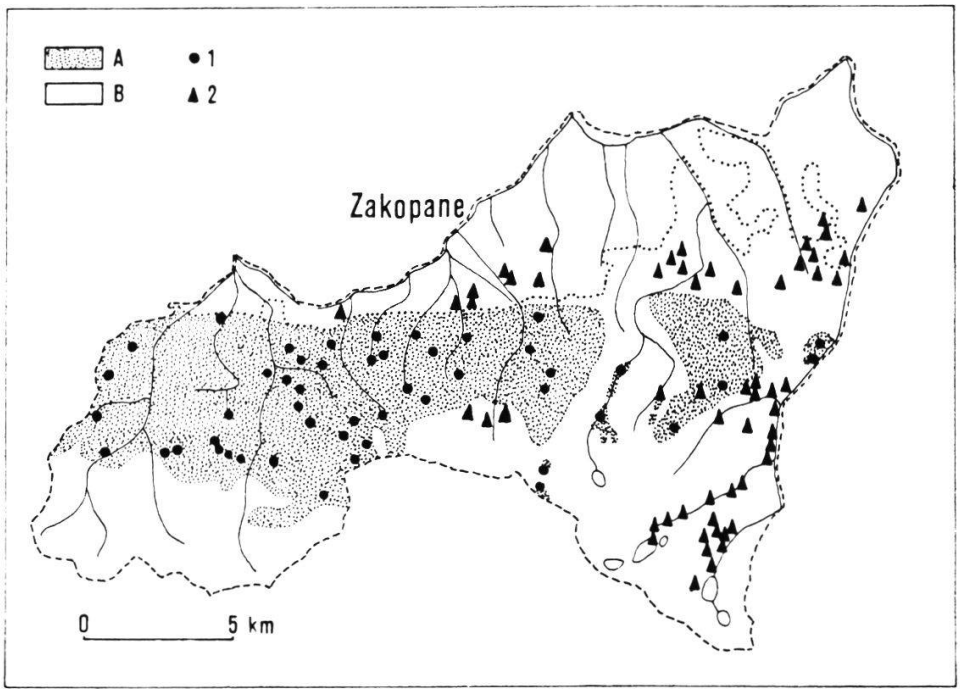

Fig. 19. Edaphic vicarism of *Galium anisophyllum* (1) and *G. saxatile* (2) in the Polish Tatra Mts. and adjacent Subtatras (MIREK and PIEKOS-MIRKOWA 1984).
A - calcareous rock, B - poor non-calcareous rock.

11. VEGETATION UNITS

About 50 well-defined associations have been recorded so far from the territory of the Polish Tatras. A list of them, their altitudinal ranges, substratum and frequency are given in Table 2.

SUMMARY

The plant cover of the Polish Tatra Mts. and its relation to the main environmental factors (climate, geomorphology, soil) is described and illustrated by numerous figures. Five climatic vegetation belts (lower montane, upper montane, dwarf pine, alpine and subnival) as well as the flora and vegetation units, distinguished according to the Braun-Blanquet school, have been described. More than 1'000 vascular plant species, c. 450 mosses, 200 liverworts, 700 lichens, 900 fungi, 70 myxomycetes and c. 1'000 algae have been reported so far. The role of the Tatra Mts. as a centre of West Carpathian endemism and an important refuge for numerous relict species has been emphasized.

Table 2. Altitudinal range, substratum and surface covered by the most important plant communities in the Tatra National Park.
Substratum: □ - siliceous, ■ - calcareous; surface: 1 = <1%, 2 = 2-5%, 3 = 6-10%, 4 = 11-15%, 5 = 16-25%.

Association	Vegetation belts					
	surface	lower montane	upper montane	sub alpine	alpine	subnival
□□ *Abieti-Piceetum montanum*	3					
■■ *Galio-Piceetum carpaticum*	2					
■■ *Dentario glandulosae-Fagetum*	2					
□□ *Luzulo nemorosae-Fagetum*	2					
■■ *Galio-Abietetum*	2					
□■ *Alnetum incanae*	1					
□■ *Caltho-Alnetum*	1					
■■ *Cirsietum rivularis*	1					
■■ *Valeriano-Caricetum flavae*	1					
□□ *Carici-Agrostietum caninae*	1					
□□ *Nardo-Juncetum squarrosi*	1					
■■ *Phyllitido-Aceretum*	1					
■■ *Vario-Pinetum*	1					
■■ *Arabido-Cratoneuretum falcati*	1					
■■ *Gladiolo-Agrostietum*	2					
□□ *Sphagnetum magellanici*	1					
□■ *Rumicetum alpini*	1					
□■ *Rumici obtusifoliae-Urticetum*	1					
■■ *Silenetum prostratae*	1					
□■ *Petasitetum kablikiani*	1					
■■ *Sorbo-Aceretum carpaticum*	1					
□□ *Plagiothecio-Piceetum tatricum*	5					
■■ *Polysticho-Piceetum tatricum*	3					
□□ *Cembro-Piceetum*	1					
■■ *Carici-Festucetum tatrae*	2					
□□ *Hieracio-Nardetum*	2					
□■ *Pinetum mughi carpaticum*	4					
□■ *Asplenietea trichomanis*	1					
□□ *Athyrietum alpestris*	2					
□■ *Aconitetum firmi*	1					
■■ *Caricetum firmae carpaticum*	2					
□□ *Empetro-Vaccinietum*	2					
□□ *Calamagrostietum villosae tatricum*	2					
■■ *Festucetum carpatici*	1					
□□ *Polytrichetum sexangularis*	1					
□□ *Salicetum herbaceae*	1					
■■ *Papaveri-Cerastietum*	1					
■■ *Saxifragetum perdurantis*	1					
■■ *Festuco versicoloris - Seslerietum tatrae*	3					
□□ *Oreochloo distichae - Juncetum trifidi*	4					
□□ *Oxyrio-Saxifragetum carpaticae*	1					
□□ *Luzuletum spadiceae*	2					
□□ *Rhizocarpetea geographici*	2					
□□ *Oreochloetum distichae subnivale*	1					

REFERENCES

CZUBINSKI Z., 1962: Mosses and liverworts. (In Polish with English summary). In: SZAFER W. (ed.), The Tatra National Park. Zaklad Ochr.Przyr.PAN, Krakow. 338-360.

HENDRYCH R., 1982: Material and notes about the geography of the highly stenochoric to monotopic endemic species of the European flora. Acta Univ.Carolinae, Biologica *3-4*, 335-372.

KAWECKA B., 1992: Algae. (In Polish with English summary). In: KLIMEK K., PIEKOS-MIRKOWA H. and GLOWACINSKI Z. (eds.), Nature of the Tatra National Park. Stud.Nat., Ser. B. (in press).

KOMOROWSKA H. and DROZDOWICZ A., 1992: Myxomycetes. (In Polish with English summary). In: KLIMEK K., PIEKOS-MIRKOWA H. and GLOWACINSKI Z. (eds.), Nature of the Tatra National Park. Stud.Nat., Ser. B. (in press).

KOTULA 1889-1890: Distributio plantarum vasculosarum in Montibus Tatricis. (In Polish). Akad.Umiejetnosci, Krakow. 542 p.

MIREK Z., 1990: Classification of the altitudinal ranges of plant species in Central Europe. In: BOHN U. and NEUHÄUSL R. (eds.), Vegetation and flora of temperate zones. Junk, The Hague. 11-19.

MIREK Z. and PIEKOS-MIRKOWA H., 1984: Distribution and habitats of *Galium saxatile* L. in the Carpathians. Acta Soc.Bot.Pol. *53(3)*, 419-427.

MYCZKOWSKI S., 1955: Ecology of the forest associations in the Polish Tatra Mountains with special consideration of its connections with the snow cover. (In Polish with English summary). Ochr.Przyr. *23*, 112-203.

MYCZKOWSKI S., 1972: Structure and ecology of the spruce association *Piceetum tatricum* at the upper limit of its distribution in the Tatra National Park. Acad.Agriculture, Krakow. 1-17.

PAWLOWSKA S., 1963: De Soldanellis, quae in parte septentrionali Carpatorum crescund. Fragm.Flor.Geobot. *9(1)*, 3-30.

PAWLOWSKA S., 1966: De positione systematica speciei *Saxifraga wahlenbergii* Ball (= S. *perdurans* Kit.). Fragm.Flor.Geobot. *12(4)*, 337-347.

PAWLOWSKI B., 1929: Die geographischen Elemente und die Herkunft der Flora der subnivalen Vegetationsstufe im Tatra-Gebirge. Bull.Intern.Acad.Polon.Sci.Lett., Math.Nat., Ser. B., 161-202.

PAWLOWSKI B., 1934: Studien über mitteleuropäische Delphinien aus der sogenannten Sektion *Elatopsis*. Bull.Intern.Acad.Polon.Sci.Lett., Math.Nat., Ser. B., 91-181.

PAWLOWSKI B., 1970a: Remarques sur l'endémisme dans la flore des Alpes et des Carpates. Vegetatio *21(4-6)*, 181-243.

PAWLOWSKI B., 1970b: De speciebus polonicis et carpaticis generis *Erigeron* L. Fragm. Flor.Geobot. *16(2)*, 255-293.

PAWLOWSKI B., 1972: Plant cover of Polish mountains. (In Polish). In: SZAFER W. and ZARZYCKI K. (eds.), Vegetation of Poland. PWN, Warszawa. 189-252.

PIEKOS H., 1968: The distribution of plants of the lower and upper montane zone on the Sarnia Skala, Krokiew and Lysanki Mts. in the Tatras. (In Polish with English summary). Fragm.Flor.Geobot. *14(3)*, 317-393.

PIEKOS-MIRKOWA H., 1981: Anthropogenic changes of plant cover in the Tatra National Park. (In Polish). Polskie Towarzystwo Przyjaciol Nauk o Ziemi i Dyrekcja Tatrzanskiego Parku Narodowego, Warszawa- Zakopane. 259-286.

PIEKOS-MIRKOWA H., 1982: Rare taxa of vascular plants of the territory of the Tatra National Park - their endangerment by tourism and problems of their conservation. (In Polish with English summary). Stud.Nat., Ser. A *22*, 79-132.

PIEKOS-MIRKOWA H., 1986: Actual problems of gene resources conservation of vascular

plants in the Tatra National Park. (In Polish with English summary). Acta Univ.Lodz., Folia Sozol. *3*, 143-159.

PIEKOS-MIRKOWA H. and MIREK Z., 1988: *Dryopteris villarii* (Bell.) Woyn. ex Schinz et Thell. - a new mountain species in the Carpathians. Fern Gazette *13(4)*, 245.

PIEKOS-MIRKOWA H. and MIREK Z., 1989: *Dryopteris villarii* (Bellardi) Woynar ex Schinz. et Thell. - a new high-mountain species in the flora of Poland. (In Polish with English summary). Fragm.Flor.Geobot. *34(3-4)*, 277-282.

PIEKOS-MIRKOWA H. and MIREK Z., 1992: Vascular plants. (In Polish with English summary). In: KLIMEK K., PIEKOS-MIRKOWA H. and GLOWACINSKI Z. (eds.), Nature of the Tatra National Park. Stud.Nat., Ser. B. (in press).

SOKOLOWSKI M., 1928: La limite supérieure de la forêt dans le massif des Tatras. (In Polish with French summary). Wyd.Fund. Zaklady Kornickie, Krakow. 188 p.

TOBOLEWSKI Z., 1992: Lichens. (In Polish with English summary). In: KLIMEK K., PIEKOS-MIRKOWA H. and GLOWACINSKI Z. (eds.), Nature of the Tatra National Park. Stud.Nat., Ser. B. (in press).

WOJEWODA W., 1992: Fungi. (In Polish with English summary). In: KLIMEK K., PIEKOS-MIRKOWA H. and GLOWACINSKI Z. (eds.), Nature of the Tatra National Park. Stud.Nat., Ser. B. (in press).

Addresses of the authors: Dr. Zbigniew MIREK
W. Szafer Institute of Botany
Polish Academy of Sciences
Lubicz 46
31-512 Krakow, Poland

Dr. Halina PIEKOS-MIRKOWA
Nature Protection Research Centre
Polish Academy of Sciences
Lubicz 46
31-512 Krakow, Poland