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Distribution and ecology of the *Dryopteris* species in the Polish Tatra Mountains

H. PIĘKOS'-MIRKOWA[1], A. MIECHÓWKA[2]
[1]*Nature Protection Research Centre, Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland*
[2]*Department of Soil Science, Agricultural University, Aleje Mickiewicza 21, 31-120 Kraków, Poland*

Abstract. The distribution, vertical ranges and ecological requirements of six *Dryopteris* species occurring in the Tatra National Park are described in this paper and presented on maps and diagrams. Of the species studied, *Dryopteris filix-mas* and *D.expansa* appear to be the most common species extending up to the alpine belt. *D.carthusiana* also occurs frequently, although generally it does not extend beyond the timberline. *D.dilatata* and *D.affinis* are much rarer. The remaining species, *D.villarii*, was recorded from one locality. All six species occur on various slopes ranging from flat areas to steep mountain slopes with a wide range of aspects. Soils on which these species grow were usually moist or very moist, rich in organic matter. The *Dryopteris* species studied encounter on various types of soils which are derived both from sedimentary alkaline rocks and from acid rocks. The mentioned species generally show a wide ecological amplitude so far as soil acidity is concerned. They occur on soils with a wide range of magnesium content and medium or low potassium content. These soils are poor in available phosphorus. Some differences in habitat requirements of the six *Dryopteris* species are discussed in paper and presented graphically.

Key-words: Dryopteris, occurrence, vertical range, edaphic and orographic factors, Tatra National Park

Introduction

The Dryopteris species have been the subject of comprehensive studies in Poland which have provided a considerable amount of information on their morphological differentiation and on their distribution (Piękos' and Passakas 1973; Piękos' 1974,1975; Piękos'-Mirkowa and Mirek 1988, 1989). However, there is little information on their ecological requirements, especially with regard to edaphic factors and, in particular, the physico-chemical properties of soil and other physical factors. Of the seven *Dryopteris* species known to occur in Poland, six can be found in the Tatra National Park (Fig.1). They are: *Dryopteris filix-mas, D.affinis, D.villarii, D.carthusiana, D.dilatata* and *D.expansa*. The aim of this paper is to present the relationships between the distribution of these six *Dryopteris* species and their habitat requirements in the Polish Tatra Mtns. The seventh species, *D.cristata*, recorded from the only site in the adjacent area has not been taken into consideration.

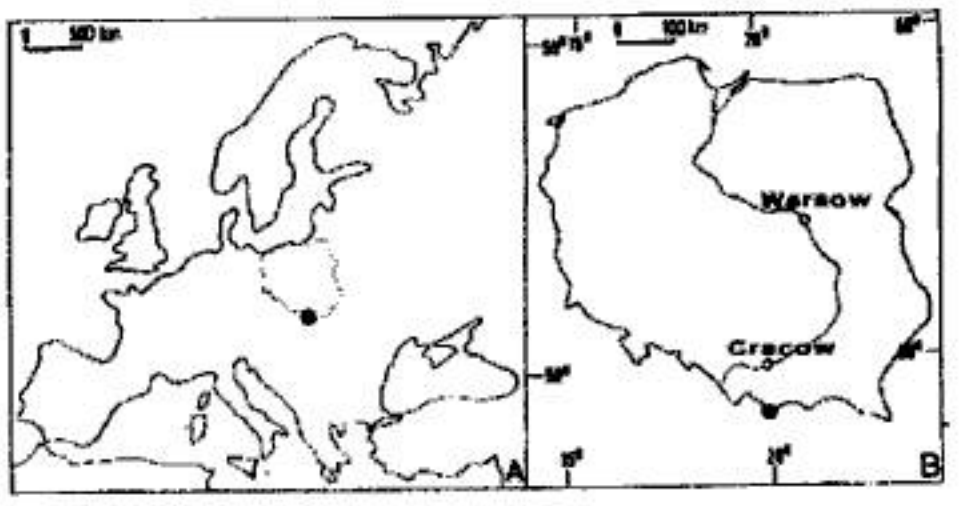

Fig. 1. Location of the area under consideration in Europe (A) and in Poland (B).

For the last fifteen years, detailed studies of the ecology of several dozen plant species have been carried out in the Pieniny Mtns (Zarzycki 1976 a,b) and in the massif of Babia Góra (Borysiak 1984; Szwed 1986), whilst the knowledge of the habitat requirements of vascular plants in the Tatra Mtns is hitherto scanty and inadequate. The ecological studies on *Dryopteris* species in the Tatra National Park were based on the same methods of collecting data and their presentation adopted by the above mentioned authors in the Babia Góra and Pieniny Mtns.

Material and Methods

The distribution of Dryopteris species in the Tatra National Park is shown on maps (Figs. 2 and 3) which were

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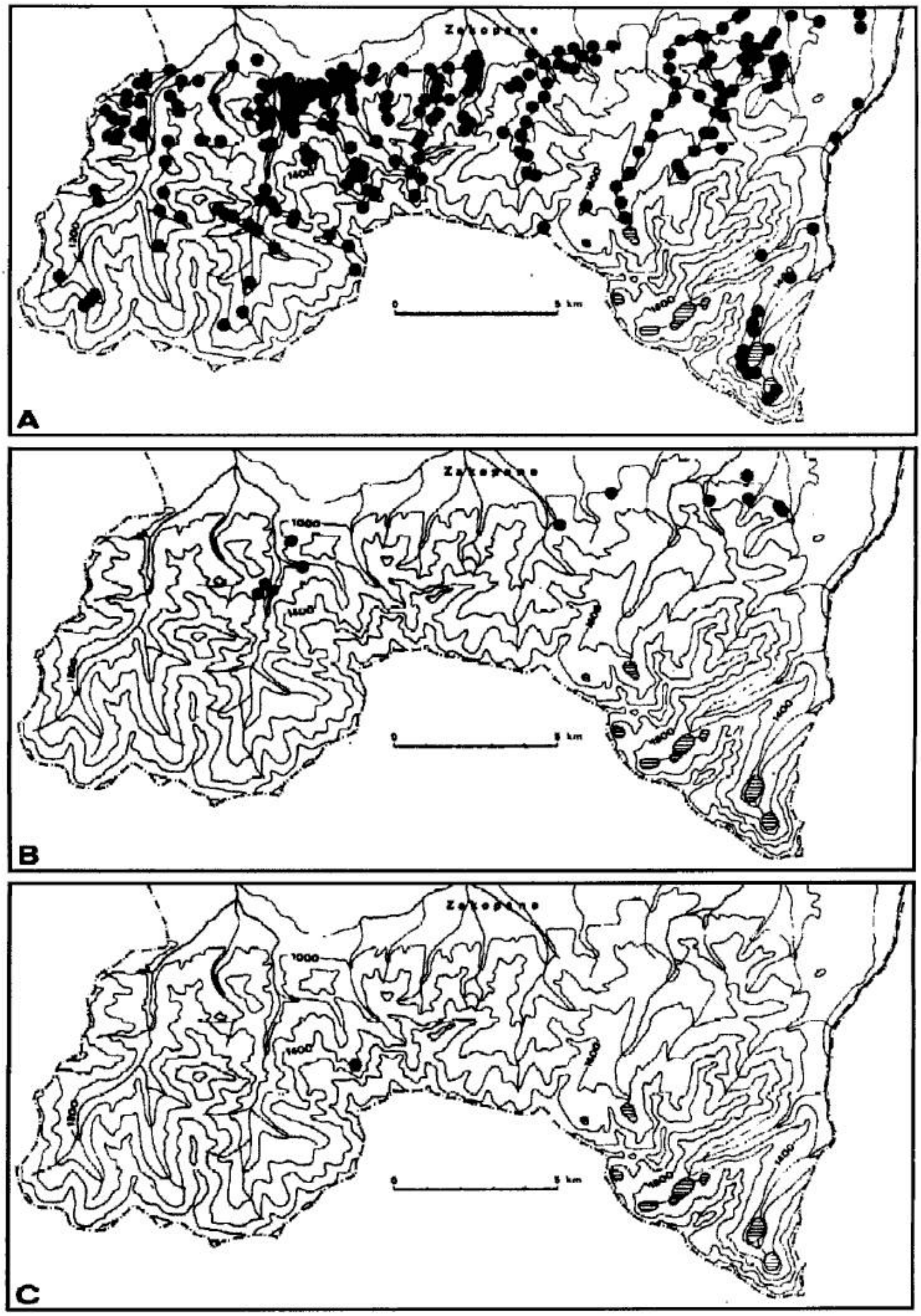

Fig. 2. Distribution of *Dryopteris filix-mas* (A), *D.affinis* (B) and *D.villarii* (C) in the Tatra National Park.

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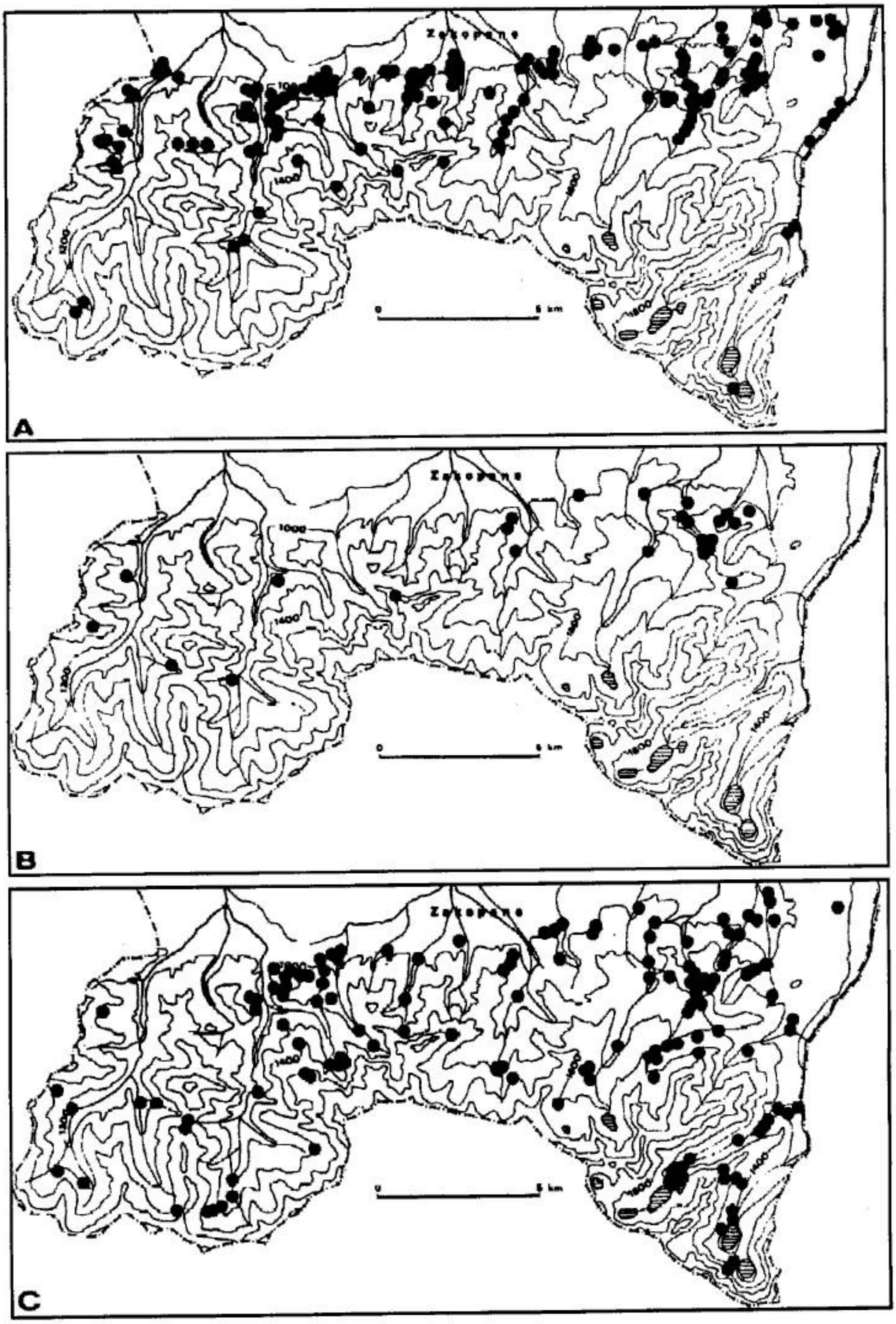

Fig. 3. Distribution of *Dryopteris carthusiana* (A), *D.dilatata* (B) and *D.expansa* (C) in the Tatra National Park.

prepared from field data collected by the authors. In the case of *D.filix-mas*, these data were supplemented with records from the literature. Data from the literature for the remaining species which could be used for this study were limited, especially in the case of *D.expansa* which has only recently been distinguished as a separate species from the closely related *D.dilatata* s. str. An additional problem is the confusion that has occurred in the past, between *D.dilatata* and *D.carthusiana*.

The investigations were carried out between June and September in 1988, 1989 and 1990. The field data for common species (i.e. *Dryopteris filix-mas*, *D.carthusiana* and *D.expansa*) were collected using transects (Zarzycki 1976 a,b; Borysiak 1984; Szwed 1986).

The field information collected for each species included: plant community, altitude above sea level, slope and aspect, parent rock, type of soil and soil moisture. The mixed soil samples taken from within the rhizosphere were collected for analysis in the laboratory.

The laboratory study of the physico-chemical properties of soils included: the active (pH_{H_2O}) and exchangeable (pH_{KCl}) acidities, organic carbon content, general nitrogen content, available phosphorus, potassium and magnesium. The active and exchangeable acidities were determined potentiometrically; the organic carbon content was determined using Tiurin's method, general nitrogen content using Kjeldahl's method, available magnesium using Schachtschabel's method, phosphorus and potassium using Egner-Riehm's method. The terms used to describe the soils are taken from the FAO/UNESCO Soil Map of the World (1988). The results obtained for particular *Dryopteris* species are presented graphically. In the case of two species (*D.affinis* and *D.villarii*) both of which are very rare, the data collected were insufficient to enable any conclusions to be drawn and are therefore omitted from Figures 5-9.

Results

The results obtained enable the characterization of particular *Dryopteris* species with respect to their distribution, vertical ranges, phytocenoses and orographic and edaphic factors.

Dryopteris filix-mas (L.) Schott

It is one of the most common and abundant ferns in Poland (Piękos'-Mirkowa 1981, 1988). In the Polish Tatra Mountains, it is widespread, extending from the foot of the mountains up to 1,770 m a.s.l., which is the vertical limit of its range in Poland. It is most common in the lower and upper forest montane belts, but it also extends up to the subalpine belt (Figs. 2 and 4). It is especially

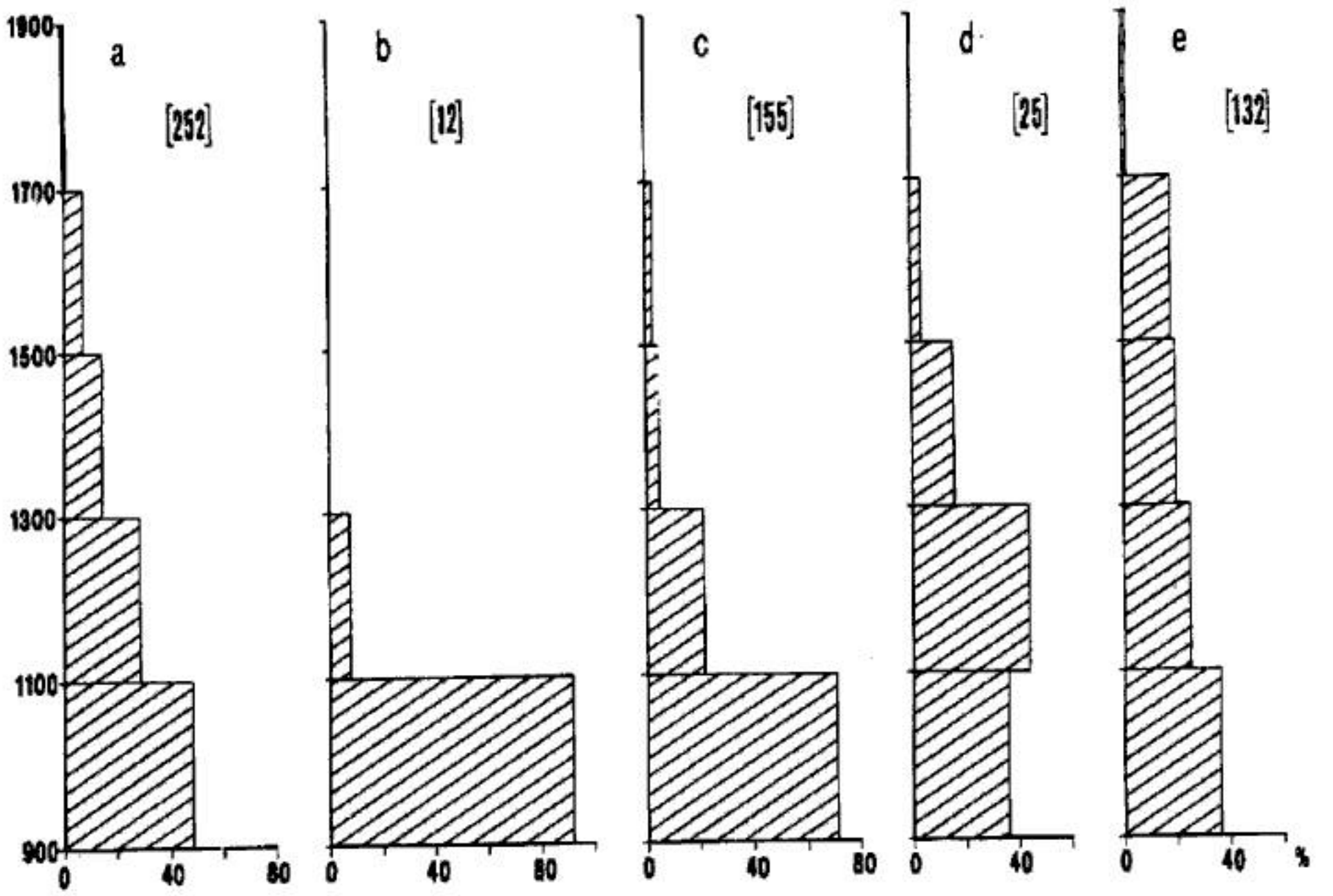

Fig. 4. Vertical distribution of *Dryopteris filix-mas* (a), *D.affinis* (b), *D.carthusiana* (c), *D.dilatata* (d) and *D.expansa* (e) in the Tatra National Park. Numbers of localities are given brackets.

frequent in beechwoods where is associated with the *Dentario glandulosae-Fagetum* community, and it is rarely found in coniferous forest communities such as the *Abieti-Piceetum, Polysticho- Piceetum, Plagiothecio-Piceetum* communities. It also occurs infrequently in the *Pinus mugo* belt which is characterized by the *Pinetum mughi carpaticum* community.

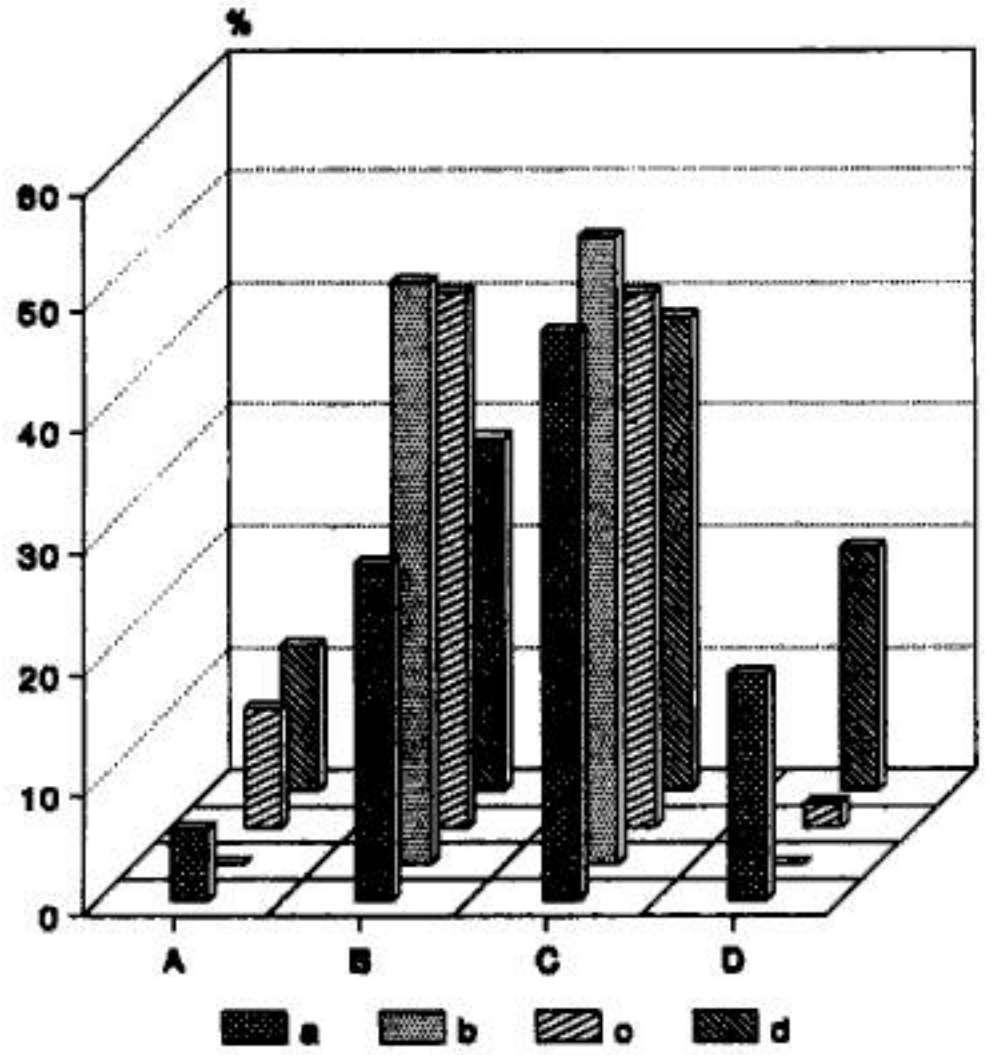

Fig. 5. Frequency (in percent) of occurrence of *Dryopteris filix-mas* (a), *D.carthusiana* (b), *D.dilatata* (c), *D.expansa* (d) on the soils of varying moisture in the Tatra National Park. A - slightly moist, B - moist, C - very moist, D - wet.

D.filix-mas was found to occur on a wide variety of slopes, ranging from flat areas to steep mountain slopes. Its occurrence is not limited by aspects. It shows a preference for very moist soils, but also occurs often on moist and wet soils (Fig.5). In the majority of the soil samples analysed (84%), the organic carbon content ranged from 2.5% to 12% (Fig.6). The C/N ratio was between 10 and 15 in 58% of the soil samples, and in 33%, the C/N ratio ranged from 16 to 20. This species was found growing in several soil types (Fig.7), although it was most frequently encountered in Rendzinas, Calcaric Cambisols and Eutric Cambisols derived from limestones, dolomites and marls of various geological formations. These soils typically showed slightly acidic to basic reactions in the deeper horizons, while the reactions in the rhizosphere varied within wide limits, from strongly acid to basic (pH_{KCl} 2.2-7.3) (Fig.8). Half of the soil samples tested proved to be very rich in available magnesium with over 20 mg MgO per 100 g soil (Fig.9). These soils were medium rich (43 percent of soil samples) or poor in available potassium. As much as 63% were found to be poor in available phosphorus, containing as little as 3 mg P_2O_5 per 100 g soil (Fig.9).

Dryopteris affinis (Lowe) Fraser-Jenkins

This species is much rarer in Poland than the closely related *D.filix-mas*. It occurs mainly in the Carpathians and appears to be associated with fir-spruce forest communities developed on acid soils (Murin and Májovský 1980; Piękos'-Mirkowa 1981, 1988). It is a rare plant in the Tatra Mtns recorded hitherto from 12 localities (Fig.2), all of which are in the lower montane belt,

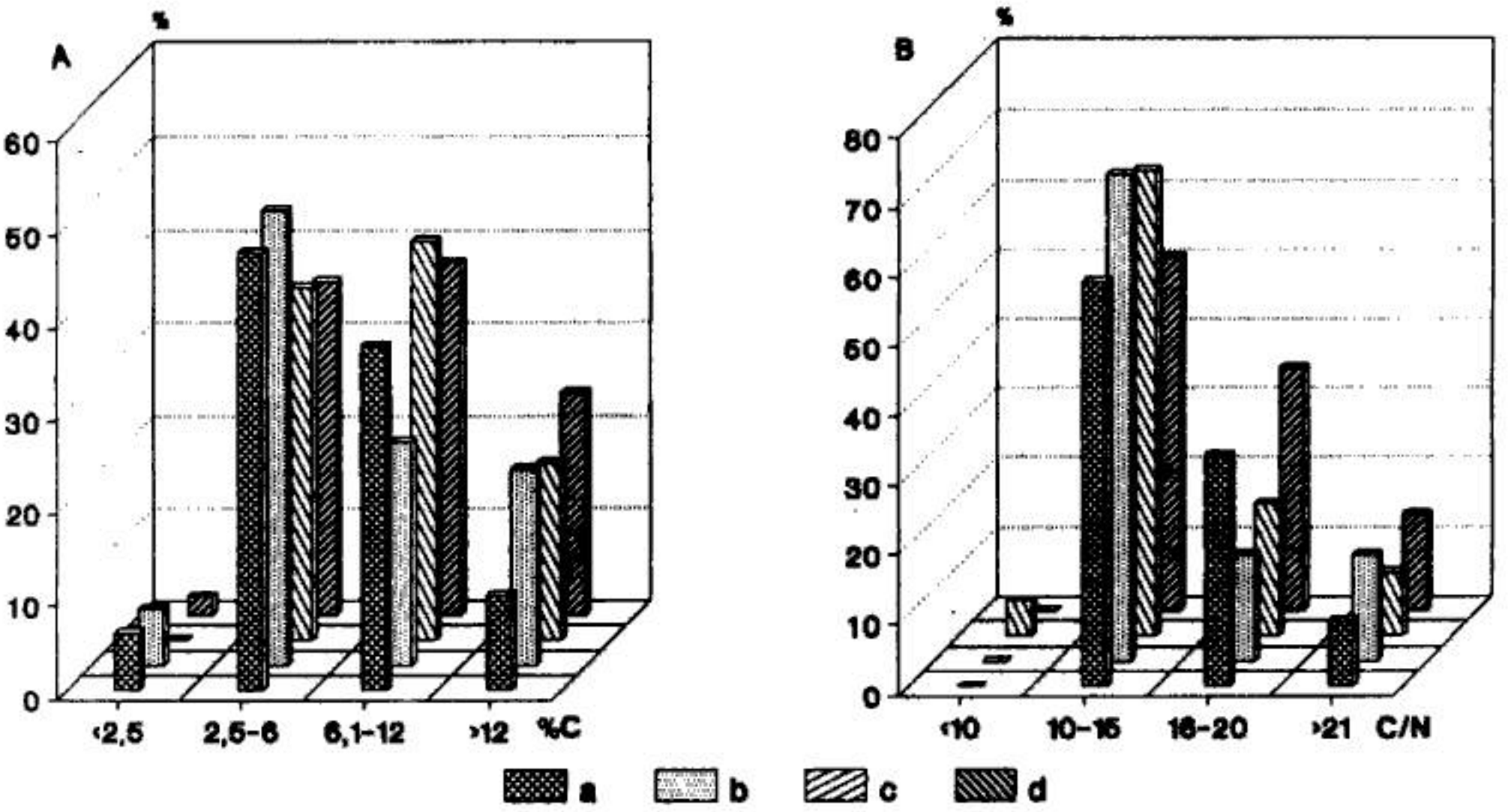

Fig. 6. Frequency of occurrence of *Dryopteris filix-mas* (a), *D.carthusiana* (b), *D.dilatata* (c) and *D.expansa* (d) on the soils with various content of organic carbon (A) and different C/N ratio (B) in the Tatra National Park.

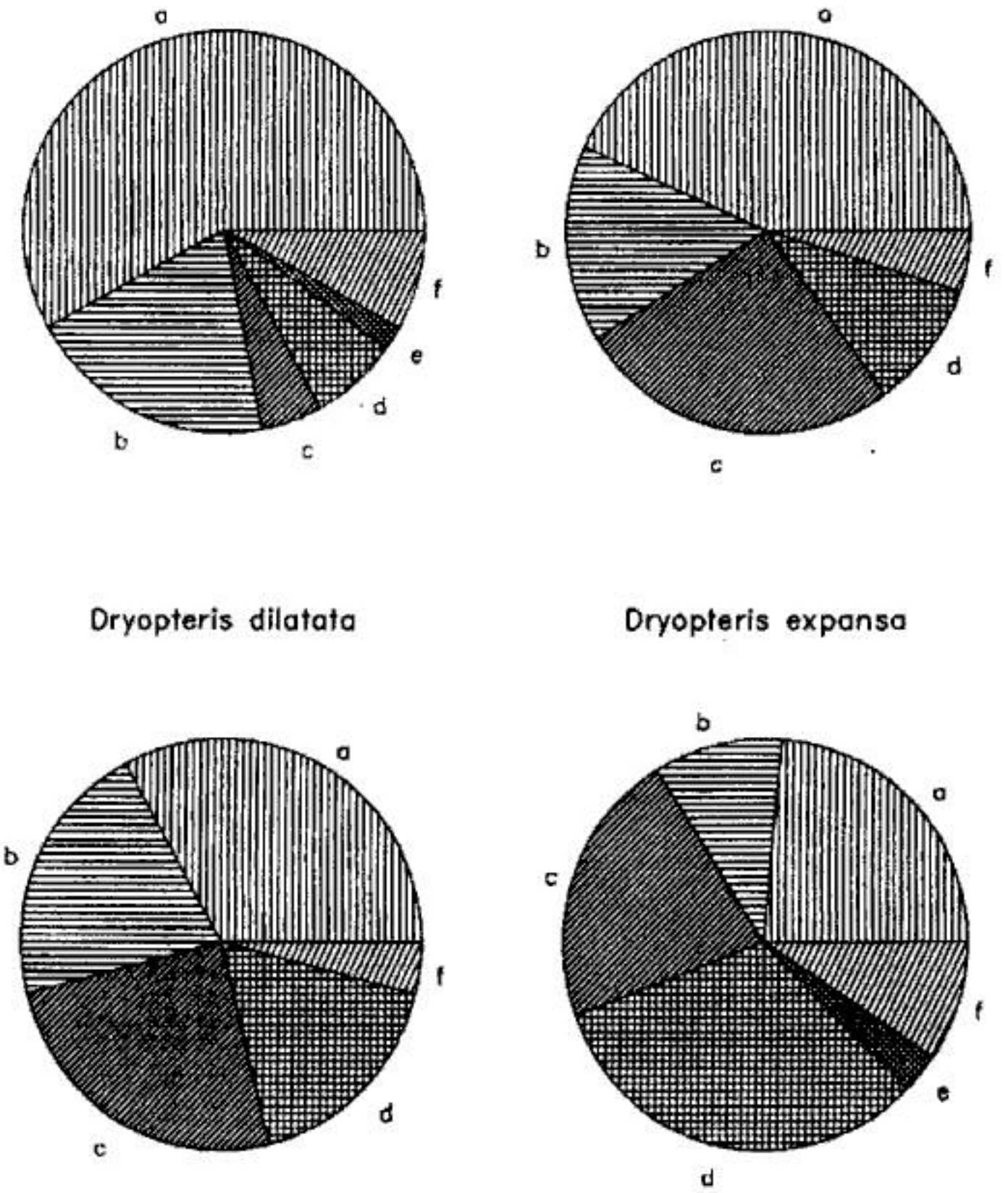

Fig. 7. Frequency of occurrence of four *Dryopteris* species on various soil types in the Tatra National Park. Soils: Orthic and Cambic Rendzinas, Calcaric Cambisols (a), Cambic Rankers and Eutric Cambisols (b), Dystric Cambisols (c), Podzolic Rankers, Haplic and Orthic Podzols (d), Dystric Histosols (e), Eutric and Calcaric Fluvisols (f).

between 980 m and 1,200 m a.s.l. (Fig.4). Soil samples were collected from four sites. These included moist or very moist raw humus mountain rendzinas*, or humic soils, derived from the mesozoic limestones and dolomites. These soils showed slightly acid or neutral reaction (pH_{KCl} 5.9-6.6). The organic carbon content ranged from 4.3 to 25.2 percent and the C/N ratio from 14 to 16. The available magnesium content varied within wide limits from 6.3 to 103.6 mg MgO per 100 g soil and the available potassium content varied from 3.0 to 15.0 mg K_2O per 100 g soil. The soil samples ranged from poor to medium rich in terms of the available phosphorus content (1.6-7.3 mg per 100 g soil).

* *The term used to describe the soils is taken from the Systematics of Polish soils*

Dryopteris villarii (Bellardi) Woynar ex Schinz et Thell.

This species has been recorded recently as a new for Poland and the whole Carpathians (Piekos'-Mirkowa and Mirek 1988, 1989). It was found in one locality in the Western Tatra Mtns in the Swistówka Wielka above Wantule at an altitude of 1,360 m a.s.l. (Fig.2). It occurs in the subalpine belt which is considerably lower at this location as a result of the orographic factor. The only population appears to be extremely small, consisting of three individuals. These are growing in an open situation, on a slightly inclined north-facing slope (5°) in a postglacial hanging valley, on limestone block scree of fairly large boulder size. The rather moist soil, consisting of mineral grains intimately mixed with well-decomposed black humus, has developed in pockets among the boulders. *D.villarii* is associated with grassland species of the *Seslerietalia variae* order.

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Dryopteris carthusiana (Vill.) H.P.Fuchs

This is a very common fern which is widespread throughout the whole of Poland (Piękos'-Mirkowa 1979, 1988, 1991). It occurs frequently in the Tatra Mtns, mainly in the lower montane belt, but it also extends into the upper montane belt, reaching up to 1,570 m a.s.l. (Figs. 3 and 4). This species is most common in beech-fir forests (*Dentario glandulosae-Fagetum*), although it is also encountered in coniferous forest communities (*Abieti-Piceetum, Polysticho-Piceetum* and *Plagiothecio-Piceetum*), in the Carpathian alder woods *Alnetum incanae* and bog alder woods *Caltho-Alnetum* as well as in peat-bog vegetation. This species occurs on various slopes ranging from flat areas to steep mountain-sides with a wide range of aspects. It grows on moist or very moist soils (Fig.5) with a high content of humus. The great majority of soil samples (73% of 62 sites) contained 2.5-12.0 percent of organic C in their upper layers, whilst 21% of the samples had more than 12% organic carbon (Fig.6). In the majority of the soil samples (70%) the C/N ratio ranged from 10 to 15 (Fig.6). *D.carthusiana* occupies as a rule Rendzinas, Calcaric Cambisols and Eutric Cambisols (in 59% of sites) (Fig.7). Their upper layers are more or less acid (Fig.8), but the lower horizons showed neutral or alkaline reactions. In 36% of the sites sampled this species was found on the Dystric Cambisols, Haplic Podzols and Orthic Podzols (Fig.7), usually derived from granite (moraines) and, less frequently, from Flysch rocks and Jurassic schists. Within the whole profile, these soils showed acid or very acid reactions. The sampled soils were generally poor in available magnesium and potassium (Fig.9). They were also very poor in available phosphorus; in 65% of samples the P_2O_5 content did not exceed 3 mg per 100 g soil (Fig.9).

Dryopteris dilatata (Hoffm.) A. Gray

This species is encountered in Poland much less frequently than *D.carthusiana* (Piękos'-Mirkowa 1979, 1988, 1991). In the Polish Tatras it occurs in scattered localities within the lower and upper montane belts, extending up to 1,505 m a.s.l. (Figs.3 and 4). *D.dilatata* was found in four main forest communities: *Dentario glandulosae-Fagetum, Abieti-Piceetum, Polysticho-Piceetum* and *Plagiothecio-Piceetum*. It grows on mountain slopes of different inclinations, with various aspects. This species was found most frequently on moist and very moist soils (Fig.5) with a high content of humus. The majority of soil samples (81% of 24 sites) contained 2.5-12 percent of organic matter. The C/N ratio varied as a rule between 10 and 15 in 67% of the soil samples (Fig.6). This fern grows on various types of soils, such as Rendzinas, Calcaric Cambisols, Eutric Cambisols, Dystric Cambisols, Orthic Podzols and Haplic Podzols (Fig.7). Their reaction in the upper horizons were usually very strongly acid, with pH_{KCl} values below 4.5 in 77% of samples (Fig.8). These soils are rich in available magnesium (with more than 9 mg MgO per 100 g soil), medium rich to poor in potassium and poor to medium rich in phosphorus (Fig.9).

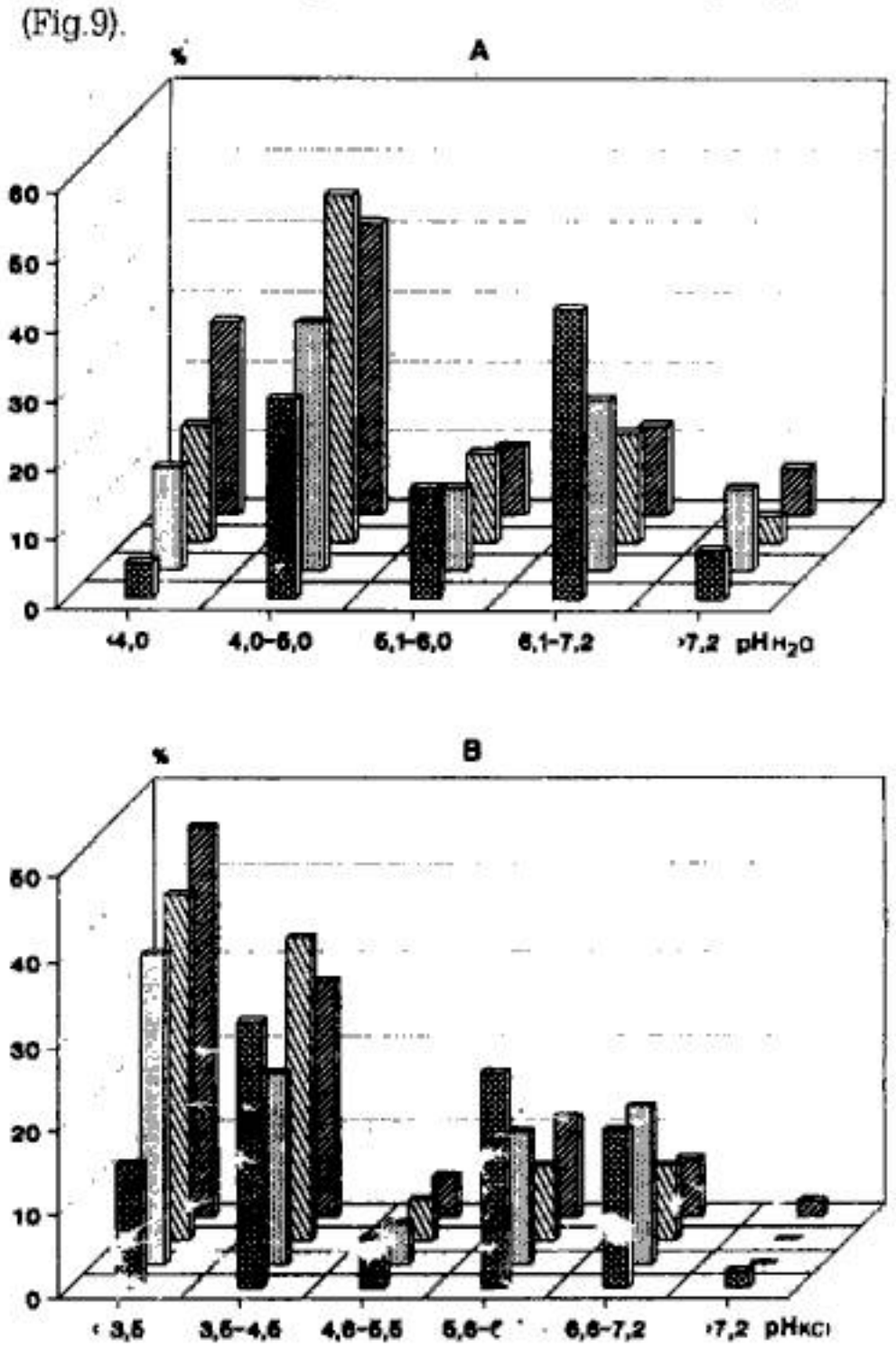

Fig. 8. Frequency of occurrence of *Dryopteris filix-mas* (a), *D.carthusiana* (b), *D.dilatata* (c), and *D.expansa* (d) on soils with varying pH values. A - pH in H_2O, B - pH in KCl .

Dryopteris expansa (C. Presl) Fraser-Jenkins et Jermy

This mountain species is scarce in the lowlands of Poland but is widespread throughout the whole Carpathians (Piekos'-Mirkowa 1979, 1988, 1991). It is one of the most common ferns in the Tatra Mtns occurring in abundance in the lower and upper montane belts as well as in the subalpine belt (Figs. 3 and 4). It extends to 1,720 m a.s.l. in the Polish Tatras and spradically to 2,098 m in Slovakian Tatras. *D.expansa* is a component of the herb layer in all forest and shrub communities found in the Tatra National Park. However, it is most common in associations of the class *Vaccinio-Piceetea* (i.e. *Abieti-Piceetum, Polysticho-Piceetum, Plagiothecio- Piceetum, Cembro-Piceetum, Pinetum mughi carpaticum*). It occurs in various places, from flat areas to very steep mountain slopes, usually with a northern aspects. This species was most frequently found on moist, very moist or wet soils (Fig.5). The majority of the soil samples (62%) had an organic carbon content of over 6 percent (Fig.6). The C/N ratio ranged from 10 to 15 in 51% of the soil samples, and

in 49%, the C/N ratio was over 15 (Fig.6). In 58% of the sample locations *D.expansa* was found growing on Dystric Cambisols, Podzolic Rankers, Orthic Podzols and Dystric Histosols (Fig.7). These develop over acid parent rocks (granites, gneisses, peats) and show a strongly acid reaction throughout the soil in profiles. In 46 % of soil samples the pH_{KCl} values were below 3.5 (Fig.8). Less frequently, this species grows on Rendzinas, Calcaric Cambisols and Eutric Cambisols (Fig.7) derived from carbonate parent rocks. These soils exhibited higher pH values in the lower genetic horizons. *D.expansa* generally occurs on soils that are poor in available potassium and phosphorus, while the magnesium content varies within rather wide limits (Fig.9).

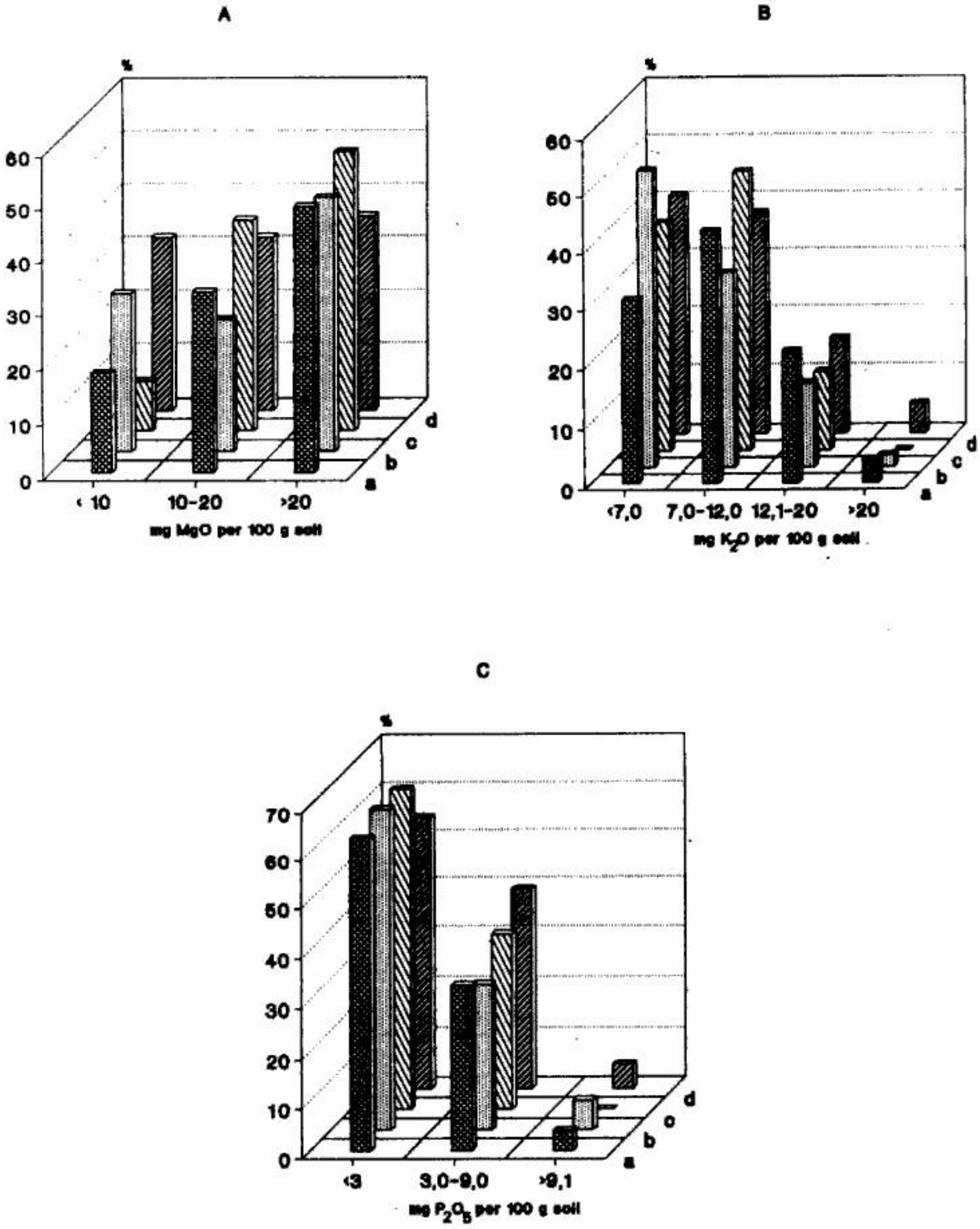

Fig. 9. Frequency of occurrence of *Dryopteris filix-mas* (a), *D.carthusiana* (b), *D.dilatata* (c) and *D.expansa* (d) on soils with varying content of available magnesium (A), potassium (B) and phosphorus (C) in the Tatra National Park.

Discussion

The studies revealed both similarities and differences in the distribution, vertical ranges and the habitat requirements of the six *Dryopteris* species occurring in the Tatra National Park. These are briefly discussed below. The studied species differ markedly both in their distribution in the Polish Tatras and in their vertical ranges. Of the six species studied, *D.filix-mas* and *D.expansa* are the most common species that are widespread from the foot of the Tatra Mtns to the alpine belt. *D.carthusiana* also appeared to be very common, although generally, it does not extend beyond the timberline. The three remaining species are much rarer.

The diagrams (Figs.5-9) showing data on the habitat conditions of particular *Dryopteris* species allow a comparison of their ecological requirements to be made.

The six species of studied ferns were found in places with different degrees of inclination from flat areas to very steep mountain slopes, and their occurrence is not related to an aspect. Soils on which these species grow were usually moist or very moist. Only *D.filix-mas* and *D.expansa* occurred sporadically on wet soils. The soils on which *Dryopteris* species appear tend to be rich in organic matter. Analysis of soil samples revealed that *D.filix-mas* and *D. expansa* grow on the soils with a high C/N ratio, indicating slightly decomposed organic matter, more frequently than the other species . Both these species occur frequently at higher elevations above sea level where the process of humification of organic matter is restricted by low temperatures and high humidity.

The six species grow on various types of soils, the properties of which depend mainly on parent rocks. Those soils that are derived from sedimentary alkaline rocks (limestones, dolomites, marls) comprise: Rendzinas, Calcaric Cambisols, Cambic Rankers, Eutric Cambisols, Eutric and Calcaric Fluvisols (Group I). The second group of soils which are derived from acid rocks (sandstones, granites, gneisses, peats) include: Dystric Cambisols, Podzolic Rankers, Haplic and Orthic Podzols and Dystric Histosols. The *Dryopteris* species studied can be arranged according to their increasing frequency of occurrence on soils of the first group (and hence decreasing frequency on soils of the second group) as follows:

D. filix-mas→D. carthusiana→D. dilatata→D. expansa.

The above mentioned species generally show a wide ecological amplitudes in so far as soil acidity is concerned. However *D. filix-mas* and *D. carthusiana* showed a preference for soils with higher pH values, whilst the two remaining species appear most frequently on soils with lower pH values. All six species occurred on soils with a wide range of magnesium content, which were poor in available phosphorus. All the samples had a medium or low potassium content. Two species, i.e. *D. filix-mas* and *D. expansa* occurred more frequently than the others on soils with a relatively higher content of available potassium and phosphorus, associated with higher accumulation of these nutrient components in the organic matter. *Dryopteris expansa* exhibited the widest ecological tolerance with respect to edaphic factors and soil types. It occurs in abundance in all main forest and shrub communities in the Tatra National Park. *D. filix-mas* also showed a wide ecological tolerance, although it occurred more freguently on soils derived from alkaline rocks. This species finds its optimum conditions in the beech-fir woods of the *Dentario glandulosae- Fagetum* association.

In conclusion, the results of the ecological studies on six *Dryopteris* species presented in this paper refer to the area within the Tatra National Park. Further studies of the *Dryopteris* species at locations throughout their ranges in Poland should be undertaken, to enable the full range of their ecological characteristics and requirements to be determined.

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