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

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**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 flex-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 are 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 (Piekos' and Paszek 1973; Piekoś 1974, 1975; Piekoś'-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 flex-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 Mts. The seventh species, *D. caesia*, 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).](image)

For the last fifteen years, detailed studies of the ecology of several dozen plant species have been carried out in the Pieniny Mts (Zarzycki 1976 a,b) and in the massif of Babia Góra (Borysuk 1984, Swed 1986), whilst the knowledge of the habitat requirements of vascular plants in the Tatra Mts 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 Mts.

**Material and Methods**

The distribution of *Dryopteris* species in the Tatra National Park is shown on maps (Figs. 2 and 3) which were
Fig. 2. Distribution of Dryopteris filix-mas (A), D. effinis (B) and D. ulianii (C) in the Tatra National Park.
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. *Dyopteris 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 ($\text{pH}_{\text{H}_2\text{O}}$) and exchangeable ($\text{pH}_{\text{CaCl}_2}$) 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 Thirn's method, general nitrogen content using Kjeldahl's method, available magnesium using Schacht-Haché'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 *Dyopteris* species are presented graphically. In the case of two species (*D. affinis* and *D. villari*) 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 *Dyopteris* species with respect to their distribution, vertical ranges, phytocenoses and floristic and edaphic factors.

*Dyopteris filix-mas* (L.) Schott

It is one of the most common and abundant ferns in Poland (Piekos-Mitkowa 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 *Dyopteris 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 in brackets.](image-url)
frequent in beechwoods where is associated with the *Denticano glandulosae-Fagetum* community, and it is rarely found in coniferous forest communities such as the Abiet-Fagetum, Piceo-Fagetum, *Piceo-Fagiotheca-Fagetum* communities. It also occurs infrequently in the *Picea abies* belt which is characterized by the *Fisetum nigrum-Carpinetum* community.

*D. filic-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 Entic Cambisols derived from limestones, dolomites and marls of various geological formations. These soils typically showed slightly acidic to slightly basic reactions in the deeper horizons, while the reactions in the rhizosphere varied within wide limits, from strongly acid to basic (pHc 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 P2O5 per 100 g soil (Fig. 9).

*Dryopteris affinis* (Lowe) Fraser-Jenkins

This species is much rarer in Poland than the closely related *D. filic-mas.* It occurs mainly in the Carpathians and appears to be associated with fir-spruce forest communities developed on acid soils (Murin and Mălovsky 1980; Păsărescu-Mărculeasa 1981, 1986). It is a rare plant in the Tatra Mts recorded hitherto from 12 localities (Fig. 2), all of which are in the lower montane belt,
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 5.9-6.6). The organic carbon content ranged from 4.3 to 25.2 percent and the C/N ratio from 14 to 18. 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 K2O per 100 g soil. The soil samples ranged from poor to medium rich in terms of the available phosphorous 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

This species has been recorded recently as a new for Poland and the whole Carpathians (Piekos-Mirkova and Mirek 1988, 1989). It was found in one locality in the Western Tatra Mts in the Swistocwka 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. villari* is associated with grassland species of the *Seslerietalia vulgaris* order.
Dropteris carthusiana (VII.) H.P. Fuchs

This is a very common fern which is widespread throughout the whole of Poland (Piekoś-Mirkowa 1970, 1988, 1991). It occurs frequently in the Tatra Mts., 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 (Dentaria glandulosa-Pagetum), although it is also encountered in coniferous forest communities (Abieti-Piceetum, Polysticho-Piceetum and Pfiagothecio-Piceetum), in the Carpathian alder woods Alnetum incanae and bog alder woods Calluno-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. 6) with a high content of humus. The great majority of soil samples (73% of 62 sites) contained 2.5-12.6 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. 8). 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 38% of the sites sampled this species was found on the Dystic Cambisols, Haplic Podzols and Orthic Podzols (Fig. 7), usually derived from granite (morenae) 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 P2O5 content did not exceed 3 mg per 100 g soil (Fig. 9).

Dropteris dilatata (Hoffm.) A. Gray

This species is encountered in Poland much less frequently than D. carthusiana (Piekoś-Mirkowa 1979, 1988, 1991). In the Polish Tatra Mts. it occurs in scattered localities within the lower and upper montane belt, extending up to 1,505 m a.s.l. (Figs. 3 and 4). D. dilatata was found in four main forest communities: Dentaria glandulosa-Pagetum, Abieti-Piceetum, Polysticho-Piceetum and Pfiagothecio-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. 8). This fern grows on various types of soils, such as Rendzinas, Calcaric Cambisols, Eutric Cambisols, Dystic Cambisols, Orthic Podzols and Haplic Podzols (Fig. 7). Their reaction in the upper horizons were usually very strongly acid, with pH 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 Dropteris dilatata a, D. carthusiana b, D. dilatata c, and D. expansa d on soils with varying pH values. A - pH in H2O, B - pH in KCl.

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

This mountain species is scarce in the lowlands of Poland but is widespread throughout the whole Carpathians (Piekoś-Mirkowa 1979, 1988, 1991). It is one of the most common ferns in the Tatra Mts 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 northwards to 2,096 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 association with the class Vaccino-Piceetos (i.e. Abieti-Piceetum, Polysticho-Piceetum, Pfiagothecio-Piceetum, Cambio-Piceetum, Pinetum mughghi carpathicum). It occurs in various places, from flat areas to very steep mountain slopes, usually with a northern aspect. 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. 5). 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 Ranks, 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 Rhodic 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. dilutata* (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 range, 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 Tatra 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 Mt. 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 6-9) 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 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 Rendzinas, 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, Podzoloc Cambisols, 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 forest and shrub communities in the Tatra National Park. D. filix-mas also showed a wide ecological tolerance, although it occurred more frequently on soils derived from alkaline rocks. This species finds its optimum conditions in the beech-fir woods of the Dentaria glandulosa-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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References


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