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Contribution to the environmental ecology of *Cryptogramma crispa* (L.) R. Br. ex Hooker in the Alps

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Abstract

We studied the habitat characteristics in a number of *Cryptogramma crispa* stations throughout the Alps. Our objectives were: (1) to define the environmental ecology of *C. crispa* in the southern part of its distributional area in Europe; (2) to test the reliability of ecological indicator values of soil reaction, nutrient and dispersion status, light and temperature for this species. The habitats of *C. crispa* mostly consisted in coarse-grained stable screes (on rock slide deposits, talus cones, talus sheets, stone fields and moraines), within a broad elevation range with maximum frequency in the subalpine and lower alpine vegetation belts. At higher altitudes, *C. crispa* was mostly found on South-exposed slopes with high potential irradiance, whereas at low altitude it was most abundant on North-exposed rather gentle slopes formed of big boulders. The screes colonized by *C. crispa* were formed of acid metamorphic rocks or igneous rocks and had a coarse texture. The soil accumulated in the spaces among boulders had sandy texture and acidic reaction, with medium to high carbon and total nitrogen contents. Calcium lacks entirely in the soil. Our field data gave support to the Ellenberg–Landolt ecological indicator values of light and temperature, but not to those of soil reaction and soil nutrient content, for which some changes are proposed.

Keywords: Scree; Fern; Radiation index; Surface stoniness profiles; Ecological indicator values; Alps

Introduction

Scree slopes are unstable as an effect of morphodynamic processes such as gelifraction, solifluction or gelifluction (Tricart and Cailleux, 1967). Tangential movements in scree slopes are brought about by gravity, freezing, avalanches, or runoff water, whereas vertical movements are essentially due to substrate cryoturbation (Somson, 1984). Geomorphologists have recognized three main categories of scree slopes: those being still active due to continuous input of rock fragments, those which are slipping (no longer active, but still unstable), and those 'at rest'. Within both active and slipping screes, substrate movement imposes stressful conditions upon the plants, which often result in strong disturbance effects from tissue damage to complete burial (Zöttl, 1951).

Resting screes, mostly originated by accumulation of boulders, offer a more stable habitat to the plants. The absence of stress induced by talus movements allows colonization of this habitat by not specialized species, including for example sward plants and ferns (Burnett,

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1964). In this habitat, the fine-grained material underlying coarse rock fragments usually has a high moisture content (Cox, 1933; Jenny-Lips, 1930; Peréz, 1998). This is due to the insulating action exerted by the cover of coarse debris and by the extensive network of air spaces among boulders, which reduce evaporative losses (Fisher, 1952; Tranquillini, 1964). The moisture content in the fine material can be further enhanced by shading effect of the boulders themselves.

Among the vascular plants colonizing stable scree slopes, one of the most representative species is the parsley fern *Cryptogramma crispa* (L.) R. Br. ex Hooker (= *Allosurus crispus* (L.) Röhling) (Adiantaceae). This fern grows on scree slopes on European and western Asian mountains (Bennert, 1999; Ferrarini et al., 1986). Other closely related taxa have been regarded either as distinct species, or as subspecies or varieties of *C. crispa* (Ferrarini et al., 1986; Kramer and Green, 1990; Pichi Sermolli, 1977; Windham, 1993). Overall, these taxa have a vast distribution area, including Himalaja, northwestern Asia, northwestern and southern America (Dostál et al., 1984; Hultén and Fries, 1986; Meusel et al., 1965; Windham, 1993).

Cryptogramma crispa has two main distribution centres in Europe: a northern one including the highest mountains in the British Isles and west Scandinavia and a southern one comprising Cordillera Cantabrica, Pyrenées, Massif Central, Corsica, the Alps and the northern Apennines (Jalas and Suominen, 1972). Within its distribution area, *C. crispa* occurs over a very broad altitudinal range, comprised between 20 m a.s.l. in Norway and about 2800 m a.s.l. in the Alps (Sato et al., 1989).

Cryptogramma crispa is a member of a biogeographic group of ferns mostly occurring in weakly oceanic to suboceanic climatic regions (Dierssen, 1996; Page, 1982). In the British Isles, the parsley fern is characteristic of areas with annual precipitation mostly exceeding 1600 mm, with at least 160 rainy days per year (Ratcliffe, 1968) and relatively cool summer temperatures. In these regions, mean annual maximum temperature usually is $<26\,^{\circ}C$ (Conolly and Dahl, 1970). At the highest altitudes, *C. crispa* requires a long-lasting snow cover, providing protection against extremely cold temperatures and desiccation (Rodwell, 1992).

The parsley fern is a strongly calcifuge species (Gjaerevøll, 1956), only growing on non-carbonaceous bedrocks. It generally avoids small-grained shifting talus in the active upper and central parts of screes, and is therefore most abundant along the flanks and at the lower edge of screes, where the debris generally are more stable (Rodwell, 1992). Here, the fern grows in spaces between the boulders, where fine-grained soil, rich in humus accumulates and the sheltered microtopography further enhances soil moisture content.

The habitat characteristics of *C. crispa* have been assessed for populations occurring in northern Europe (mostly in the British Isles), while little is yet known about the environmental ecology of this fern in its southern European distribution centre. In particular, the environmental ecology of alpine and central-European *Cryptogramma* populations has been firstly defined indirectly, through field observations (Frey, 1922; Jenny-Lips, 1930; Lüdi, 1921) and, more recently, through direct measures of some habitat factors for the populations occurring in the southern Germany (Bennert, 1999). Moreover, the environmental ecology of the parsley fern has been defined using ecological indicator values (Ellenberg et al., 1992; Landolt, 1977). We designed the present investigation considering that: (1) the environmental ecology of plant species can vary throughout their distribution area, due to both interrelationships between ecological factors and competition (Ellenberg et al., 1992; Landolt, 1977); (2) new calibrations, based on measured environmental variables, have changed the Ellenberg values for several species (Lawesson et al., 2003; Schaffers and Sỳkora, 2000; Thompson et al., 1993). Our primary objective was to characterize the habitat and to define the environmental ecology of *C. crispa* in the Alps. To this aim, we analysed a large set of field data on topographic and pedological variables and a smaller set of data on physical and chemical soil characteristics. A secondary objective was to test the reliability of both Landolt and Ellenberg indicator values of soil reaction, nutrient and dispersion status, light and temperature for our target species.

Materials and methods

Study area

Our study was conducted throughout the Alps, from the Maritime Alps to Niedere Tauern (Fig. 1). The Alps are comprised between 43° and 48°N and between 5° and 17°E, with a total area of ca. 200,000 km^2. This region is noted for its geological diversity, with a great variety of eruptive, sedimentary and metamorphic rock types, of Paleozoic to Neozoic age (see Dainelli, 1963; Dal Piaz, 1950; Veiret and Veiret, 1976). Climate also exhibits a very broad range of variation, mostly determined by the geographic position of the Alps at the interface of the Mediterranean, West European and Central European bioclimatic regions. At a large scale, climate is characterized by two horizontal (latitudinal and longitudinal) gradients. Moreover, a third sharp altitudinal gradient occurs at the local scale. Detailed data on climate in the Alps are in Rehder (1965), Fliri