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The C-S-R model applied to the flora of the "Isola Piana" of Stintino (NW Sardinia)*

Abstract

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The author reports on the results obtained by applying the CSR model to the flora of the Isola Piana (NW Sardinia). The R strategy, which includes the plant species which live in habitats with frequent disturbances and which are characterised by a short life cycle and abundant seed production is the most widely represented. The triangular arrangement has also been applied to the main systematic groups and in particular, to endemic species which, because they occupy particular ecological niches and differ for the strategy from the other species.

Introduction

The study of the flora of a territory includes, in addition to geological, pedologic, climatic and historical data, a detailed and comprehensive floristic inventory including a series of observations and notes made by the botanist in the course of his research. This list, which is organised according to specific classification systems, is then utilised in the discussion section to present and to highlight the botanical resources of the territory. This includes a detailed description of the floristic component divided into families and genera, a detailed list of endemic species or taxa presenting special interest from the point of view of plant geography, biological spectrum, chorological spectrum and finally some additional information considered useful by the author.

However, we may often notice that several authors (Couteron & Kokou 1997, Hunt & Cornelissen 1997, Médail & Verlaque 1997, Vidal & al. 1998, Greulich & Bornette 1999, Hodgson & al. 1999, etc.) interpret the flora of a site in a different manner, and analyse the rarity or the ecological features of some species by means of a classification system based on ecological preferences, and in particular on survival strategies (Grime 1977).

Indeed, among plants, as well as among animals, there are taxa perfectly specialised in the occupation of habitats that can be extremely difficult or even impossible to colonise for

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other species. The mechanisms which prevent certain plants from occupying these habitats can be interpreted on the basis of the different ecological requirements of the plant which already lives in this ecosystem with respect to the plant which is trying to occupy it. This approach was used by Grime (1974, 1979, 1984, 1985) who, studying the flora of a given area, interpreted the vegetation cover as the result of the balance established between the intensity of stress (interpreted as limitation to production), disturbance (physical damage to the vegetation cover) and competition (the attempt, by species living on the borders of a given population, to assault and occupy their location, that is the same resource unit). According to this author, stress and disturbance regulate the overall intensity of competition by restricting the density and vigour of the vegetation cover. Where stress and disturbance remain low, the result may be a single-species vegetation cover, while in those areas in which stress and disturbance are both very high the end result may even be the total absence of any type of vegetation.

On the basis of these remarks, we have applied the Grime model to the flora of the Isola Piana of Stintino (NW Sardinia; Gauss-Boaga: x=1434200, y=4536320; UTM=32TML3435), a well-defined territory whose floristic components and main aspects of vegetation landscape are well known.

Materials and methods

The materials used for this model are the 208 entities identifled on the island called Isola Piana of Stintino (NW Sardinia) whose flora and vegetation landscape have recently been the subject of a study (Bocchieri 1999) to which the reader is referred for additional data and description. Each of these entities was assigned a code, corresponding to its functional group, taken from the dichotomic list propounded by Grime (1979, 1984). This dichotomic key (the reader is referred to Grime's works for further information) is applied to the morphology of aerial parts, biological form, phenology, seed production and longevity of the leaves. In addition, the author of this paper drew on his personal knowledge of the ecology of the various taxa which grow on the island. The various strategies displayed by the different taxa were then counted and classified, according to the triangle proposed by Grime, by their general floristic component, most representative taxonomic groups, and endemic species. In order to facilitate the interpretation of the triangle, the model has been slightly modified, namely, the various percentages are represented graphically: they are shown as surfaces whose position and extension allow the reader to have a more rapid overall vision and, in particular, to better comprehend the strategies referred to the whole flora or to specific aspects of it, singly taken.

To make easier the reading of the model proposed by Grime, we would like to remind that the related abbreviations represent the type of strategy that the plants have in nature. To this purpose Grime has individualised three "primary strategies": the C strategy = competitive, the S strategy = stress tolerant and the R strategy = ruderal.

The C strategy, identifiable as a competitive kind, represents thoses group of plants specialised in subtracting resources to other plants. The S strategy includes plants which are adapted to habitats where the limiting factors are dominant. Finally the R strategy include plants adapted to environments where, generally, the factors of disturbance predominate.

These primary strategies are completed by four secondary strategies which represent

plants presenting intermediary adaptations: SC= stress tolerant-competitive; SR= stress tolerant-ruderal; CR= competitive-ruderal. Besides Grime has recognised the CSR strategy related to plants presenting an intermediary adaptation among the three primary strategies.

Results and discussion

The results obtained allow us to observe that the flora of Isola Piana mainly consists of entities which gravitate in the ruderal sector (Fig. 1), with tendency, which is at all events equidistant, towards stress-tolerant-ruderal species (SR) and competitive-ruderal species (CR). This type of strategy, together with the typically ruderal (R) one, is the most widespread on the island and represents over 80% of the entire floristic component.

These results agree entirely with the proposal made by Grime who included in the R strategy mostly herbaceous species, adapted to environments with frequent and intense disturbance, and which concentrate their rapid development in the short periods in which resources are available. Indeed, ruderal species devote almost all their resources to seed production and are characterised by brief blooming and production of a large number of seeds; they thus accomplish their vital cycle by exploiting to the full the short period of favourable conditions. Correspondence with Grime's model is moreover confirmed by the factors to which the island's environment is subjected. Indeed, trampling and grazing, which occur in a cyclical fashion, are currently the main external factors affecting plant life on the island. If we refer to biological forms, we may observe that over half of the species living on the island has an annual cycle; to these plants over 30% herbaceous entities must be added.

Fig. 1 also shows a tendency of the flora towards the S strategy (stress-tolerant) which includes a category of plants subject to environmental factors responsible for restrictions

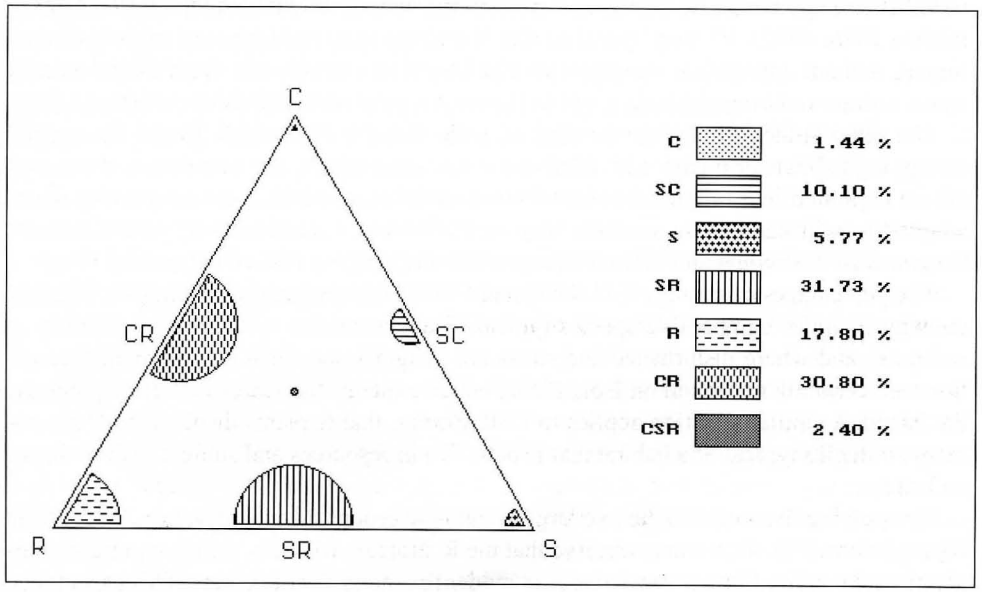

Fig. 1 — The CSR model applied to the floristic component of Isola Piana.

in plant productivity, such as scarcity of water or nutrients, or unfavourable climatic conditions. These are the conditions in which endemic species grow and succeed in surviving in a territory, thus making up its genetic features and conservation properties. Indeed, in Fig. 2 we may notice how this chorological category occupies ecological niches which are quite different from the other species. These results are in agreement with those obtained by Medail & Verlaque (1997) who analysed the strategies of the coastal endemic species in Southeast France.

The CR strategy, illustrated in Fig. 1 is also especially interesting: it includes species such as *Salsola soda*, *Silene gallica*, *Spergularia marina*, *Dactylis glomerata* and others. These entities, which at times possess notable allelopathic potential and high competitive ability, manage to occupy niches in which, in spite of disturbance, resources are more abundant. They are thus the most successful plant species: on the island, they are quite common and cover the largest extension. This is the case, for instance, of *Thymelaea hirsuta* which, while remaining low and at times also repent, it has high coverage indices, having colonised most of the southern sector of the island.

If we take into account CR and SR strategies, it is significant that the presence of these two groups on the island is quite similar in percent terms. This aspect should be taken into consideration within the dynamic of the vegetation cover, since, should disturbances or interferences be eliminated, CR-strategy species could overcome various SR species, which, as we have already noticed, make up approximately 50% of endemic species. Among the disturbances which are expected to disappear we may mention grazing, which should cease from the year 2000. With the elimination of this type of disturbance, CR species, which are particularly sought by herbivourous animals, would no longer be grazed, and would therefore overpower SR species, limiting the space and resources at their disposal. In this case, CR strategy species would become dominating, while those with SR strategy would be placed in a subordinate role or would be doomed to disappear (Grime 1986, 1987). We may speculate that if grazing were suddenly and entirely discontinued, without appropriate management and long term control, this event might actually cause serious and irreparable damages to the most typical components of the island's flora.

The other strategy found in the flora of Isola Piana is SC, which groups the species occupying habitats or niches with fairly good resources which, due to constant stress cannot be exploited in a rational manner. Consequently, these niches are occupied by plants adapted to withstand these stresses, such as *Halimione*, *Camphorosma*, *Arthrocnemum*, *Ranunculus*, *Limonium* and various others which account for 10% of the overall flora.

The percentages of strategy C (1.44%) and CSR (2.40%) plants are negligible. The first strategy includes competitive species typical of environments with great availability of resources and where disturbance and stress are insignificant. Such environmental conditions are certainly not found on Isola Piana, which explains the scarcity of these plants on the island. A similar situation applies to CSR species, that is plants displaying all the primary strategies typical of a habitat that is both rich in resources and subject to disturbance and stress.

By applying the model to the two large taxonomic groups, Monocotyledons (Fig. 3) and Dicotyledons (Fig. 4), we may observe that the R strategy, which as we have noticed characterises the entire flora, is particularly in evidence among Dicotyledons. This aspect may be explained by the fact that Monocotyledons have specialised, at least on Isola Piana, in

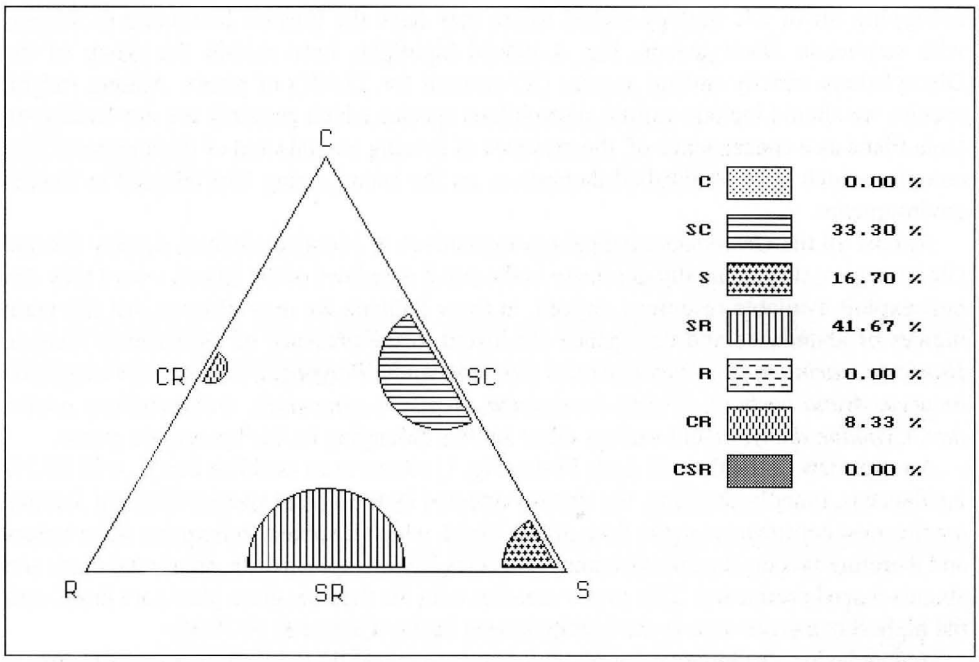

Fig. 2 — The CSR model applied to the endemic species of Isola Piana.

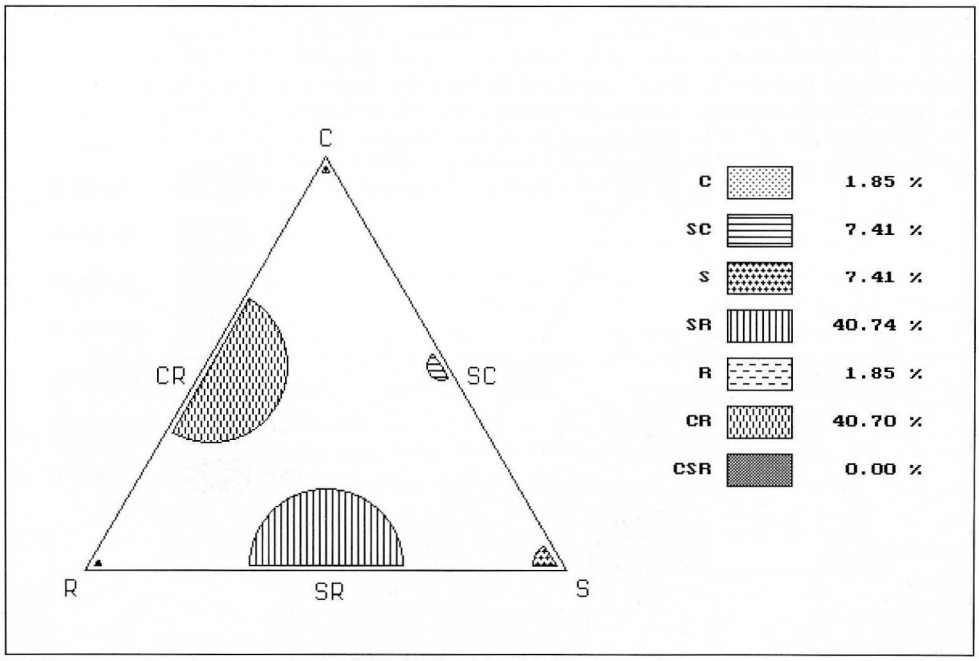

Fig. 3 — The CSR model applied to Monocotyledon plants on Isola Piana.

occupying SR or CR strategy niches where they have the greatest likelihood of success with respect to Dicotyledons. Fig. 4 indeed highlights how, within the group of the Dicotyledons, strictly ruderal species (R) account for 23.50% of plants. Among ruderal species we should include various nitrophilous species which certainly are not lacking on Isola Piana as a consequence of the presence of grazing animals and of the numerous bird colonies which have established themselves on the island, being best adapted to ruderal environments.

Almost all the *Gramineae*, typical representatives of Monocotyledons, display SR and CR strategies; they generally dominate in the small meadows of the island, where they can best exploit available resources. Indeed, in these habitats we may observe that the main indices of abundance and dominance are linked to the presence of *Desmazeria marina*, *Hordeum marinum*, *Hordeum murinum* ssp. *leporinum*, *Polypogon maritimus*, *Parapholis incurva*, *Avena barbata*, *Bromus hordeaceus*, *Aegilops geniculata*, *Anthoxanthum aristatum*, *Cynodon dactylon* and various other entities belonging to this taxonomic group.

An overview of the flora of Isola Piana (Fig. 1) allows us to establish that R, with 80.3% incidence is, broadly speaking, the strategy adopted by most plant species. Ruderal features are the most conspicuous in the flora of this island, which is subject to frequent disturbances and therefore favours the establishment of species having rapid growth, short vital cycle and abundant seed production. This aspect matches with the fact that grass plants are those with the highest expansion rate in the Mediterranean basin. (Quezel & al. 1990).

In conclusion, we believe that it should be recognised that the application of Grime 's triangular model offers a new approach and an attempt to interpret the flora of a territory

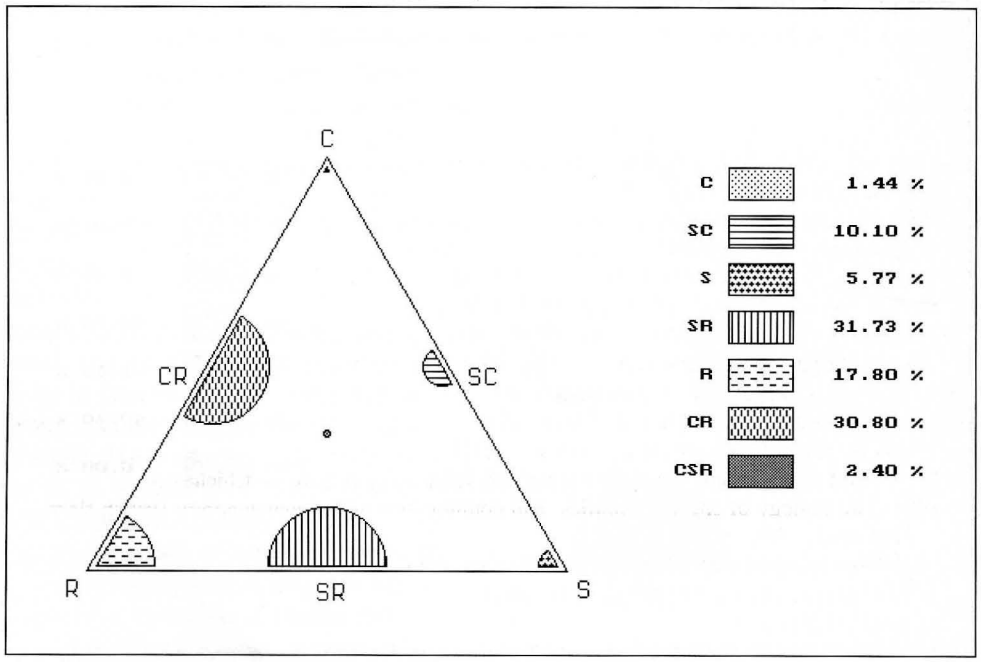

Fig. 4 — The CSR model applied to the Dicotyledons of Isola Piana.

with the aim of providing useful additional data for the conservation and/or preservation of the botanical patrimony. A particularly meaningful aspect is the identification of the survival strategy which, in the framework of plant communities must be aimed at minimising competition and promoting coexistence. Favouring the diffusion of dominant species has negative effects on the vitality of the others entities; indeed, damaging actions, the appropriation of resources, emissions of phyto-toxins and creation of substrata that allow the growth of epiphyte or parasitic species are the negative effects which dominant species have on their neighbours. The CSR model allows us to identify, albeit in general terms, the potentially dominant species which, due to stress, ruderality and competition may alter the floristic component, forcing species of significant phyto-geographical relevance to occupy increasingly poor and limited niches. If we could foresee these events, we would probably be able to avoid the failed findings or even the disappearance of various species which occurred on some small islands of the Sardinian coast, where over 130 previously reported species where no longer found on subsequent explorations (Bocchieri 1998).

Finally we believe that the triangular model proposed by Grime allows to explain the vegetable cover of a site in a different way than the traditional methods, while it should not be forgotten that other parameters, such as the forms of growth and the ecological elements, are essential to appraise the importance of the floristic components of a site.

Besides, we want to remember that this metod was elaborated using plants that lives in different ecological situation as regard on the mediterranean climate.

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