The flora of the Apuan Alps (Tuscany, Italy): survey of biosystematic investigations

Authors: Garbari, Fabio, and Bedini, Gianni

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FABIO GARBARI & GIANNI BEDINI

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Abstract

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After a brief review of the floristic exploration of the Apuan Alps, the authors report on the most significant cytotaxonomic and systematic research and population analyses on endemic or phytogeographically interesting plant taxa of that area, contributed by Pisa botanists in the last 35 years.

Key words: botany, cytotaxonomy, endemism, floristic investigation, University of Pisa.

Introduction

The Apuan Alps are an isolated mountain massif, which is adjacent to, but distinctly separated from, the Tuscan Apennines and is delimited by the rivers Magra, Aulella and Serchio in the North, East and South, respectively, and by the Versilian plains and the Thyrrhenian Sea in the West. The Apuan Alps occupy an elliptical area of about 55 × 25 km, the main axis being oriented NW-SE. The highest peaks (Monte Pisanino, Monte Cavallo, Monte Tambura, Pizzo d'Uccello) reach almost 2000 m. The area has a great variety of rocks and soils (Carmignani & al. 2000) and is well known for its marble quarries since Roman times. The climate, too, is very variable, both over the seasons and at the different altitudes and aspects.

Therefore, flora and vegetation are very diverse and have attracted botanists for a long time, as Pichi Sermolli (1999) shows in his history of the floristic exploration of the Apuan Alps: Luca Ghini (1490-1556) and his herbalist Luigi Anguillara (1512-70) are known to have ascended Mt Pania on 4 July 1545, where they collected *Hypericum coris* before bad weather drove them back. Ghini's student Andrea Cesalpino (1525-1603) visited, among many places, Montignoso, where he reported *Euphorbia dendroides*. In 1553 Ulisse Aldrovandi (1522-1605) went on collecting expeditions to the Apuan Alps and the Apennines. Paolo Silvio Boccone (1633-1703), from Palermo, well known author of "Museo di piante rare" in 1684, also collected plants from the Apuan Alps, at the orders of grand-duke Ferdinand II.

Among the early students of the flora of the Apuan Alps are also the Florentine Bruno Tozzi (1656-1743), monk in Vallombrosa, the famous Tuscan abbey, who was in touch with renowned botanists and naturalists of the 17th and 18th century, such as Pier Antonio Micheli (1619-1737), father of modern mycology, and his disciple Giovanni Targioni-Tozzetti (1712-83), author of 17 manuscript volumes entitled "Selva di notizie spettanti all'origine dei progressi e miglioramenti delle Scienze fisiche in Toscana" [Notes on the origin of the progress and improvements of Natural Sciences in Tuscany], as well as of "Relazioni" (Targioni-Tozzetti 1768-79) of his travels in Tuscany.

Domenico Vandelli (1691-1784), famous geographer and mathematician, father of the homonymous Domenico Vandelli (1732-89) – teacher in Padua, scholar of the Veneto flora and founder of the Coimbra Botanic Garden in Portugal – contributed remarkably to scientific knowledge of the Apuan Alps after building the road linking Modena (in the Po valley) to Massa (on the Tyrrhenian coast at the foot of the Apuan massif), thereafter dedicated to him as "Via Vandelli" (Pellegrini & Pozzi 1989, Moggi 2004). Fulgenzio Vitman (1728-1806), monk in Vallombrosa as Bruno Tozzi, in 1772 collected 440 specimens in the Tuscan-Aemilian Appenine and the Apuan Alps. He is better known for establishing the Brera Botanic Garden in Milan in 1781. Domenico Viviani (1772-1840), from La Spezia, the curator of Clelia Durazzo Grimaldi's Botanic garden in Genoa, was the author of several Apuan species such as *Centaurea arachnoidea*. We also have to mention Antonio Bertoloni (1775-1869), author of "Flora italica" in ten volumes (Bertoloni 1833-56) and also of many Apuan species, and his son Giuseppe (1804-78). The pharmacist Antonio Bottari (1780-1853), brother of Giovan Battista, physician of Maria Luisa of the royal house of Bourbon, had met Antonio Bertoloni and collected many plants on the Apuan Alps, which are nowadays kept in Bertoloni's herbarium at Bologna (BOLO).

Of the nineteenth century, two botanists must be reminded: Emilio Simi (1820-75), author of "Flora Alpium Versiliensium" (Simi 1851), and Stefano Sommier (1848-1922), the first botanist who climbed the top of Mt Procinto, in 1886, where he discovered *Rhamnus glaucophylla*.

In the twentieth century, the Tuscan botany school began its investigations, starting with Alberto Chiarugi (1901-60), followed by his disciples Giuseppe Martinoli (1911-70) and Francesco D'Amato (1916-98). An eminent specialist for the Apuan botany was Erminio Ferrarini (1919-2002), at first teacher at the Scientific Lyceum of Carrara and later professor of Phytogeography at the University of Siena. He produced the three volumes of "Prodromo alla Flora della Regione apuana" (1994-2000), the first volume co-authored by D. Marchetti (Ferrarini & Marchetti 1994), the second with R. E. G. Pichi Sermolli, P. Bizzarri and I. Ronchieri (Ferrarini & al. 1997), the third by E. Ferrarini alone (Ferrarini 2000).

Also pteridologically the area is well studied: a first list (Pichi Sermolli 1970) was recently updated by Marchetti (2004). A contribution on the bryophytes was made by Cortini Pedrotti & al. (1991) after the revision of many Apuan specimens; it was followed by "Flora dei Muschi d'Italia" (Cortini Pedrotti 2001).

The Apuan Alps have been the subject of several popular floristic books, e.g., Ansaldi & al. (1994), which describes the showy flowering plants, unfortunately with many mistakes, and Narducci & Petrucci (1996), on selected macromycetes. Both were published by the Regional Park of the Apuan Alps, established in 1985 by regional law and enclosing most of the area. The Park issues also a periodical, Acta Apuana, with interesting notes on geological, botanical, zoological and other subjects.

Contributions of the Pisa school of botany

In the wake of the tradition initiated in Pisa by Alberto Chiarugi, the studies on the Apuan flora were continued by the senior author, who introduced cytotaxonomic methods to develop a typology of endemic plants, based on the classification of Favarger and his collaborators (Favarger & Siljak-Yakovlev 1986).

These investigations have contributed to an understanding of the history and cytogeography of the endemic Apuan taxa and have shed light both on the conservative component of this flora,

represented by palaeoendemics and patroendemics, and on the innovative, active element represented by schizoendemics and apoendemics (Bechi & al. 1996b).

The remarkable near-endemic *Globularia incanescens* is assigned to the category of the palaeoendemics. Its range extends to the neighbouring northern Apennines and southern Liguria, reaching sea level and expressing a remarkable ecological fitness, which deserves further ecophysiological investigation. It is a clearly isolated taxon, which even has been treated as a distinct genus, *Carradoria* DC., and is the only species of *Globularia* producing the flavon quercetin and showing a linear rather than a bifid upper lip, a character fixed in homozygosis. This diploid, markedly thermophilous species appears to have been differentiated in the early Pleistocene. Molecular studies would be helpful to confirm these results and also to place this Apuan species in the phylogenetic framework developed for the genus (Comes & Kadereit 2003).

Another noteworthy palaeoendemic is *Salix crataegifolia,* restricted to the Apuan region where it is frequent in the central and northern part of the massif, preferably on shady calcareous, rarely siliceous cliffs. It is considered one of the most interesting willows in Europe, because of its pendulous catkins and the vascular bundles of periphloematic concentric type, which are interpreted as primitive characters, forming a phylogenetic link to the genus *Populus* (Bechi & al. 1996a).

Athamanta cortiana, a strict Apuan endemic, growing only on higher peaks above 1700 m, is represented by populations of few individuals on cliffs and screes, preferably on limestone (Di Fazio & al. 2004). According to Tutin (1968), this species is closely related to *A. densa* Boiss. & Orph. from Albania and Greece. Morphological and structural characters of its mericarps link it also to *A. vestina* and *A. cretensis* occurring in the southern European mountains from eastern Spain to former Yugoslavia. The plesiomorphic characters of the fruit support the hypothesis that it is a patroendemic unit with respect to the corresponding taxa in the Alps. The plant is one of the few species of EU interest in the Tuscan flora: it is included in the Annex II of the Habitat Directive (92/43/CEE), as well as in the Red book of the Italian flora (Conti & al. 1992) and in the Tuscan Red list (Conti & al. 1997). Another unit interpreted as patroendemic is *Polygala carueliana* (Bennet) Caruel, a strictly Apuan calcicolous, thermoxerophilous species showing morphological affinities with *P. serpyllifolia* J. A. C. Hose from Central Europe.

A schizoendemic taxon, orginated through progressive differentiation from a common ancestor, is *Astrantia pauciflora* Bertol. subsp. *pauciflora,* endemovicariant of *A. minor* in the Alps. Its relationship with the Central Apennines triploid *A. tenorei* (Bechi & al. 1996b) is not yet solved. Another example of progressive differentiation interpreted as schizoendemism is *Buphthalmum salicifolium* subsp. *flexile* (Bertol.) Garbari, related to *B. salicifolium* L. subsp. *salicifolium,* from which it can be distinguished by characters showing a clinal variation from the E Alps to the Apuan Alps. They merit investigations by more advanced techniques (see Vargas 2003) to shed light on the phylogeography and on the time of migration of these plants into the Apuan district.

The Pisa botany school has also investigated the demography of rare species, either endemics or relics, in order to contribute to their in situ and ex situ conservation (Vaira & al. 2005). For this aim, a protocol was signed by the Department of Botanical Sciences of Pisa University and the Regional Park of the Apuan Alps in order to choose priority species, study their current status, ecological requirements, reproductive biology and risk factors, and suggest the most appropriate protection measures. A first communication about this research program was given during the XI OPTIMA meeting in Belgrade (Bedini & al. 2005).

The senior author has dealt with karyology, cytotaxonomy and biosystematics of the Apuan flora since 1969 (Garbari 1970), thanks to support by the Italian National Research Council, which allowed to establish a laboratory and to arrange field excursions and trekking and climbing expeditions to the attractive cliffs of many famous Apuan peaks, which are true climbing schools (Mariani 1986). One of the most interesting peaks, both from an alpinistic and a botanical point of view, is Mt Procinto. As already stated, it was visited by Sommier in 1886 and subsequently became a popular destination for botanists and naturalists from Italy and abroad. Werner Greuter arrived here 30 years ago on an excursion with André Charpin, Hervé Burdet, Pierre Haynard and a group of Swiss students, led by the senior author. Its summit is a small botanic garden, rich in en-

demic species; its cliffs are a refuge or a preferential habitat for several chasmophytes. Some of these need further investigation in order to clarify yet unrevealed aspects. The above cited *Rhamnus glaucophylla* is a stenochorous, calcicolous and xerophilous chasmophyte, exclusive of the Apuan Alps and of the neighbouring Lucca Apennine. Vent (1962) considered it a representative of the Tertiary flora, which survived the Quaternary glaciations. Since it is a diploid sharing morphological characters with *R. alpina* and the oriental species *R. fallax* or *R. sibthorpiana,* it is unclear if it should be regarded as a palaeoendemic or a schizoendemic, on the basis of the possible organographic and karyologic correlations. The students on their way to the foot of Mt Procinto, several years ago, were impressed to see how the plant was able to grow on vertical cliffs apparently lacking any cracks, with proximal branches showing the same colour as that of the rock on which it was growing.

The case of *Rhamnus glaucophylla* contrasts with another endemic of Mt Procinto, *Sesleria tuzsonii.* Sommier collected it in 1894 and Ujhely (1940, 1959) described it as a separate taxon, but controlled cultivation of plants collected from the locus classicus and from other stations led to the conclusion that the name should be regarded as a synonym of *S. autumnalis* (Bechi & Garbari 1996).

In cracks and fissures facing east and in small karstic holes of Mt Procinto one can find the elegant *Veronica longistyla*, based by Ball in 1850 on specimens collected by himself in 1844 on Pania della Croce, one of the highest and most imposing peaks of the Apuan Alps, and then deposited in Kew (K). Karyological investigations revealed that this unit has the same diploid chromosome number as *V. aphylla* from the Alps, but capsule shape, pollen size and style length differentiate the Apuan unit from its Alps counterpart (Bechi & al. 1996a). The subspecific rank used by Arcangeli in 1882 is in our opinion the most appropriate, but more sophisticated analyses might point out a large genetic distance and suggest a reconsideration of its taxonomic rank.

In the forest below Mt Procinto a *Senecio* of the *S. nemorensis* group grows, which was described by Tausch in 1828 and classified as *S. nemorensis* var. *apuanus* by Fiori (1928). Experimental data are lacking to support the adequacy of the rank so far proposed, and the type specimen, probably kept in PRC (Bechi & al. 1996a), has not yet been restudied. The characters of this *Senecio*, diploid like *S. nemorensis*, the strong, curly indumentum of the leaves and the villose-glandulose inflorescence, suggest subspecific rank.

Cerastium apuanum Parl., a diploid previously considered a variety of *C. arvense* s.l., must be excluded from that aggregate because characters of the reproductive structures point out affinities with *C. etruscum* distributed in Tuscany and in northern Latium, and with *C. hirsutum* of Campania, Calabria and Sicily (Bechi & al. 1992). As confirmed by karyological investigations on the group (Bechi 1998), diploid, tetraploid and hexaploid cytotypes are known for the *C. arvense* group, which led some authors to interpret *C. apuanum* as a member of the *C. arvense* complex. *C. apuanum* is an example of the difficulty to adopt a taxonomic hierarchy adequate to accomodate a highly complex systematic situation.

Until the early 1970s, a tiny calcicolous *Galium,* living in cracks of rocks or on debris with small pebbles, was identified as *G. pyrenaicum* var. *olympicum* by all Italian botanists. Distributed in sizeable populations on the Apuan Alps, it is also present on some mountains of Campania and Calabria. Its range is fragmented. F. Ehrendorfer set out to clarify the real nature of this plant, which belongs to the group of eastern diploid *Galium* sect. *Orientigalium* Ehrend., which spread and differentiated during E-W migrations taking place in the Tertiary (Ehrendorfer & Schönbeck-Temesy 2005). This species, named *G. palaeoitalicum* Ehrend., was carefully analyzed by the researchers in Pisa as regards anatomical aspects of vegetative structures, reproductive biology and karyology. Karyological data confirmed the result of Ehrendorfer (1971) and Ehrendorfer & Krendl (1974) that the chromosome number is $2n = 20$ instead of $2n = 22$, the typical number of all corresponding eastern and western taxa of this group. It was also found that one chromosome pair of *G. palaeoitalicum* shows a much larger size than the others, supporting the hypothesis that the descending disploid number is the result of a centric fusion. This supports the hypothesis that this entity is an apoendemic (Bechi & al. 1996b).

Many problems are still awaiting a solution through the finer methods of molecular investigations. As an example we may cite the research on the presumed phyletic links between the highly polyploid unit *Centaurea montis-borlae* Soldano, a calcicolous lithophyte exclusive of Mt Borla and adjacent calcareous plateaus, with *C. procumbens* Balbis of the surroundings of Nice and *C. balbisiana* of the Maritime Alps. Because of its extremely restricted range and the risk from bushfires and quarrying activities, as well as the low number of fertile fruits partly eaten by insect larvae, this species is critically endangered (Vaira & al. 2005). In agreement with the Regional Park of the Apuan Alps, this species is constantly monitored in the framework of an integrated in situ-ex situ conservation programme carried out with the aid of the germplasm bank of the Botanic Garden of Pisa.

Recent results

It is striking that the Apuan Alps, despite an extensive exploration by many botanists and naturalists over 400 years, still offer new floristic records. In 2001, a *Silene* previously ascribed to *S. graminea* or *S. vallesia*, was identified as a distinct, new species named *S. pichiana* by Ferrarini & Cecchi (2001) and systematically linked to species of S France (*S. petrarchae* Ferrarini & Cecchi) and the central Apennines (*S. cattariniana* Ferrarini & Cecchi of Abruzzo). In the genus *Biscutella*, the Apuan plants previously ascribed to *B. laevigata* var. *ambigua* have been reassigned to a new strictly endemic species named *B. apuana* (Raffaelli & Fiesoli 1993), a calcicolous lithophyte of scattered thickets, grasslands and debris. Another example is *Pinguicula reichenbachiana*. It was previously considered a subspecies of *P. longifolia* Ramond, but its taxonomic and nomenclatural position will be probably reconsidered in the light of the surveys being conducted by J. Casper in the Apuan Alps and in the neighbouring Apennines with the collaboration of Pisan researchers.

The constant attention of botanists in Pisa to the Apuan territory continues to uncover new findings, thus attesting the significance of the area. Recently Ansaldi & al. (2003) have discovered a population of *Rhododendron ferrugineum,* hitherto unknown from the area and very rare in the neighbouring Apennines, strangely at an altitude of only about 500 m, on Palaeozoic phyllites in a woody environment where a population of about 40 individuals lives on a nearly vertical cliff, thus excluding intentional cultivation. Habitus and leaf anatomy, currently under investigation, suggest the existence of differences with the Apennines and Alps populations. Its presence may be related to the migration of orophilous floristic elements into lower altitude during the last glaciation.

Probably linked to the same glaciation processes are the relic *Sphagnum* communities, which are currently being inventoried. They attest to the diffusion of environments with specialized substrate and climatic conditions, which maintain a microthermic florula (Amadei & Guazzi 2005). The communities included new stations for taxa of this important bryophyte group.

Fritillaria orientalis Adams is the newest finding of relevance. We found the species at the beginning of April 2005 on pillow lavas of Mesozoic basalts of Piazza al Serchio, at about 600 m. It is new for the Apuan area and very rare on the Apennines massif (Garbari & Betti 2005). Karyological analyses are in progress to look for accessory chromosomes, as are already found elsewhere in the species (Moore 1982). The Apuan plants are particularly robust and have multiflorous scapes, generally with 3-4 flowers.

Concluding remarks

Results of biosystematic research are of value also for the development of management and land use plans for the Apuan territory, much needed for the preservation of its very significant phytogenetic resources. In this way the strong cooperation between the Department of Botanical Sciences of Pisa University and the Regional Park of the Apuan Alps is very fortunate, as it facilitates both scientific research and environmental safeguard programmes. The protocol will be operative for the next years and will allow a continuation of research and an increasing geobotanical knowledge of the territory, for the mutual benefit of both institutions.

The present contribution is dedicated to Werner Greuter, who explored the Apuan Alps for the first time 30 years ago and whose scientific collaboration the senior author enjoys even longer (see Garbari & Greuter 1970). We wish that in September 2007, when Pisa will host the XII Meeting of OPTIMA, we can show up with further discoveries from this territory, in the hope that Werner Greuter and his friends may visit again the area that had so much attracted his attention before.

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Address of the authors:
Prof. Dr Fabio Garbari and Dr Gianni Bedini, Department of Botanical Sciences, University of Pisa, Via L. Ghini 5, I–Pisa, Italy; e-mail: garbari@dsb.unipi.it, gianni@dsb.unipi.it