

Checklist of the vascular flora of the “Piani di Montelago” (Marche, Italy)

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Abstract

This study aims to provide a checklist of the vascular flora of the Piani di Montelago (Marche, Italy), a wetland of high conservation interest, by integrating historical records with data collected in a dedicated survey, and assess the changes in the occurrence of taxa of conservation interest over the last few decades. The floristic list consists of 481 specific and subspecific taxa, belonging to 65 families and 263 genera. Two taxa are floristic novelties to Italy (*Taraxacum subalpinum* and *T. porrigentilobatum* group), and six are new to the Marche regional flora (*Carex paniculata* subsp. *paniculata*, *Hypericum perfoliatum*, *Lophiolepis eriophora*, *Mentha arvensis*, *Taraxacum friscum*, and *T. olivaceum*). Twenty-one taxa are included in the IUCN Red List of the Italian Flora, six of which were not found in our survey. Among the taxa that were not found, 17 are typical of wetlands or are interesting from a conservation viewpoint. Most of these floristic losses can be traced back to the anthropogenic alterations that occurred in this wetland between the 1960s and 1970s.

Keywords

Central Apennines, endemic species, Herbarium CAME, nature conservation, wetland

Introduction

This study refers to the “Piani di Montelago”, a mountain district in the Umbria-Marche Apennines (Province of Macerata, Marche, Italy), characterised by the occurrence of wetlands and meadows of high conservation interest that host a flora and a

vegetation of great significance, including species and vegetation types that are rare and of biogeographic relevance (Pedrotti 1965, 1971, 1982; Ballelli et al. 1981).

The floristic value of the “Piani di Montelago” is known thanks to plant collections and vegetation studies carried out by the botanists of the University of Camerino, V. Marchesoni, F. Pedrotti, and S. Ballelli. Marchesoni collected most of the samples in the early 1960s (Ballelli et al. 2005); they are stored in the Herbarium Universitatis Camerinensis (CAME) and in the Herbarium Centrale Italicum (FI). Pedrotti collected specimens, stored in CAME, within phytosociological surveys and cartographic studies (Pedrotti 1966, 1967, 1976), providing most of the floristic records over the 1960s. Ballelli collected most of the specimens, stored in CAME, between the 1970s and 1980s. Other minor collectors were D. Lucarini, F. Maggi, and R. Venanzoni (CAME). Moreover, Pedrotti (1971, 1976, 1982, 2008), Giordano and Pedrotti (1976), Ballelli et al. (1981), Canullo and Venanzoni (1984), Venanzoni (1986), Buchwald (1992, 1994), and Klaver (2019) reported the occurrence of rare taxa, of biogeographic interest.

To date, a comprehensive inventory of the vascular flora of this area is lacking. The objectives of this study are therefore to: i) compile a checklist of the vascular flora of the Piani di Montelago by integrating historical data from the literature and herbarium specimens, with recent records obtained through a dedicated survey conducted over the past five years, and ii) assess changes in the occurrence of taxa of conservation interest over the past 65 years.

Study area

The study area is located in the upper valley of the River Potenza (Umbria-Marche Apennine ridge, Marche Region), and extends over approximately 1.7 km² (43°06'48"N, 12°58'30"E, coordinate system UTM-WGS84; Fig. 1). Situated in the western sector of the Province of Macerata at about 900 m a.s.l., it is almost entirely within the Municipality of Sefro, with a small part belonging to the Municipality of Camerino. The area occupies an inter-mountain basin composed of two plains; the upper one, called “Piano superiore” (upper plain), is located at about 920–930 m a.s.l., the lower one, called “Piano inferiore” (lower plain), is at about 890–900 m a.s.l. These two plains are collectively known as “Piani di Montelago”.

Climate

The study area falls under the sub-Mediterranean variant (very weak sub-Mediterranean) of the Temperate macroclimatic region, characterized by cold winters and dry summers (Pesaresi et al. 2017). The thermotype is lower Supratemperate; the ombrotype is upper humid (Pesaresi et al. 2017). The mean, maximum, and minimum annual temperatures are 13.2, 18.4, and 7.9 °C, respectively. The cold stress period—defined by Mitrakos (1982) as the number of months in which the mean minimum monthly temperature is lower than 10 °C—lasts eight months (from January to May and from October to December, with maximum intensity between January and March). The mean annual rainfall and the mean summer rainfall are 1344 mm and 188 mm, respectively. The growing

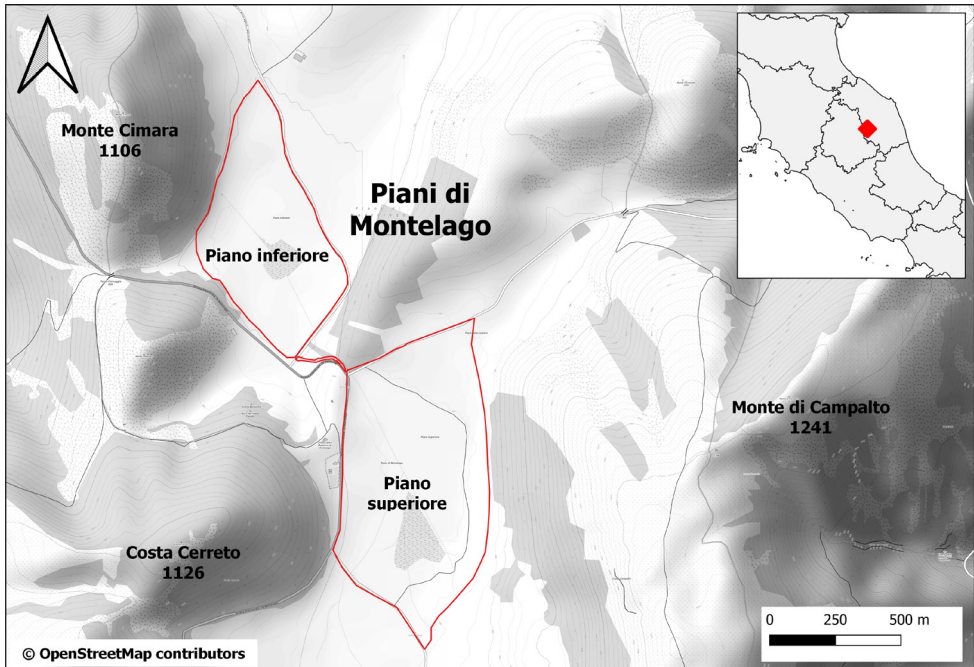


Figure 1. Boundaries of the study area (shown in red) and its location in Italy (red symbol in the top-right inset). Data extracted from OpenStreetMap are licensed under the Open Database License (<https://www.openstreetmap.org/copyright/en>).

season (i.e. the number of days with minimum temperatures above 6 °C) extends from May to October. Climatic data, drawn from the Sorti meteorological station located near the study area, refer to the period 2021–2024 and should be regarded as preliminary only, as the standard reference period for climate analyses is 30 years (data retrieved from <https://scia.isprambiente.it/servetsdailyutm/serietemporalidaily400.php#Help>).

Geology, geomorphology, and hydrology

The Piani di Montelago, surrounded by calcareous Apennine mountains, are closed basins of structural and tectonic origin affected by karstic erosion, whose bottoms are covered by clayey deposits and impermeable rock layers (Pierantoni and Invernizzi 2008). Along the outer edge of the lower plain, there are some sinkholes, which collect the surface water through a system of canals and ditches. On the upper plain, which includes several sinkholes, Giulio Cesare da Varano, Lord of Camerino, had a canal dug in 1458 to drain the water collected by numerous artificial ditches onto the lower plain (Galdenzi et al. 2008). The outflow of the water that collects in the plains takes place exclusively underground. Only following intense rainy periods and/or snowmelt, do two temporary lakes form (Pierantoni and Invernizzi 2008); these are less evident in the upper plain and broader in the lower one (Pedrotti 2008). During the dry season, the water gradually recedes through the sinkholes until it disappears (Pedrotti 2008).

Vegetation types

The main vegetation types are hay-meadows dominated by *Ranunculus velutinus* and *Carex distans* (belonging to the *Hordeo-Ranunculetum velutini* and *Deschampsio-Caricetum distantis* associations) in the external parts of the basins, and the vegetation dominated by *Carex acuta* (*Caricetum gracilis* association) in the internal parts and inside ditches, where water remains longer into the summer (Pedrotti 2008).

The upper plain is of particular interest due to the layers of peat in the soil (Sanesi 1982), which support the development of a peat bog vegetation dominated by *Eriophorum latifolium*. Pictures of the study area are provided in Suppl. material 1: part 1.

Land use history

During the Renaissance (15th century), in an attempt to reclaim the upper Montelago plain, the Da Varano family, lords of Camerino, demolished the natural rock barrier separating the two plains and excavated an artificial cut to facilitate the flow of water from the upper to the lower level. This reclamation enabled agricultural exploitation of the plain until the 1970s (Pedrotti 2008). In the following centuries, further interventions were carried out on the floor of the upper plain, specifically: tillage, the excavation of ditches, and conversion into agricultural land. In the early 1960s, the Piani di Montelago were still well preserved, despite the fact that the external areas had been cultivated for centuries. Between 1963 and 1979, several highly damaging interventions were carried out across large sections of the upper Montelago plain, adjacent to the peat bog; these included the plowing of the turf and tillage to convert the land into cropland, as well as the digging of deep drainage canals. Consequently, the area occupied by humid, marshy, and peaty meadow vegetation has been progressively reduced. The most recent tillage was documented in 2006. The lower plain, however, remained practically intact and today still largely maintains its natural characteristics (Pedrotti 2008). Currently, the meadows are mowed and grazed by sheep and cattle.

Nowadays, this area falls within the Special Area of Conservation (SAC) “IT5330019 Piani di Montelago” and the Special Protection Area (SPA) “IT5330028 Valle Scurosa, Piano di Montelago e Gola di Pioraco” of the European ecological network “Natura 2000”.

Materials and methods

A bibliographic search was conducted by examining various literature sources: Flora Italica (Bertoloni 1833–1854), Flora Italiana (Parlatore 1848–1896), Florae Romanae Prodromus (Sanguinetti 1864), Flora Marchigiana (Paolucci 1890), Flora d'Italia (Pignatti 1982; Pignatti et al. 2017–2019), and other publications reporting the occurrence of plant species (Pedrotti 1971, 1982, 2008; Giordano and Pedrotti 1976; Ballelli et al. 1981, 2005; Canullo and Venanzoni 1984; Venanzoni 1986; Ballelli and Pedrotti

1992; Gubellini and Pinzi 2010; Klaver 2019). We also consulted phytosociological relevés carried out in the study area by Pedrotti (1976) and Buchwald (1992, 1994).

We examined specimens stored in the Herbarium Universitatis Camerinensis (CAME) collected by V. Marchesoni (Hb. V. Marchesoni), F. Pedrotti, S. Ballelli (Hb. S. Ballelli), R. Venanzoni, D. Lucarini, and F. Maggi. We did not consider specimens collected in grasslands and woodlands on the slopes surrounding the plains. No literature or herbarium data predated 1954 for the study area.

To increase the floristic knowledge of the study area and verify the occurrence of species of conservation interest, we carried out floristic field surveys from 2021 to 2025, between March and October. We restricted our surveys to wet and humid habitats (marshy, humid, and peaty meadows, water bodies such as ditches and ponds), croplands, uncultivated lands, hedges, and the borders of paths and roads. We did not consider woodlands, shrublands, xeric and mesophilous grasslands on the borders of the plains.

The collected plants were identified using standard floras (Fiori 1923–1929; Tutin et al. 1964–1980, 1993; Castroviejo et al. 1986–2021; Arrigoni 2016–2021; Pignatti et al. 2017–2019). To identify taxa within critical groups, we consulted specific taxonomic studies (Kreutz 1995; Del Carratore et al. 1998; Brullo et al. 2009; Arrigoni 2014; Koopman 2022). Some herbarium specimens belonging to critical genera were sent to specialists for revision: *Taraxacum* F.H.Wigg. (J. Štěpánek, Prague), *Orobanch* L. and *Thymus* L. (F. Bartolucci, L'Aquila). The exsiccata of collected plants are deposited in the Herbarium Universitatis Camerinensis (CAME).

The nomenclature of the floristic list (Suppl. material 1: part 2) follows the updated checklists of the native (Bartolucci et al. 2024) and alien (Galasso et al. 2024) vascular flora of Italy.

The systematic order of families follows Bartolucci et al. (2024) and Galasso et al. (2024), with taxa sorted alphabetically within each family. For each taxon, the following information is reported: accepted name, endemic and/or alien status (Peruzzi et al. 2014, 2015; Bartolucci et al. 2024), conservation status (inclusion in the IUCN Red List of the Italian Flora, following Rossi et al. 2013, 2020 and Orsenigo et al. 2018, 2021), life form, and chorology. The definition of alien status follows Pyšek et al. (2004). When a taxon was not confirmed for the study area, we cited the latest known record (herbarium specimen or literature reference). In the floristic list, the names of the unconfirmed taxa are written in italics.

Life forms and chorological types were assigned according to Pignatti et al. (2017–2019); when needed, the latter were compared and adjusted based on the distribution data available in POWO (2025).

Results

We found 162 taxa recorded in the literature and 262 documented by herbarium specimens (Akosim 2020). The checklist consists of 481 species and subspecies, distributed among 65 families and 263 genera (Suppl. material 1: part 2). Eleven taxa are

endemic to Italy; three of them were not found in the recent survey (Suppl. material 1: part 3). Nine taxa are alien, six of which are archaeophytes and three are neophytes (Suppl. material 1: part 4).

The most represented families are Asteraceae (58 taxa), Poaceae (53), Fabaceae (44), Lamiaceae (26), Cyperaceae and Rosaceae (23), Apiaceae (19), Brassicaceae (18), Orchidaceae and Caryophyllaceae (16 each). The richest genera are *Carex* (18 taxa), *Trifolium* (15), and *Veronica* (10).

One taxon is new to Italy (*Taraxacum subalpinum* Hudziok) (Suppl. material 1: part 5a), whereas six taxa are new to the Marche region (*Carex paniculata* L. subsp. *paniculata*, *Hypericum perforatum* L., *Lophiolepis eriophora* (L.) Del Guacchio, Bureš, Iamónico & P.Caputo, *Mentha arvensis* L., *Taraxacum friscum* Soest, and *T. olivaceum* Soest). Among the historical herbarium records, we also have a specimen of the genus *Taraxacum*, identified as a member of the *T. tragopogon* Kirschner & Štěpánek (now *T. porrigentilobatum* Rail.) group (Suppl. material 1: part 5b); its distribution is uncertain, and, to the best of our knowledge, is also new to Italy. Twenty-one taxa (Suppl. material 1: part 3) are included in the IUCN Red List of the Italian Flora, six of which were not found in our survey.

The life-form spectrum of the flora shows a dominance of hemicryptophytes (50.7%) and therophytes (22.7%), while less represented are geophytes (14.3%), phanerophytes (8.7%), chamaephytes (1.7%), hydrophytes (1.5%), and helophytes (0.4%).

Regarding chorological types, the checklist includes 60.2% Eurasian taxa, 16.9% Mediterranean taxa; 9.5% Boreal taxa; 9.1% wide-distribution taxa, 2.9% endemic/subendemic taxa; and 1.4% Atlantic taxa (Suppl. material 1: part 6).

Discussion

The checklist consists of 481 taxa, 68 of which were recorded more than 30 years ago and were not found during the recent survey. For approximately 20 of these (including two Italian endemics and three Red-listed taxa), the labels of the examined specimens provided only a generic locality (“Monte Lago”), lacking information on altitude and habitat. In other cases, the locality data were more detailed (e.g. “Piani di Montelago” with an elevation range of 888–916 m a.s.l.), but still omitted the habitat. Consequently, these specimens may have been collected outside our study area or in habitats not covered by our research (woodlands, shrublands, and grasslands on the slopes surrounding the plains). Seventeen unconfirmed taxa are typical of wetlands or of conservation interest. In particular, the latest record of *Epipactis palustris* (L.) Crantz dates back to 1963; those of *Juncus conglomeratus* L., *Carex riparia* Curtis, *Taraxacum subalpinum* Hudziok, *T. friscum* Soest, *T. olivaceum* Soest, and *Eleocharis uniglumis* (Link) Schult. to 1966. *Limniris pseudacorus* (L.) Fuss was last recorded in 1978; *Glyceria maxima* (Hartm.) Holmb. subsp. *maxima* and *Juncus fontanesii* J.Gay subsp. *fontanesii* in 1981, *Lysimachia nummularia* L. in 1982; *Ophioglossum vulgatum* L., and

Isolepis cernua (Vahl) Roem. & Schult. in 1984; and *C. paniculata* L. subsp. *paniculata*, *Galium palustre* L. subsp. *palustre*, *Glyceria notata* Chevall., and *Equisetum fluviatile* L. in 1991. Among the taxa new to Italy or Marche, *Carex paniculata* L. subsp. *paniculata*, *Taraxacum friscum* Soest, *T. olivaceum* Soest, *T. porrigentilobatum* Rail. group, and *T. subalpinum* Hudziok are to be considered historical records. Most of these floristic losses can be traced back to works carried out between 1963 and 1979 in large areas of the upper Montelago plain, close to the peat bog. These interventions involved plowing the turf, tilling, and digging deep drainage channels to convert the plain into agricultural land (Pedrotti 2008). The most recent tilling was documented in 2006. These actions progressively reduced the area occupied by vegetation of humid, marshy, and peaty meadows (Pedrotti 2008).

Among 21 taxa listed in the IUCN Red List of the Italian Flora (Rossi et al. 2013, 2020; Orsenigo et al. 2018, 2021), including 11 endemics, the most threatened is *Ranunculus ophioglossifolius*, classified as Vulnerable (VU). Additionally, two are classified as Near Threatened (NT), 15 as Least Concern (LC), and three as Data Deficient (DD). We did not find six of these taxa, only one of which—*Epipactis palustris* (NT)—was linked to peaty and marshy meadows.

Among the alien taxa (1.9% of the flora), the three neophytes are invasive in the Marche region (*Populus × canadensis* Moench nothosubsp. *canadensis*, *Veronica persica* Poir., and *Crepis sancta* (L.) Bornm. subsp. *nemausensis* (P.Fourn.) Babç.; Galasso et al. 2024), but not within the study area. The four identified archaeophyte taxa reflect historical and persisting practices within the mountain rural economy. *Medicago sativa* L., traditionally cultivated as the primary protein-rich fodder, remains a functional component of crop rotation systems near Montelago. *Centaurea cyanus* L., a characteristic weed of cereal crops, is an indicator of low-input or chemical-free agronomic management. *Malus domestica* (Suckow) Borkh. constitutes a structural element of traditional intercropping systems, formerly widespread in subsistence-based Apennine agroecosystems. Finally, *Galega officinalis* L., historically valued for its pharmacological properties, remains a vestige of ancient medicinal cultivation, persisting within the modern agricultural landscape along ditches and in damp, uncultivated lands. Regarding the life form spectrum, the dominance of hemicryptophytes (ca. 51%) can be explained by the fact that the entire study area is covered by perennial grasslands. The contribution of therophytes (ca. 23%) testifies the transition between Temperate and Mediterranean climates. Phanerophytes account for 8.7%, reflecting the distribution of trees and shrubs along pathways and ditches. Chamaephytes (1.7%) are related to xeric habitats at the borders of the plateaux. The modest percentage of hydrophytes (1.5%) indicates that aquatic habitats are quite rare. Regarding chorotypes composition, taxa with distribution centered in Eurasia and across the boreal and temperate regions of the northern hemisphere (69.7%) clearly predominate over those restricted to Mediterranean and Atlantic regions (18.3%).

Compared to the vascular flora of the neighbouring Altipiani di Colfiorito (Ballelli et al. 2010), the Montelago plains exhibit a higher percentage of hemicryptophytes (+5–10% compared to each of the seven plains) and geophytes (+3–6%), and a lower percentage of therophytes (–9–14%). This is due to the more limited presence of species associated with

croplands and uncultivated lands, which occur only along the boundaries of the study area. Likely for the same reason, Montelago has fewer alien taxa (six archaeophytes and three neophytes) than Colfiorito (14 archaeophytes and 9 neophytes; Ballelli et al. 2010).

In the study area, the percentages of Eurasian and boreal elements are similar to those of the Colfiorito plains, reflecting the severe and prolonged cold stress that characterises this sector of the Apennines. Mediterranean and Atlantic taxa are approximately 1–4% fewer, offset by an increase in endemic/subendemic (+1.2–1.6%) and widely distributed taxa (+0.1–3.5%). Moreover, Montelago exhibits a higher number of Italian endemic taxa (11 vs. 6) and Italian Red List species (21 vs. 17) than Colfiorito. The number of unconfirmed taxa, typical of wetlands or of conservation interest, was 17 in Montelago and 15 in the Palude di Colfiorito. Notably, *Hippuris vulgaris* L. and *Hydrocotyle vulgaris* L., last recorded in the Palude di Colfiorito in 1967 and 1977, respectively, and currently listed as Endangered in the Italian Red List, have disappeared due to peat extraction (Ballelli et al. 2010). This suggests that, from a conservation perspective, the Montelago and Colfiorito plains share a legacy of similar past anthropogenic pressures (Pedrotti 2019; Tardella and Di Agostino 2020).

Conclusions

The goals of this research were to compile a checklist of the vascular flora of a wetland that had not been investigated in depth and to evaluate changes occurring over the last few decades in the presence of species of conservation interest, based on historical records. We recorded 481 taxa; 68 previously documented were not found during our survey. Eight taxa are new records for the Italian or regional floras, although five of them are considered historical records. Twenty-one taxa are included in the Red List of the Italian Flora, six of which were not found in the recent survey. Overall, our study indicates that a significant loss of plant species has occurred in recent decades, primarily due to habitat destruction and alteration. Indeed, most losses of species of conservation interest can be traced back to anthropogenic alterations that occurred in this wetland between the 1960s and 1970s. However, the negligible percentage of alien species (1.9%), along with the persistence of several taxa of conservation interest, reflects the currently limited anthropogenic pressure and highlights the key role of the “Piani di Montelago” site for species conservation in the central Apennines.

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Supplementary material I

Additional information

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Data type: doc

Explanation note: **Part 1.** Pictures of the study area. **Part 2.** Checklist of the vascular flora of the “Piani di Montelago” (Marche, Italy). **Part 3.** List of the Italian endemic taxa and included in the IUCN Red List of the Italian Flora in the study area. **Part 4.** List of the alien taxa and their status in the study area, in Marche, and in Italy for alien species following Galasso et al. (2024). The taxa that were not found in the recent survey are not in bold. **Part 5.** Images of the herbarium specimens kept in CAME of a) *Taraxacum subalpinum* Hudziok and b) *Taraxacum porrigentilobatum* Rail. (syn. *T. tragopogon* Kirschner & Štěpánek) group. **Part 6.** Chorological spectrum, reporting the number and percent values of taxa per chorological type and the percentages of chorological groups. The number and percentage of taxa not found in the recent survey are indicated in brackets.

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