Plant Sociology 59(2) 2022, 51–70 | DOI 10.3897/pls2022592/05

PENSOFT

Società Italiana di Scienza della Vegetazione (SISV)

Floristic and coenological data from the travertine substrates of the SAC "Travertini Acque Albule (Bagni di Tivoli)" (Lazio Region – Central Italy)

Romeo Di Pietro[1], Marco Giardini[2], Duilio Iamonico[3], Giancarlo Tondi[4], Daniele Angeloni[5], Emanuela Carli[6], Michele Aleffi[7], Mattia Martin Azzella[1], Francesco Di Pietro[8], Elisa Proietti[9], Sonia Ravera[10], Paola Fortini[9]

1 *Department PDTA (Section Environment and Landscape), "Sapienza" University of Roma, Via Flaminia 72, I-00196, Rome, Italy*
2 *Istituto d'Istruzione Superiore Via Roma 298 Guidonia, Via Roma 298, I-00012 Guidonia Montecelio, Italy*
3 *Ce.R.S.I.Te.S., Università di Roma 'Sapienza', Viale XXIV Maggio, 7, I-04100 Latina, Italy*
4 *Via F. D'Ovidio 89, I-00137 Roma, Italy*
5 *Via Trilussa 6, I-00011 Tivoli Terme (Roma), Italy*
6 *ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale), via Vitaliano Brancati 48, I-00144, Roma, Italy.*
7 *School of Biosciences and Veterinary Medicine, University of Camerino, Via Pontoni 5, I-62032 Camerino (MC), Italy.*
8 *Via Boccea 752, I-00166, Roma, Italy*
9 *Department of Bioscience and Territory, University of Molise, I-86090 Pesche, IS, Italy*
10 *Department of Biological, Chemical and Pharmaceutical Sciences and Technologies, University of Palermo, I-90123 Palermo, Italy*

Corresponding author: Romeo Di Pietro (romeo.dipietro@uniroma1.it)

Subject editor: Simonetta Bagella ♦ **Received** 15 October 2022 ♦ **Accepted** 5 December 2022 ♦ **Published** 30 December 2022

Abstract

During a phytosociological field-work campaign on the vegetation of the travertine outcrops, included in the Special Area of Conservation (SAC) "Travertini Acque Albule (Bagni di Tivoli)" (Central Italy), several taxa of particular interest were identified. *Carex vulpina*, *Lolium apenninum*, *Onosma echioides* subsp. *angustifolia*, *Typha domingensis*, *T. laxmannii* and *Vicia pannonica* subsp. *pannonica* are new for the Lazio administrative Region, while *Ophrys illyrica* and *Zannichellia peltata* are confirmed for the flora of this Region. For each of these taxa phytosociological samples describing the plant communities in which they were found are provided. New records for rare species were also reported for cryptogams such as Algae, Lichens and Mosses.

Keywords

flora, Habitat Directive, landscape planning, nature conservation, phytosociology, taxonomy

Introduction

The "Acque Albule" travertines have always been considered a site of great historical, archaeological and naturalistic interest. The Acque Albule plain (Fig. 1) is the largest travertine basin of Italy (about 45 km^2) and has been an obliged destination for travellers on the Grand Tour since the 17th century. It is a depression on the right bank of the lower Aniene river valley that began to form about 115,000 years ago in areas of subsidence due to relaxing dynamics involving a system of transcurrent and direct faults (Faccenna 1994; Petitta et al. 2011). Due to the lithological nature of the substrate and the intense karst processes, this area exhibits an extremely varied geomorphology, characterized by travertine outcrops, sulphurous freshwaters pools and channels, petrifying springs. The Acque Albule plain was included among those identified as deserving protection in the survey of biotopes carried out by the Italian Botanical Society already in 1971 (Montelucci 1969). In 1982 the "Sorgenti Albule e Platea dei Tartari" area was included in the European Community list of "biotopes of significance for nature conservation" (code number 6559). The lithological and geomorphological characteristics of the Acque

Albule plain allowed the development of a varied vegetation pattern which includes two priority habitats listed in European Interpretation Manual of the Annex I of the Council Directive 92/43/EEC: 6110* "Rupicolous calcareous or basophilic grasslands of the *Alysso-Sedion albi*" and 6220* "Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*". The occurrence of these two habitats brought to the institution of a Site of Community Importance (SCI, code: IT6030033) in 1995. Subsequently, two further priority habitats were identified in the SCI area (7210* "Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*" and 7220* "Petrifying springs with tufa formation (*Cratoneurion*)" (Guidi 2007). In the same year Giardini (2007) put forward a proposal for the establishment of four natural monuments (which later turned out to be useful for the enlargement of the borders of the SAC). In 2019 the Site IT6030033 was designated as Special Area of Conservation (SAC). Despite its unique environmental features and the presence of four priority habitats, the Acque Albule plain has been subject to numerous tampering in the last 50 years, among which urban sprawl, industrial settlements and lowering of the water table due to the intense activity of thermal resorts and travertine extraction quarries. All these activities negatively influenced the functionality of the ecosystems (Brunetti et al. 2013). The degree of conservation of the priority habitats occurring in the SAC is rather poor and the ecosystems are strongly threatened by anthropogenic disturbance. In fact, a large part of the area is an open illegal landfill, thus the plant communities have been subject to strong fragmentation (Fig. 2). In accordance with a research project between the Monti Lucretili Regional Park (designed as SAC management authority) and the Department Planning, Design and Architecture Technology of Sapienza University, a floristic and phytosociological study started in 2021. The aim of the current project is to identify the fine-scale spatial pattern of the plant communities occurring in the SAC, assess the conservation status of those included in the list of protected habitats, and provide the basic information for drawing up the management plan.

A comprehensive floristic-phytosociological survey of this area has never been carried out and only local contributions or investigations on specific aspects were published. Sebastiani and Mauri (1818) cited some interesting plant species for the "*Solfatara di Tivoli*" which is known today as Lago della Regina, while Sanguinetti (1855), drew up a list of species near the so called "*Lago dei Tartari*", a sulphurous freshwater pool that no longer exists due to expansion of urbanization. Between 1882 and 1884 Pirotta, Baccarini, Canepa and Pedicino (unpublished data) performed floristic field excursions, mentioning in their notes some interesting species that have now disappeared in the Plain, such as *Ophioglossum vulgatum* L. (Anzalone et al. 2010). The first outline of the flora and vegetation of this area were broadly described in the middle of the last century (Montelucci 1946). The same author published many papers about flora of the travertines (Montelucci 1947; 1949; 1954; 1963), also making every effort to try to achieve its protection (Montelucci, 1969; Giardini 2004; 2008). As

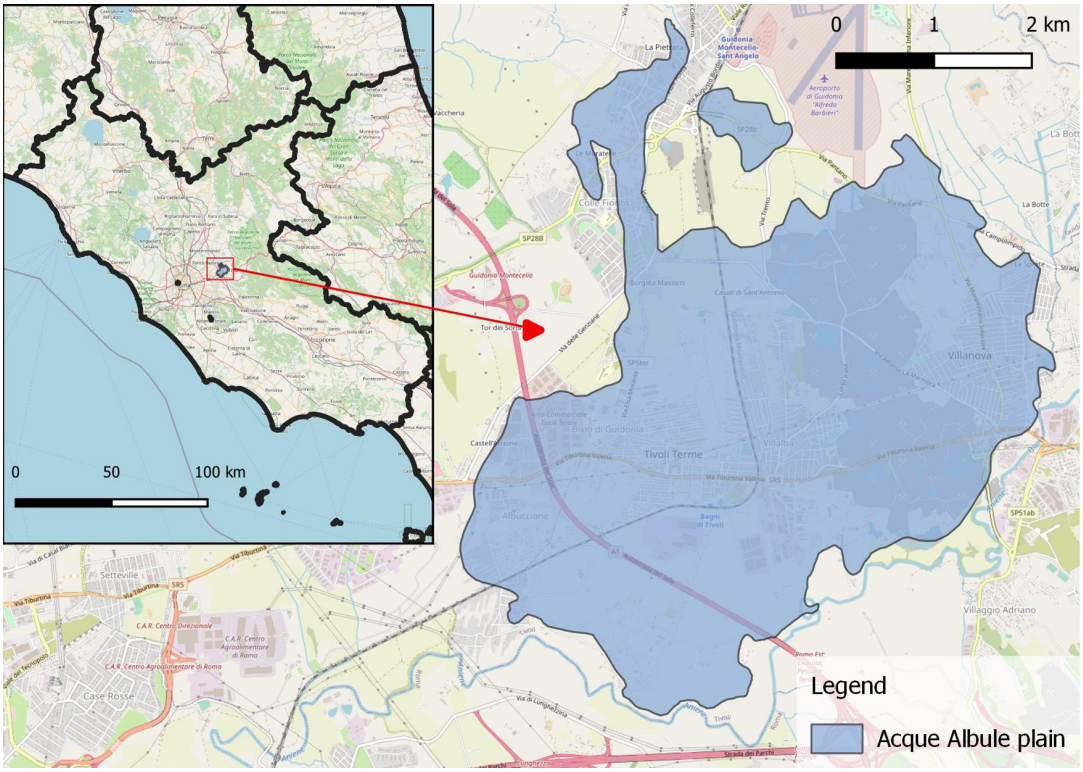

Figure 1. Acque Albule Plain.

regards previous studies concerning the vegetation the study area was only marginally involved by phytosociological contributions, most of which mainly focusing on surrounding areas (Pignatti et al. 1961; Fanelli 1998; Di Pietro and Germani 2007; Guidi 2007; Fanelli et al. 2010; Di Pietro and Germani 2012; Di Pietro et al. 2017). Among the most recent contributions on the Acque Albule area is the phytosociological study of Fanelli (2007), on some aspects of the therophytic vegetation of travertine outcrops, a first provisional draft of vegetation map proposed by Guidi (2007); the floristic studies of on the "Montarozzo del Barco", an anthropogenic hill of the Roman age (Giardini 2005, 2012), the landscape planning contribute of Iamonico and Di Pietro (2017) on a possible variation of the SAC boundaries. Except for an old contribute of Fiorini-Mazzanti (1857) described two new species of algae (*Calothrix Jantiphora* Fior-Mazz. Mss. and *Hydrurus Aquae-Albulae* Fior-Mazz. Mss.) on the walls of a sulphur spring channel outside the current boundaries of the SAC, no other algological, bryological or lichenological data are available for the study area. In this paper, some floristic records deriving from a phytosociological sampling field-work are presented, among which eight new records for the flora of the Lazio administrative region (six vascular plants and two bryophytes).

Study area

The Acque Albule basin is a travertine outcrop limited by three main structural elements: the Cornicolano-Lucretile-Tiburtino limestone range, the Colli Albani Volcanic system, and the Pliocenic-Quaternary subsident subcoastal area (Della Porta et al. 2017). The study area is represented by the sole territory of the "Travertini Acque Albule (Bagni di Tivoli)" SAC area. This SAC (code IT6030033) covers an area of 430.7 ha (of which 388.0 ha referring to the site originally established in 1995 and 42.7 ha referring to a subsequent enlargement). The SAC is in the Municipality of Tivoli, in the eastern sector of the Roman countryside (around 50 m a.s.l.). The original and widest surface of the SAC is bordered by: Aniene river (south and east), highway A1 south-west), via Tiburtina (north). According to the biogeographical map proposed in Natura 2000 network (https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2) the SAC belong to the Mediterranean Region. More precisely it is located in an area intermediate between the Italo-Tyrrhenian biogeographical province of the Mediterranean Region and the Apennine-Balkan province of the Eurosiberian Region according to Rivas-Martínez et al. (2002). The study area is included in the bioclimatic Transition Mediterranean Region with meso-Mediterranean thermotype and upper sub-humid umbrotype (Blasi 1994) with mean annual Temperature of 15.3° and mean annual rainfall 853 mm (Thermo-pluviometric station of Guidonia Airport located less than 5 kilometres far from the study area).

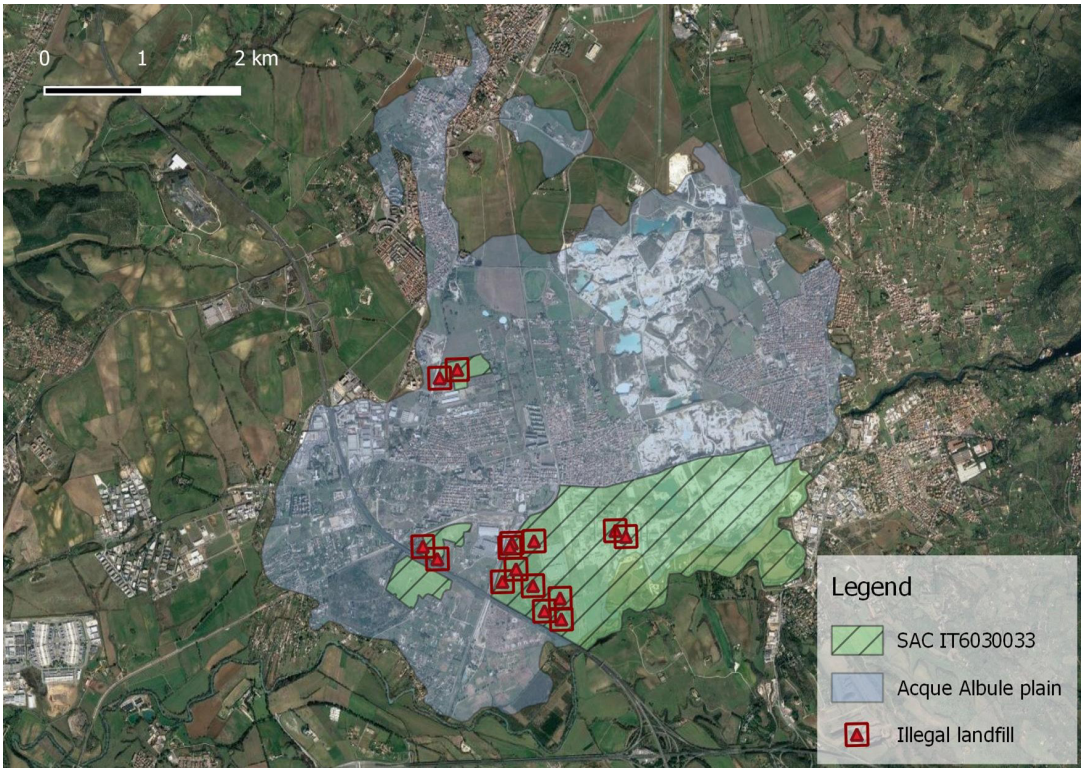

Figure 2. The SAC IT6030033 territory is fragmented due to the presence of urbanized areas, quarries and illegal landfill.

Materials and methods

Plant collections and phytosociological sampling according to national habitat monitoring standards was conducted by using the floristic and vegetation relevé (Angelini et al. 2016, Gigante et al. 2016), which represent a basic standard also to identify and characterise typical species sensu art. 17 of the Directive 92/43/EEC (Bonari et al. 2021) in the SAC "Travertini Acque Albule (Bagni di Tivoli)" (code IT6030033) where new floristic records for both vascular plants and cryptogams were considered. The vascular plants collected in the field are preserved in the *Herbarium Flaminio* (HFLA; Thiers, 2022 [continuously updated]) and were identified on the basis of Pignatti (2017-2019). The nomenclature of the taxa collected follows Bartolucci et al. (2018) and Galasso et al. (2018). The collected bryophytes are kept in HFLA; Cortini Pedrotti (2001, 2005) was followed for the taxonomical identification of mosses; nomenclature follows Hodgetts et al. (2020); the species distribution in Italy refers to Aleffi et al. (2020a). Nomenclature of stoneworts follows Bazzichelli and Abdelahad (2009). Lichens have been identified in the field, using a magnifying glass. For more complex identifications, samples were collected and identified using a stereo microscope and a light microscope for microscopic diagnostic characters and chemical spot tests K (a solution of 10% potassium hydroxide), C (sodium hypochlorite solution), KC. For the identification of the lichen species several keys were used, mainly Smith et al. (2009). Nomenclature and bio-ecological characterization follows Nimis (2016).

Phytosociological sampling was carried out using the Zurich-Montpellier phytosociological approach (Braun-Blanquet 1964). For syntaxa nomenclature and syntaxonomic classification of single species at the class rank reference was made to Mucina et al. (2016).

Results

Two hundred and twenty-four phytosociological relevés were performed between 2021 and 2022 to describe and classify the vegetation pattern of the Acque Albule basin. The coenological analysis is still in progress so that a complete classification of the plant communities will be the subject of a further paper. However, a first preliminary floristic analysis led us to the identification of several taxa of biogeographical importance among which some new records for the flora of Lazio administrative Region. For each of these new reports, one or more phytosociological relevés referring to the plant communities in which the taxa in issue were collected are presented. These relevés have been arranged in three phytosociological tables referring to the type of environment in which the taxa were found (Tab. 1, xerophilous and semi-mesophilous communities; Tab. 2, mesophilous communities; Tab. 3, hygrophilous and helophytic communities)

Vascular Plants

AMELICHLOA CAUDATA (Trin.) Arriaga & Barkworth Sida 22(1): 148 (2006).

Bas.: *Stipa caudata* Trin., Mém. Acad. Imp. Sci. St.-Pétersbourg, Sér. 6, Sci. Math 1: 75 (1831)

Taxon confirmed for the Lazio region and second record for Italy.

Plant native to South America (Argentina, Uruguay and Chile). This species (Fig. 3) was reported for the metropolitan area of Rome, in the Valle dell'Inferno (Anzalone 1982) which prior to our study represented the only Italian records for this species. In Galasso et al. (2018) it is classified as casual alien. Within the Acque Albule SAC *Amelichloa caudata* can be observed in semi-mesophilous grasslands characterized by a certain degree of anthropic disturbance. These grasslands exhibit the co-dominance of perennial grasses, such as *Oloptum miliaceum*, *Dactylis glomerata*, *Avena barbata, Poa pratensis* which grow together other species which are typical of disturbed clay-

Figure 3. *Amelichloa caudata* (Trin.) Arriaga & Barkworth.

rich soils, such as *Daucus carota* and *Dittrichia viscosa* s.str. (Table 1 rel. 7). The most probable syntaxonomic reference is the *Artemisietea* class. The high degree of anthropic disturbance does not allow a certain classification at the alliance rank where similarities are found for *Bromo-Oryzopsion* and *Inulo-Agropyrion* as well. This new record confirms the slow expansion of *A. caudata* at the footslopes of the Lazio region sub-Apennines where it is probable that the species is now to be considered as a naturalized alien species rather than a casual alien (see Galasso et al. 2018).

CAREX VULPINA L.
Sp. Pl. 2: 973 (1753)
New record for Lazio region.

Carex vulpina exhibits a mainly Eurosiberian distribution. It is a recent addition to the Italian flora where it is reported only for Piedmont, Lombardy, Veneto, Umbria and Abruzzo whereas it is considered doubtful in the Aosta Valley. In morphological terms *C. vulpina* is similar to *C. otrubae* Podp., but it exhibits stems with subwinged edges and concave faces; leaves with ligule wider than long (2-5 mm) on the sides protruding beyond the leaf margin; brown glume with green central nerve; dark brown and papillose utricles. The morphological differences between *C. otrubae* and *C. vulpina* were identified by Haussknecht (in Österr. Bot. Zeitschr., 1877), and later by Samuelsson (1922). *C. vulpina*, although, as reported by Smith and Ashton (2006), not all authors agree about the real taxonomic value of all the morphological traits that are considered as diagnostic. In ecological terms, *C. vulpina* is typical of the banks of the great middle-European and Siberian rivers, adapted to the strong variations of the phreatic level. In the Acque Albule SAC, this species grows within the floodplain of the Aniene river, in the undergrowth and at the edge of *Phragmites australis* communities bordering the course of the river. In these *Phragmito-Magnocaricetea* and *Molinio-Arrhenatheretea* communities *C. vulpina* is associated with other typical of wet meadows species, such as *Carex acutiformis*, *Ranunculus repens*, etc (Table 2 rel.7).

LOLIUM APENNINUM (De Not.) Ardenghi & Foggi
Taxon 64 (5): 1039 (2015)
Bas.: *Festuca apennina* De Not., Repert. Fl. Ligust.: 468 (1844)
Syn.: *Lolium pratense* subsp. *apenninum* (De Not.) Banfi, Bracchi & Galasso; *Schedonorus apenninus* (De Not.) Tzvelev; *Schedonorus pratensis* (Huds.) P. Beauv. subsp. *apenninus* (De Not.) H. Scholz & Valdés
New record for Lazio region.

Plant usually of mesophilic and semi-mesophylous mountain meadows, it is widespread in northern and central Italy, up to Campania (southern Italy), and has recently been reported for Sicily (Gianguzzi et al. 2018) while it was currently considered absent in Lazio region. Within the SAC, this species is mainly found on the *Molinio-Arrhenatheretea* wet meadows (Table 2 rels 1–3) which are mowed during the summer, where meso-hygrophylous species (e.g., *Carex otrubae*, *Cyperus longus*) grows together with typical species of mesophilous grasslands (e.g. *Poa pratensis*, *Elymus repens*, *Agrostis stolonifera*). The relatively moist soils allow partial high-coverage of *Cirsium arvense*, this latter being also advantaged by a moderate degree of anthropic disturbance. The syntaxonomical reference is in the mesophilous fringe of *Cynosurion cristati*. *Lolium apenninum* can be also found in *Thinopyrum acutum* communities developed in small depressions on clayey soils which occupy an intermediate position between *Cynosurion cristati* and *Convolvulo-Agropyrion*. At present the Acque Albule SAC represents the lower altitudinal limit for the species in Italy.

ONOSMA ECHIOIDES (L.) L. subsp. *ANGUSTIFOLIA* (Lehm.) Peruzzi et N.G.Passal.
Bot. J. Linn. Soc. 157(4): 772 (2008)
Bas.: *Onosma angustifolia* Lehm.
New record for Lazio region.

Onosma echioides (L.) L. includes 4 subspecies in Italy: subsp. *dalmatica* (Scheele) Peruzzi et N.G. Passal., from Friuli-Venezia Giulia and Veneto, subsp. *canescens* (J. Presl et C. Presl) Peruzzi et N.G. Passal., endemic to northern Sicily, subsp. *echioides*, with a South European range, ranging from Emilia-Romagna to Calabria NW, and subsp. *angustifolia* (Lehm.) Peruzzi et N.G. Passal. endemic to central and southern Italy (Abruzzo, Basilicata, Puglia and Calabria NE) (Peruzzi and Passalaqua 2004; 2008; Conti et al. 2016). The subsp. *angustifolia* differs from the other subspecies for the green-ashy leaves covered by very dense greyish-white hairs completely appressed to the leaf blade (Pignatti 2017-2019). In the Acque Albule SAC, *O. echioides* subsp. *angustifolia* exhibits its lowermost altitudinal limit for the whole central Italy (41 m a.s.l.). In the study area this species is found within in three different environments, i) fissures of travertine compact pavements dominated by *Sedum hispanicum* and/or *Sedum rupestre* assignable to *Sedo-Scleranthetea* (Tab. 1 rels 3–4); ii) travertine rocky outcrops with other micro-chamaephytes such as *Teucrium capitatum* and *Thymus striatus* subsp. *acicularis* or in mixed hemycryptophytic-therophytic dry grasslands assignable to *Ononido-Rosmarinetea* and *Cisto-Micromerietalia* (Tab. 1 rel. 5); iii) dry grasslands together with *Ampelodesmos mauritanicus* developed on substrates characterized by less rockiness and greater stoniness than the two previous types (Tab. 1 rels 1–2, Fig. 4). The syntaxonomic classification of this community remains very uncertain. The high therophytic component, the presence of *Petrorhagia saxifraga*, *Ziziphora acinos*, *Saxifraga tridactylites* and the rich cryptogamic component suggest a classification in the *Sedo-Scleranthetea*. As a consequence it could still be classified in habitat 6110*. On the other hand the dominance of *Ampelodesmos mauritanicus*, together with a strong Mediterranean therophitic component could support a classification in *Lygeo-Stipetea* then a possible identification of the Habitat 5330 "Thermo-Mediterranean and pre-desert scrub" subtype 32.23 - Diss-dominated garrigues.

Table 1. Xerophilous grasslands .

Relevé nb.	1	2	3	4	5	6	7
Altitude	60	59	67	67	50	51	45
Aspect	,	,	,	,	,	,	.
Slope (°)	,	,	,	,	,	,	,
Rockiness (%)	20	20	40	35	50	25	.
Stoniness (%)	25	40	20	15	15	15	15
Area (m^2)	16	15	4	15	3	30	20
Cover (%)	65	60	70	70	40	80	85
***Onosma echioides* subsp. *angustifolia* communities**							
Onosma echioides (L.) L. subsp. *angustifolia* (Lehm.) Peruzzi & N.G.PassaL.	2	2	2	3	2	.	.
Ampelodesmos mauritanicus (Poir.) T.Durand & Schinz	3	3	.	.	.	.	.
Hippocrepis ciliata Willd.	1	2	.	.	.	.	.
Linum strictum L.	1	1	.	.	.	.	.
Petrosedum rupestre (L.) P.V. Heath	.	.	1	2	.	.	.
Sedum hispanicum L.	.	.	4	2	.	.	.
Reseda phyteuma L.	.	.	2	1	.	.	.
Teucrium capitatum L.	+	1	.	.	2	.	.
Cerastium glomeratum Thuill.	.	.	.	.	1	.	.
Senecio leucanthemifolius Poir.	.	.	.	.	+	1	.
Ononido-Rosmarinetea							
Teucrium flavum L. subsp. *flavum*	+	.	.	.	.	.	.
Thymus striatus Vahl subsp. *acicularis* (Waldst. & Kit.) Ronniger	.	.	.	1	.	.	.
Sedo-Schleranthetea							
Petrorhagia saxifraga (L.) Link	2	1	1	+	+	+	.
Campanula erinus L.	1	+	.	1	+	+	.
Daucus broteri Ten.	+	.	2	2	+	+	.
Festuca incurva (Gouan) Gutermann	2	1	2	+	1	.	.
Rostraria cristata (L.) Tzvelev	1	1	2	.	+	.	.
Saxifraga tridactylites L.	1	+	+	.	.	+	.
Sabulina tenuifolia (L.) Rchb. subsp. *tenuifolia*	.	+	1	+	.	.	.
Valantia muralis L.	.	.	+	+	1	.	.
Ziziphora acinos (L.) Melnikov	1	1	.	+	.	.	.
Sabulina mediterranea (Ledeb. ex Link) Rchb.	.	.	.	.	+	1	.
Aethionema saxatile (L.) R.Br.	1	.	.	.	.		.
Ajuga chamaepitys (L.) Schreb. subsp. *chamaepitys*		.	.	.	.	+	.
Allium sphaerocephalon L. subsp. *sphaerocephalon*	+	.	.	.	.	.	.
Linaria simplex (Willd.) Desf.	.	.	.	+	.	.	.
Poa bulbosa L.	.	.	.	+	.	.	.
Rostraria hispida (Savi) Doğan	.	.	.	.	1	.	.
Valerianella muricata (Steven ex M.Bieb.) W.H.Baxter & Wooster	+	.	.	.	.	.	.
Draba verna L. subsp. *praecox* (Steven) Rouy & Foucaud	.	.	.	.	.	1	.
***Medicago minima* & *Festuca ligustica* comm.**							
Medicago minima (L.) L.	.	.	.	.	.	3	.
Festuca ligustica (All.) Bertol.	.	.	.	.	.	2	.
Ophrys illyrica S. Hertel & K. Hertel	.	.	.	.	.	+	.
Stipo-Trachynetea							
Helianthemum salicifolium (L.) Mill.	2	1	1	1	1	2	.
Stachys romana (L.) E.H.L. Krause	+	+	1	1	.	.	.
Catapodium rigidum (L.) C.E. Hubb.	1	1	.	.	+	.	.
Hypochaeris achyrophorus L.	.	.	+	1	.	+	.
Plantago afra L. subsp. *afra*	.	1	.	.	+	+	.
Trifolium scabrum L.	.	.	2	+		1	.
Crepis neglecta L.	.	.	+	.	.	.	.
Anisantha madritensis (L.) Nevski	.	.	+	.	.	.	.
Coronilla scorpioides (L.) W.D.J. Koch	.	.	+	.	.	.	.
Macrobriza maxima (L.) Tzvelev	.	+	.	.	.	.	.
Plantago bellardii All.	.	+	.	.	.	.	.
Arenaria leptoclados (Rchb.) Guss.	.	.	.	.	.	1	.
Astragalus hamosus L.	.	.	.	.	.	+	.
Festuca myuros L.	.	.	.	.	.	+	.
Hippocrepis biflora Spreng.	.	.	.	.	.	+	.
Polycarpon tetraphyllum subsp. *diphyllum* (Cav.) O. Bolòs & Font Quer	.	.	.	.	.	+	.
Chenopodietea			.	.	.	.	.
Urospermum dalechampii (L.) F.W. Schmidt	+	.	1	1	+	.	.
Anisantha diandra (Roth) Tutin ex Tzvelev	.	.	.	1	.	1	.
Anisantha rigida (Roth) Hyl.	.	.	.	+	.	.	1
Helminthotheca echioides (L.) Holub	.	.	.	+	.	.	1
Knautia integrifolia (L.) Bertol.	.	+	.	.	.	+	.
Allium polyanthum Schult. & Schult.f.	.	.	.	.	.	.	+
Avena fatua L.	.	.	.	+	.	.	.
Bunias erucago L.	.	.	.	+	.	.	.
Festuca danthonii Asch. & Graebn.	.	.	1	.	.	.	.

Table 1. Continuation.

Relevé nb.	1	2	3	4	5	6	7
Altitude	60	59	67	67	50	51	45
Aspect	,	,	,	,	,	,	.
Slope (°)	,	,	,	,	,	,	,
Rockiness (%)	20	20	40	35	50	25	.
Stoniness (%)	25	40	20	15	15	15	15
Area (m^2)	16	15	4	15	3	30	20
Cover (%)	65	60	70	70	40	80	85
Lagurus ovatus L. subsp. *ovatus*	+	.	.	.	.	.	.
Trigonella sulcata (Desf.) Coulot & Rabaute	.	1	.	.	.	.	.
Triticum vagans (Jord. & Fourr.) Greuter	.	+	.	.	.	.	.
Valerianella locusta (L.) Laterr.	.	.	.	.	+	.	
Vicia sativa L. subsp. *sativa*	.	.	.	.	.	.	+
Valerianella rimosa Bastard	.	.	.	.	.	+	.
Euphorbia helioscopia L. subsp. *helioscopia*	.	.	.	.	.	+	.
Dasypyrum villosum (L.) P. Candargy	.	.	.	+	.	1	.
***Dittrichia viscosa* & *Oloptum miliaceum* comm.**							
Dactylis glomerata L. subsp. *glomerata*	.	.	.	.	.	.	2
Daucus carota L. subsp. *carota*	.	.	.	.	.	.	2
Oloptum miliaceum (L.) Röser & H.R. Hamasha	.	.	.	.	.	.	2
Dittrichia viscosa (L.) Greuter subsp. *viscosa*	.	.	.	.	.	.	2
Amelichloa caudata (Trin.) Arriaga et Barkworth	.	.	.	.	.	.	1
Artemisietea							
Silene vulgaris (Moench) Garcke	1	.	1	1	.	.	.
Artemisia vulgaris L.	.	.	.	.	.	.	1
Picris hieracioides L. subsp. *hieracioides*	.	.	.	.	.	.	1
Sixalix atropurpurea (L.) Greuter & Burdet	.	.	.	+	.	.	.
Verbascum sinuatum L.	.	+	.	.	.	.	.
Convolvulus arvensis L.	.	.	.	.	.	.	1
Festuco-Brometea							
Poterium sanguisorba L.	1	2	1	1	1	.	1
Trigonella gladiata M.Bieb.	.	.	+	.	.	.	.
Centaurea deusta Ten.	.	.	+	+	.	.	.
Lygeo-Stipetea	.	.	.	.	.	.	.
Avena barbata Pott ex Link	1	.	2	+	+	1	2
Convolvulus cantabrica L.	2	2	.	1	+	1	.
Reichardia picroides (L.) Roth	.	.	+	.	+	.	.
Bituminaria bituminosa (L.) C.H.Stirt.	.	.	.	.	.	.	1
Molinio-Arrhenatheretea	.	.	.	.	.	.	.
Blackstonia perfoliata (L.) Huds.	+	.	.	.	.	.	.
Elymus repens (L.) Gould subsp. *repens*	.	.	.	.	.	.	1
Galium mollugo L.	.	.	.	.	.	.	1
Poa pratensis L. subsp. *pratensis*	.	.	.	.	.	.	2
Rumex crispus L.	.	.	.	.	.	.	+
Trifolium pratense L. subsp. *pratense*	.	.	.	.	.	.	1
Papaveretea rhoeadis							
Papaver dubium L.	.	.	2	1	.	+	.
Lysimachia arvensis (L.) U. Manns & Anderb.	1	.	.	.	.	.	.
Papaver hybridum L.	+	.	.	.	.	.	.
Anthemis arvensis L.	.	.	.	.	.	+	.
Serapias lingua L.	.	.	.	.	+	.	.
Quercetea ilicis* & *Crataego-Prunetea							
Phillyrea latifolia L.	.	+	.	.	.	.	.
Rhamnus alaternus L. subsp. *alaternus*	.	.	.	.	+	.	.
Pistacia terebinthus L. subsp. *terebinthus*	.	.	.	+	+	.	.
Rubus ulmifolius Schott	.	.	.	.	.	.	1
Styrax officinalis L.	.	+	.	.	.	.	.
Sambucus ebulus L.	.	.	.	.	.	.	+
Trifolio-Geranietea							
Geranium columbinum L.	.	.	.	.	.	+	.
Silene latifolia Poir.	.	.	.	.	.	.	1
Geranium rotundifolium L.	.	.	.	.	.	+	.
Torilis japonica (Houtt.) DC.	.	.	.	.	.	.	1
Ceratodonto purpurei-Polytrichetea piliferi							
Cladonia foliacea (Huds.) Willd.	3	2	2	2	2	.	.
Cladonia rangiformis Hoffm.	1	1	2	1	.	.	.
Cladonia furcata subsp. *subrangiformis* auct. non (Sandst.) Abbayes	.	.	1	1	1	.	.
Psoretea decipientis* & *Verrucarietea nigrescentis							
Didymodon vinealis (Brid.) R.H.Zander	1	3	.	1	2	2	.
Xalocoa ocellata (Fr.) Kraichak, Lücking & Lumbsch	.	.	.	+	.	.	.

Table 1. Continuation.

Relevé nb.	1	2	3	4	5	6	7
Altitude	60	59	67	67	50	51	45
Aspect	,	,	,	,	,	,	.
Slope (°)	,	,	,	,	,	,	,
Rockiness (%)	20	20	40	35	50	25	.
Stoniness (%)	25	40	20	15	15	15	15
Area (m^2)	16	15	4	15	3	30	20
Cover (%)	65	60	70	70	40	80	85
Squamarina cartilaginea (With.) P. James var. *cartilaginea*	.	.	.	1	.	.	.
Psora decipiens (Hedw.) Hoffm.	.	.	.	.	1	.	.
Gyalolechia fulgens (Sw.) Søchting, Frödén & Arup	.	.	.	+	.	.	.
Squamarina stella-petraea Poelt	.	.	.	1	.	.	.
Verrucaria nigrescens Pers. f. *nigrescens*	.	.	.	2	.	.	.
Hylocomietea splendentis							
Pleurochaete squarrosa (Brid.) Limpr.	+	.	+	2	1	.	.

OPHRYS ILLYRICA S. Hertel & K. Hertel.
J. Eur. Orch. 34 (3): 512 (2002)
Syn.: *Ophrys araneola* subsp. *illyrica* (S. Hertel & K. Hertel) Kreutz.
FJGJT-J343T-HTJ7
Taxon confirmed for the Lazio region.

Ophrys illirica (Fig. 5) is currently reported for Croatia, Istrian peninsula, southern Dalmatia, Kvarner islands (Devillers and Devillers-Terschuren 2004; Delforge 2016) and southwestern Slovenia (Paušič and Bakan 2016), where it exhibits a scattered distribution. This species belongs to the medium-small flowered group in the *O. sphegodes* micro-species complex of which *O. illyrica* represents one of the later flowering species (Hertel and Presser 2006). The presence of *O. illyrica* was reported in Italy only for the sites of Vetralla and Tarquinia in the northern Lazio region (Antonj et al. 2018) and Abruzzo (Bartolucci & Galasso 2022). This new record of *O. illyrica* for the SAC Acque Albule (60 m a.s.l.) represents both the southernmost limit of the whole range of the species and the lowermost altitudinal limit in the Italian Peninsula (51 m a.s.l.), the previous record ranging between 185 and 302 m a.s.l. (Antonj et al. 2018). In the study area *O. illyrica* occurs with few individuals in mixed hemycryptophytic-therophytic semi-mesophilous grasslands (Tab. 1 rel. 6) in areas characterized by rocky outcrops and shallow soils and subjected to a significant degree of anthropic disturbance which leads the community to be characterized by several synanthropic species. For this reason the syntaxonomic classification is intermediate between *Stipo-Trachynetea* (*Brachypodietalia distachyi*), *Chenopodietea* (*Brometalia rubenti-tectorum*) and *Sedo-Scleranthetea*.

TYPHA DOMINGENSIS (Pers.) Steud.
Nomencl. Bot.: 860 (1824)
Bas: *Typha latifolia* subsp. *domingensis* Pers., Syn. Pl. 2: 532 (1807)
New record for Lazio region.

It is a wide pantropical range species. In Italy it is recorded in Lombardy, Veneto, Emilia Romagna, Marche, Abruzzo, Molise, Puglia, Calabria and Sicily. The absence

Figure 4. *Onosma echioides* (L.) L. subsp. *angustifolia* (Lehm.) Peruzzi et N.G.Passalacqua , together with *Ampelodesmos mauritanicus*.

Figure 5. *Ophrys illyrica* S. Hertel & K. Hertel.

of reports for some regions is probably due to the not easy distinction from the more widespread *Typha angustifolia*, of which it has long been considered a subspecies and with which it is easily confused. Our specimens exhibit some diagnostic traits which are considered diagnostic for the identification of this taxon (https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=47463), such as the leaf blade gland-dotted adaxially near base, pistillate spike cinnamon to medium brown paler than stigma, ovary separated from the stigma and located close to the base of the pistil. In the Acque Albule SAC, *T. domingensis* grows near a sulphur water spring in typical helophytic *Phragmitetalia* communities, together with other *Typha* species such as *Typha angustifolia*, *T. latifolia*, *T. laxmannii* (see figure 6). Other typical species of wet meadows and marshes occurring in these communities are *Phragmites australis*, *Cyperus longus*, *C. fuscus*, *Juncus articulatus*, *Schoenoplectus tabernaemontani*, *Ranunculus repens* (Tab. 3 rel. 1). The *Typha* sp. pl. communities are not directly protected by the Annex 1 of the Habitat directive, but in the Acque Albule SAC they represent one of the few survived examples of the helophytic vegetation which in the past was very abundant around the sulphurous pools.

Figure 6. *Typha laxmannii* Lepech individual (dark and large female spike in the foreground) together with several *Typha dominigensis* (Pers.) Steud. individuals all around.

TYPHA LAXMANNII Lepech
Nova Acta Acad. Sci. Imp. Petrop. Hist. Acad. 12: 84: (1801)
New record for Lazio region.

Typha laxmannii is a species with a wide distribution ranging from SE-Europe to Japan. In Italy it is reported as native species in all the regions of northern Italy (with the exception of Aosta Valley, where it is absent and Trentino Alto-Adige where it is considered as naturalized alien). It occurs also within the Adriatic side of the Italian Peninsula in Emilia-Romagna, Marche, Abruzzo and Molise regions and in Sicily whereas it is doubtful in Calabria and completely absent in the Tyrrhenian side of the peninsula and in Sardinia. The specimens collected exhibited some diagnostic morphological traits of *T. laxmannii* that allow it to be distinguished from the co-occurring *T. latifolia*, such as male and female inflorescence separated by a space wider than 3 cm, a short and large female spike ¼ - ½ shorter than male spike and a relatively low dimension of the mature plants (about 1 m in height). At the same time these specimens cannot be assigned to *T. minima* Hoppe due to having up to 1 cm wide leaves exceeding the inflorescence. In the study area *T. laxmannii* was found in the same helophytic community already described in the previous note for *T. domingensis*.

VICIA PANNONICA Crantz subsp. *PANNONICA*
Stirpium Austriarum Fasciculus (ed. 2) 5: 393. 1769.
New record for Lazio region.

Vicia pannonica Crantz is a species native to central-southern Europe and western Asia (Caucasian region, Turkey and Iran), but was introduced in Europe, U.S.A., North Africa, E-China and the Far East. It is frequently cultivated as a good fodder species and easily tends to become a naturalized species in agricultural habitats, uncultivated or abandoned industrial areas. In Italy there are two subspecies: the subsp. *pannonica*, rarer and widespread in Lombardy, Veneto, Trentino-Alto Adige, Friuli, Emilia Romagna and Abruzzo that is characterized by yellowish-white flowers, and the subsp. *striata* (M. Bieb.) Nyman with red-violet flowers, widespread in almost all of Italy, excluding Aosta Valley, Liguria, Campania, Basilicata, Calabria and the major islands. The specimens collected within the SAC exhibited yellow flowers and were found in *Thinopyrum acutum* meadows and in the contact areas between these latter and the shrublands dominated by *Rubus ulmifolius*, or the reeds with *Arundo donax* (Tab. 2 rels 4-6). Despite the absolute dominance of *Thinopyrum acutum* linked to the clayey soils, these communities are also characterized by several synathropic species and for this reasons their more reasonable classification is in the class *Artemisietea* than *Molinio-Arrhenatheretea*.

ZANNICHELLIA PELTATA Bertol.
Fl. Ital. 10: 10 (1854)
Taxon confirmed for Lazio region.

It is a rooting hydrophyte species having an European-Atlantic and W-Mediterranean range. It is known in Italy with certainty only for Emilia-Romagna, Tuscany, Basilicata and Sicily (Bernardo & Caldararo 2014). *Zannichellia peltata* was described by Bertoloni (1854) on samples from Calabria ("*Habui ex fossis, et aquis quietis Calabriae prope Rosarno a Gasparrinio*") but it has not been

Table 2. Mesophilous grasslands .

Relevé nb.	1	2	3	4	5	6	7
Altitude	40	40	40	47	47	47	39
Aspect	,	,	,	,	,	,	.
Slope (°)	,	,	,	,	,	,	,
Rockiness (%)							
Stoniness (%)	,	,	,	5	3	2	
Area (m^2)	25	25	20	25	25	25	30
Cover (%)	100	100	100	100	100	100	100
***Carex otrubae* & *Lolium apenninum* comm.**							
Carex otrubae Podp.	2	2	2	.	.	.	.
Lolium apenninum (De Not.) Ardenghi & Foggi	2	4	2	.	1	+	.
Convolvulus sepium L.	3	2	3	.	.	.	.
Cyperus longus L.	2	1	+	.	.	.	.
Arrhenatheretalia elatioris*; *Molinio-Arrhenatheretea							
Poa pratensis L. subsp. *pratensis*	+	2	+	.	1	.	.
Agrostis stolonifera L. subsp. *stolonifera*	.	2	+	.	.	.	.
Rumex obtusifolius L. subsp. *obtusifolius*	1	+	+	.	.	.	.
Dactylis glomerata L. subsp. *glomerata*	.	.	.	1	+	2	.
Daucus carota L. subsp. *carota*	.	.	.	.	1	.	.
Elymus repens (L.) Gould subsp. *repens*	.	2	1	.	.	.	.
Tragopogon porrifolius L.	+	.	.	.	.	1	.
Cirsium arvense (L.) Scop.	4	.	.	.	.	.	1
Carex acutiformis Ehrh.	.	.	.	.	.	.	+
Carex vulpina L.	.	.	.	.	.	.	1
Epilobium tetragonum L.	+	.	.	.	.	.	.
Lathyrus pratensis L. subsp. *pratensis*	1	.	.	.	.	.	.
Lotus tenuis Waldst. & Kit. ex Willd.	+	.	.	.	.	.	.
Potentilla reptans L.	.	.	.	.	.	.	+
Tragopogon pratensis L.	.	1	.	.	.	.	.
***Thynopyrum acutum* & *Convolvulus arvensis* comm.**							.
Convolvulus arvensis L.	.	.	.	3	3	1	.
Thinopyrum acutum (DC.) Banfi	.	.	.	5	5	4	.
Foeniculum vulgare Mill.	.	.	.	1	2	1	.
Inulo-Agropyrion repentis*; *Elytrigio-Dittrichietalia viscosae*; *Artemisietea							.
Avena fatua L.	2	2	.	2	1	2	.
Vicia pannonica Crantz subsp. *pannonica*	.	.	.	2	1	+	.
Silene vulgaris (Moench) Garcke	.	.	.	.	+	1	.
Campanula rapunculus L.	.	.	.	.	+	2	.
Symphyotrichum squamatum (Spreng.) G.L.Nesom.	.	+	+	.	.	.	.
Anisantha sterilis (L.) Nevski	.	.	.	.	.	.	+
Stachys germanica L. subsp. *salviifolia* (Ten.) Gams	.	.	.	.	+	.	.
***Phragmites australis* & *Urtica dioica* comm.**							.
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	.	.	.	.	.	5
Urtica dioica L. subsp. *dioica*	.	.	.	.	.	.	3
Festuco-Brometea							.
Cota tinctoria (L.) J.Gay subsp. *tinctoria*	.	.	.	.	+	.	.
Festuca rubra L. subsp. *rubra*	.	.	.	.	+	+	.
Poterium sanguisorba L.	.	.	.	2	.	1	.
Ononis spinosa L. subsp. *spinosa*	.	.	.	.	.	+	.
Ranunculus bulbosus L.	.	+	.	.	.	.	.
Allium sphaerocephalon L. subsp. *sphaerocephalon*	.	.	.	.	+	.	.
Chenopodietea* & *Artemisietea							.
Vicia hybrida L.	.	.	.	3	2	1	.
Dasypyrum villosum (L.) P. Candargy	.	.	.	+	+	1	.
Trigonella esculenta Willd.	.	.	.	.	+	.	.
Trigonella italica (L.) Coulot & Rabaute	.	.	.	.	.	+	.
Allium polyanthum Schult. & Schult.f.	.	.	.	2	+	+	.
Knautia integrifolia (L.) Bertol.	.	.	.	.	.	1	.
Securigera securidaca (L.) Degen & Dörfl.	.	.	.	.	.	1	.
Vicia sativa L. subsp. *sativa*	.	+	.	.	.	.	.
Galium aparine L.	.	.	.	.	+	.	1
Sherardia arvensis L.	.	.	.	.	+	.	.
Trifolio-Geranietea							
Silene latifolia Poir.	.	.	.	.	+	.	.
Geranium columbinum L.	.	.	.	.	+	.	.
Geranium dissectum L.	.	.	.	.	.	.	2
Lygeo-Stipetea* & *Sedo-Scleranthetea							.
Avena barbata Pott ex Link	.	.	.	1	1	+	.
Bituminaria bituminosa (L.) C.H.Stirt.	.	.	.	2	2	.	.
Quercetea ilicis* & *Crataego-Prunetea							.
Asparagus acutifolius L.	.	.	.	.	+	.	.
Euonymus europaeus L.	.	.	.	.	.	.	1
Rubus caesius L.	.	.	.	.	.	.	2
Sambucus ebulus L.	.	.	.	.	.	+	.

Table 3. Helophytic and hygrophylous communities .

Relevé nb.	1	2	3
Altitude	44	33	22
Aspect	.	.	.
Slope (°)	.	.	.
Rockiness (%)	.	.	.
Stoniness (%)	.	.	.
Area (m^2)	10	4	10
Cover (%)	100	90	100
***Typha* sp.pl. comm.**			
Typha angustifolia L.	3	.	1
Typha domingensis (Pers.) Steud	2	.	.
Typha latifolia L.	2	+	.
Typha laxmannii Lepech	1	.	.
Phragmito-Magnocaricetea			
Alisma plantago-aquatica L.	.	1	.
Berula erecta (Huds.) Coville	.	.	1
Convolvulus sepium L.	1	.	.
Schoenoplectus tabernaemontani (C.C.Gmel.) Palla	1	.	.
Veronica anagallis-aquatica L. subsp. *anagallis-aquatica*	.	.	+
Molinio-Arrhenatheretea			
Agrostis stolonifera L. subsp. *stolonifera*	+	+	+
Juncus articulatus L. subsp. *articulatus*	2	2	1
Scirpoides holoschoenus (L.) Soják	2	2	.
Cyperus longus L.	.	.	+
Elymus repens (L.) Gould subsp. *repens*	.	.	+
Samolus valerandi L.	.	.	+
Cyperus fuscus L.	1	.	.
Ruppietea maritimae			
Zannichellia peltata Bertol	.	2	.
Charetea intermediae			
Chara sp. pl.	.	.	5
Tolypella hispanica Nordstedt ex T.F.Allen	.	.	1
Alno-Populetea			
Salix alba L.	1	1	.
Populus canescens (Aiton) Sm.	+	.	.
Populus nigra L. subsp. *nigra*	.	.	+
Papaveretea rhoeadis			
Sonchus oleraceus L.	.	.	+
Artemisietea			
Symphyotrichum squamatum (Spreng.) G.L.Nesom.	.	+	.
Pegano-Salsoletea			
Polypogon monspeliensis (L.) Desf.	.	.	1

found since then in that region. Similarly, for Lazio there is only an ancient record relating to a sample collected in Rome (I.IV.1894, leg. "*sine coll*" and preserved in G (Talavera et al. 1986). Therefore this record for the Acque Albule site is a confirmation of the presence of this plant in Lazio. According to Talavera et al. (1986), the genus *Zannichellia* is divided into two sections. Sect. *Zannichellia* includes polyploid species (*Z. palustris* L., *Z. pedunculata* Rchb., *Z. major* Boenn. ex Rchb. and *Z. melitensis* Brullo, Giusso et Lanf) and is characterized by bearing male and female flowers on the same node and having stamens with short filaments and bilocular anthers. Sect. *Monopus* Graebner, consisting of *Z. peltata* Bertol., *Z. obtusifolia* Talavera, Garcia-Mur. et H. Smit and *Z. contorta* (Desf.) Chamisso et Schlecht., includes all diploid species and has male and female flowers on different nodes and stamens with long filaments and tetralocular anthers. Our specimens show the latter morphological traits and are distinguished by being annual plants with acute-apex leaves. In the study area this taxon was found in a fresh-water pool at the base of a travertine cliff bordered by a *Typha latifolia* stand.

Bryophytes

Bryophytic studies are few throughout the whole Lazio region and these were carried out in a few well-defined areas. In addition to Carcano's study (1989) on the bryophytic flora of the city of Rome, the Circeo National Park (Aleffi et al. 1998) and on the Lazio side of the Monti della Laga (Aleffi et al. 1997), recent research has been carried out in the Monterano Nature Reserve (Aleffi and Tacchi 2004). Other studies regarded more artificial environments, such as the Vatican Gardens (Aleffi 2015) and in the Pontifical Villas of Castel Gandolfo (Aleffi 2017) and Villa Gregoriana in Tivoli (Aleffi et al. 2020b), where several species belonging to the *Cratoneurion* alliance have been found. The most recent study was that carried out in coastal reserve of Castelporziano (Aleffi 2021). As far as the bryosociological studies are concerned, a survey on the bryophyte vegetation of the Circeo National Park (Privitera and Puglisi 2009), and another on the Mediterranean temporary ponds of some Italian territories including Lazio region were carried out (Puglisi et al. 2015).

BRACHYTHECIUM ALBICANS (Hedw.) Schimp.
B.S.G. Bryol. Eur. 6: 23. 553 (1853)
Bas.: *Hypnum albicans* Hedwig, Sp. Musc. Frond.: 251 (1801).
New record for Lazio region.

Brachythecium albicans occurs in almost all Italian regions, albeit with sporadic and point-like reports, often dating back to the late 19th century. It is a moss species with a characteristic morphology due to its pale whitish-green or yellow-green color, and the presence of string-like shoots. The plants are sparsely branched, generally 2–5 cm long, with tall, mostly erect branches. This moss species typically grows on light and shallow soils, not very rich in organic matter, especially sandy substrates. It can also be found in pastures and within roads edges or uncultivated lands. Although *B. albicans* prefers acidic substrates, it can also occur on leached calcareous soils and limestone rocks. It acts as typical open habitat species so that it rarely occurs in shaded environments.

GRIMMIA MONTANA Bruch & Schimp.
B.S.G. Bryol. Eur. 3: 128 (1845).
New record for Lazio region.

This species is currently recorded only for the Alps and few scattered sites in southern Italy, Sardinia and Sicily. This report for the Lazio region is the first for central Italy. *Grimmia montana* is normally found in the form of small cushions whose colour ranges from dark green to almost black. Gametophytes are up to 1 cm thick and grow on different types of substrates, from very base-rich to acidic, usually in environments well exposed to light. It is common at moderate to high elevations, but it can grow at low altitudes too.

Lichens

There are few references to date on the lichenological component of the travertine outcrops of Acque Albule. Ravera, in Fanelli (2007), identified *Cladonia foliacea* (Huds.) Willd. *Gyalolechia fulgens* (Sw.) Søchting, Frödén & Arup., *Psora decipiens* (Hedw.) Hoffm, *Toninia* sp., and *Collema* sp. in a study concerning a particular type of therophytic grassland of the *Alysso-Sedion* identified in the Platea dei Tartari located outside the boundary of the current SAC. In our paper we report a new short list of rare lichens for the Lazio region.

ARTHONIA GALACTITES (DC.) Dufour
J. Phys. Hist. Nat., 87: 203, 1818.
Bas.: *Verrucaria galactites* DC in Lamarck & de Candolle, Fl. Franç., éd. 3, 2: 315, 1805.
Taxon confirmed for Lazio region.

It is an epiphytic crustose lichen, rather hygrophytic to mesophitic, extremely rare to rare in Italy, usually found on smooth barks, e.g., *Populus* sp.pl., *Fraxinus ornus*. Previous reports for the flora of Lazio date back to the end of the nineteenth century (Tamburlini 1884; Jatta 1889). In the study area it occurs on *Populus* sp. on a small stream bank.

DIPLOSCHISTES GYPSACEUS (Ach.) Zahlbr.
Hedwigia, 31: 35, 1892.
Bas.: *Urceolaria gypsacea* Ach., Lichenogr. Univ.: 338, 1810.
Second record for Lazio region

This is an extremely rare to rather rare crustose lichen in Italy, currently known in the Lazio region only in the Monterano Nature Reserve (Genovesi et al. 2011); previous reports date back to the end of the nineteenth century (Tamburlini 1884; Jatta 1889). This species is usually found in rock fissures, on vertical or underhanging surfaces of calcareous rocks (Fig. 7). In the study area it widely occurs only at the edge of geyser form structures.

PLACIDIUM RUFESCENS (Ach.) A. Massal.
Sched. Crit., 6: 114, 1856.
Bas.: *Endocarpon rufescens* Ach., Lichenogr. Univ.: 304, 1810.
Second record for Lazio region.

It is a squamulose lichen (Fig. 8) very rare to rather rare in Italy, usually found with cyanobacteria on vertical seepage tracks of calcareous rocks. This is the second record from Lazio region where the species is only known on limestone within the montane belt of Mount S.Angelo in the Aurunci mountains (Nimis and Tretiach 2004).

SQUAMARINA LENTIGERA (Weber) Poelt
Mitt. bot. Staatss. München, 2: 536, 1958.
Bas.: *Lichen lentigerus* Weber - Spicil. Fl. Goett.: 192, 1778.
New record of rare species for Lazio region.

This is a squamulose lichen very rare to rather rare in Italy, only locally common, especially on gypsaceous or clayey soil in dry grasslands (Fig. 9).

XALOCOA OCELLATA (Fr.) Kraichak, Lücking & Lumbsch
Austral. Syst. Bot., 26: 472, 2013.
Bas.: Parmelia ocellata Fr. - Lich. Eur. Ref.: 190, 1831
Taxon confirmed for Lazio region.

Figure 7. *Diploschistes gypsaceus* (Ach.) Zahlbr.

Figure 8. *Placidium rufescens* (Ach.) A. Massal.

Figure 9. *Squamarina lentigera* (Weber) Poelt.

It is a very rare to rather rare crustose lichen, occurring only on the geyseriform structures; previous reports in Lazio region date back to the end of the nineteenth century (Tamburlini 1884; Jatta 1889).

Algae (Charophyceae)

The Italian flora includes 39 species of Charophytes, also known as stoneworts (Bazzichelli and Abdelahad 2009; Romanov et al. 2019; Becker 2019; Becker et al. 2021). Their presence often goes unnoticed and few recent studies have analyzed their distribution in Italy (Becker 2019). Stoneworts play an important ecological role in aquatic ecosystems (Vestergaard and Sand-Jensen 2000, Kufel and Kufel 2002), are threatened at European and global level (Baastrup-Spohr et al. 2013; Azzella 2014) and has used in bioindication (Doege et al. 2016; Poikane et al. 2018). In the absence of anthropogenic disturbance, when the ecological conditions are favorable, stoneworts are the dominant elements in a variety of wetland and freshwater or brackish habitats. Stoneworts need freshwater with high conductivity and low concentration of nitrates and phosphates. Therefore, the SAC "Travertini Acque Albule (Bagni di Tivoli)" is potentially a favorable habitat for their proliferation, but few studies report information of stoneworts occurrences. At the beginning of the twentieth century in the "Herbarium romanum" (RO) (Thiers 2022) of the Royal botanical institute were preserved four specimens from the area of Acque Albule: *Chara tomentosa*, *C. gymnophylla*, *C. crassicaulis*, and *C. vulgaris* (Formiggini 1909). Since then, the botanical studies in this area have mainly focused on the vascular flora while the investigations relating to the *Characeae* broke off. In the surveys made in the SAC "Travertini Acque Albule (Bagni di Tivoli)", vegetation dominated by algae of the *Charophyceae* class was observed in the quarry areas flooded by groundwater. Extensive populations dominated by six species of the genus *Chara* and one dominated by a species of the genus *Tolypella* were found.

TOLYPELLA HISPANICA Nordstedt ex T.F.Allen 1888

This is a particularly rare species, with a range restricted to the coastal areas of the western Mediterranean and at risk of extinction in Italy.

CHARA DELICATULA C.Agardh
CHARA GLOBULARIS Thuillier
CHARA ASPERA Wildenow
CHARA VULGARIS L.
CHARA HISPIDA L.
CHARA INTERMEDIA A.Braun ex Lange

They are all typical species of oligo-mesotrophic waters rich in dissolved silicates and carbonates. The quarry areas in this context therefore represent an ideal ecosystem for the development of stoneworts (Fig. 10), plants sensitive to increased trophic loads and water turbidity. The first three species belong to the Grovesia Wood 1962 sub-section of the species of the genus *Chara* with triplostic cauloid and are easy to identify. *C. hispida* and *C. intermedia* belong to the Hartmania Wood 1962 sub-section and their identification is more complex, especially, as in our case, when calcareous incrustations on single individuals are found. *C. vulgaris*, *C. globularis* and *C. delicatula* are the most common species. *C. globularis* and *C. delicatula* rarely colonize the same water body (Pelechaty et al. 2004) so it is peculiar we have found them growing together in a restricted ecological space such as that of the quarry pools. However the simultaneous occurrence of *C. globularis* and *C. delicatula* was already reported for the Lazio region in the volcanic lakes of Bracciano, Bolsena and Vico (Azzella 2014) where, the coexistence of these two species is certainly more plausible given the large size and the high depth gradient of these lakes.

The aquatic community we identified in the Acque Albule area could be classified in the habitat 3140 of 92/43/EEC Directive "Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp."

Discussion and conclusion

Plant communities, which in their different way of spatial arrangement give rise to the landscape, are living systems whose ecological and structural characteristics are based on a well-defined specific and biogeographical heritage which refer only and exclusively to their lists of plant species. Therefore, the knowledge of the Flora is useful not

only to achieve scientific or academic goals but has an essential value for those who deal with environmental management at a political or administrative level. For example, in this research, thanks to the floristic new reports associated with the phytosociological data, the presence of two further Habitats (i.e. 5330 and 3140) listed in the Habitat directive is hypothesized. This information will be considered and verified by the offices that deal with environmental protection (in particular with the application of Habitat Directive rules) and will certainly have repercussions in the future management policies of the SAC. The "Travertini Acque Albule (Bagni di Tivoli)" SAC, considering the environmental uniqueness of the site, could really play the role of identity marker for the local populations. However, this is not happening (at least for the moment). In fact, local populations still perceive the environment that surrounds them as something foreign, sometimes even hostile, towards which no sense of belonging is manifested. It is probable that at the basis of this substantial indifference between local populations and surrounding environment there are the numerous anthropic tampering to which the Acque Albule area is constantly subjected, which has distorted its original characteristics and highly fragmented the landscape. Hence, a greater effort of protection associated to a sustainable management policy based on scientific data is strongly required. It is well-known that the sense of belonging to a place and the willingness to fight for its protection fail when there is no knowledge of it. The restricted list of new floristic records associated to phytosociological relevés published in this paper can be considered a small step forward in that direction.

The new record of *Onosma echioides* subsp. *angustifolia* confirms the attitude of the Acque Albule area to host plant species that normally occurs at considerably higher altitudes (e.g. *Chaenorhinum rubrifolium* and *Thymus striatus* subsp. *acicularis* which also occur in this area). In its whole distribution area *Onosma echioides* subsp. *angustifolia* is reported for altitudes ranging around 400–700 m (Anzalone et al. 2010; Bartolucci et al. 2018). For this reason, the record at 41 m a.s.l. represents by far the lowermost altitudinal limit in Italy for this subspecies and for the entire group of *Onosma echioides* s.l as well. From a phytosociological point of view *O. echioides* subsp. *angustifolia* is currently reported only for the *Stipo austroitaliacae-Seslerietum juncifoliae* of the Gargano promontory (Di Pietro and Wagensommer 2008, 2014). Beyond the importance of the new floristic record, it is the peculiar coenological context of *O. echioides* subsp. *angustifolia* in the Acque Albule area which is to be considered noteworthy. In fact, this species can be found in three different coenological situations, namely co-dominance with *Teucrium capitatum* in typical micro-chamaephytic garrigues developed on coarse travertine debris, high frequency species in *Sedo-Scleranthetea* communities dominated by *Sedum hispanicum* and co-dominance with *Ampelodesmos mauritanicus* in open *Lygeo-Stipetea* steppe-like grasslands on compact travertine slabs.

The new record of *Ophrys illyrica* represents a very interesting finding, especially considering that this species is even classified as a rare species in its *locus classicus* area (Pezzetta 2020). In the study this species was found in an intermediate coenological situation between *Stipo-Tra-*

Figure 10. *Chara aspera* Wildenow meadow.

chynetea (Habitat 6220), *Sedo-Scleranthetea* (Habitat 6110) and *Chenopodietea*. A more detailed classification at lower hierarchical rank is not possible at the moment due to the well-known large floristic overlaps between these three classes and to the excessive number of associations currently proposed by the Italian phytosociological literature for Mediterranean therophytic vegetation (see Fanelli and Lucchese 1998; Di Pietro and Blasi 2002; Fanelli et al. 2010; Di Pietro et al. 2021). Our identification of *Ophrys illyrica* was based on some diagnostic characters of the species, such as the lax inflorescence, the reddish brown, flat to slightly convex labellum with narrow submarginal hairiness and absence of basal hump and also by the late flowering period (see Antonj et al. 2018). We are aware that not all taxonomic doubts are currently resolved in the differentiation and identification of *O. illyrica*, *O. tommasini* and *O. ausonia*. To note, however, that the Acque Albule natural landscape and that of the surrounding hills (e.g. Cornicolani mountains) is typically characterized by "Illyrian" *šibljak* communities (see Adamovic 1902), in this case dominated by small trees, such as *Pistacia terebinthus*, *Carpinus orientalis*, *Cercis siliquastrum*, and tall shrubs, such as *Styrax officinalis*, *Phillyrea latifolia* and *Paliurus spina-christi*.

The new records of *Typha domingensis* and *T. laxmannii* deserve a separate discussion. It should first be established whether their presence is natural or whether instead they were directly or indirectly introduced due to anthropic activities that took place in the proximity of depressed and humid areas. In fact, these two species were found in helophytic communities hosting also *T. latifolia* and *T. angustifolia*, that develop in a small overflow loop of a little stream of sulphurous waters bordering a bathhouse and running downstream of an ancient spring pool of sulphurous water (of which it probably represented the natural emissary), now cemented and transformed into a swimming pool. It is known that wetlands are particularly vulnerable for biological invasions especially around newly constructed secondary water bodies or pools. At the same time the genus *Typha* is composed of highly potential invasive species (Bansal et al. 2019) capable of quickly colonizing mud banks thanks to their high ability of long-distance dispersal and adaptations to strong competition after initial establishment (Shipley et al. 1989). To be noted that *Typha* species normally build monodominant stands, so that direct interspecific competition within the genus as well as between *Typha* and other plant species typical of wet areas is not a common phenomenon (Stewart et al., 1997). Rasran et al. (2021) report about different ecological optimum for *T. angustifolia*, *T. latifolia* and *T. laxmannii* as regards their response to different water level with *T. angustifolia* about 40 cm water depth, *T. latifolia* 20 cm, and *T. laxmannii* between 0 and 20 cm up to non-flooded sites. It is possible that the peculiar micro-geomorphology and hydro-geology of the Acque Albule area, characterized by considerable and sudden variations in the water table (also due to the millennial activity of the adjacent travertine quarries and thermal establishments and resorts) and the consequent flooding or drying-up of the wetlands, allowed each of the four cattails species observed to find their own ecological niche. If this were the case, *T. domingensis* and *T. laxmanni* would assume the status of native species in the area in issue like *T. latifolia* and *T. angustifolia*. These new records are very important from a phytogeographic point of view. Especially for *T. laxmanni* this would be the first record for the Tyrrhenian side of the Italian peninsula. It should be noted that *T. laxmanni* is not the only case of species showing this peculiar distribution in the study area. In fact, also *Onosma echioides* subsp. *angustifolia* was known to date only from the Adriatic side of the Italian Peninsula and *Styrax officinalis* itself is an E-Mediterranean species occurring only in the Tyrrhenian side of the Peninsula. On the other hand, the fact that *T. laxmannii* and *T. domingensis* had never been recorded previously in the study area and that the wetlands in which we collected them is placed in spatial contact with a thermal resort may leave doubts on a possible recent arrival of these species linked to the remodeling work carried out in the last two decades on the ancient natural pools to transform them into swimming pools. Further studies will be needed to decide on the native status of both *T. domingensis* and *T. laxmanni*. However, the constant tampering of the natural areas (especially the humid ones) in the Acque Albule site still remains a major problem for the monitoring of ecosystems and the conservation of biodiversity. Already the summer following our spring field surveys, the helophytic community dominated by *Typha* species was inexplicably subjected to mowing in defiance of all the rules and prohibitions relating to the conservation measures that characterize a protected area.

As far as the bryophytic flora is concerned, the new regional record of *Grimmia montana* is a further example of a species which is normally found at higher altitudes and that marks in the Acque Albule site one of its lowermost stations in peninsular Italy.

Considering the valuable lichen flora, *Squamarina lentigera* stands out because it is of particular interest both from a phytogeographic and conservation point of view. It belongs, together with *Gyalolechia fulgens*, to a small group of sub-continental species present in areas with a dry-sub-continental climate (e.g. dry alpine valleys, parts of Mediterranean Italy) which represent less than 4% of the total Italian lichen flora (see Nimis and Martellos 2022). It is only locally common, especially on gypsaceous or clayey soil in dry grasslands and declining rapidly.

Finally, of particular interest is the reporting of stonewort pools. The surveyed communities can be classified in the *Charetea intermediae* class belonging to the habitat of community interest "3140 - Calcareous oligo-mesotrophic waters with benthic vegetation of *Chara* spp" which had never been reported for this SAC. It should be emphasized however that the reference to the Habitat 3140 is just to be considered a preliminary hypothesis. In fact, quarries are typical "not natural" environments that are strongly shaped and reworked by the travertine extraction activity so that

the newly formed communities dominated by stoneworts identified in the study area are not currently part of the natural landscape of the SAC. However, part of the innovative character of the Habitats Directive is precisely that of protecting some habitats whose biotic characteristics are clearly the result of human action (e.g. 6210*secondary grasslands, 6310 Dehesas with sclerophyllous trees, or, even more fitting, the 6130 Calaminarian grasslands on old terrils or spoil heaps around mines). For this reason, even the pools with stoneworts identified in the study area, although temporary and strongly subject to travertine management and exploitation, could be included in a sustainable management project aimed at safeguarding biodiversity directly inside the quarry. There are already virtuous examples of protection of new born ecosystems in Europe and they expressly concern quarry environments. For example, LIFE14 NAT/BE/000364 "life in Quarries" project has succeeded with concrete actions in protecting newly formed ecosystems referable to Habitat 3140. Based on these positive examples, we could work on a special type of *in situ* conservation, identifying protection areas directly in the quarries where the degree of naturalness is notoriously very low, but when present, it can play a key role in the conservation of ecosystems which, as is the case of SAC "Travertini Acque Albule (Bagni di Tivoli), are no longer traceable in natural areas. On the basis of a diachronic analysis using satellite images, the flooded areas inside the quarry exhibit a relatively short life and changed their spatial position in relation with the processes necessary for the extraction of the travertine (Fig. 11). The detected communities could therefore be considered pioneer communities although the occurrence of species (e.g. *Chara hispida* and *Tolypella hispanica)* that generally dominate in stable communities. In the flooded quarry areas the waters are oligotrophic in a first stage (Seelen et al. 2021) and this promotes the colonization by *Charetea intermediae* species (Habitat 3140). If the hydrological regime allows the maintenance of good water quality and low nutrients concentration, Habitat 3140 stabilizes. Otherwise, a process of natural eutrophication occurs due to water stagnation. The increase in the load of nutrients leads to a regime-shift towards eutrophic conditions (Viaroli et al. 2002) and stoneworts decreasing.

Figure 11. The variations of the flooded areas in the quarries of the SAC.

Acknowledgements

The authors thank Professors Simonetta Bagella, Marta Puglisi and the anonymous reviewer for their constructive comments and suggestions to the manuscript. The authors thank also the members of Protezione Civile of the Tivoli Municipality and the Rangers of the Monti Lucretili Regional Park Authority for their logistic support during the sampling work. The study was financed by Ente Parco Naturale Regionale dei Monti Lucretili (det. Dir. n. 76 del 02/04/2021): Agreement between Ente Parco Naturale Regionale dei Monti Lucretili and Department PDTA of Sapienza Università di Roma (Resp. Romeo Di Pietro). The work of M.M. Azzella concerns a research project partially funded by the Italian legislative decree 1062/2021.

Bibliography

Adamović L (1902) Die Šibljak- Formation, ein wenig bekanntes Buschwerk der Balkanländer, Botanische Jahrsbücher für Systematik, Phlanzengeschichte und Pflanzengeographie 31(1): 1–29, Leipzig.

Aleffi M (2015) The bryophyte flora of the Vatican City State. Cryptogamie, Bryologie 36(2): 155–169. https://doi.org/10.7872/cryb.v36.iss2.2015.155

Aleffi M (2017) Contribution to the knowledge of the bryophyte flora of the Vatican City State: the pontifical villas of Castel Gandolfo (Rome, Italy). Flora Mediterranea 27: 137–150. https://doi.org/10.7320/FlMedit27.137

Aleffi M (2021) Aspetti floristici, biogeografici ed ecologici delle Briofite della Tenuta presidenziale di Castelporziano. In: "Il Sistema Ambientale della Tenuta presidenziale di Castelporziano. Ricerche sulla complessità di un ecosistema forestale costiero mediterraneo", Scritti e documenti LXII. Accademia Nazionale delle Scienze detta dei XL, in collaborazione con Segretariato Generale della Presidenza della Repubblica. ISBN 978-88-98075-42-3, ISSN 03-91-4666.

Aleffi, M, Tacchi R (2004) *Sphagnum capillifolium* (Ehrh.) Hedw. var. *tenerum* (Sull. & Lesq. ex Sull.) HA Crum and *S. girgensohnii* Russow, new to central and southern Italy. Webbia 59(2): 469–475. https://doi.org/10.1080/00837792.2004.10670779

Aleffi M, Cortini Pedrotti C, Schumacker R (1997) Flora briologica dei Monti della Laga (Italia centrale). Webbia 52(1): 1–41. https://doi.org/10.1080/00837792.1997.10670631

Aleffi M, Tacchi R, Poponessi S (2020a) New checklist of the bryophytes of Italy. Cryptogamie, Bryologie 41(13): 147–195. https://doi.org/10.5252/cryptogamie-bryologie2020v41a13

Aleffi M, Carratello A, Poponessi S (2020b) Le Briofite del Parco di Villa Gregoriana a Tivoli (Roma, Italia). Notiziario della Società Botanica Italiana 4(1): 6–11.

Aleffi M, Bonini I, Cogoni A, Concu AP, Cortini Pedrotti C, Esposito A, Miserere L, Pezzino FM, Privitera M, Puglisi M, Sambataro R (1998) Contributo alla flora briologica del Parco Nazionale del Circeo (Lazio). Informatore Botanico Italiano 30 (1-3): 37–46.

Angelini, P., Casella, L., Grignetti, A., & Genovesi, P. (Eds.). (2016). Manuali per il monitoraggio di specie e habitat di interesse comunitario (Direttiva 92/43/CEE) in Italia: habitat. ISPRA, Serie Manuali e Linee Guida, 142/2016. http://www.isprambiente.gov.it/public_files/direttiva-habitat/Manuale-142-2016.pdf

Antonj M, Rempicci M, Buono S, Gransinigh E (2018) Sulla presenza di *Ophrys illyrica i*n Italia, e in particolare nel Lazio. GIROS Orchidee Spontanee d'Europa 61: 91–102.

Anzalone B (1982) *Stipa caudata* Trinius (Gramineae), new for Europe, Webbia 35(2): 355–360. https://doi.org/10.1080/00837792.1982.10670231

Anzalone B, Iberite M, Lattanzi E (2010) La flora vascolare del Lazio. Inform. Bot. Ital. 42(1): 187–317.

Azzella MM (2014) Italian Volcanic lakes: a diversity hotspot and refuge for European charophytes. Journal of Limnology 73: 502–510. https://doi.org/10.4081/jlimnol.2014.950

Baastrup-Spohr L, Iversen LL, Dahl-Nielsen J, Sand-Jensen K (2013) Seventy years of changes in the abundance of Danish charophytes. Freshwater Biol. 58: 1682–1693. https://doi.org/10.1111/fwb.12159

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, et al. (2018). An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179–303. https://doi.org/10.1080/11263504.2017.1419996

Bartolucci F., Galasso G. (2022) Notulae to the Italian native vascular flora: 13. Italian Botanist 13 Supplementary data.

Bazzichelli G, Abdelahad N (2009) Flora analitica delle Caroficee. La Sapienza University of Rome: 80 pp.

Becker R (2019) The *Characeae* (*Charales*, *Charophyceae*) of Sardinia (Italy): habitats, distribution and conservation. Webbia 74(1): 83–101. https://doi.org/10.1080/00837792.2019.1607497

Becker R, Schubert H, Nowak P (2021) *Chara zeylanica* JG Klein ex Willd. (*Charophyceae*, *Charales*, *Characeae*): First European Record from the Island of Sardinia, Italy. Plants 10(10): 2069. https://doi.org/10.3390/plants10102069

Bansal S, Lishawa SC, Newman S, Tangen BA, Wilcox D, Albert D, et al. (2019) *Typha* (Cattail) invasion in North American wetlands: biology, regional problems, impacts, ecosystem services, and management. Wetlands 39: 645–684. https://doi.org/10.1007/s13157-019-01174-7

Bernardo L, Caldararo F (2014) Nuove acquisizioni per la flora della Basilicata. Inform. Bot. Ital. 46(1): 56–57.

Bertoloni A (1854) Flora italica sistens plantas in Italia et in insulis circumstantibus sponte nascentes, 10 (1-5). Ex Typographaeo Haeredum Richardi Masii, Bononiae, Bologna: 1–640.

Blasi C (1994) Fitoclimatologia del Lazio. Univ. La Sapienza: Regione Lazio, Assessorato Agricoltura-Foreste, Caccia e Pesca.

Bonari G, Fantinato E, Lazzaro L et al (2021) Shedding light on typical species: implications for habitat monitoring. Plant Sociol 58:157–166. https://doi.org/10.3897/pls2020581/08

Braun-Blanquet J (1964) Pflanzensoziologie. Grundzüge der Vegetationskunde. Springer Verlag. https://doi.org/10.1007/978-3-7091-8110-2

Brunetti E, Jones J P, Petitta M, Rudolph D L (2013) Assessing the impact of large-scale dewatering on fault-controlled aquifer systems: a case study in the Acque Albule basin (Tivoli, central Italy). Hydrogeology journal 21(2): 401–423. https://doi.org/10.1007/s10040-012-0918-3

Carcano L (1989) Moss inventary of the urban area of Rome (Italy). Braun Blanquetia 3: 147–150.

Conti F, Bartolucci F, Manzi A, Paolucci M, Santucci B, Petriccione B, Miglio M, Ciaschetti G, Stinca A (2015) Integrazioni alla flora vascolare dell'Italia centrale. Atti Soc. Tosc. Sci. Nat., Mem., Serie B 122: 33–42.

Cortini Pedrotti C (2001) Flora dei muschi d'Italia. *Sphagnopsida*, *Andreaeopsida*, *Bryopsida* (I parte). Roma, Antonio Delfino Editore. 832 pp.

Cortini Pedrotti C (2005) Flora dei muschi d'Italia. *Bryopsida* (II parte). Roma, Antonio Delfino Editore. 432 pp.

Delforge P (2016) Guide des orchidées d'Europe, d'Afrique du Nord et du Proche Orient. Delachaux et Niestlé, Paris 481pp.

Della Porta G, Croci A, Marini M, Kele S (2017) Depositional architecture, facies character and geochemical signature of the Tivoli travertines (Pleistocene, Acque Albule Basin, Central Italy). Rivista Italiana di Paleontologia e Stratigrafia (Research in Paleontology and Stratigraphy) 123(3): 487–540.

Devillers P, Devillers-Terschuren J (2004) Scolopaxoid Ophrys of the Adriatic: Diversity and biogeographical context. Natural. Belges 85 (Orchid. 17): 188–234.

Di Pietro R, Blasi C (2002) A phytosociological analysis of abandoned olive groves grasslands of Ausoni Mountains (Tyrrhenian district of Central Italy). Lazaroa 23: 79–93.

Di Pietro R, Germani D (2007) Considerazioni cenologiche e fitosociologiche preliminari sulla presenza di *Styrax officinalis* L. nei Monti Cornicolani (Lazio centrale). Fitosociologia 44(2)suppl. 1: 219–224.

Di Pietro R, Germani D (2012) La vegetazione. In: Giardini M. (ed.). Sant'Angelo Romano (Monti Cornicolani, Roma). Un territorio ricco di storia e di natura. Comune di Sant'Angelo Romano, Regione Lazio: 112–133.

Di Pietro R, Wagensommer RP (2008) Analisi fitosociologica su alcune specie rare o minacciate del Parco Nazionale del Gargano (Italia centro-meridionale) e considerazioni sintassonomiche sulle comunità casmofitiche della Puglia. Fitosociologia 45: 177–200.

Di Pietro R, Wagensommer RP (2014) A new *Sesleria juncifolia* association from south-eastern Italy and its position in the amphi-Adriatic biogeographical context. Acta Botanica Croatica 73(1): 171–207. https://doi.org/10.2478/botcro-2013-0018

Di Pietro R, Germani D, Fortini P (2017) A phytosociological investigation on the mixed hemycryptophitic and Therophitic grasslands of the Cornicolani Mountains (Latium Region -Central Italy). Plant Sociology 54(1): 107–128.

Di Pietro R, Fortini P, Misano G, Terzi M (2021) Phytosociology of *Atractylis cancellata* and *Micromeria microphylla* communities in southern Italy with insights on the xerothermic steno-Mediterranean grasslands high-rank syntaxa. Plant Sociology 58(1): 133–155. https://doi.org/10.3897/pls2021581/07

Doege A, van de Weyer K, Becker R, Schubert H (2016) Chapter 8 Bioindikation mit Characeen [Bioindication using Characeae]. In: Armleuchteralgen. Die Characeen Deutschlands [Stoneworts. Characeae of Germany]; Arbeitsgruppe Characeen Deutschlands, Ed.; Springer: Berlin/Heidelberg, Germany: 97-138. https://doi.org/10.1007/978-3-662-47797-7_8

Faccenna C (1994) Structural and hydrogeological features of Pleistocene shear zones in the area of Rome (central Italy). Ann. Geofis. 37(1):121-133. https://doi.org/10.4401/ag-4240

Fanelli G (1998) Dasypyrum villosum vegetation in the territory of Rome. Rend. Fis. Accad. Lincei 9: 149–170. https://doi.org/10.1007/BF02904397

Fanelli G (2007) Cryptogams rich nanotherophytic vegetation on travertine outcrops near Tivoli", Annali di Botanica (Roma) 7: 85–92.

Fanelli G, Bianco P, De Sanctis M, Serafini-Sauli A (2010) The alliance Trachynion distachyae Rivas-Martinez 1978 in Central Italy. Annali di Botanica (Roma) 0: 39–50.

Fanelli G, Lucchese F (1998) The status of *Brometalia rubenti-tectorum* in the Mediterranean area in different syntaxonomical schemes. Rend. Fis. Acc. Lincei 9: 241–255. https://doi.org/10.1007/BF02904407

Fiorini Mazzanti E (1857) Sovra due nuove alghe delle Acque Albule. In: Viale B, Latini V, Sulle Acque Albule presso Tivoli. Analisi chimica: 69–74.

Formiggini L (1909) Contributo alla conoscenza delle Caracee del Lazio. Annali di Botanica (Roma) 7: 207–211.

Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E et al (2018) An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556–592. https://doi.org/10.1080/11263504.2018.1441197

Genovesi V, Ravera S, Verri F (2011) Flora lichenica epilitica della Riserva Monterano. In: La Riserva Regionale Naturale Monterano. Ricerca e Gestione. Quaderni della Riserva Naturale Regionale Monterano, vol. 11. Comune di Canale Monterano.

Gianguzzi L, Caldarella O, Di Pietro R (2018) A phytosociological analysis of the Brachypodium rupestre (Host) Roem. & Schult. communities of Sicily. Plant Sociology 55(1): 665–88.

Giardini M (2004) L'impegno di Montelucci nella conservazione della natura e nell'educazione ambientale. Ann. Bot. (Roma), n.s. 4: 199–203.

Giardini M (2005) Note preliminari sulla flora del Montarozzo del Barco (Tivoli, Roma), un monumento naturale da conservare. Inform. Bot. Ital. 37(1, Parte A): 134–135.

Giardini M (2012) La flora vascolare del Montarozzo del Barco (Tivoli, Roma). Ann. Mus. civ. Rovereto 28: 161–197.

Giardini M (2008) Le «Conversazioni di Ecologia» di Giuliano Montelucci. Comune di Guidonia Montecelio, Associazione Culturale Archeologica Ambientalista Onlus «Amici dell'Inviolata», con il patrocinio della Sezione Laziale «Giuliano Montelucci» della Società Botanica Italiana. Grafica Ripoli editrice snc, Tivoli. 104 pp.

Giardini M., Calamita U., Ippoliti V., Ramondo P., D'Alessandro G. 2007. La piana dei Travertini. Conoscere, conservare, valorizzare. Quattro proposte di Monumento Naturale nei territori di Tivoli e Guidonia Montecelio. Laboratorio territoriale provinciale di informazione ed Educazione Ambientale di Tivoli, Provincia di Roma. 57 pp.

Gigante D, Attorre F, Venanzoni R, Acosta ATR, Agrillo E, Aleffi M, et al. (2016) A methodological protocol for Annex I Habitats monitoring: The contribution of vegetation science. Plant Sociology 53(2): 77–87. https://doi.org/10.7338/pls2016532/06

Guidi A (2007) VIII. Varietà del paesaggio vegetale e della flora nel territorio tiburtino. La flora del travertino e degli ambienti alofili nella Piana di Tivoli e il Sito di Importanza Comunitaria IT 603033 "Travertini Acque Albule (Bagni di Tivoli)". In: Guidi A (ed), La Riserva Naturale di Monte Catillo. Provincia di Roma: 129–165.

Hertel S, Presser H (2006) Zur Kenntnis der italienischen Orchideen. Jour. Eur. Orch. 38(3): 485–532.

Hodgetts NG, Söderström L, Blockeel TL, Caspari S, Ignatov MS, Konstantinova NA, et al. (2020) An annotated checklist of bryophytes of Europe, Macaronesia and Cyprus. Journal of Bryology 42(1): 1–116. https://doi.org/10.1080/03736687.2019.1694329

Iamonico D, Di Pietro R (2017) Plant Ecology for the active conservation and sustainable management of the territory. The question of the "Travertini Acque Albule" protected area. Urbanistica 4: 209–213

Jatta A (1889) Monographia lichenum Italiae meridionalis. - Trano: Typis V. Vecchi & C.

Kufel L, Kufel I (2002) Chara beds acting as nutrient sinks in shallow lakes-a review. Aquatic botany 72(3–4): 249–260. https://doi.org/10.1016/S0304-3770(01)00204-2

Montelucci G (1946) Investigazioni botaniche nel Lazio. I. Lo Styrax officinalis nei dintorni di Tivoli. Nuovo Giorn. Bot. Ital., n.s. 53: 230–268. https://doi.org/10.1080/11263504609440990

Montelucci G (1947) Investigazioni botaniche nel Lazio. III. Aspetti della vegetazione dei travertini delle Acque Albule (Tivoli). Nuovo Giorn. Bot. Ital., n.s. 54(3-4): 494–504. https://doi.org/10.1080/11263504709440451

Montelucci G (1949) Cenni ecologici su alcune piante notevoli (o nuove) per la flora romana e loro attività nella costituzione della vegetazione laziale. Nuovo Giorn. Bot. Ital., n.s. 56(3): 366–418. https://doi.org/10.1080/11263505009432109

Montelucci G (1954) Sui *Sedum* del territorio Cornicolano-Tiburtino. Nuovo Giorn. Bot. Ital., n.s. 61: 440–444.

Montelucci G (1963) Ancora nuove località di piante laziali. Giorn. Bot. Ital. 70: 616–619.

Montelucci G (1969) Scheda 14-1: Sorgenti Albule e Platea dei Tartari. In: Società Botanica Italiana, 1971. Censimento dei biotopi di rilevante interesse vegetazionale meritevoli di conservazione in Italia. Camerino.

Mucina L, Bültmann H, Dierßen K, Theurillat JP, Raus T, Čarni A, et al. (2016) Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. Applied Vegetation Science 19 (S1): 3–264. https://doi.org/10.1111/avsc.12257

Nimis PL (2016) The Lichens of Italy. A Second Annotated Catalogue. EUT, Trieste. 739 pp.

Nimis PL, Martellos S (2022) ITALIC - The Information System on Italian Lichens. Version 6.0. University of Trieste, Dept. of Biology. www.italic.units.it [accessed 27.9.2022]

Nimis PL, Tretiach M (2004) Delimiting Tyrrhenian Italy: A lichen foray in the SW part of the Italian peninsula. Bibl. Lichenol. 88: 465–478.

Paušič I, Žan C, Bakan B (2016) *Ophrys illyrica* S. Hertel & K. Hertel (Orchidaceae), a new species in the Slovenian flora. Annales Ser. Hist. Nat. 26 (1): 105–112.

Pelechaty M, Pukacz A, Pelechata A (2004) Co-occurrence of two stoneworts of reverse ecological spectra in the same lake ecosystem. Habitat requirements of *Chara delicatula* Agardh and *Chara globularis* Thuillier in the context of bioindication. Polish Journal of Environmental Studies 13(5): 551–556.

Peruzzi L, Passalacqua NG (2004) Problematiche relative al gruppo *Onosma echioides* (L.) L. (*Boraginaceae*) in Italia. Informatore Botanico Italiano 36: 162–164.

Peruzzi L, Passalacqua NG (2008) Taxonomy of the *Onosma echioides* (L.) L. complex (*Boraginaceae*) based on morphometric analysis. Botanical Journal of the Linnean Society 157(4): 763–774. https://doi.org/10.1111/j.1095-8339.2008.00827.x

Petitta M, Primavera P, Tuccimei P, Aravena R (2011) Interaction between deep and shallow groundwater systems in areas affected by Quaternary tectonics (Central Italy): a geochemical and isotope approach. Environmental Earth Sciences 63: 11–30. https://doi.org/10.1007/s12665-010-0663-7

Pezzetta A (2020) Le *Orchidaceae* della Dalmazia Atti Mus. Civ. St. Nat. Trieste 61: 201–260.

Pignatti S (2017-2019) Flora d'Italia. 4 Voll. Bologna, Edagricole.

Pignatti S, Pedrotti F, Lorenzoni GG (1961) Ricerche fitosociologiche sulla vegetazione ad *Ampelodesmos tenax* Link presso Tivoli e Sezze nel Lazio. Delpinoa, n.s. 3: 337–372.

Poikane S, Portielje R, Denys L, Elferts D, Kelly M, Kolada A, van den Berg MS (2018) Macrophyte assessment in European lakes: Diverse approaches but convergent views of 'good'ecological status. Ecological indicators 94: 185–197. https://doi.org/10.1016/j.ecolind.2018.06.056

Privitera M, Puglisi M (2009) Outlines of the bryophyte vegetation of the Circeo National Park (central Italy). Cryptogamie, Bryologie 30 (1): 91–107.

Puglisi M, Minissale P, Sciandrello S, Privitera M (2015) The bryophyte vegetation of the Mediterranean temporary ponds in Italy. Plant Sociology 52 (2): 69–78. https://doi.org/10.7338/pls2015522/03

Rasran L, Hacker P, Tumpold R, Bernhardt K G (2021) Ecological niches of an introduced species *Typha laxmannii* and native *Typha* species in Austria. Aquat Bot. 174 (1). https://doi.org/10.1016/j.aquabot.2021.103430

Rivas-Martínez S, Rivas-Saenz S, Penas A (2002) Worldwide bioclimatic classification system. Kerkwerve, The Netherlands: Backhuys Pub.

Romanov R, Napolitano T, Van De Weyer K, Troia A (2019) New records and observations to the Characean flora (*Charales*, *Charophyceae*) of Sicily (Italy). Webbia 74(1): 111–119. https://doi.org/10.1080/00837792.2019.1609258

Sanguinetti P (1855) Florae romanae prodromus alter. Roma

Sebastiani A, Mauri E (1818) Florae romanae prodromus. Roma

Seelen LM, Teurlincx S, Bruinsma J, Huijsmans TM, van Donk E, Lürling M, de Senerpont Domis LN (2021) The value of novel ecosystems: Disclosing the ecological quality of quarry lakes. Science of the Total Environment 769. https://doi.org/10.1016/j.scitotenv.2020.144294

Shipley B, Keddy PA, Moore DRJ, Lemky K (1989) Regeneration and establishment strategies of emergent macrophytes. J. Ecol. 77: 1093–1110. https://doi.org/10.2307/2260825

Smith C, Ashton PA (2006) Distinction between the sedges *Carex vulpina* L. and C. otrubae Podp. and the potential for identification of hybrids. Watsonia 26: 15–25.

Smith CW, Aptroot A, Coppins BJ, Fletcher A, Gilbert OL, James PW, Wolseley PA (2009) The Lichens of Great Britain and Ireland. The British Lichen Society, Department of Botany, The Natural History Museum, Cromwell Road, London. 1046 pp.

Stewart H, Miao SL, Colbert M, Carraher CE (1997) Seed germination of two cattail (*Typha*) species as a function of Everglandes nutrient levels. Wetlands 17: 116–122. https://doi.org/10.1007/BF03160723

Talavera S, Garcia Murillo P, Smit H (1986) Sobre el genero *Zannichellia* L. (*Zannichelliaceae*). Lagascalia 14: 241–71.

Tamburlini F (1884) Prima contribuzione alla lichenografia romana. - Annuario R. Ist. Bot. Roma 1(1): 122–153.

Thiers B (2022 [continuously updated]) Index Herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. Available from: http://sweetgum.nybg.org/science/ih (accessed September 2022)

Vestergaard O, Sand-Jensen K (2000) Alkalinity and trophic state regulate aquatic plant distribution in Danish lakes. Aquat. Bot. 67: 85–107. https://doi.org/10.1016/S0304-3770(00)00086-3

Viaroli P, Ferrari I, Rossetti G (2002) Long-term limnological research in a quarry lake of the Po River, Italy. Internationale Vereinigung für theoretische und angewandte Limnologie: Verhandlungen 28(2): 576–581. https://doi.org/10.1080/03680770.2001.11901782

Appendixes

Appendix I: Place and date of samples

Table 1 - Xerophilous grasslands: Rel. 1: Via Cesurni left side 41°56'46.6"N, 12°43'26.6"E; Rel. 2: Via Cesurni left side 41°56'46.8"N, 12°43'26.8"E; Rel. 3: Bagni vecchi 41°56'46.8"N, 12°43'26.8"E; Rel. 4: Bagni vecchi 41°57'44.8"N, 12°42'56.3"E; Rel. 5: Stacchini ex powder factory 41°56'23.5"N 12°43'45.8"E; REl. 6: Stacchini ex powder factory 41°56'35.21"N; 12°43'32.31"E ; Rel. 7: Surroundings of the ring road between Via del Ponte Lucano and the Aniene river 41°57'11.3"N; 12°45'26.7"E.

Table 2 - Mesophilous grasslands: Rel. 1: Lawn meadows surrounding Albulè bathing site 41°56'34"N, 12°44'15"E; Rel. 2: Lawn meadows surrounding Albulè bathing site 41°56'36.0"N, 12°44'16.1"E; Rel. 3: Lawn meadows surrounding Albulè bathing site 41°56'36.6"N, 12°44'17.3"E; Rel. 4: Boundary of Stacchini ex powder factory 41°56'40.3"N, 12°43'20.5"E; Rel. 5: Boundary of Stacchini ex powder factory 41°56'40.8"N, 12°43'21.5"E; REl. 6: Boundary of Stacchini ex powder factory 41°56'38.0"N, 12°43'14.7"E; Rel. 7: Banks of the Aniene river 41°56'31.9"N 12°44'01.7"E.

Table 3 - Helophytic and hygrophylous communities: Rel. 1: Surrounding Albulè bathing site 41°56'41.4"N; 12°44'42.4"E; Rel. 2: Estraba travertine quarries 41°57'13.0"N; 12°45'10.8"E ; Rel. 3: Estraba travertine quarries 41°57'13.0"N; 12°45'10.8"E.

Appendix II: List of the complete names of the syntaxa quoted in the text and tables

Agropyretalia intermedio-repentis T. Müller et Görs 1969; *Alno glutinosae-Populetea albae* P. Fukarek et Fabijanić 1968; *Alysso alyssoidis-Sedion* Oberd. et T. Müller in T. Müller 1961; *Artemisietea vulgaris* Lohmeyer et al. in Tx. ex von Rochow 1951; *Brometalia rubenti-tectorum* (Rivas Goday et Rivas-Mart. 1973) Rivas-Mart. et Izco 1977; *Bromo-Oryzopsion miliaceae* O. de Bolòs 1970; *Ceratodonto purpurei-Polytrichetea piliferi* Mohan 1978; *Chare-*

tea intermediae F. Fukarek 1961; *Chenopodietea* Br.-Bl. in Br.-Bl. et al. 1952; *Cisto-Micromerietalia julianae* Oberd. 1954; *Convolvulo arvensis-Agropyrion repentis* Görs 1967; *Crataego-Prunetea* Tx. 1962; *Cratoneurion commutati* Koch 1928; *Cynosurion cristati* Tx. 1947; *Elytrigio repentis-Dittrichietalia viscosae* Mucina ined.; *Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947; *Hylocomietea splendentis* Gillet ex Marstaller 1933; *Inulo viscosae-Agropyrion repentis* Biondi et Allegrezza 1996; *Lygeo sparti-Stipetea tenacissimae* Rivas-Mart. 1978; *Molinio-Arrhenatheretea* Tx. 1937; *Ononido-Rosmarinetea* Br.-Bl. in A. Bolòs y Vayreda 1950; *Papaveretea rhoeadis* S. Brullo et al. 2001; *Pegano harmalae-Salsoletea vermiculatae* Br.-Bl. et O. de Bolòs 1958; *Phragmitetalia* Koch 1926; *Phragmito-Magnocaricetea* Klika in Klika et Novák 1941; *Psoretea decipientis* Mattick ex Follmann 1974; *Quercetea ilicis* Br.-Bl. ex A. Bolòs et O. de Bolòs in A. Bolòs y Vayreda 1950; *Ruppietea maritimae* J. Tx. ex Den Hartog et Segal 1964; *Sedo-Scleranthetea* Br.-Bl. 1955; *Stipo-Trachynietea distachyae* S. Brullo in S. Brullo et al. 2001; *Trifolio-Geranietea sanguinei* T. Müller 1962; *Verrucarietea nigrescentis* Wirth 1980.