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Plants Growing on the Walls of Italian Towns
1. Sites and Distribution

By

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With 3 Figures

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Key words: Wall plants. – Water availability, colonization, exposure, substrate.

Summary

LISCI M. & PACINI E. 1993. Plants growing on the walls of Italian towns. 1. Sites and distribution. – Phyton (Horn, Austria) 33 (1): 15–26, 3 figures. – English with German summary.

The site and colonization mode of plants growing on the walls of certain Italian towns (Pavia, Roma, Siena) were studied. Colonization is essentially conditioned by the adaptability of the species and the efficiency of their methods of reproduction. Nine niche types are distinguished. The chemical and mechanical effects of plant colonization of walls and methods of conserving the aesthetic and functional integrity of the walls are briefly discussed.

Zusammenfassung

LISCI M. & PACINI E. 1993. Pflanzen auf den Mauern italienischer Städte. 1. Kleinstandorte und Verbreitung. – Phyton (Horn, Austria) 33 (1): 15–26, 3 Abbildungen. – Englisch mit deutscher Zusammenfassung.

Standorte und Ansiedlungsweise von Pflanzen auf den Mauern einiger italienischer Städte (Pavia, Rom, Siena) wurden studiert. Die Besiedlung wird hauptsächlich durch die Anpassungsfähigkeit der Arten und ihre Fortpflanzungsweise bestimmt. Neun Nischen-Typen können an den Mauern unterschieden werden. Chemische und mechanische Auswirkungen der pflanzlichen Besiedlung und Schutzmaßnahmen zur Erhaltung der Mauern werden kurz diskutiert.

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Erratum

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Im Beitrag

„SAUKEL J. & LÄNGER R., *Achillea pratensis* SAUKEL & LÄNGER, spec. nova, eine tetraploide Sippe der Achillea millefolium-Gruppe *(Asteraceae)*"
wurden bedauerlicherweise die Abbildungen 1 und 8 vertauscht.

Die korrekte Abbildungslegende für Seite 161 lautet:
Abb. 8. Habitusbilder von *Achillea roseo-alba* (Rosental, Kärnten).

Abbildungslegende für Seite 171:
Abb. 1. Habitusbilder der *Achillea pratensis,* a Isotypus, b Holotypus (beide im Herbar W).

In the paper

‚SAUKEL J. & LÄNGER R., *Achillea pratensis* SAUKEL & LÄNGER, spec. nova, a new tetraploid species of the *Achillea millefolium*-group *(Asteraceae)*'
regrettably an interchange of figure 1 and 8 happened by mistake.

The correct legend for the figure at page 161 reads:
Abb. 8. Habitusbilder von *Achillea roseo-alba* (Rosental, Kärnten).

For the figure at page 171:
Abb. 1. Habitusbilder der *Achillea pratensis,* a Isotypus, b Holotypus (beide im Herbar W).

1. Introduction

Plants can live in aquatic, terrestrial and organic environments (PUTMAN & WRATTEN 1984). Their growth in these environments is influenced by many parameters. There are habitats in which the extreme conditions lead to the selection of species with morphological and physiological adaptations enabling them to survive. Walls constitute a specialized microhabitat; since they are built by man, they are restricted to inhabited areas. Mural flora developed in historical periods in which civilized man constructed buildings. The oldest walls, or those most characteristically covered in vegetation, must therefore be sought in places inhabited for millennia (see Rome) or in mediaeval walled towns. The number of species depends greatly on climate, especially rainfall. In the arid walls of cities like Alexandria and Cairo fewer species are able to survive than in the Italien towns considered in this study.

In general it is possible to distinguish stonework which is an integral part of inhabited buildings, stonework on the ground (part of old fortifications, roads, etc.) and isolated walls (ANZALONE 1951). The best habitats are provided by retaining walls; through the cracks the earth supplies moisture, particles of soil and nutrients. Hence the main factors conditioning the colonization of a wall by plants are its edaphic preferences, the quantity of seeds produced and the method of dispersal:

Edaphic Preferences

species- and environment dependent:

- volume of substrate available
- type of substrate
- exposure
- moisture requirements for germination and reproduction

Dispersal Methods

in order of decreasing advantage:

- Anemochory due to lightness of seeds
- Anemochory due to special structures (pappi, wings, etc.)
- Myrmecochory
- Zoochory
- other dispersal mechanism

The aim of this study was to investigate the ecological and physiological characteristics of mural flora. This paper is a first study on the relations between stonework and higher plants and will be followed by other more specific studies on the characteristics of the vegetative and reproductive systems of such plants. Previous studies include investigations of lichens on Italian monuments (MONTE 1991, NIMIS & al. 1987, NIMIS & MONTE 1988, PIERVITTORI & SAMPO' 1988, ROCCARDI & BIANCHETTI 1988, SEAWARD & GIACOBINI 1988). Wall vegetation has been studied from a phytosociological point of view by HRUŠKA 1979, 1987, OBERDORFER 1969, a bibliography has been compiled by IZCO & al. 1977.

2. Materials and Methods

Three Italian cities, Siena, Rome and Pavia, were chosen because of climatic and environmental differences (Fig. 1). The mural flora of each of these towns has been documented earlier (ANZALONE 1951, TRAVERSO 1898, 1899, GABELLI 1915).

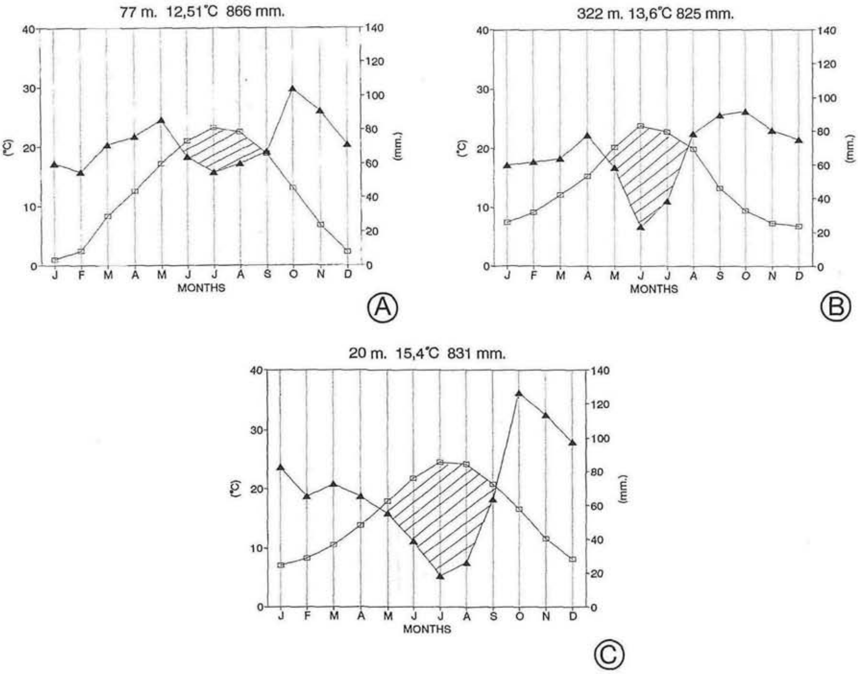


Fig. 1. Climatographs of Pavia (A), Siena (B) and Rome (C).

TRAVERSO found 200 species growing in the stonework of Pavia; GABELLI found 127 species in Siena. In Rome, ANZALONE found 385 species in varying percentages; he distinguished them as typical, indifferent and accidental according to their relationship to the stonework.

We only considered species regarded as typical by ANZALONE. Periodic observations were made of the main types and distribution of mural flora, colonization modes and damage or changes to stonework caused by the plants. Binoculars were used to observe species located high above the ground. The nomenclature of PIGNATTI 1982 is used.

3. Results

The data collected enabled us to prepare a model (Fig. 2) of the distribution of mural flora. These plants may grow on a substrate inside cavities in the stonework (Fig. 2, situations A, B, C, D, E, F, G) or on a substrate formed on horizontal porous surfaces (Fig. 2, situations H, I). The different situations can be summarized as follows:

3.1. Different sites and their ecology

A. Cavities at ground level

This situation permits the growth of many species since heterogeneous material is able to collect matter to form substrate, and rain water does not flow off. Under certain conditions the plant roots may even penetrate the earth. Hence plants growing in this situation suffer less environmental stress;

B. Cavities in inclined surfaces

In this situation there are greater possibilities of receiving water and it is easier for seeds to lodge than on a vertical surface;

C. Cavities at the interface between two types of building material

The availability of nutrients is greater, the greater the chemical difference between the two materials;

D. Cavities in a vertical face of homogeneous material

This is the situation most hostile to plant growth since water availability is limited to wind-blown rain;

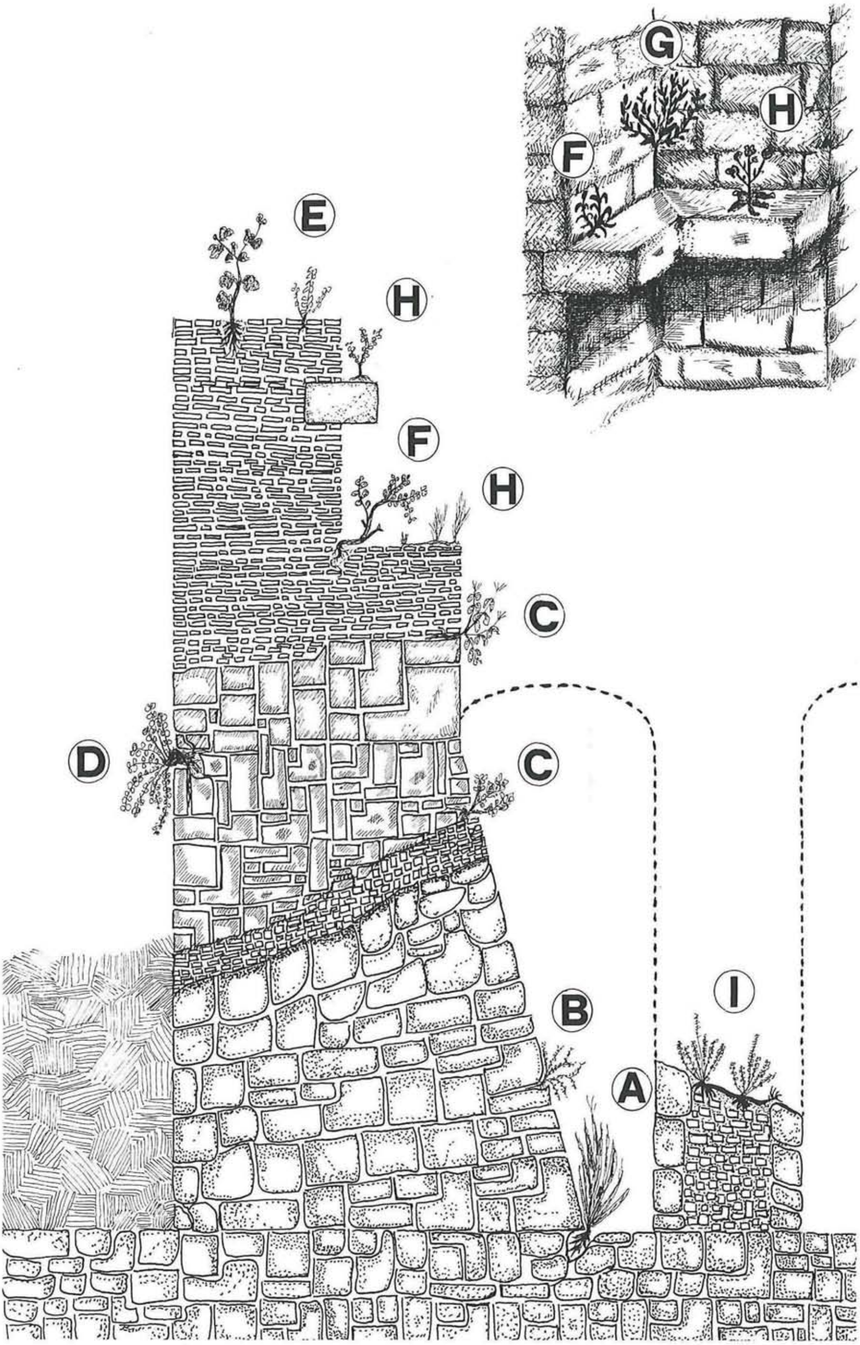
E. Cavities in horizontal surfaces

This is the situation with the greatest water availability but if the plant is not adapted to retain it, it has little chance of survival;

Fig. 2. Examples of the main situations of mural flora. The plants may grow in substrate inside cavities (A–G) or in substrate forming on porous horizontal surfaces (H, I). The situations may be classified as follows:

A. cavities at ground level;
B. cavities in inclined surfaces;
C. cavities at the interface between two types of building material;
D. cavities in a vertical face of homogeneous material;
E. cavities in a horizontal surface;
F. cavities at the intersection of vertical and horizontal surfaces;
G. cavities where two vertical surfaces meet;
H. substrate formed on a horizontal porous surface;
I. substrate formed on ruined stonework.

In each situation, the availability of water is different. It is very low in situations B, C and D being mainly in the form of wind-driven rain. It is higher in situations A, F and G which retain rainwater. It is greatest in cases H, I and E because the horizontal substrate retains all rain.


G
H
F
E
H
F
H
C
D
C
B
A
I

F. Cavities at the intersection of vertical and horizontal surfaces

This situation is similar to A as far as water is concerned, but there is less substrate;

G. Cavities where two vertical surfaces meet

This situation is similar to F but less water is available;

H. Substrate formed on a horizontal porous surface

The situation ist constituted by a corbel which is a decorative element in roman buildings and baroque and renaissance churches. It usually consists of marble, travertine or sandstone;

I. Substrate formed on ruined stonework

This is a special situation, mainly found in ruins of roman monuments. It results from the destruction of walls or pillars built with an outer layer of bricks or squared stones enclosing a space filled with irregular stones or broken bricks held together with lime mortar. Exposure of the central core by man or weathering provides the ideal situation for the collection of substrate which can host plants of different species even in a very limited area.

3.2. Quantitative distribution of mural vegetation

The mural vegetation is quantitatively different in each situation: it is generally more abundant on horizontal surfaces which provide better growing conditions. Exposure and moisture are more crucial for vertical than for horizontal surfaces. More species grow in the lower than the upper parts of a wall: survival is more difficult high on the wall because of the necessity of suitable cavities and substrates, whereas lower down favourable conditions are easier to find. In general, irrespective of whether the seed vector is biotic or abiotic, the number of seeds dispersed decreases in direct proportion to height above ground level. This is another reason why only few plants grow high on walls. Table 1 gives the main distribution pattern of plants typical of wall habitats. For many reasons it was impossible to determine the percentage representation and frequencies of every species. Presence and frequency vary widely with longitude, climate, substrate, moisture and exposure. Such figures are not impossible to abtain, but would only hold for walls with homogeneous characteristics.

3.3. Local conditions for mural vegetation

Building materials vary greatly from town to town according to what has been available in the surrounding area and the importance of the town in the course of history. Bricks are found everywhere, in Pavia combined

	P	R	S	O	A	B	C	D	E	F	G	H	I
Water supply					**	*	*	*	***	**	*	***	***
ADIANTACEAE													
Adiantum capillus-veneris L.		o	o	o	+	+	+	+					
GYMNOGRAMMACEAE													
Anogramma leptophylla (L.)Link		o											
ASPLENIACEAE													
Asplenium adiantum-nigrum L.		o		o	+	+	+	+					
Asplenium trichomanes L.	o	o	o	o	+	+	+	+					
Ceterach officinarum DC.	o	o	o	o	+	+	+	+					
POLYPODIACEAE													
Polypodium vulgare L.		o	o	o	+	+	+	+					
ULMACEAE													
Ulmus minor Miller.	o	o		o					+	+		+	+
MORACEAE													
Ficus carica L.	o	o	o	o	+	+	+		+	+		+	+
URTICACEAE													
Parietaria cretica L.		o											
Parietaria diffusa Martens & Koch	o	o	o	o	+	+	+	+	+	+	+	+	+
Parietaria lusitanica L.		o											
Parietaria officinalis L.		o											
CARYOPHYLLACEAE													
Petrorhagia saxifraga (L.)Link	o	o	o	o					+	+		+	+
GUTTIFERAE													
Hypericum perforatum L.	o	o	o	o	+		+		+	+		+	+
CAPPARIDACEAE													
Capparis spinosa L.		o	o	o		+	+	+			+		
CRUCIFERAE													
Diplotaxis muralis (L.)DC.		o											
Draba muralis L.	o	o		o	+		+					+	+
Erysimum cheiri (L.) Crantz		o	o	o	+	+	+		+	+		+	+
Matthiola fruticulosa (L.)Maire		o											
RESEDACEAE													
Reseda alba L.		o		o			+		+			+	+
Reseda luteola L.		o		o			+		+			+	+
Reseda phyteuma L.		o											
CRASSULACEAE													
Sedum album L.	o	o		o		+	+	+	+	+	+	+	+
Sedum hispanicum L.		o		o		+	+	+	+	+	+	+	+
Sedum sediforme (Jacq.)Pan		o		o		+	+	+	+	+	+	+	+
Umbilicus horizontalis (Guss.)DC.		o											
Umbilicus rupestris (Salisb.)Dandy.		o	o	o		+	+	+	+	+	+	+	+
SAXIFRAGACEAE													
Saxifraga tridactylites L.	o	o		o	+	+	+	+	+			+	+
ROSACEAE													
Sanguisorba minor Scop. ssp. muricata (Gremli)Briq.		o	o	o					+	+		+	+
LEGUMINOSAE													
Trigonella corniculata (L.)L.		o											
THELIGONACEAE													
Theligonum cynocrambe L.		o		o					+	+		+	+
ARALIACEAE													
Hedera helix L.	o	o	o	o	+	+	+	+			+		
Hedera helix L. ssp. poetarum Nyman		o		o	+	+	+	+			+		
RUBIACEAE													
Galium murale (L.)All.		o		o					+	+		+	+
Valantia muralis L.		o											
LABIATAE													
Micromeria graeca (L.)Bentham		o		o		+	+	+	+			+	+
SCROPHULARIACEAE													
Antirrhinum majus L.		o	o	o		+	+	+	+	+		+	+
Cymbalaria muralis Gaert.,Mey.,Scherb.	o	o	o	o		+	+	+	+	+		+	+
Veronica cymbalaria Bodard.		o		o	+	+	+	+				+	+
VALERIANACEAE													
Centranthus ruber (L.)DC.		o	o	o		+	+	+	+	+		+	+
CAMPANULACEAE													
Campanula erinus L.		o		o		+	+	+	+	+		+	+
Trachelium coeruleum L.		o		o	+	+	+	+	+	+	+	+	+
COMPOSITAE													
Anthemis tinctoria L.		o	o	o		+	+	+	+	+		+	+
Artemisia arborescens L.		o		o	+	+	+	+	+	+	+	+	+
Erigeron karvinskianus DC.		o		o		+	+	+	+	+		+	+
Phagnalon sordidum (L.)Rchb.		o											
Sonchus tenerrimus L.		o		o	+	+	+	+	+	+	+	+	+
LILIACEAE													
Allium ampeloprasum L.		o		o	+		+		+			+	+
Allium subhirsutum L.		o		o	+		+		+			+	+
GRAMINACEAE													
Brachypodium distachyum (L.)Beauv.		o		o	+		+		+			+	+
Catapodium rigidum (L.)Hubbard		o	o										
Melica minuta L.		o		o	+	+	+		+			+	+

Table 1. Distribution of mural flora in three italian cities on the basis of situations A–I (see Fig. 2): Pavia, dominating substrates are bricks and yellow sandstone – plant list of TRAVERSO (P); Roma, dominating substrates are bricks, travertine and volcanic material – plants recorded by ANZALONE (R); Siena, dominating substrate are bricks, limestone and travertine – plants listed by GABELLI (S) and plants observed by us in Siena (O). Water supply: * very poor, ** poor, *** moderate.

with yellow sandstone, in Siena with limestone and travertine, in Rome with travertine and volcanic stone. These are the most common materials, however in Rome all building materials of the mediterranean area may be found. This is directly related to its political and economic importance over centuries.

The porosity of building materials determines its water-retaining capacity and facilitates the formation of substrate suitable for plant growth. Travertine, limestone and sandstone are the most porous materials and are colonized more readily than compact materials like granite and other siliceous rocks. In the case of bricks, the plants grow in weathered interstitial lime mortar.

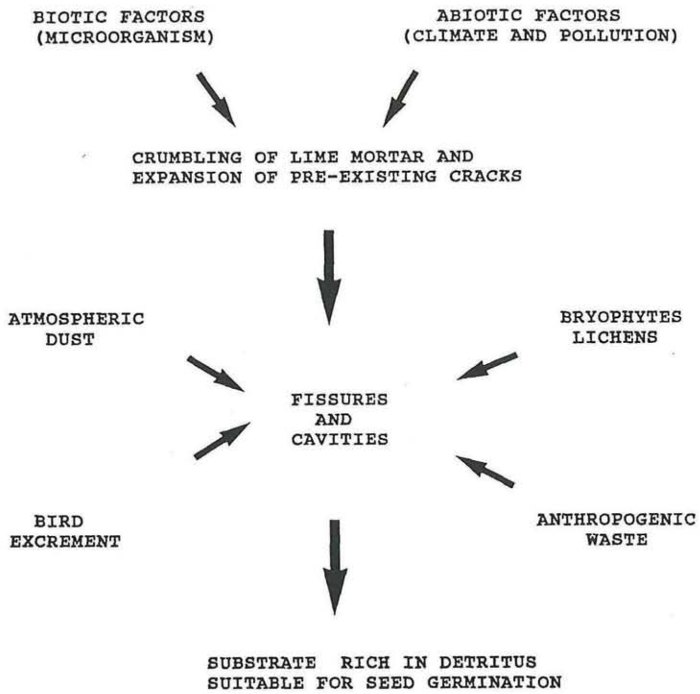
The plants most common and most adaptable to wall habitats are insensitive to the type of building material. *Parietaria diffusa* MARTENS & KOCH, *Capparis spinosa* L. and *Ficus carica* L. may be found on any type of substrate. *Parietaria diffusa* and *Ficus carica* are highly adaptable as far as light is concerned, growing in extremely exposed sites as well as in heavy shade.

Plants growing in man-made stonework have to adapt to conditions of stress. Stonework is certainly not the ideal habitat but can provide a suitable substrate via the crumbling of mortar, bricks and different materials and the formation of cracks. A substrate suitable for the germination of a seed may be formed from atmospheric dust and the remains of plants like bryophytes, collecting in a crack. The plants which survive grow under the conditions they find and their roots continue the crumbling process.

4. Discussion

4.1. Distribution of mural flora

In the model of Fig. 2, nine different situations are listed. They depend on wall inclination, building materials, the homogeneity of this material and the condition of the wall. Plants typical of walls are classified according to these criteria (Table 1) however a species may be found in a situation not listed in the Table. Problems of this kind arise from edaphic preferences which depend on species, environment and dispersal (Fig. 3). Many mural species are anemochorous, making the variety of possible sites greater than for zoochorous species and those with other methods of dispersal. For example, the two plants most typical of walls, *Sonchus tenerrimus* L. and *Parietaria diffusa,* are anemochorous and their distribution varies widely (Table 1). The seeds, blown in large quantities against the surfaces of walls, succeed in germinating and taking root here and there. There is also the possibility of vegetative propagation. Many



perennials *(Allium subhirsutum* L., *Capparis spinosa, Centranthus ruber* (L.) DC., *Erysimum cheiri* (L.) CRANTZ, *Hedera helix* L., *Parietaria diffusa, Sedum album* L., *Trachelium coeruleum* L., etc.) colonize large areas of stonework and the tops of walls, through stolons and rhizomes, thus reducing competition from other species. Preexisting plant cover may favour the growth of other specimens, Protecting against evaporation and sun exposure, and regulating relative humidity (SEGAL 1969).

4.2. Main ecological factors for the development of mural vegetation.

Of the ecological factors which influence the development of mural vegetation, three parameters are of fundamental importance: availability of water, exposure and substrate.

4.2.1. Water

Water is one of the essential conditions for the establishment and maintenance of vegetation. Naturally the availability of water varies with the type of surface and its exposure. In situations B, C, D and G (Fig. 2) the moisture level is very low, coming mainly from wind-driven rain; it is higher in situations A and F (Fig. 2) which collect water with every rainfall; moisture is highest in situations H, I and E (Fig. 2) because water does not flow off the horizontal substrate.

4.2.2. Exposure

The exposure of the wall is important above all in relation to the main direction of the rains. Arid walls exposed to the sun for many hours of the day determine strict selection of species. Such stonework is colonized by perennials *(Parietaria diffusa)*, shrubs *(Capparis spinosa)* or trees *(Ficus carica)* nable to survive the driest conditions. Damp shaded walls are colonized more abundantly *(Adiantum capillus-veneris* L., *Ceterach officinarum* DC., *Ranunculus ficaria* L., *Cardamine hirsuta* L., etc.). The constant humidity of such environments favours the growth of a larger number of species, including those normally found in other natural settings.

4.2.3. Substrate

The substrate is one of the key factors for evaluating the adaptability of plants in certain situations. The formation of substrate does not regard only the manner in which the wall is built, but also biotic (decomposition by microorganisms) and abiotic (climatic agents and atmospheric pollution) factors. These factors contribute to the crumbling of lime mortar, leading to the formation of fissures and cavities within the walls (Fig. 3). Substrate rich in detritus can form in these spaces with the auxiliary of atmospheric dust, bird excrement, human wastes, bryophytes, lichens, bacteria and fungi normally present in soil. Moss often creates the environment necessary for the germination of seeds; in some cases the relations between tracheophytes and bryophytes are regulated by inhibitory allelopathic mechanisms. In fact substances which inhibit seed germination and root growth of higher plants have been isolated from many bryophytes, e. g. lunaric acid from *Lunularia cruciata* (L.) DUM. (ASAKAWA 1981). In other cases the gametophyte of moss, constituting an absorbant surface, collects dust and other material. The resulting substrate of organic and inorganic residues can host the germination of seeds. Plants surviving in such environments often have reduced vegetative and reproductive parts, since the mural habitat does not permit them to develop to normal size. Places facilitating the rooting of plants of this type may be protruding shelves or irregular surfaces which provide space for the build-up of detritus or soil. The amount of substrate needed for seed germination varies from species to species. Shrubs and trees (chamaephytes, phanerophytes) require more substrate and therefore prefer to grow along earth-fill walls offering a substantial amount of soil. Grasses predominate on ruins and small arid walls with little soil. *Parietaria diffusa* is a limiting case because the seeds will even germinate in the space left by a nail.

4.3. Damage to stonework by mural vegetation and their control

The variety and wide distribution of mural vegetation means that even monuments and archeological sites are colonized. The effect is picturesque and linked to the antiquity of the monuments but is also one of the main causes of their deterioration (DIA & NOT 1991). Although the causes and damage are different, even lichens contribute to the deterioration of monuments (SEAWARD & GIACOBINI 1988). The aerial parts and especially the roots of plants damage wall structure. The aerial part causes aesthetic and static alterations to wall structure and can also give rise to fires which cause damage, ranging from crumbling of mortar to deterioration of stone and even total destruction of the monument. Roots can grow very large and go very deep, causing physical and/or chemical damage to wall structure. Root secretions contain substances which attack building materials (SALISBURY & ROSS 1978); mechanical stress due to root expansion produces cracking and scaling.

Vegetation control can be performed by hand or with herbicides (CANEVA & DE MARCO 1986). In the first case, manual or mechanical means are required to remove the entire plants in order to repair the cracks. This method is good for removing seedlings but difficult in impervious and high situations. There is a real risk of damaging the wall when mechanical means are used. Sealing of exposed parts with materials preventing plant growth is another possibility of manual damage control. Chemical herbicides are much faster and more efficient but in order to apply them, climate, properties of building materials and vegetation type must be known as well as herbicide properties (toxicity, volatility, biodegradability).

5. Conclusion

Many factors (historical, topographic, temporal, access, edaphic, climatic, ecological) influence the establishment of mural vegetation. Plants may colonize stonework in specific areas, depending on their capacity to adapt and develop, on the volumes and types of substrate and on the efficiency of their reproductive mechanisms. Anemochorous plants (e. g. *Parietaria diffusa)* have a greater possibility of colonizing different situations and spreading than have plants dispersed by birds. Mural vegetation colonizes monumental and archeological stonework in particular, causing conservation problems. Many methods can be used to control mural vegetation, but often a combined programme (manual and chemical methods) is required to solve the problem.

6. Acknowledgements

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