Article

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Flora diversity and distribution across some Lebanese archeological sites

Abstract

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With the aim of recording the present flora present across the Lebanese archeological sites, a survey including 15 different sites located in various bioclimatic regimes was conducted. The inventory documented 262 taxa from 32 families, encompassing 87 species and 75 genera. The most frequently occurring species were *Cichorium intybus* and *Hyoscyamus aureus*. Among the reported species, 14.95% were found to be endemic species to either Lebanon or the Eastern Mediterranean region, 2.35% were alien species, 28.73% were unique species; i.e. observed only in one site. This survey showed a first insight into the flora present in Lebanese archaeological sites and highlighted the role of these sites in harboring rich floral diversity. Thus, it is of fundamental importance to strengthen the conservation and protection efforts of the archaeological sites' natural landscape and its sustainable utilization along the cultural heritage.

Key words: ruins, plant species, conservation, diversity, Mediterranean.

Introduction

Located on the eastern side of the Mediterranean Sea, Lebanon is a small country with a total surface area of 10,452 km² and characterized by a mountainous topography, and the presence of nine bioclimatic regimes (Jomaa & al. 2008; Chalak & al. 2016). The country is considered to have one of the highest densities of floral diversity across the Mediterranean basin and home to 2600 different plant species (Tohme & Tohme 2014). Besides, Lebanon is part of the Mediterranean biodiversity hotspot, one of 25 such recognized threatened areas around the world by Conservation International (Chalak 2016).

Since antiquity, the Lebanese territory has been home to several civilizations perceived today by the presence of more than 350 different archaeological sites across the country. These sites are distributed across various bioclimatic regions, and ecological habitats, varying widely in size ranging between 3 and 25 hectares (Kabalan & Stănciulescu 2018). However, major sites are managed and largely protected, while other are left somehow unmanaged. Normally, archaeological sites comprise an excavated zone and a surrounding

peripheral protective 'buffer zone' harboring several species of the local flora conquering the walls, rubbles, and fallow areas of the sites (Talhouk & al. 2014).

The conservation of the cultural landscape, which is defined as the combined work of man and nature, helps in ensuring human and environmental well-being (Panitsa & al. 2021). Hence, it is of societal priority to conserve the historic landmarks, which contributes to the country's cultural heritage, along with maintaining national biodiversity (Krigas & al. 1999; Aslan & Amatov 2005; Iatrous & al. 2007; Motti & Stinca 2011; Caschin & al. 2014; Papafotiou & al. 2017; Cicinelli & al. 2018; Dahmani & al. 2020; Panitsa & al. 2021). Explorations and studies in Lebanon have been mainly focused on assessing the floral biodiversity of high mountains and natural reserves. However, as to our knowledge, there are no data related to the vascular flora found in the important archeological sites across Lebanon. Such surveys are particularly valuable in preserving the cultural, archeological, and natural landscape. To fill this gap, we analyzed in this study the floral diversity present in 15 different Lebanese archeological sites, in an aim to provide a scientific baseline on the existing diversity and its proper management.

Materials and Methods

The study was carried out from March until May 2021. Research work was performed in 15 different archeological sites located in different bioclimatic regions: Thermo-Mediterranean, Eu-Mediterranean and Supra-Mediterranean (Luterbacher & al. 2012) extending along the four edges of the Lebanese territories (Fig. 1). The floristic data was collected based on field observations done by the authors on their botanical explorations of the selected sites. Plant species were identified according to Mouterde (1984), Tohme & Thome (2014) and on the Lebanese flora digital data base (www.lebanese-flora.org). Species names mentioned in this article follow Tohme & Thome (2014).

The number of occurrences of each species in the different archeological sites was reported. Species were considered unique when observed only in one site. Moreover, species were examined for their state of endemism either to the Eastern Mediterranean region, Lebanon, Syria, and Palestine or strictly to Lebanon.

Chi-squared test of independence (χ^2) was used to test the distribution of flora between the 15 archeological sites and significance was set at $P = 0.05$. All statistical analysis and plots were generated using R studio.

Results

In the 15 surveyed archaeological sites, 262 taxa were recorded, including 87 species belonging to 75 genera and 32 families. The list of plant species observed in this study is reported in the Electronic Supplementary File (ESF) 1. The three most represented families are: *Asteraceae* (15%) with 13 species, *Poaceae* (13%) with 11 species and *Fabaceae* (7%) with 7 species. The other 29 families each with 6 species or less include the remaining 56 species (Fig. 2, 3). A snapshot of some of the observed plant species are shown in Fig. 4. Our findings showed an unevenness distribution among the study sites ($\chi^2 = 31.93$ df = 14,

p< 0.01, CV = 24.54). the number of species per sites ranged from 9 to 27 with an average of 12.82 ± 5.27. The highest number of species was recorded in the Citadels of Byblos and Anjar with 27 plant species in each site. While the lowest number of species was recorded in Sidon Sea Castle and Qsarnaba Roman Temple with 9 and 10 species respectively (Fig. 3). The Eu-Mediterranean regime recorded the highest number of species followed by the Thermo- Mediterranean and Supra- Mediterranean regimes with an average of 21 ± 5.56, 18.3 ± 7.19 and 14.2 ± 3.06 species respectively.

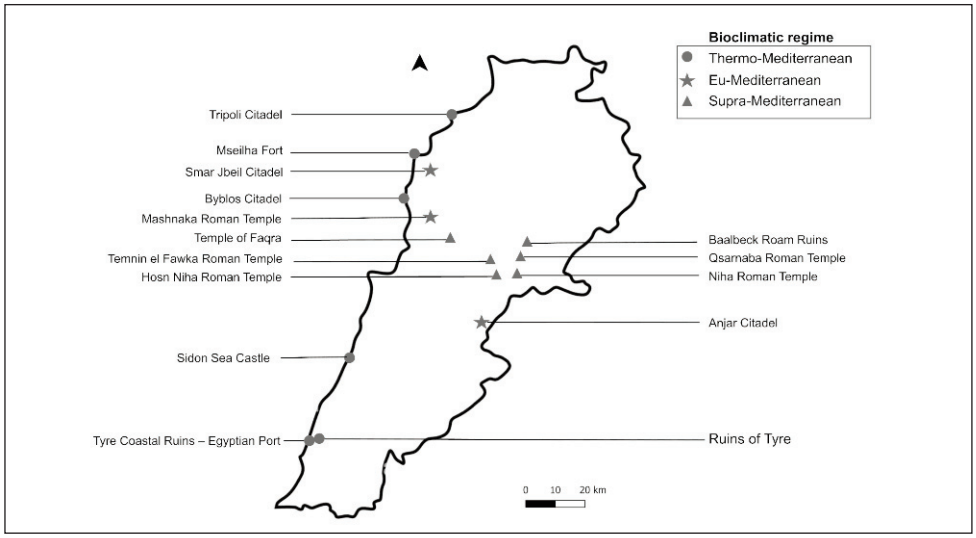

Fig. 1. The 15 Lebanese archeological sites analyzed in this study with their respective bioclimatic regime.

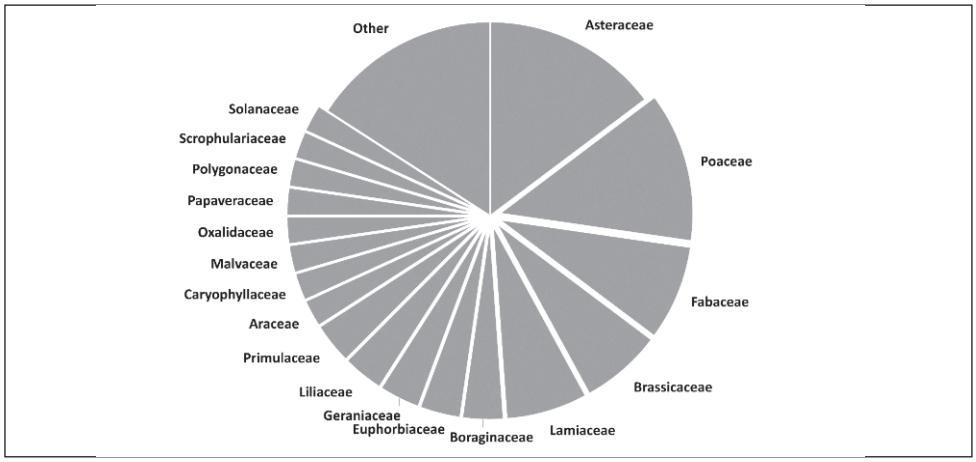

Fig. 2. Taxonomic richness by family observed across the 15 Lebanese archeological sites analysed in this study.

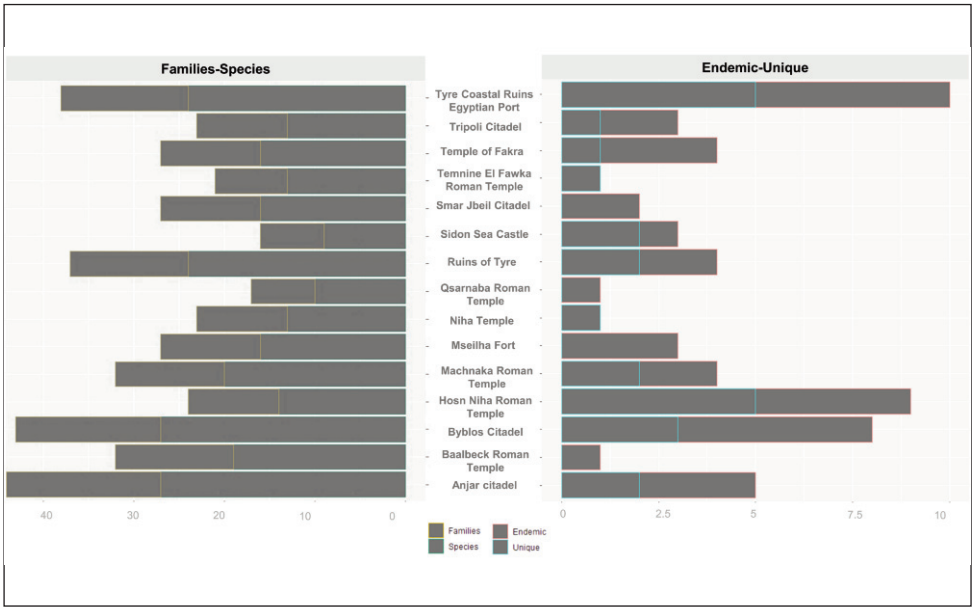

Fig. 3. Number of species and families reported across the 15 Lebanese archeological sites, analysed and classified by their endemism to the eastern Mediterranean region and their uniqueness, i.e. observed only in one site.

In whole, out of the 87 species observed, the following 10 species are classified as endemic to the Eastern Mediterranean Region; *Alopecurus utriculatus* Banks & Sol., *Arum Hygrophilum* Boiss., *Crepis palaestina* (Boiss.) Bornn., *Cyclamen persicum* Mill., *Hyoscyamus aureus* L., *Lamium moschatum* Mill., *Origanum syriacum* L., *Trifolium clypeatum* L. and *Tripleurospermum oreades* (Boiss.) Rech. One species is endemic to Lebanon, Syria and Palestine, *Arum palaestinum* Boiss., and two are strictly endemic to Lebanon *Prunus agrestis* (Boiss.) Mouterde and *Salvia libanotica* Boiss. & Gaill. The Coastal Ruins of Tyre and citadel of Byblos hold the highest count with five endemic species in each site.

In addition, 25 species were reported only in one site and were not observed in any different locations; hence, they were considered as unique species. In the Roman temple of Hosn Niha and Tyre Coastal Ruins, five unique species were found in each site where two and one of them respectively are also endemic (Fig. 3). As to alien or invasive species, only two species were recorded, *Bidens pilosa* subsp. *radiata* Schl. and *Oxalis pes-caprae* L.

Among the documented taxa in this study, *Cichorium intybus* subsp. *intybus* L. and *Hyoscaymus aureus* L. were the most recorded plant species in the 15 study sites; they were found in eight different archeological sites. *Anthemis chia* L., *Diplotaxis erucoides* (L.) DC. and *Senecio vulgaris* L. were the second most frequent species as they were present in seven sites, while *Crepis sancta* (L.) Balcock, *Euphorbia helioscopia* L., *Lamium moschatum* Mill., *Parietaria judaica* L., *Trifolium resupinatum* L., and *Veronica persica* Poir. were found in six sites (Fig. 4).

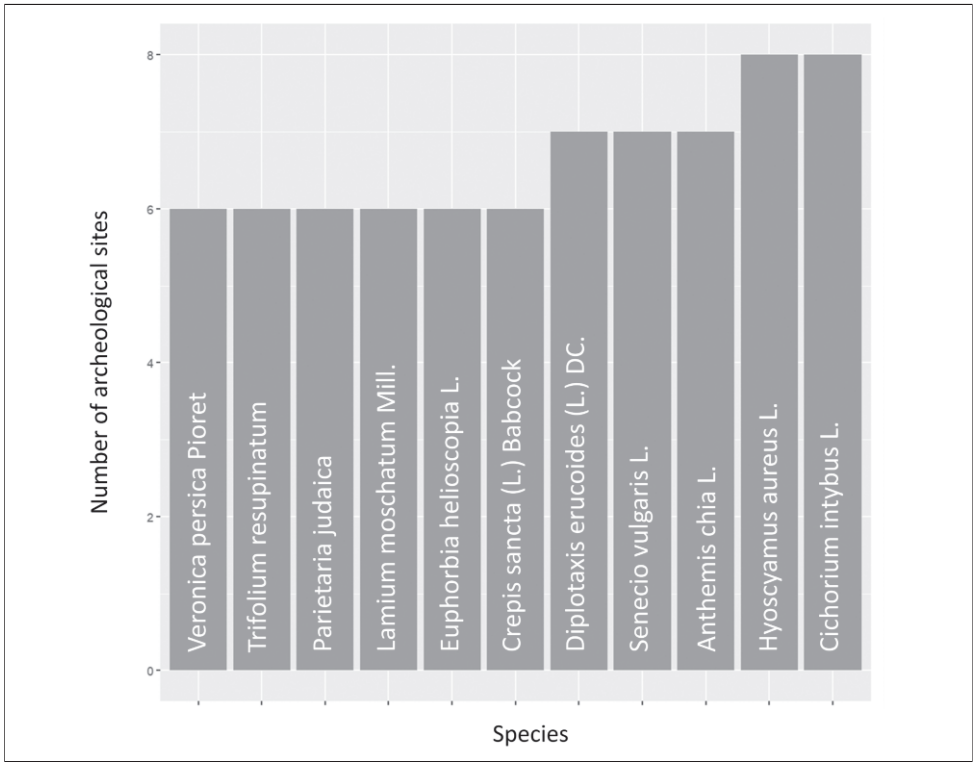

Fig. 4. Most frequent species in this study with respect to number of sites.

Discussion

This study revealed the existence of an important and diversified flora scattered across different Lebanese archaeological sites. The first annotated checklist presented here, surveyed 15 archeological sites located in different geographic areas and bioclimatic regimes in Lebanon.

The highest count of species was observed in the citadels of Anjar and Byblos along with both archaeological sites located in the city of Tyre, ranging between 27 and 24 species per site, this could be due to their large buffer zones surrounding the citadels and ruins in addition to their proper management as these two sites are listed in as World Heritage Sites (Talhouk & al. 2014). Moreover, according to Bou Dagher-Kharat & al. (2018) the coastal area of Byblos was defined as an important plant area (IPA). While Sidon Sea Castle had the lowest count of species which could be attributed to its geographical location on a small island adjacent to the salty sea waves with just a narrow ramp linking it to the mainland.

At the national context, when comparing our results to previous plant biodiversity assessment missions conducted across the nation, *Prunus agrestis* (Boiss.) Mouterde was also reported as less common or rare (Chalak & al. 2014; Chalak & Hamadeh 2015; Bou Dagher-Kharat & al. 2018). Numerous species of the Lebanese wild flora were also report-

ed having economic importance such as *Origanum syriacum* L., *Laurus nobilis* L., and *Ficus carica* L. (Baydoun & al. 2015, 2017).

Internationally, comparing between the flora of Lebanese archaeological sites and those present across Mediterranean sites reveals some similarities. For instance, the most commonly found species in our sites, e.g Cichorium *intybus* L., *Hyoscyamus aureus* L., *Parietaria judaica* L. *Senecio vulgaris* L., *Euphorbia helioscopia* L., *Trifolium resupinatum* L., *Veronica persica* Poir., and *Anthemis chia* L. were all reported in several Mediterranean archeological sites located mainly in Italy and Greece (Krigas & al. 1999; Aslan & Amatov, 2005, Iatrous & al. 2007; Motti & Stinca, 2011; Ceschin & al. 2014; Papafotiou & al. 2017; Cicinelli & al. 2018; Dahmani & al. 2020; Motti & al. 2020). However, due to both the richness of biodiversity and high level of endemism in the country, some species observed in our study, precisely *Arum palaestinum* Boiss., *Crepis palaestina* (Boiss.) Bornn., and *Prunus agrestis* (Boiss.) Mouterde were not reported in any other similar Mediterranean studies, proving the significant uniqueness of the flora present in Lebanese archeological sites.

Nowadays plant biodiversity is facing globally severe threats mainly due to anthropogenic factors, where in our inventory this was clearly observed through the management of these archaeological sites by weeding and removal of plants growing on the walls and between the ruins, like in Sidon Sea castle and citadel of Tripoli. Human interference was also reported through the habitat loss and fragmentation of the buffer zones surrounding the excavated sites that harbor the majority of plant species. In some locations, buffer zones are used to build additional constructions to the site for touristic purposes mainly, such as ticket and info desks, souvenir shops, and toilets. Visitors tend also to cause further threats to the flora by polluting the site premises. Additional threats are imposed by local people through the performance of some agricultural activities like in Hosn Niha Roman Temple where part of the zone adjacent to the ruins are planted with fruit trees or being grazed by small ruminants. Other threatening factors, include invasive alien species like those reported in our study; *Bidens pilosa radiata* Schl. and *Oxalis pes-caprae* are widely spreading in the country and are causing conflict with the native and indigenous species.

Although plants contribute to the natural landscape of the archaeological sites, their role is controversial as they may possess threats on the structure of archaeological sites (Domina 2018). If not properly managed, vascular plants may cause deterioration, a process defined as the undesirable changes in the properties of a materials caused by vital activities of living organisms (Papafotiou & al. 2017; Cicinelli & al. 2018). Growing flora may lead to cracks, collapse, fissures, and detachment of archaeological materials (Motti & Stinca 2011; Bartoli & al. 2017; Motti & al. 2020; Celesti-Grapow & Ricotta 2021).

Future perspectives

Based on our observations, these archeological sites play an important role in the conservation of diverse and endemic flora. Here we provide the following recommendations that should be adapted for appropriate management and preservation.

Implementing methodologies which include plant management practices in coordination with the archaeological conservation protocols such as adapting selective weeding programs and keeping deep rooted plants from destroying stones and walls.

Educating visitors and tourists on the importance of both the natural and cultural complex of the site.

Further protection and conservation of the natural landscape surrounding the excavated sites should be implemented by creating the ancillary botanical gardens in Lebanese archeological sites. Buffer zones surrounding the excavated sites are ideal for the implementation of this. Based on our survey, Hosn Niha Roman Temple known for its prominent neglected structure, serves as a perfect spot for the application of this concept, since its harbors unique, endemic, and rich flora diversity.

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References

Aslan, M. & Atamov, V. 2006: Flora and Vegetation of Stony Walls in South-east Turkey (Sanliurfa). – Asian J. Pl. Sci. **5(1):** 153-162. https://doi. org/10.3923/ajps.2006.153.162

Bartoli, F., Romiti, F. & Caneva, G. 2017: Aggressiveness of *Hedera helix* L. growing on monuments: evaluation in Roman archaeological sites and guidelines for a general method- ological approach. – Pl. Biosyst. **151:** 866-877. https://doi. org/10.1080/11263504.2016.1218969

Baydoun, S. Chalak, L. Dalleh, H. & Arnold N. 2015: Ethnopharmacological survey of medicinal plants used in traditional medicine by the communities of Mount Hermon, Lebanon. – J. Ethnopharmacol. **173:** 139-156. https://doi. org/10.1016/j.jep.2015.06.052

Baydoun, S., Kanj, D., Raafat, K., Aboul, E. M., Chalak, L. & Arnold, A. N. 2017: Ethnobotanical and Economic Importance of Wild Plant Species of Jabal Moussa Bioreserve, Lebanon. – J. Ecosyst. Ecogr. **7(3):** 1000245. https://doi.org/10.4172/2157-7625.1000245

Bou Dagher-Kharrat, M., El Zein, H. & Rouhan, G. 2018: Setting conservation priorities for Lebanese flora-Identification of important plant areas. – J. Nat. Conserv. **43:** 85-94. https://doi.org/10.1016/j.jnc.2017.11.004

Caneva, G., Pacini, A., Celesti Grapow, L. & Ceschin, S. 2003: The Colosseum. – Int. Biodeterior. Biodegr. **51(3)**: 211-219. https://doi.org/10.1016/s0964-8305(02)00173-7

Celesti-Grapow, L. & Ricotta, C. 2021: Plant invasion as an emerging challenge for the conservation of heritage sites: the spread of ornamental trees on ancient monuments in Rome, Italy. – Biol. Invas. **23:** 1191-1206. https://doi.org/10.1007/s10530-020-02429-9

Ceschin, S., Bartoli, F., Salerno, G., Zuccarello, V. & Caneva, G. 2014: Natural habitats of typical plants growing on ruins of Roman archaeological sites (Rome, Italy). – Pl. Biosyst. **150(5):** 866-875. https://doi.org/10.1080/11263504.2014.990536

Chalak, L. 2016: Proposed Regulations on Access and Benefit-sharing for Biological and Genetic Resources of Lebanon. – Pp. 86-98 in: International Workshop on Access and Benefit-sharing for Genetic Resources for Food and Agriculture. – Rome.

— & Hamadeh, B. 2015: Almond wild relatives in Lebanon: distribution, uses and main threats. – Acta Hort. **1074:** 43-48. https://doi.org/10.17660/actahortic.2015.1074.5

—, Elbitar, A. & Chehade, A. 2014: Diversity of wild prunus in the Bekaa province, Lebanon. – Acta Hort. **1032:** 207-214. https://doi.org/10.17660/actahortic.2014.1032.28

Cicinelli, E., Salerno, G. & Caneva, G. 2018: An assessment methodology to combine the preservation of biodiversity and cultural heritage: the San Vincenzo al Volturno historical site (Molise, Italy). – Biodiv. Conserv. **27(5):** 1073-1093. https://doi.org/10.1007/s10531-017-1480-z

Dahmani, J., Benharbit, M., Fassar, M., Hajila, R., Zidane, L., Magri, N. & Belahbib N. 2020: Vascular plants census linked to the biodeterioration process of the Portuguese city of Mazagan in El Jadida, Morocco. – J. King Saud Univ. Sci. **32(1):** 682-689. https://doi.org/10.1016/j.jksus.2018.10.015

Domina, G. 2018: The floristic research in Italian archaeological sites. – Fl. Medit. **28:** 377-383. https://doi.org/10.7320/FlMedit28.377

Fenu, G., Bacchetta, G., Christodoulou, C. S., Cogoni, D., Fournaraki, C., Giusso, G. P., Gotsiou, P., Kyratzis, A., Piazza, C., Vicens, M. & De Montmollin, B. 2020: A Common Approach to the Conservation of Threatened Island Vascular Plants: First Results in the Mediterranean Basin. – Diversity **12(4):** 157. https://doi.org/10.3390/d12040157

Fisher, C. 2019: Archaeology for Sustainable Agriculture. – J. Archaeol. Res. **28(3):** 393-441. https://doi.org/10.1007/s10814-019-09138-5

Iatrou, G., Trigas, P. & Pettas, N. 2007: The vascular flora of Akrokorinthos Castle and its surrounding area (NE Peloponnese, Greece). – Phytol. Balc. **13(1):** 83-93.

Jomaa, I., Auda, Y., Abi Saleh, B., Hamzé, M. & Safi, S. 2008: Landscape spatial dynamics over 38 years under natural and anthropogenic pressures in Mount Lebanon. – Landscape Urban Plann. **87(1):** 67-75. https://doi.org/10.1016/j.landurbplan.2008.04.007

Kabalan, H. & Stănciulescu, G. 2018: Untapped touristic potential in South Lebanon. – Knowledge Horizons. Econ. **10(2):** 59-66.

Krigas, N., Lagiou, E., Hanlidou, E. & Kokkini, S. 1999: The vascular flora of the Byzantine Walls of Thessaloniki (N Greece). – Willdenowia. **29(1):** 77-94. https://doi.org/10.3372/wi.29.2907

Luterbacher, J., Gonzalez-Rouco, F., McCarroll, D., Wagner, S. & Zorita, E. 2012: Synthesizing paleoclimatic data to reconstruct 2000 years of European/Mediterranean temperature change. – PAGES Mews **20(2):** 94-94. https://doi.org/10.22498/pages.20.2.94

Motti, R. & Stinca, A. 2011: Analysis of the biodeteriogenic vascular flora at the Royal Palace of Portici in southern Italy. – Internat. Biodeterior. Biodegr. **65(8):** 1256-1265. https://doi.org/10.1016/j.ibiod.2010.03.010

—, Bonanomi, G. & Stinca, A. 2020: Deteriogenic flora of the Phlegraean Fields Archaeological Park: ecological analysis and management guidelines. – Nordic J. Bot. **38(5)**: e02627. https://doi.org/10.1111/njb.02627

Mouterde, P. 1984: Nouvelle flore du Liban et de la Syrie. [New flora of Lebanon and Syria], **3.** – Beyrouth.

Panitsa, M., Panayiotis, T., Kontakos, D., Valli, A. & Iatrou, G. 2021: Natural and cultural heritage interaction: aspects of plant diversity in three East Peloponnesian castles (Greece) and conservation evaluation. – Pl. Biosyst. **156:** 538-552. https://doi.org/10.1080/11263504.2021.1889701

Papafotiou, M. Kanellou, E. & Economou, G. 2017: Integrated design and management of vegetation at archaeological sites to protect monuments and enhance the historical landscape. – Acta Hort. **1189:** 1-10. https://doi.org/10.1080/11263504.2021.188970110.17660/actahortic.2017.1189.1

Talhouk, S. Abunnasr, Y, Hall, M. Miller, T. & Seif, A. 2014: Ancillary Botanic Gardens in Lebanon. – Sibbaldia: Intern. J. Bot. Gard. Hort. **(12)**: 111-128. https://doi.org/10.24823/sibbaldia.2014.27

Talhouk, S. N., Itani, M. & Al-Zein, M. 2018: Biodiversity in Lebanon. – Pp. 259-306 in: Pullaiah, T. (ed.), Global Biodiversity. – New York. https://doi.org/10.1201/9780429487743-9

Tohme, G. & Tohme, H. 2014: Illustrated flora of Lebanon, 2° ed. – Beirut.

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