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CONTRIBUTION TO THE STUDY OF THE VASCULAR FLORA OF THE ARCHAEOLOGICAL SITE OF VOLUBILIS (MOROCCO)

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Abstract

The archaeological site of Volubilis (Morocco) is located at the foot of Djebel Zerhoun, three km from the small town of Moulay Idriss, in the suburbs of Meknes. It overlooks a vast plain whose natural conditions and geographical position have favored the settlement of several plant species, particularly vascular plants. For this reason, the objective of our study was to develop a catalog of the vascular plants present in Volubilis and analyze its flora. A systematic sampling by transects was carried out along paths and trails of the site. After identification of the plant samples, we obtained a list of 94 species, divided into 82 genera and 33 families, including 28 Dicotyledons, 4 Monocotyledonsand 2 Pteridophytes. The Asteraceae family is the richest in species. Therophytes are the most represented in the site with a proportion of nearly 51% followed by the Hemicryptophytes which contain almost 21% of all known species. Other biological types such as phanerophytes, chamephytesand geophytes are represented by a small proportion. The rate of endemism is close to 2% of the total flora, the proportion of taxa classified as rare or threatened on a national scale is estimated at 4% in the site.

Key words: Vascular plants, Taxa, Biodiversity, Archaeological site, Volubilis, Morocco.

Introduction

The vascular flora is a valuable biological resource as well as an important gene pool. It is an important component of natural ecosystems, while its presence in archaeological sites is considered harmful because it accelerates the processes of their deterioration.

The vascular flora of Morocco has been the subject of numerous studies since the beginning of the twentieth century (Benabid, 1976; Benabid, 1982; Benabid and Benabid *et al.,* 1994; Hamada *et al.,* 2004; Taleb *et al.,* 2004; Aafi, 2005; Orch *et al.,* 2013). These studies concerned the Rif mountains and the Atlas chains as well as the vegetation of the plains and wetlands. However, few floristic studies in archaeological sites in Morocco exist, as is the case of the Portuguese city of Mazagan in El Jadida (Dahmani *et al.,* 2020) and the Kasbah of Mehdia or the Kasbah of Moulay Elhassan in Kenitra (Zaidi *et al.,* 2016).

As for the archaeological site of Volubilis, it has never been the subject of a study focusing on its vascular flora despite the negative impact that this flora can have on the future of the monument. The natural conditions and the geographical position of the site have favored the establishment of vegetation. Volubilis,therefore, presents a natural, original and rich plant biodiversity.

In this context, the objective of the present study is to establish an exhaustive catalog of the vascular flora of the Volubilis site, to proceed with its floristic analysis and to evaluate the rate of endemism and rarity of taxa.

Materials and Methods

The study area

The Volubilis site is located three kilometers from the town of Moulay Idriss, and about thirty kilometers north of Meknes in Morocco Fig. 1. It rises on a plateau nearly 400 m high at the foot of Djebel Zerhoun (Alaioud, 2016). The city of Volubilis occupies an area of 42 hectares

at the foot of the Zerhoun massif, it is crossed to the east by the Fertassa wadi and to the west by the Khoumane wadi (Panetier, 2002). The name of the site comes from the Latin "Volubilis" which means "turning"; Moroccans call it "Walili" from the name of the bindweed flower.

Volubilis is an ancient Berber city romanized during the period of the II^{d} century BC, it was the capital of the kingdom of Mauritania and one of the largest Roman cities in Africa. It was founded in the IIIrd century BC and the city grew rapidly when it was controlled by the Romans. At its peak, Volubilis had between 10,000 and 20,000 inhabitants. These inhabitants lived mainly from the olive oil trade. Abandoned by the Romans towards the end of the IIIrdcentury AD. It was inhabited by a Christian community and later, with the advent of Islam in Morocco, the city will become Muslim.

The city is relatively well preserved; it was, however, damaged by the Lisbon earthquake in the middle of the XVIIIth century (Wikipedia, 2020). It is listed as UNESCO World Heritage Site since 1997.

Volubilis has a subhumid Mediterranean climate with cold winters and hot summers according to the bioclimatic scale of Emberger (1955). Precipitation averages 580 mm and the average temperature of the minima is 11°C, that of the maxima is 26°C (Slimani *et al.,* 2016). The dominant soil is calcareous and clay-limestone (Slimani *et al.,* 2016). The geological substratum is formed by deposits of Plio-Villafranchian gravels and Miocene marls (Dekayir, 2008).

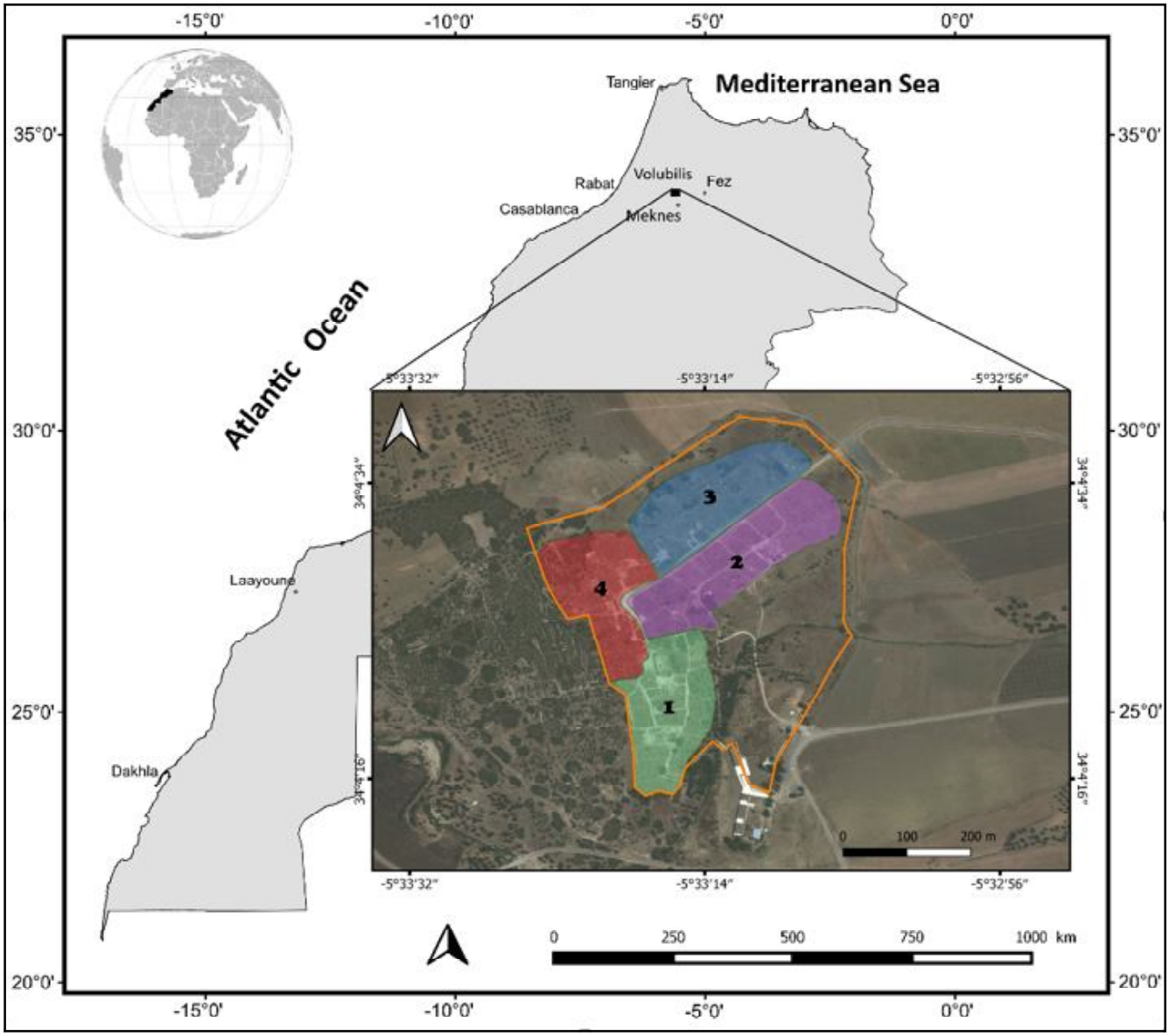

Fig. 1: Localization of archaeological site and transectsof Volubilis.

The sampling mode

Prospecting work at the Volubilis archaeological site took place for almost 2 years, in 2018 and 2019, with further investigation during the spring and summer seasons. Floristic surveys were conducted on four transects covering almost the entire archaeological site. For each of the species identified, a cover index was assigned according to the Braun-Blanquet mixed abundance-dominance scale (Braun-Blanquet,1952), where (r) rare or isolated individuals, (+) rare individuals, with a very low covering, (1) rare individuals, with a low covering, (2) very abundant individuals or covering less than 1/20 of the surface, (3) individuals covering from 1/ 4 to 1/2 of the surface, (4) individuals covering from 1/2 to 3/4 of the surface, (5) individuals covering more than 3/4 of the surface.

Each sample is photographed before being collected for the elaboration of a herbarium. We then proceeded to determine the species collected. Identification was based on morphological characters using several documents such as the Practical Flora of Morocco (Fennane *et al.,* 1999), (Fennane *et al.,* 2007) and (Fennane *et al.,* 2014), the new flora of Algeria and southern desert regions (Quezel and Santa., 1962-1963) and thanks tospecialized websites such as Tela Botanica (Tela Botanica, 2020). The catalog of vascular species at the Volubilis archaeological site will then be presented with, for each taxon, the biological type, native status, and cover index.

The comparison of the list of species obtained with the work of Fennane and Ibn Tattou., (1998, 1999) and El Oualidi *et al.,* (2012), will make it possible to highlight rare, threatened, or endemic taxa. The abbreviations adopted are those used by these same authors:

E: endemic to Morocco; **RR**: very rare (number of known localities ≤ 5 across Morocco) (Fennane and Ibn Tattou., 1998, 1999).

Results and Discussion

The inventory of vascular plants of Volubilis made it possible to identify 94 plant species, affiliated to 82 genera and 33 families table 1.

The species recorded in Volubilis therefore belong to 33 families table 1, which shows great diversity, given that Morocco's flora has 135 families (Benabid, 2000).

We note the absence of the Gymnosperms. Within the angiosperms, the dicotyledonous class dominates by far (80 species, or 85%) and the monocotyledonous class (12 species, or 13%) table 2. This order is the same as that recorded for all Moroccan flora (Fennane and Ibn Tattou., 2012).

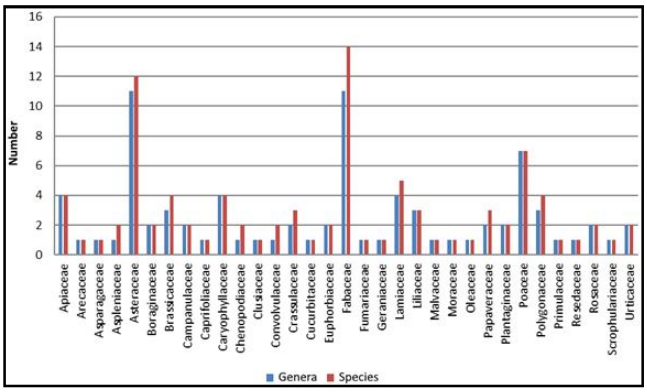

Fig. 2: Number of genera and species per family.

Specific richness per family

The specific and generic richness for each of the 33 families identified is illustrated in Fig. 2 hereafter.

The most represented families are Fabaceae (14 species), Asteraceae (12 species), Poaceae (9 species), Lamiaceae (5 species), Apiaceae, Brassicaceae, Caryophyllaceae and Polygonaceae (4 species each). Families that are represented by 3 species are Papaveraceae, Crassulaceae and Liliaceae. Those with 2 species are Aspleniaceae, Campanulaceae, Chenopodiaceae, Convolvulaceae, Euphorbiaceae, Plantaginaceae, Rosaceaeand Urticaceae. The last 12 families are monospecific: Arecaceae, Asparagaceae, Caprifoliaceae, Clusiaceae, Fumariaceae, Geraniaceae, Malvaceae, Moraceae, Oleaceae, Primulaceae, Resedaceaeand Scrophulariaceae.

The three leading families (Fabaceae, Asteraceae and Poaceae) in our site are also at the national level but with the Asteraceae at the top. According to (Fennane and Ibn Tatou., 2012), these three families amount 1329 species in Morocco, which is more than a third of the specific inventory of the Kingdom. Among the monospecific families encountered, the Arecaceae, Caprifoliaceaeand Cucurbitaceae also have low species richness in the flora of Morocco (Fennane and Ibn Tattou., 1999).

From a generic point of view, 70 genera that account for 85 % of the total number ofrecords are represented in the Volubilis site by a single species. The specific diversity of the 12 remaining genera (*Asplenium, Sonchus, Diplotaxis, Chenopodium, Convolvulus, Sedum, Ononis, Trifolium, Vicia, Lavandula, Papaver* and *Rumex)* is limited to 2 species each. This reflects the natural dynamics in the area, which is governed mainly by the ability of these species to spread from neighboring plant formations.

Table 1: List of species inventoried in the archaeological site of Volubilis in Morocco.

Family	Genus	Species	Biological type	Status	Cover rate
Apiaceae	Ammi	Ammi visnaga (L.) Lam	Therophyte	Spontaneous	3
	Eryngium	Eryngium campestre L.	Hemicryptophyte	Spontaneous	2
	Ferula	Ferula communis L.	Geophyte	Spontaneous	2
	Foeniculum	Foeniculum vulgare Miller	Hemicryptophyte	Sub-Spontaneous	r
Arecaceae	Chamaerops	Chamaerops humilis L.	Phanerophyte	Spontaneous	r
Asparagaceae	Asparagus	Asparagus albus L.	Phanerophyte	Spontaneous	3
Aspleniaceae	Asplenium	Asplenium cterach L.	Geophyte	Spontaneous	+
		Asplenium petrarchae	Hemicryptophyte	Spontaneous	1
Asteraceae	Andryala	Andryala integrifolia L.	Therophyte	Spontaneous	4
	Calendula	Calendula meuselii Ohle	Therophyte	Spontaneous	3
	Centaurea	Centaurea calcitrapa L.	Hemicryptophyte	Spontaneous	1
	Cladanthus	Cladanthus mixtus (L.) Chevall.	Hemicryptophyte	Spontaneous	3
	Glebionis	Glebionis coronaria (L.) Spach.	Therophyte	Spontaneous	4
	Heterotheca	Heterotheca subaxillaris Lam.	Therophyte	Spontaneous	3
	Pallenis	Pallenis spinosa(L.) Cass.	Hemicryptophyte	Spontaneous	3
	Phagnalon	Phagnalon saxatile (L.) Cass.	Chamephyte	Spontaneous	3
	Scolymus	Scolymus hispanicus L.	Hemicryptophyte	Spontaneous	2
	Sonchus	Sonchus asper (L.) Hill	Therophyte	Spontaneous	2
		Sonchus tenerrimus L.	Therophyte	Spontaneous	4
	Urospermum	Urospermum dalechampii (L.) F. W. Schmidt	Hemicryptophyte	Spontaneous	3
Boraginaceae	Anchusa	Anchusa italica Retz.	Hemicryptophyte	Spontaneous	2
	Echium	Echium horridum Batt.	Hemicryptophyte	Spontaneous	3
Brassicaceae	Diplotaxis	Diplotaxis catholica (L.) DC.	Therophyte	Spontaneous	4
		Diplotaxis tenuifolia L.	Hemicryptophyte	Spontaneous	5
	Raphanus	Raphanus raphanistrum L.	Therophyte	Spontaneous	3
	Sinapis	Sinapis arvensis L.	Therophyte	Spontaneous	5
Campanulaceae	Campanula	Campanula erinus L.	Therophyte	Spontaneous	2
	Legousia	Legousia falcata (Ten.) Fritsch	Therophyte	Spontaneous	3
Caprifoliaceae	Centranthus	Centranthus calcitrapae (L.) Dufr.	Therophyte	Spontaneous	2
Caryophyllaceae	Paronychia	Paronychia velata (Maire) Chaudhri	Hemicryptophyte	Spontaneous	4
	Sagina	Sagina procumbens L.	Hemicryptophyte	Spontaneous	2
	Silene	Silene gallica L.	Therophyte	Spontaneous	3
	Spergula	Spergul aarvensis L.	Therophyte	Spontaneous	4
Chenopodiaceae	Chenopodium	Chenopodium album L.	Therophyte	Spontaneous	2
		Chenopodium murale L.	Therophyte	Spontaneous	2
Clusiaceae	Hypericum	Hypericum perforatum L.	Chamephyte	Spontaneous	3
Convolvulaceae	Convolvulus	Convolvulus althaeoides L.	Hemicryptophyte	Spontaneous	3
		Convolvulus arvensis L.	Geophyte	Spontaneous	4
Crassulaceae	Sedum	Sedum album L.	Chamephyte	Spontaneous	1
		Sedum rubens L.	Therophyte	Spontaneous	+
	Umbilicus	Umbilicus rupestris(Salisb.)Dandy	Geophyte	Spontaneous	r
Cucurbitaceae	Bryonia	Bryonia alba Jacq.	Geophyte	Spontaneous	2
Euphorbiaceae	Euphorbia	Euphorbia segetalis L.	Therophyte	Spontaneous	5
	Mercurialis	Mercurialis ambigua L.	Therophyte	Spontaneous	3
Fabaceae	Tripodion	Tripodion tetraphyllum (L.) Fourr	Therophyte	Spontaneous	3
	Ceratonia	Ceratonia siliqua L.	Phanerophyte	Spontaneous	+
	Cytisus	Cytisus maurus Humber andMaire.	Phanerophyte	Spontaneous	3
	Glycyrrhiza	Glycyrrhiza glabra L.	Hemicryptophyte	Introduced	2

Table Continued.....

Table Continued.....

	Lotus	Lotus corniculatus L.	Hemicryptophyte	Spontaneous	4
	Medicago	Medicago polymorpha L.	Therophyte	Spontaneous	3
	Melilotus	Melilotus indicus(L.) All.	Therophyte	Spontaneous	2
	Ononis	Ononis reclinata L.	Therophyte	Spontaneous	2
		Ononis spinosa L.	Chamephyte	Spontaneous	3
	Scorpiurus	Scorpiurus muricatus L.	Therophyte	Spontaneous	3
	Trifolium	Trifolium angustifolium L.	Therophyte	Spontaneous	2
		Trifoliumstellatum L.	Therophyte	Spontaneous	3
	Vicia	Viciahirsuta (L.) S.F.Gray	Therophyte	Spontaneous	2
		Vicia sativa L.	Therophyte	Spontaneous	1
Fumariaceae	Fumaria	Fumaria capreolata L.	Therophyte	Spontaneous	3
Geraniaceae	Geranium	Geranium rotundifoliumL.	Therophyte	Spontaneous	4
Lamiaceae	Ajuga	Ajuga iva (L.) Schreber	Hemicryptophyte	Spontaneous	2
	Lamium	Lamium amplexicaule L.	Therophyte	Spontaneous	2
	Lavandula	Lavandula multifida L.	Chamephyte	Spontaneous	3
		Lavandula angustifoliaMill	Chamephyte	Introduced	1
	Marrubium	Marrubium vulgare L.	Chamephyte	Spontaneous	1
Liliaceae	Allium	Allium nigrum L.	Geophyte	Spontaneous	+
	Tulipa	Tulipa sylvestris L.	Geophyte	Spontaneous	2
	Drimia	Drimiamaritima (L.) Stearn	Geophyte	Spontaneous	1
Malvaceae	Malva	Malva parviflora L.	Therophyte	Spontaneous	2
Moraceae	Ficus	Ficus carica L.	Phanerophyte	Sub-Spontaneous	r
Oleaceae	Olea	Olea europaea L.	Phanerophyte	Spontaneous	2
Papaveraceae	Fumaria	Fumaria officinalis L.	Therophyte	Spontaneous	3
	Papaver	Papaver hybridum L.	Therophyte	Spontaneous	3
		Papaver rhoeas L.	Therophyte	Spontaneous	5
Plantaginaceae	Misopates	Misopates orontium (L.) Rafin.	Therophyte	Spontaneous	2
	Plantago	Plantago afra L.	Therophyte	Spontaneous	1
Poaceae ?	Avena	Avena sterilis L.	Therophyte	Spontaneous	4
	Anisantha	Anisantha Rubens (L.) Nevski	Therophyte	Spontaneous	3
	Cynodon	Cynodon dactylon (L.) Pers	Geophyte	Spontaneous	4
	Hordeum	Hordeum murinum L.	Therophyte	Spontaneous	3
	Lamarckia	Lamarckia aurea (L.) Moench	Therophyte	Spontaneous	2
	Paspalum	Paspalum vaginatum Swartz	Geophyte	Naturalized	2
	Cenchrus	Cenchrus setaceus (Forssk.) Morrone	Chamephyte	Spontaneous	3
Polygonaceae	Emex	Emex spinosa (L.) Camad	Therophyte	Spontaneous	1
	Fallopia	Fallopia convolvus (L.) A. Löve	Therophyte	Spontaneous	2
	Rumex	Rumex acetosa L.	Hemicryptophyte	Spontaneous	2
		Rumex crispus L.	Hemicryptophyte	Spontaneous	2
Primulaceae	Anagallis	Anagallis arvensis L.	Therophyte	Spontaneous	3
Resedaceae	Reseda	Reseda phyteuma L.	Therophyte	Spontaneous	1
Rosaceae	Rosa	Rosa abietina Gren.	Phanerophyte	Spontaneous	3
	Rubus	Rubus ulmifolius Schott	Phanerophyte	Spontaneous	4
Scrophulariaceae	Verbascum	Verbascum sinuatum L.	Therophyte	Spontaneous	4
Urticaceae	Parietaria	Parietaria Judaica L.	Hemicryptophyte	Spontaneous	3
	Urtica	Urtica urens L.	Therophyte	Spontaneous	1
Total:	33 F	82 G	94 sp		

Both pteridophytesinventoried, *Asplenium ceterach* and *Aspelinium petrarchae*, belong to a genus that is represented in Morocco by 18 taxa (Fennane, 2016), which are quite common in the territory of the Kingdom

Table 2: Systematic groups identified at the Volubilis site.

Group	Number of species	Percentages
Monocotyledons	12	13%
Dicotyledons	80	85%
Pteridophytes	2	2%
Total:	94	100%

and therefore, always according to (Fennane, 2016), do not present a great risk of disappearance. However, these taxa do need moisture. Their presence on the sunny limestone rocks and the walls of Volubilis show how much these substrates can retain, despite the sunshine, a certain amount of humidity that favors colonization.

Asplenium petrarchae is a Mediterranean fern (Prelly, 1985) that grows on old rocks (Fennane and Ibn Tattou., 1999). It has a narrow distribution compared to *Asplenium ceterach,* which is widely found in low and medium non-desert mountains; it was reported by Benabid (2000) in the same region of Zerhoun.

The specific richness found in the archaeological site of Volubilis is much greater than that of the surrounding areas because the site is closed to grazing and is not subject to any human activity except tourism. On the contrary, this vegetation is growing despite the manual weeding regularly practiced on the main trails of the site.

Biological spectrum

The listed species belong to 5 biological types table 3 whose distribution in the plant formation of Volubilis follows this order: Therophytes > Hemicryptophytes > Geophytes > Chamephytes; Phanerophytes table 3. This distribution is entirely consistent with that of the vegetation of the Mediterranean basin, which is dominated by the therophytes. The latter adapt to summer drought conditions by shortening their life cycle. They then spend the unfavorable seasons in the form of seeds. This explains the low specific richness recorded in summer and autumn compared to that of spring.

The therophytization of the Volubilis site would then be due to the adaptation of the vegetation to the edaphic and climatic conditions and to the measures taken to combat the spread of plants.

The floristic structure of the vascular vegetation of Volubilis is variable, it can change from one year to another, or even within the same year from one season to another. In spring, the landscape is generally dominated by the yellow color of Asteracae (*Glebionis coronaria* and *Heterotheca subaxillaris)*, Fabaceae (*Lotus corniculatus, Medicago polymorpha)* and Brassicaceae (*Diplotaxis catholica* and *Diplotaxis tenuifolia*), which are in bloom. In summer other species bloom such as *Ononis reclinata* and *Ferula communis*. This seasonal pattern is also observed in the dominance of green color in spring and the dominance of yellow (dry grass) in summer and autumn. Indeed, spring corresponds to the flowering and fruiting period of the majority of the vascular plants listed in this catalog. Fewer species flower in summer and autumn.

The year 2017 saw a very low rainfall of only 216 mm, in contrast to 2018 whose cumulative rainfall was estimated at 770 mm (Infoclimat, 2018). This limited the expansion of the flora during the year 2017 and favored its development in 2018.

The number of biological types per family varies from 1 to 4. Fabaceae are represented by 4 biological types, followed by Poaceae, Lamiaceae, Crassulaceae, Asteraceaeand Apiaceae with 3 biological types. The other families appear in the third position with one or two biological types each Fig. 3.

Indigenous status

Spontaneous species show the highest proportion among the 94 taxa recorded in the area. Their number amounts to 89 taxa, or nearly 95% of the total population table 4.

Naturalized species are represented only by *Paspalum vaginatum*, belonging to the family Poaceae table 1. Sub-spontaneous species are *Foeniculum vulgare* and *Ficus carica*, of the respective families Apiaceae and Moraceae table 1. Ornamentally planted species are *Glycyrrhiza glabra* and *Lavandula angustifolia*, two species belonging respectively to the families Fabaceae and Lamiaceae. This exotic flora was initially introduced for ornamental purposes but later spread throughout the city through the spread of seeds by wind and animals.

Table 3: Specific richness by biological type.

Biological type	Number of species	Percentage
Therophytes	48	51%
Hemicryptophytes	20	21%
Geophytes	10	11%
Chamephytes	8	8.5%
Phanerophytes	8	8.5%

Table 4: Specific Richness by Status.

Status	Number of species	Percentage
Spontaneous	89	95%
Sub-spontaneous	2	2%
Naturalized	1	1%
Introduced	2	2%
Total:	94	100%

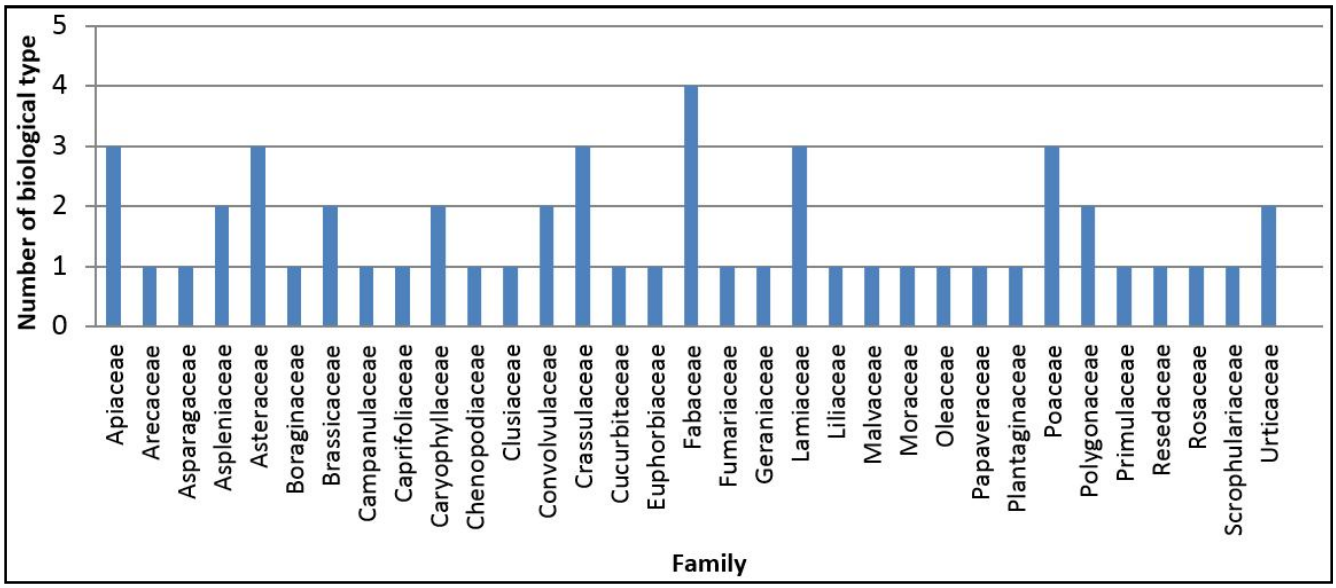

Fig. 3: Diversity of biological types per family.

The dynamic of the vegetation is favored in this preserved enclosure but it does not manage to go beyond the brush stage in some places due to the regular manual weeding. Moreover, Volubilis is located on a plateau which exposes it to the sun's rays for a large part of the day. The species that develop there are rather xerophilic. On the other hand, many attempts to control the spread of *Ficus carica* have been undertaken, but all have been unsuccessful.

Cover rate

The counting of the species according to their recovery rate made it possible to assign themto 7 categories table 5.

Table 5: Categories of species according to the cover rate.

Cover rate	Number of species
r: rare or isolated individuals	4
+: rare individuals with very low cover	4
1: rare individuals with low cover	11
2: very abundant individuals or covering less than 1/20 of the area	27
3: Individuals covering from 1/4 to 1/2 of the area	31
4: Individuals covering from 1/2 to 3/4 of the area	13
5: Individuals covering more than 3/4 of the area	4

Species covering between 25 and 50% are the most numerous with 31 species or 33%. The second category includes taxa that are very abundant or covering less than 1/20 of the area, they are represented by 27 species or 29%. Next, come 13 species that cover from 1/2 to 3/ 4 of the area with a percentage of 14%.

For rare species, with a low covering, they are represented by 11 species or 12% of the total number of species recorded: *Asplenium petrarchae, Emex spinosa*, *Centaurea calcitrapa*, *Sedum rubens*, *Marrubium vulgare*, *Plantago afra*, *Vicia sativa, Lavandula angustifolia*, *Drimia maritima, Reseda phyteuma*and *Urtica urens*.

There are not many rare or isolated species, there are 4 taxa. We cite: *Foeniculum vulgare*, *Chamaerops humilis*, *Umbilicus rupestris*and *Ficus carica.* The rare species, with a very low coverare: *Asplenium ceterach*, *Sedum rubens*, *Ceratonia siliqua* and *Allium nigrum*. *Ficus carica* is listed in its category because it is tracked by workers who clean up the site.

The species covering more than 3/4 of the area: *Diplotaxis tenuifolia*, *Sinapis arvensis*, *Euphorbia segetalis*and *Papaver rhoeas*.

The rarity here is considered to the study area, according to the cover rate. This local rarity is different from the rarity estimated at the national level by Fennane and Ibn Tattou., (1998, 1999) and El Oualidi *et al.,* (2012).

Table 6: List of endemic and rare species in Morocco recorded in the Volubilis site.

Family	Species	Rarity	Endemism
Asteraceae	*Calendula meuselii* Ohle		E
Caryophyllaceae	*Paronychia velata* (Maire) Chaudhri	RR	E
Euphorbiaceae	*Euphorbia segetalis* L.	RR	
Poaceae	Paspalum vaginatum Swartz.	RR	
Rosaceae	Rosa abietina Gren.	RR	
Total:	5		

RR: very rare, E: endemic

Rarity and endemism

It would be interesting to note, among the species inventoried in the Volubilis site, those that are considered on a national level as rare or threatened or endemic. For this purpose, the use of the lists of rare and threatened species and endemic species established by Fennane and Ibn Tattou., (1998, 1999) and El Oualidi *et al.,* (2012) is necessary. The comparison carried out has led to the results shown in table 6.

Thus, the analysis of the vascular flora of Volubilis according to rarity and endemism in comparison with previous studies (Fennane and Ibn Tattou., 1998) and (Elouailidi *et al.,* 2012), shows that 4 species recorded in the Volubilis site (*Paronychia velata*, *Euphorbia segetalis, Paspalum vaginatum, Rosa abietina*) are very rare (RR), so 4% of the total flora. These species are respectively belonging to these 4 families: Caryophyllaceae, Euphorbiaceae, Poaceae, and Rosaceae. Two taxa (*Calendula meuselii* and *Paronychia velata*) are strict Moroccan endemics (E), representing 2% of the total flora; they belong respectively to the Asteraceae and Caryophyllaceae.

Among the endemic taxa, *Calendula meuselii,* was reported by Montserrat *et al.,* (2006) in the Moulay Idriss Zerhoun region, its distribution area remains poorly known in other regions of Morocco. The species seems to be relict, taking refuge on cliffs and rocky outcrops in the Zerhoun massif (Fennane, 2017).

Paronychia velata, is a hemicryptophyte species, endemic to Morocco and threatened with extinction (Fennane and Ibn Tattou., 1998). Indeed, it is an aromatic and medicinal plant used in Morocco for its many virtues (ElMzaiti *et al.,* 2014), which is under heavy exploitation that compromises its sustainability.

The rate of rare or threatened species at the national level is very high, estimated at almost 52% with 2374 threatened taxa over 4500 taxa in total (Fougrach *et al.,* 2007). Volubilis, being a protected area, could contribute to the conservation of the species listed in the site, especially those that are threatened, provided that the biodeterioration of historical monuments is not accentuated.

The rate of endemism of the vascular flora, on a national scale, is estimated at nearly 21.1% (Fennane, 2004). This rate reaches maximum values in sites such as Toubkal National Park where 25.4% of the total flora of the site is endemic (Ouhammou, 2005). In the archaeological site of Volubilis, 2% of the recorded vascular flora is endemic. This value is significant given the area of the archaeological site. The main areas of Moroccan endemism are generally found in the high mountain peaks (Fougrach *et al.,* 2007) and (Fennane and Ibn Tattou., 1999) where according to Quézel (1995, 1999), the evolutionary processes of local progressive speciation are implemented, but our site can at least be considered as a reservoir of biodiversity due to its relative isolation from human influences and its "historical" isolation.

Conclusion

The Moroccan archaeological sites are a historical heritage that makes the richness of the country. These sites host another heritage, this time a natural one consisting of its flora. For botanists, these sites are reservoirs of biodiversity. Volubilis contains 94 plant species with 2 endemic and 4 rare or endangered species. Anthropozoogenic pressure outside the site's enclosure considerably reduces this number. The site, classified as a UNESCO World Heritage Site because of its historical value, could also be classified as a "Site of Biological and Ecological Interest" (SIBE) or at least as ZIP (Zone of Interest for Plants). For archaeologists, this biodiversity is synonymous with the biodeterioration of monuments so they fight it for better conservation of the historical relics. In all cases, our results are a valuable source of information for the studied site and also for the vascular flora of Morocco.

References

Aafi, A., A. El kadmiri, A. Achhal, A. Benabid and M. Rochdi (2005). Richesse et diversité floristique de la suberaie de la Mamora (Maroc). *Acta Botanica Malacitana,* **30:** p. 127-138.

Alaioud, S.M. (2016). La production de l'huile dans le Maroc antique : le cas de Volubilis. In: M. Ater (ed.), L. Essalouh (ed.), H. Ilbert (ed.), A. Moukhli (ed.), B. Khadari (ed.). L'oléiculture au Maroc de la préhistoire à nos jours : pratiques, diversité, adaptation, usages, commerce et politiques. Montpellier: CIHEAM, p. 45-51 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 118).

Benabid, A. and M. Fennane (1994). Connaissances sur la végétation du Maroc : phytogéographie, phytosociologie et séries de végétation. *Lazaroa,* **14:** 21.

Benabid, A. (1976). Etude Phytoécologique, Phytosociologique et Sylvo-Pastorale de la Tétraclinaie de l'Amsittène. Doct. 3rd cycle, Fac. Sci. St. Jerôme, Marseille III, France. 155p.

Benabid, A. (1982). Etudes phytoécologique, biogéographique et dynamique des associations et séries sylvatique du Rif Occidental (Maroc). Thesis Doct. ès-Sc. Fac. Sci. et Techn. St Jérôme, Aix Marseille III, 199 p. + annexes.

Benabid, A. (2000). Flore et écosystèmes du Maroc. Évaluation et préservation de la biodiversité. Ibis Press. Paris, and Kalila Wa Dimna, Rabat, 360.

Braun-BIanquet, J. (1952). Podrome des groupements végétaux

de la France Méditerranéenne. CNRS, Serv. Cart. Group. Dir. Cart. Group. Vég. D'Afrique du Nord.

Dahmani, J., M. Benharbit, M. Fassar, R. Hajila, L. Zidane, N. Magri and N. Belahbib (2020). Vascular plants census linked to the biodeterioration process of the Portuguese city of Mazagan in El Jadida, Morocco. *Journal of King SaudUniversity Science,* **32:** pp. 682–689.

Dakki, M. (2007). Etudes sur la végétation des zones humides du MAROC, Catalogue et Analyse de la Biodiversité Floristique et Identification des principaux Groupements Végétaux. Thesis Doct. ès-Sc, Univ. Mohammed V, Rabat, 148 p. + Annexes.

Dekayir, A. (2008). Etude de la dégradation des mosaïques romaines de Volubilis (Maroc). JMR, pp. 33-38.

EL Mzaiti, I., N. Zine and A. Boukil (2014). Caractérisation de la flore de la forêt d'Achemeche pour un aménagement intégré et un developpement territorial durable de la commune rurale de Ras Jerry, province d'El Hajeb, Maroc. *European Scientific Journal, edition,* **10(32):** ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431.

El Ouailidi, J., H. Khamar, M. Fennane, M. Ibn Tatou, S. Chauvet and M.S. Taleb (2012). Checklist des endémiques et spécimens types de la flore vasculaire de l'Afrique du Nord, Document de L'Institut *Scientifique, Rabat,* **25:** 193 p.

Emberger, L. (1939). Aperçu général sur la végétation du Maroc. Commentaire de la carte phytogéographique du Maroc au 1/500 000. *Veröff. Geobot. Inst. Rübel in Zürich,* **14:** 40-157. + carte hors texte.

Emberger, L. (1955). Une classification biogéographique des climats. *Rec. Trav. Lab. Bot. Zool. Fac. Sc de Montpellier,* **7:** 3-43.

Fennane, M. and M. Ibn Tattou (2012). Statistiques et commentaires sur l'inventaire actuel de la flore vasculaire du Maroc. *Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie,* **34(1):** p. 1-9.

Fennane, M. and M. IbnTattou (1998). Catalogue des plantes endémiques, rares oumenacées du Maroc. *Bocconea,* **8:** pp. 1-243.

Fennane, M. (2004). Propositions de zones importantes pour les plantes au Maroc (ZIP Maroc). Atelier National, Zones importantes de plantes au Maroc. Institut Scientifique. Rabat, Morocco.

Fennane, M. (2016). Eléments pour un Livre rouge de la flore vasculaire du Maroc. Fascicule1. Pteridophyta (Version 1). Edit. Tela-Botanica. Licence CC-BY NC ND.

Fennane, M. (2017). Eléments pour un Livre rouge de la flore vasculaire du Maroc. Fascicule 3. Asteraceae (version 1). Edit. Tela-Botanica. Licence CC-BY NC ND.

Fennane, M., M. Ibn Tatou, A. Ouyahya and J. El Oualidi (2007). Flore pratique du Maroc : Manuel de détermination des plantes vasculaires. Volume 2. *Travaux de l'Institut Scientifique, série botanique,* **38:** Rabat-Agdal, Maroc.

Fennane, M., M. Ibn Tatou and J. El Oualidi (2014). Flore pratique du Maroc : Manuel de détermination des plantes vasculaires. Volume 3. *Travaux de l'Institut Scientifique, série botanique,* **40:** Rabat-Agdal, Maroc.

Fennane, M., M. Ibn Tattou, J. Mathez, A. Ouyahya and J. El Oualidi (1999). Flore pratique du Maroc ; Manuel de détermination des plantes vasculaires, Volume 1. *Travaux de l'Institut Scientifique, série botanique,* **36:** pp.1-558 p.

Fougrach, H., W. Badri and M. Malki (2007). Flore vasculaire rareet menacée du massif deTazekka (Région De Taza, Maroc). *Bulletin De L'institut Scientifique, Rabat, Section Sciences De La Vie, Maroc.,* **29:** pp. 1-10.

Hammada, S., M. Dakki, M.I. Tattou, A. Ouyahya and M. Fennane (2004). Analyse de la biodiversiteì floristique des zones humides du Maroc: flore rare, menaceìe et halophile. *Acta Botanica Malacitana,* **29:** p. 43-66.

Infoclimate (2018). Weather data website accessed on 06/20/2018; URL: https://www.infoclimat.fr/climatologie/annee/2017/meknes/valeurs/60150.html.

Montserrat, J.M., M. Fennane and O. Bennig (2006). Novedades floristicas para las comarcas de Zerhoun, Mamora y Tanger (N de Marruecos). *Lagascalia,* **26:** 149-153.

Orch. H., L. Zidane and A. Douira (2013). Contribution à la connaissance de la Flore vasculaire du massif d'Izarène (Nord Ouest Maroc). *Journal of Animal and Plant Sciences,* **2:** 3093-3112.

Ouhammou, A. (2005). Flore et végétation du Parc National de Toubkal, typologie, écologie et conservation. Thesis Doct. ès-Sc., Univ. Cadi Ayyad, Marrakech, 258 p. + Annexes.

Panetier, J.L. (2002). Volubilis, une cité du Maroc antique, Paris, Maisonneuve et Larose, p. 12.

Prelly, R. (1985). Guide des fougères et plantes alliées. Le chevallier, Paris.199p.

Quezel, P. and S. Santa (1962-1963). Nouvelle flore d'Algérie et des régions désertiques méridionales. 2 tomes. Paris, France 1170 p.

Quézel, P. (1995). La flore du bassin méditerranéen, origine, mise en place, endémisme - C.R. Congr. intern. Conservation des flores dans les îles méditerranéennes" Ajaccio. EcologiaMediterranea, n° sp., XXI, 1-2, 19-39.

Quézel, P. (1999). Les grandes structures de végétation en région méditerranéenne, facteurs déterminants dans leur mise en place post-glaciaire. *Geobios,* **32:** 1, 19-32.

Slimani, I., L. Nassiri, A. Boukil, E. Bouiamrine, L. Bachiri, M. Bammou and J. Ibijbijen (2016). Inventaire des plantes aromatiques et médicinales du site d'intérêt biologique et écologique de Jbel Zerhoun, région Meknès Tafilalet. Afrique SCIENCE, pp. 393-409.

Taleb, M. and M. Fennane (2008). Diversité floristique du parc national du haut atlas oriental et des massifs Ayachi et Maâsker (Maroc). *Acta Botanica Malacitana,* **33:** 125-145.

Tela Botanica (2020). Knowledgebase of the network of French-speaking botanists. Web site consulted on 10/25/2020; URL: https://www.tela-botanica.org/site:botanique.

Wikipedia (2020). Lisbon earthquake of 1 November 1755. Free online encyclopedia; accessed on 06/12/2020; URL: https://fr.wikipedia.org/wiki/S%C3%A9isme_du_1er_novembre_1755_%C3%A0_Lisbonne.

Zaidi, M., B. Baghdad, S. Chakiri and A. Taleb (2016). Characterization of the Biodegradation of Kasbahs of the Gharb Region (Mehdia and Kenitra Kasbahs, Morocco). Open Journal of Ecology, pp. 753-766.