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Vegetation changes during the last millennium in the Wet Complex of El-Kala (Algeria): palynological records and comparative study case of Alder of Ain Khiar & El Ghorra Mountain

Kahit Fatima Zahra[1*], Youbi Mustapha[1], Danu Mihaela Aurelia[2], Benslama Mohamed[1]

[1]*Laboratory of Soil and Sustainable Development, Badji Mokhtar University of Annaba, Algeria*

[2]*Faculty of Biology, Research Department, Alexandru Ioan Cuza University of Iasi, Romania*

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Abstract

The objective of this work is information providing about the vegetation and climate changes that occurred in the last millennium at the Wet Complex of El-Kala (Algeria). In order to contribute in the understanding of past dynamics and current wet area from this region, two case studies are described here: the alder-peatland of Ain-Khiar and Gbar El Halouf at El-Ghorra Mountain. Pollen data obtained from sediments of El-Kala allowed us to make inferences regarding the past vegetation and climate history. For this, two palynological cores from this area were analyzed. The results are supported by five AMS radiocarbon dates. The oldest data was recorded at El Ghorra Mountain (925±29 AD) while the recent data was recorded at the alder peatland of Ain Khiar (1809±97 AD). The obtained data highlight that starting with Medieval Warm Period (MWP) around 925±29 AD until 1581±52 AD, the landscape characterized by domination of thermophilous taxa related by warm temperatures average at both of studied sites, at the beginning of Little Ice Age (LIA) the landscape at both sites has the same appearance domination of hygrophilous taxa and decline of thermophilous taxa related by low temperatures average mentioned at that period and it was finished around (1809±97 AD). This study shows that from 19th century to present days the landscape is characterized by the expansion of thermophilous taxa at El Ghorra Mountain and traces of anthropogenic activities and at Alder of Ain Khiar retains its appearance despite the decline of all of local and regional vegetation.

* **Corresponding Author:** Kahit Fatima Zahra ✉ zahrakahit@gmail.com

Introduction

Today, climate change studies are a great challenge to control and overcome its consequences on human society as well as on environment. Palaeobotanical and palaeoclimatical studies are the most reliable ways for understanding these changes and explaining past events through the study of vegetation dynamics mainly in peatlands, which are the record of vegetation and climate history.

In Algeria peatlands are located on the north-east of the country and represent 1% of total area. Both studied sites, alder-peatland of Ain-Khiar & El Ghorra Mountain, are situated in the Wet Complex of El-Kala at different altitudes.

They are the subject of this comparative study, following the works of Kahit *et al.* (2017), Youbi and Benslama (2015) and Benslama *et al.* (2010). Five A.M.S. radiocarbon analyzes revealed dates of about 1000 BP, were applied in order to retrace the vegetation history and understand its dynamics, and conditions that influenced these dynamics and to make the link between this study and previous studies at the local level in Algeria and in the Mediterranean region.

Materials and methods

Geographical situation

El Kala region is one of the richest from the biodiversity area from the north-eastern of Algeria, has been protected by the establishment of a national park of approximately 80 000 ha since 1983 and has been registered as a biosphere reserve by UNESCO since 1990.

The region is bounded on the east by Tunisian borders, on the north by the Mediterranean Sea, on the west by Cap Rosa, on the south by the foothills of El-Ghorra Mountains (Benslama *et al.,* 2010).

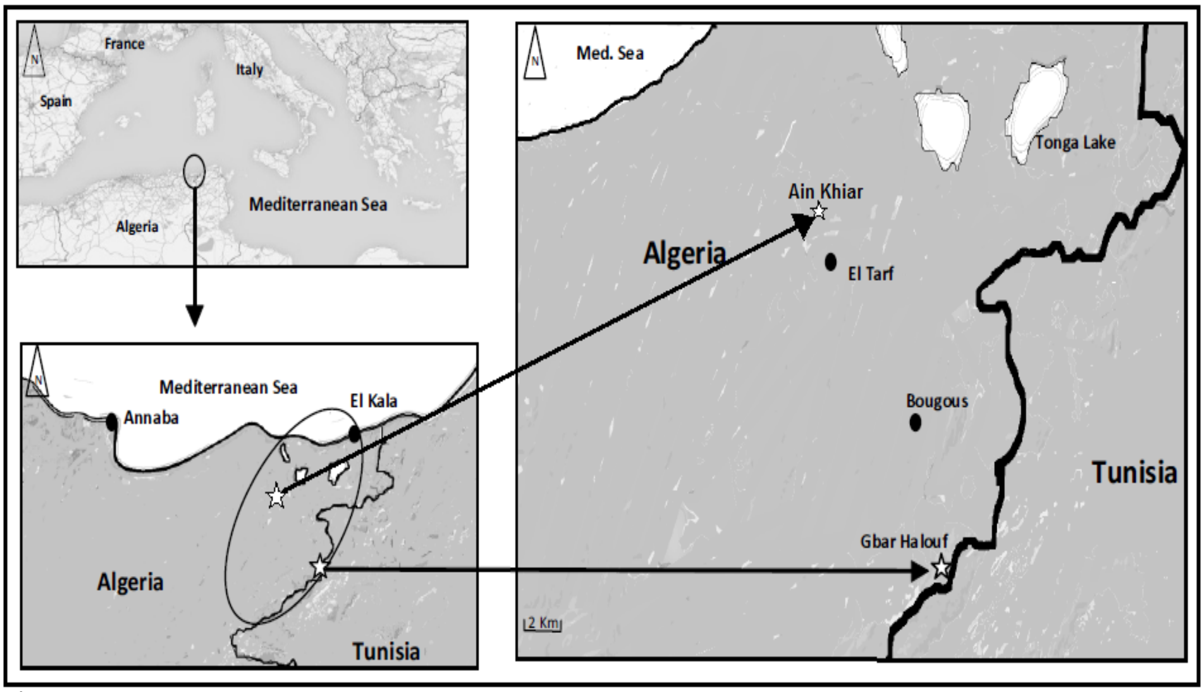

Fig. 1. Location of studied areas (Using QGIS Software).

The wet complex of El-Kala contains several sites distributed from the east of Oued Mafragh (longitude E 7°50') to the west of Kef Segleb (long 8°30'), several of them have evolved into peat bogs to form the largest area of peatlands active in Algeria about 1000 ha (Benslama, 2002). Our study is based on two sites, the first one is the Alder of Ain-Khiar, RAMSAR site since 2003 (36°480'.62''N, 8°18'58.50''E°), which is located at an altitude of 24-30 m, about 170 ha constitutes the area which 20 ha are peatland. It is bordered to the north by the sand dunes, to the south by Oued El Kebir and the agricultural plains of El

Tarf city, to the east by the watershed of Oubeïra Lake and to the west by a degraded oak forest, receives water flood oued El-Kebir in winter to turn into the swampy area (Kahit *et al.,* 2017). The second site is El-Ghorra Mountain located at an altitude of 1003 m in a place known as "Gbar Halouf" with an estimated surface of 300 m². The site (36°35'14.47 " N; 8°21'31.64" E) is close to the border between Algeria and Tunisia. The peat deposit lays in the middle of a mid-altitude lawn slightly slopped oriented N-E / S-W. Several ridges dominate the lawn including one, where rocky material flushes with a source of water trickling downward along the site (Youbi and Benslama, 2015).

Current local climate

The El-Kala region is located in the sub-humid Mediterranean climate (De Belair, 1990), with a mild summer with average temperatures of 31°C, The lowest temperatures are recorded in altitudes during the winter; February is the coldest month with 18°C while the month of August is the hottest. Annual precipitation is more than 700 mm; prevailing winds are from the north-west resulting in 70% atmospheric humidity.

This climate is particularly favorable to the development of forest vegetation which occupies 72.75% of the total area, 9% of agricultural land and 18% of lakes, marshes, and riparian areas.

Current vegetation

According to Thomas (1975), Aouadi (1989), De Belair (1990), Benslama *et al.* (2010) and Belouahem (2012) the vegetation cover in El Kala wetland is largely dominated by cork oak forest with an undergrowth of *Erica arborea* and *Myrtus communis*, while the dune formations are occupied by *Quercus coccifera*, the alders represent a small and fragile ecosystem of the region characterized by wetland vegetation:

Heliophytic vegetation: *Alnus glutinosa, Salix pedicillata, Erica scoparia, Rubus ulmifolius, Vitis vinifera, Athyrium filix-femina, Osmunda regalis, Laurus nobilis,*

Hygrophilous vegetation: *Ormenis mixta, Mentha rotundifolia, Trifolium maritimum,*

Amphibious vegetation: *Scirpus acutus, Phragmites australis, Typha latifolia, Juncus capitatus.*

Aquatic vegetation: *Nymphea alba, Callitriche pallustris, Ranunculus aquatilis, Polygonum salcifolium, Salvinia natans.*

According to Youbi and Benslama (2015) contemporary flora in the site of Gbar Halouf is characterized by the abundance of herbaceous taxa including Poaceae, *Asphodelus microcarpus*, *Urgenia maritima* and few species of Asteraceae (Compositae) such as *Bellis* sp. Trees and shrubs are absent excepting some specimens of *Erica arborea* and *Cistus monspliensis.*

The peat deposit is also characterized by the presence of some wetland species like *Juncus* sp., *Carex* sp. and *Lemna* sp. Around the study site (at lower altitudes), *Erica* sp., *Calycotome* sp., and *Cistus* sp. are structured in sparse shrub associations that mix gradually with *Quercus canariensis* before they completely disappear to the benefit of small Zeen-oak woodlands. The latter are accompanied by a *sciaphilous ferns stratum*, *Ivy* and *Crataegus azerolus* at the edges.

Sampling

Russian corer has been used for sampling. Coring was carried out alternately in two parallel holes. Cores were placed immediately in plastic gutters and packed in plastic bags to prevent them from breaking and drying. Then they were transported immediately to the laboratory and stored in the shade at ambient temperature (Reille, 1990).

Two cores were taken, the 1st is of 260 cm length from Alder Ain Khiar the 2nd is of 115 cm from El Ghorra Mountain, total of 75 samples (each 5 cm of the sequences) were treated to carry out pollen analyses following a standard method (Erdtman, 1960); (Faegri, 1989), based on a series of treatment with: NaOH (20%), HF (70%), HCl (10%), CH_3COOH, acetolysis and finally conservation of pollen material in glycerin. Pollen and spores identification was made under optical microscopy using several pollen and spores atlas (Reille, 1992; Reille, 1996; Reille, 1998; HJ Beug, 2004).

Pollen diagram

The numbers are expressed in relative frequencies in relation to the total pollen sum and Plotted graphically using TILIA and TG View (Grim, 1991) for Alder of Ain Khiar samples and C2 stat software for El Ghorra Mountain Samples.

Chronology

Alder of Ain Khiar

El Ghorra Mountain

Plant macro-fossils were extracted from the sediment in order to be used for ^{14}C Dating. Radiometric measurements were performed at the KECK CARBON CYCLE AMS FACILITY in California (USA) through the Center for Nordic Studies (CEN) in Quebec (CANADA). Radiocarbon results were corrected according to Stuiver and Polach (1977), with values σ13C measured on Graphite, using AMS spectrometry. Calibration of the obtained dates was made by means of Calib 7.0.2. Software based on the IntCal13 curve. The radiocarbon results are given in Table 1.

Results

After pollen extraction, 90 spectra were established for both of sites alder Ain Khiar and El Ghorra Mountain, based on a minimum of 300 counts. Aquatic taxa and Pteridophyteae were excluded from the total pollen sum, which reveals 3 pollen zones from pollen Diagram of Ain Khiar (Fig. 2) and 5 pollen zones from El Ghorra Mountain (Fig. 3). The radiocarbon dates were integrated in the diagram as well as the stratigraphic description as shown in Fig. 2 and Fig. 3.

Table 1. AMS Radiocarbon dating of the studied cores (according to Youbi and Benslama, 2015 and Kahit *et al.*, 2017).

Site	Dated samples levels (cm)	Lab code	Dated material	Non calibrated ^{14}C (Yr BP)	Calibrated ^{14}C (Yr BP)	Calibrated ^{14}C (Yr AD)
Ain Khiar	20-25	Poz-79132	Peat	85 ± 30	141± 97	1809± 97
	120-125	Poz-79262	Sandy peat	380 ± 30	420 ± 69	1530 ± 69
El Ghorra Mountain	50 - 55	UCIAMS-139240 (ULA-4610)	Plant Macro-rests	220±20	227±77	1722±68
	80 - 90	UCIAMS-139239 (ULA-4609)	Plant Macro-rests	295±20	365±66	1581±52
	108 - 110	UCIAMS-139241 (ULA-4611)	Plant Macro-rests	1125±20	1017±47	903±61

For ^{14}C dating, two peat samples were selected, the dating analyzes were carried out in Poznan radiocarbon laboratory, POLAND by the AMS spectrometry method, the dates obtained are calibrated on the site http: //www.calpal -online.de/.

Discussion

According to the obtained results of Youbi and Benslama (2015) presented in Fig.3 and Kahit *et al.* (2017) presented in Fig.2, we will try to find the link of the chronology of vegetation dynamics at different altitudes in both of sites: alder Ain-Khiar (30m) and Gbar El Halouf at El Ghorra Mountain (1002m) during the last millennium. We refer to previous works at the local and regional level (Bentiba and Reille, 1982); (Benslama *et al.*, 2010); (Youbi and Benslama, 2015); (Kahit *et al., 2017)* and others.

Chronology and vegetation dynamics

From a palaeoclimatological point of view, there is a scientific consensus on the fact that the last millennium climate in the Northern Hemisphere varied between hot and cold periods (Lamb, 1965; Cook *et al*, 2002; Mann, 2005; Wassenburg *et al.*, 2013). If the global scale of these changes is not yet unanimously admitted, there are more and more evidences that the Northern Hemisphere experienced significant changes in its average temperatures of the air and the water just before the crusades (Kaniewski *et al*., 2011). Scientists talk of a warm period between 900 and 1300 AD which corresponds to The Medieval Optimum, followed by a cold period between 1450 AD and 1850 AD known as "The Little Ice Age" (LIA). These climatic fluctuations have been reported in Italy (Calo *et al*., 2013), France (Jalut *et al*., 2000), Spain (Jalut *et al*., 2000; Martin-Puertas *et al*., 2010; Schutt, 2005; Julia *et al*., 2007), Turkey (Öner, 2009), Syria (Kaniewski *et al*., 2011) as well as other areas of the Mediterranean region.

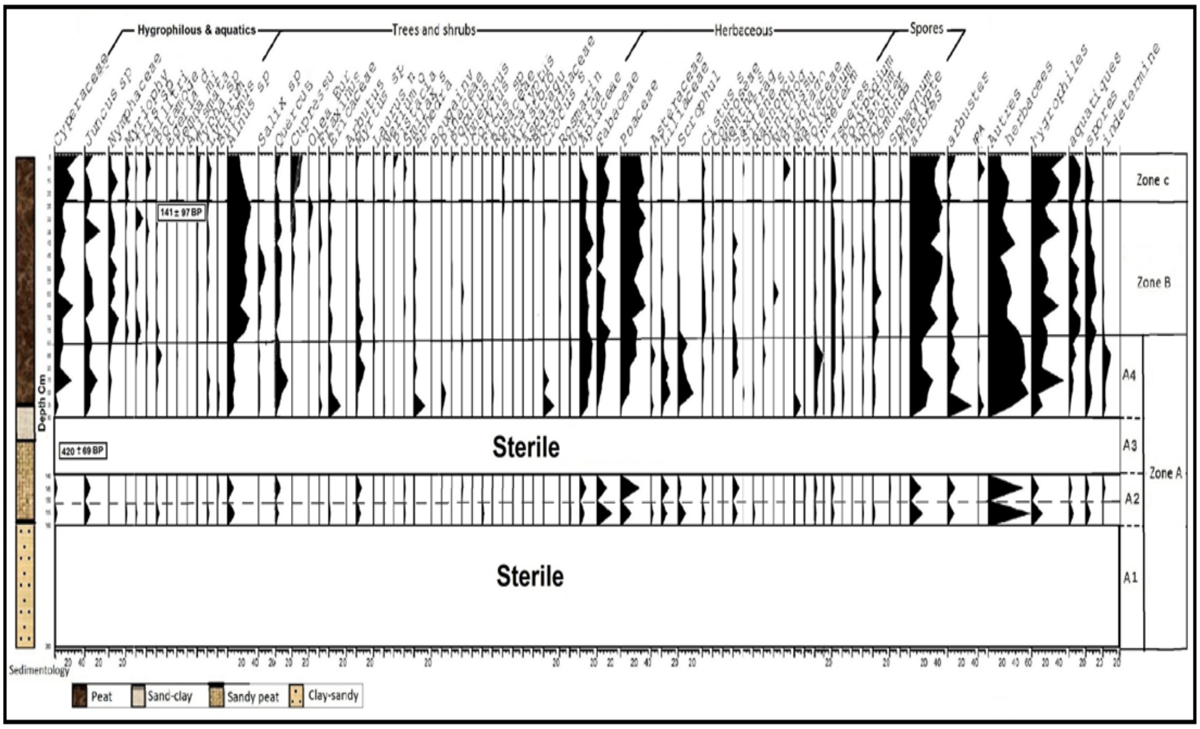

Fig. 2. Pollen diagram of Alder Ain Khiar (after Kahit *et al*., 2017).

At the Medieval Warm Period (MWP): 900-1300 AD

At low altitude in Alder of Ain Khiar, the timid presence of *Alnus* association and Cyperaceae indicates the presence of wet grassland, due to the mild climate notices at that time (Martin-Puertas *et al*., 2010); (Calo *et al*., 2013), spores fluctuations low aquatic taxa presence due to site's situation and relationship with Garaat El Ouez the closest permanent stretch of water according to Benslama (2010).

According to Reille *et al.* (1997) because of increased temperatures in the northern hemisphere and in Mediterranean corresponds to the Medieval Warm Period; there was an extension of the cork oak forest at the west of the Mediterranean. According to Kahit *et al.* (2017) at low altitudes in El Kala region exactly at the Alder of Ain Khiar, while mesophilous (*Quercus suber, Erica arborea* and *Myrtus*) association with heliophytic herbaceous (Fabaceae, Liliaceae, Asteraceae, and Poaceae) marks its maximum presence at regional level of alder Ain-Khiar.

At high altitude, El-Ghorra Mountain, according to Youbi and Benslama (2015), the landscape surrounding the peat deposit appears to be characterized by retreating deciduous oak forests, the site is rather dominated by a herbaceous stratum composed by Poaceae and Compositeae. These herbaceous plants seem to occupy areas no longer occupied by *Quercus* caduc, but they would also be very present in the prairies and lawns of El-Ghorra taking advantage of higher temperatures. The other element of the plant landscape is composed of thermophilous taxa as *Erica* and *Cistus* which seem to be present in a fragmented manner. *Alnus*, a taxa attached to wetlands, is lightly present at this period, which may have a link with the warming of the climate at that epoch (Martin-Puertas *et al.*, 2010; Calo *et al.*, 2013). With regards to the human activity, this period corresponds to the arrival of Yemeni tribes (Banou Hillal, Banou Salim...), who replaced the Byzantines and the Romans (Brun, 1992). In many regions across the Mediterranean basin, Romano-Byzantine presence is marked by cereal and olive cultivation (Brun, 1992) which the pollen is observed at the bottom of the core (*Cerealia*-type and *Olea*). It is known that these crops were neglected by the Arab tribes whose the main activity was grazing. This may explain the reason behind the disappearance of *Cerealia-type* with the departure of the Byzantines (around 800 AD) and to a lesser extent *Olea*.

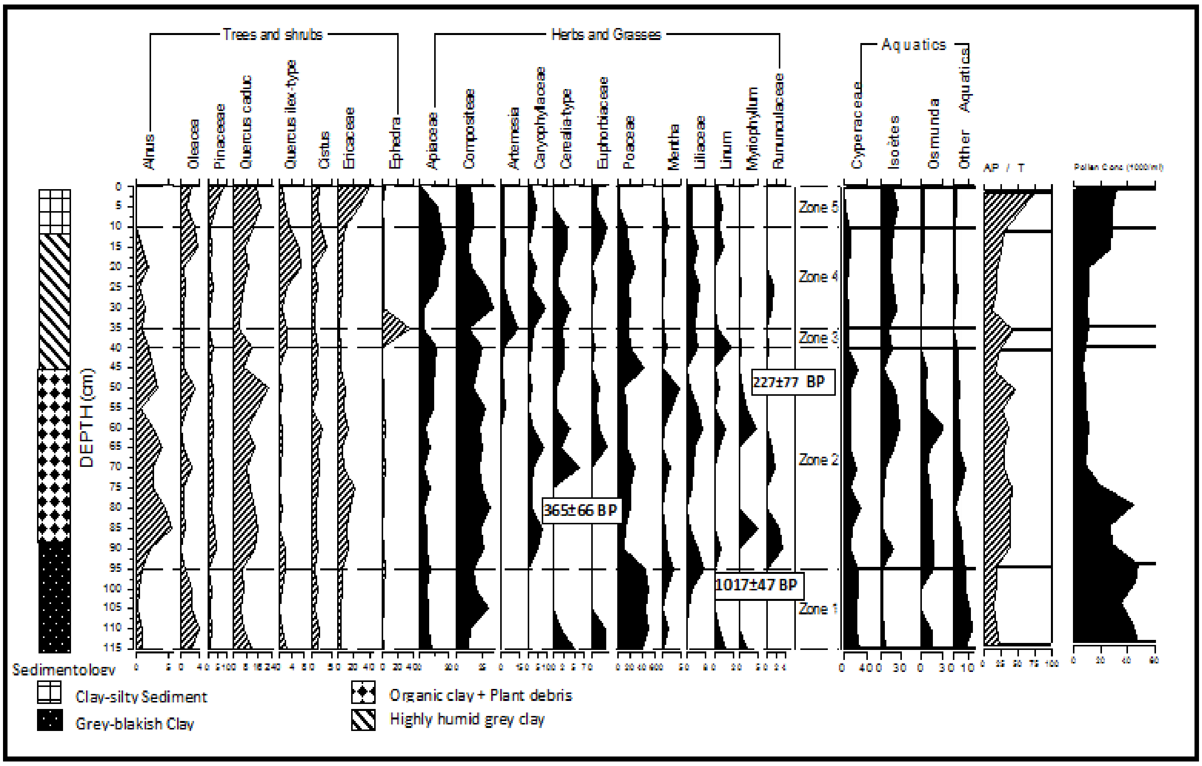

Fig. 3. Pollen diagram of Gbar El Halouf - El Ghorra Mountain (after Youbi and Benslama, 2015).

Around 1200 AD, the climate became more clement with a decline in temperatures; the Medieval Warm was retreating. Across the Mediterranean, this epoch, which lasted between 2 and 3 centuries, was characterized by a mild and wetter climate (Jalut *et al.*, 2000; Martin-Puertas *et al.*, 2010; Schutt, 2005; Julia *et al.*, 2007).

At El-Ghorra mid-altitude areas, rainfall increases and the temperature decline allowed the mid-altitude deciduous oak forest to extend and proliferate.

The same observation has already been made by Stambouli-Essassi *et al.* (2007) in the Tunisian side of the Mountain. The presence of the evergreen oak seems to be limited whereas Poaceae, which are more or less thermophilous, regressed to the benefit of the deciduous oak.

The regression of herbaceous taxa is accompanied by a better presence of *Osmunda* and *Isoetes* then their decline, which would be evidence in favor of an increase in precipitations and a more organic sedimentation (Salamani, 1991).

Alnus is a well present element featuring the mountain landscape at this period, likely because of adequate humidity and temperature. The thermophilous shrubs progress timidly.

At the Little Ice Age Period (LIA): 1500-1850 AD

At the beginning of this epoch, European climate was experiencing significant reductions in average temperatures along with the settlement of a cold period which lasted approximately 3 centuries (Lamb, 1965; Jalut *et al.*, 2000; Martin-Puertas *et al.*, 2010; Schutt, 2005; Julia *et al.*, 2007; Mann, 2005).

According to Kahit *et al.* (2017), at low altitude in the Alder of Ain Khiar, Hygrophilous taxa (*Alnus*, Cyperaceae, Juncaceae, and Nymphaeaceae) represent their maximum extension, mesophilous taxa remoting (*Quercus suber, Erica arborea* and *Myrtus*) and other mesophilous taxa (undetermined taxa) disappearance.

According to Youbi and Benslama (2015) at El Ghorra Mountain, the landscape is characterized by a decline of almost all forest and herbaceous taxa with the exception *Ephedra* and *Artemisia*, well known to be highly thermophilous. By referring to the existing literature, it has been very difficult for us to explain this short but remarkable expansion of *Ephedra* and *Artemisia* between 150-100 BP which also corresponds to the first years of the French occupation of the region and everything that has accompanied those historical events. However, in view of the obtained results and according to the results of Brewer *et al.* (2007) dealing with drought periodicities in the Mediterranean region during the last 5 centuries, we propose, with reservation, the hypothesis of a possible dry period (short but significant) which would have affected the local vegetation around 1800-1850 AD. On the other hand, fire may also be responsible for such pollen data but would need an anthropological approach to be discussed.

From the late 19th century to present days: 1809 ± 97 AD

The anthropogenic activity characterizes this epoch at the Alder of Ain Khiar, *Eucalyptus* reforestation between (1854-1860) in Algerian sub-humid areas, according the FAO (1982), also the appearance of *Cupressus*, a tree used as protective barrier of agricultural land around the site, the landscape retains its appearance despite the decline of all of local and regional vegetation (Kahit *et al.,* 2017).

According to Youbi and Benslama (2015) during this period at El Ghorra Mountain, the deciduous oak forest seems resuming its expansion after a short phase of regression but is more or less fragmented in comparison with the second phase of the Medieval Warm Period. The landscape in the studied region is characterized by a remarkable expansion of thermophilous taxa including *Erica* and *Pinus*. The evergreen oak seems better represented by occupying more and more parcels where micro-climate and soil conditions are favorable. *Erica* and *Cistus* are highly abundant as it is the case in present days. It is obvious to establish a link between Global Warming in modern Era and the expansion of thermophilous taxa. The current plant landscape could be the result of these variations particularly in a region as vulnerable as the Mediterranean (Mann, 2005). During the study of the current flora, we have not noticed the presence of the genus *Pinus* or other Pinaceae, which poses the problem with regards to the origin their pollen. *Pinus* is very characteristic of the contemporary Mediterranean flora at lower altitudes where it is gradually replacing the spontaneous cork forests (Reille *et al.*, 1997).

Conclusions

This palaeo-palynological study allowed us to highlight the vegetation history and climate changes in the last millennium (925±29 AD - 1809±97 AD) in the wet complex of El-Kala, north-east of Algeria. Starting with Medieval Warm Period (MWP), around 925±29 AD until 1581±52 AD, the landscape is characterized by domination of thermophilous taxa related by warm temperatures average. At the beginning of Little Ice Age (LIA) the landscape has the same appearance domination of hygrophilous taxa and decline of thermophilous taxa related by low temperatures average mentioned at that period at the Mediterranean region finished around 1809±97 AD. The period from19th century to present days the landscape is characterized by the expansion of thermophilous taxa at El Ghorra Mountain and traces of anthropogenic activities. At the Alder of Ain Khiar the landscape retains its appearance despite the decline of all of local and regional vegetation. Further works are needed in the context of climate changes in the Mediterranean region.

References

Aouadi H. 1989. La végétation de l'Algérie Nord – Orientale: Histoire des influences anthropiques et cartographie à 1/200000, PhD thesis. Grenoble: Joseph Fourier University.

Belouahem D. 2012. Etude écologique des peuplements forestiers des zones humides dans les régions de Skikda, Annaba et El Tarf (Nord-Est algérien) PhD thesis. Annaba: Université Badji Mokhtar.

Ben Tiba B, Reille M. 1982. Recherches pollenanalytiques dans les montagnes de Kroumirie: (Tunisie septentrionale) premiers résultats. Ecologia Mediterranea **8(4),** 75-86.

Benslama M. 2002. Caractérisation morpho-analytique des sols tourbeux de la Numidie Orientale. 7ème Journée nationale de l'étude des sols. 22-24 oct. Orléans France.

Benslama M, Andrieu-Ponel V, Guiter F, Reille M, De Beaulieu JL, Migliore J, Djamali M. 2010. Nouvelles contributions à l'histoire tradiglaciaire et holocène de la végétation en Algérie: analyses polliniques de deux profils sédimentaires du complexe humide d'El-Kala. Comptes Rendus de Biologie **333,** 744-754.

Beug HJ. 2004. Leitfaden der Pollenbestimmung: für Mitteleuropa und angrenzende Gebiete. München: Dr Friedrich Pfeil.

Brewer S, Alleaume S, Guiot J, Nicault A. 2007. Historical droughts in Mediterranean regions during the last 500 years: a data/model approach. Climate of the Past **3,** 355-366.

Brun A. 1992. Pollens dans les séries marines du Golfe de Gabès et du plateau des Kerkennah (Tunisie) : signaux climatiques et anthropiques. Quaternaire **3,** 31-39.

Calò C, Henne P, Eugster P, Van Leeuwen J, Gilli A, Hamann Y, La Mantia T, Pasta S, Vescovi E, Tinner W. 2013. 1200 years of decadal-scale variability of Mediterranean vegetation and climate at Pantelleria Island, Italy. The Holocene **23,** 1477-1486.

Cook ER, Palmer JG, Rosanne D, D'Arrigo R D. 2002. Evidence for a 'Medieval Warm Period' in a 1,100 year tree-ring reconstruction of past austral summer temperatures in New Zealand. Geophysical Research Letters **29,** 12.1-12.4.

De Belair G. 1990. Structure, fonctionnement et perspectives de gestion de quatre ecocomplexes lacustres et marécageux (El Kala, Est Algérien). PhD thesis. Montpellier: Université de Montpellier II.

Erdtman G. 1960. The acetolysis method. Svensk: Botanisk Tidskrift.

Faegri K, Iversen J. 1989. Manuels d'analyse de pollen Wiley: Chichester.

Food and Agriculture Organization of the United Nations (FAO). 1982. Les eucalyptus dans les reboisements. ROME: FAO.

Grimm EC. 1991. TILIA and TILIA GRAPH. Illinois: State Museum.

Jalut G, Amat AE, Bonnet L, Gauquelin T, Fontugne M. 2000. Holocene climatic changes in the Western Mediterranean, from south-east France to South-east Spain. Palaeogeography, Palaeoclimatology, Palaeoecology **160,** 255-290.

Julià R, Luque JA, Riera S, Alejandro JA. 2007. Climatic and land use changes on the NW of Iberian Peninsula recorded in a 1,500-year record from Lake

Sanabria. Contributions to Science **3,** 355-369.

Kahit FZ, Zaoui L, Danu MA, Romanescu G, Benslama M. 2017. A new vegetation history documented by pollen analysis and C14 dating in the alder of Ain Khiar – El Kala wet complex, Algeria. International Journal of Biosciences **11,** 192-199. http://dx.doi.org/10.12692/ijb/11.6.192-199

Kaniewski D, Van Campo E, Paulissen E, Weiss H, Otto T, Bakker J, Rossignol I, Van Lerberghem K. 2011. Medieval coastal Syrian vegetation patterns in the principality of Antioch .The Holocene **21,** 251-262.

Lamb HH. 1965. The early medieval warm epoch and its sequels. Palaeogeography, Paleoclimatology, Palaeoecology **1,** 13-37.

Mann ME. 2002. Little Ice Age. Encyclopedia of Global Environmental Change **1,** 504–509.

Mann ME. 2005. Climate changes over the past millennium: Relationships with Mediterranean climates. IL NUOVO CIMENTO **29(1),** 73-80.

Martín-Puertas C, Jiménez-Espejo F, Martínez-Ruiz F, Nieto-Moreno V, Rodrigo M, Mata MP, Valero-Garcés BL. 2010. Late Holocene climate variability in the southwestern Mediterranean region: an integrated marine and terrestrial geochemical approach. Climate of the Past **6,** 807-816.

Öner S. 2009. Vegetation history and human activity in 2nd millennium AD in Turkey: Pollen analysis of a peat bog. Annales Botanici Fennici **46,** 192-200.

Pfister C, Luterbacher J, Schwarz-Zanetti G, Wegmann M. 1998. Winter air temperature variations in Western Europe during the Early and High Middle Ages (AD 750–1300). The Holocene **8,** 535–552.

Quezel P, Barbero M, Loisel R. 1990. Les reboisements en région méditerranéenne. Incidences biologiques et économiques .Forêt méditerranéenne **XII(2),** 103-114

Reille M. 1990. Leçon de palynologie et d'analyse pollinique. Paris: C.N.R.S.

Reille M. 1998. Pollen et spores d'Europe et d'Afrique du Nord. Marseille: Laboratoire de Botanique Historique et Palynologie.

Reille M, Gamisans J, De Beaulieu JL. 1997. The late glacial at lac de Creno (Corsica, France): a key site in the western Mediterranean basin. New phytologist **135,** 547-559.

Salamani M. 1991. Premières données palynologiques sur l'histoire Holocène du massif de l'Akfadou grande Kabylie, Algérie. Ecologia Mediterranea **17,** 145-159.

Schutt B. 2005. Late Quaternary Environmental Change on the Iberian Peninsula. DIE ERDE **136,** 3-14.

Stambouli-Essassi S, Roche E, Bouzid S. 2007. Evolution of vegetation and climatic changes in North-Western Tunisia during the last 40 millennia. International Journal of Tropical Geology, Geography and Ecology **31,** 171-214.

Stuiver M, Polach HA. 1977. Discussion: reporting of 14C data. Radiocarbon **19,** 355-363.

Thomas JP. 1975. Ecology and dynamism Quaternary coastal and terrestrial sand vegetation dunes from Jijel to El Kala (East Algeria). PhD thesis. Montpellier: Université Sciences et techniques Languedoc., 165p.

Wassenburg JA, Immenhauser A, Richter D K, Niedermay A, Riechelmann S, Fietzke J, Scholz D, Jochum KP, Fohlmeister J, Schröder-Ritzrau A, Sabaoui A, Riechelmann DFC, Schneider L, Esperm J. 2013. Moroccan speleothem and tree ring records suggest a variable positive state of the North Atlantic Oscillation during the Medieval Warm Period. Earth and Planetary Science Letters **375,** 291-302.

Youbi M, Benslama M. 2015. A 1000-year record from El-Ghorra mountain (NE Algeria): Mediterranean vegetation dynamic in response to climatic variation. Ecology, Environment and Conservation **21,** 1189-1198.