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Pollen approach and evolution of the floristic biodiversity of the humid and salty zone of the Fetzara lake (Northeast of Algeria)

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Abstract

The study of pollen grain deposits in two transects of Fetzara lake (North/East of Algeria) was confronted with the floristic environment cover. This study required an inventory of vegetation (264 species) supported by archival documents (ancient botanical studies) and pollen analyzes (86 taxa). A total of 12 surface pollen samples was collected, then, chemically treated according to the standard method. Percentages of pollen were calculated in all samples. The results have showed that the current deposits palynomorphes in lake surface sediments reflect the regional vegetation of the watershed. The differential distribution indicates a dominance of non-arboreal pollen (52%) represented by the Asteraceae, Poaceae and Asphodelaceae on two transects. This reflects the current state of the vegetation cover, further, the presence of *Alnus* probably comes from the wet complex Guerbès Sanhadja, while that of *Pinus*, *Quercus* and *Pistacia* come from the bushes and the degraded subery of the Edough. The dominance of halophyte species such as *Suaeda maritima* L. and *Salsola soda*, as well as pollen from Chenopodiaceae, confirms the salinity of the environment. The richness of the site of aquatic and semi-aquatic vegetation such as *Typha domingensis* (Pers.) Steudel, *Juncus acutus* L. and *Myriophyllum verticillatum* L. indicates the existence of water less than a wet period in the site. The study also showed the presence of a large amount of damaged pollen, probably related to poor conservation conditions and especially the moisture and desiccation phenomena that prevail on the surface of the soil.

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Introduction

The palynological studies are considered as an important tool for the interpretation of the environment passt and elucidating the questions about the paleoclimate and paleoecolgy (Ybert *et al.*,1992 ; Salgado-Labouriau, 2001). However, the understanding of the production's control, dispersion, deposit and conservation of the pollen grains and spores dynamics, are a must for trying to interpret the fossil records, the most important problem consists in the characterization of the relation between the modern pollen spectrum and the vegetation that produces it (Davis & Fall, 2001).

All the ecological studies done on the Fetzara lake shows that the sometimes excessive salinity of soil and water as well as hydromorphy are the main features of this site protected by various international conventions (AJCI, 1985; Djamai, 2007). However, it has been found that in all these studies, palynology has never been addressed, which gives our work a certain originality.

Contrary to the majority of saline soils observed in Algeria, which are found mostly under arid climate (Daoud & Halitim, 1994), the soils of Fetzara lake are located in a region characterized by a sub-humid climate. Which could undoubtedly lead to a different soil-vegetation interaction than that found in arid zone soils, as well as the conservation of pollen grains. Salinization causes harmful effects on soils and plants, which will result in decreased fertility, which may lead to the disappearance of natural vegetation cover (Cheverry & Robert, 1998; Saidi *et al.,* 2004).

The objective of this study is to carry out two transects on Fetzara lake that will make it possible to establish a pollen inventory of surface that will be confronted with the floristic coverage of the species counted on the site of study.

Material and methods

Study area

Fetzara lake is located 18 km to the south / west of Annaba. It lies at the center of the grid between latitudes 36° 43' and 36° 50' North and longitudes 7° 24' and 7° 39' East. It is represented by a large depression whose dimensions are approximately 17 km from West to East and 13 km from North to South with an area of approximately 18600 ha. The flooded part of the lake in winter is located in the center and covers an area estimated at 13000 ha (Fig.1).

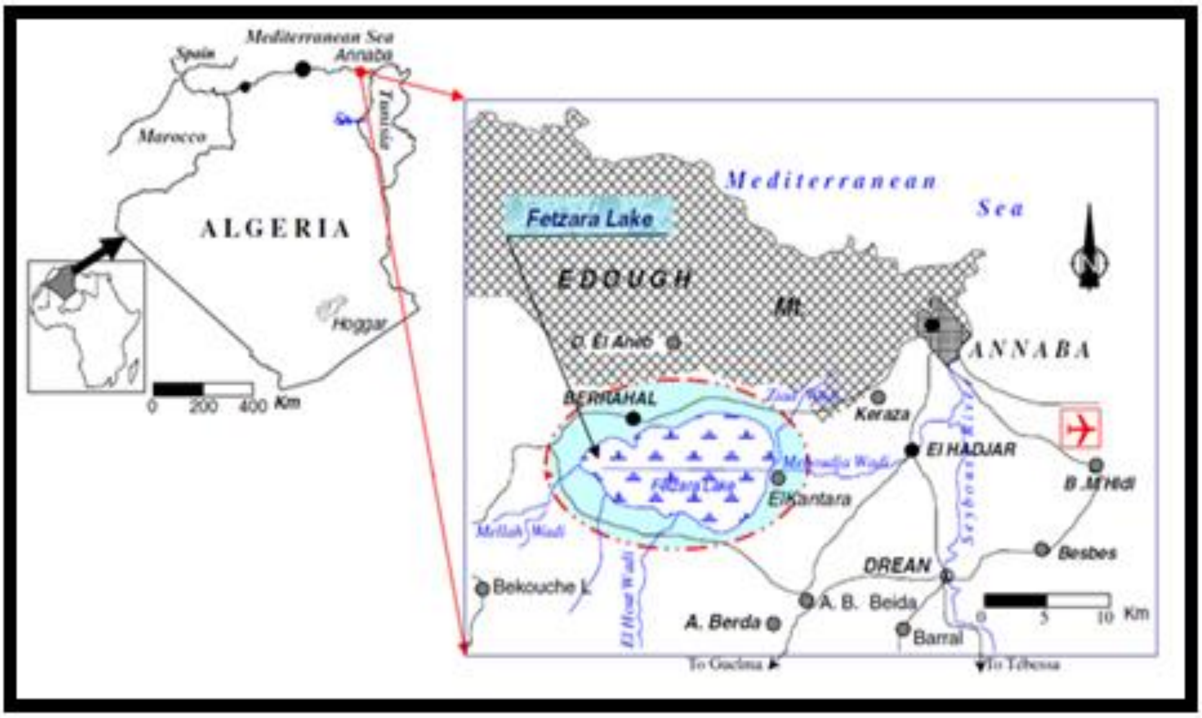

Fig. 1. Location of the study area.

The presence of a main canal running through the lake from West to East ensures its drainage, but it is insufficient to evacuate all the water in winter (Durand, 1950).

The soil cover of the lake consists of 4 types of soils (AJCI, 1985), distributed as follows (CPCS, 1967): halomorphic soils located in the center and occupy 55% of the total area; the poorly developed soils that cover virtually the entire periphery of the lake and constitute the peripheral areas with 28%; the hydromorphic soils forming a discontinuous crown around the halomorphic soils with 13.7% and finally the vertisols with 3.3% of the surface and occupy the western and southwestern parts of the lake.

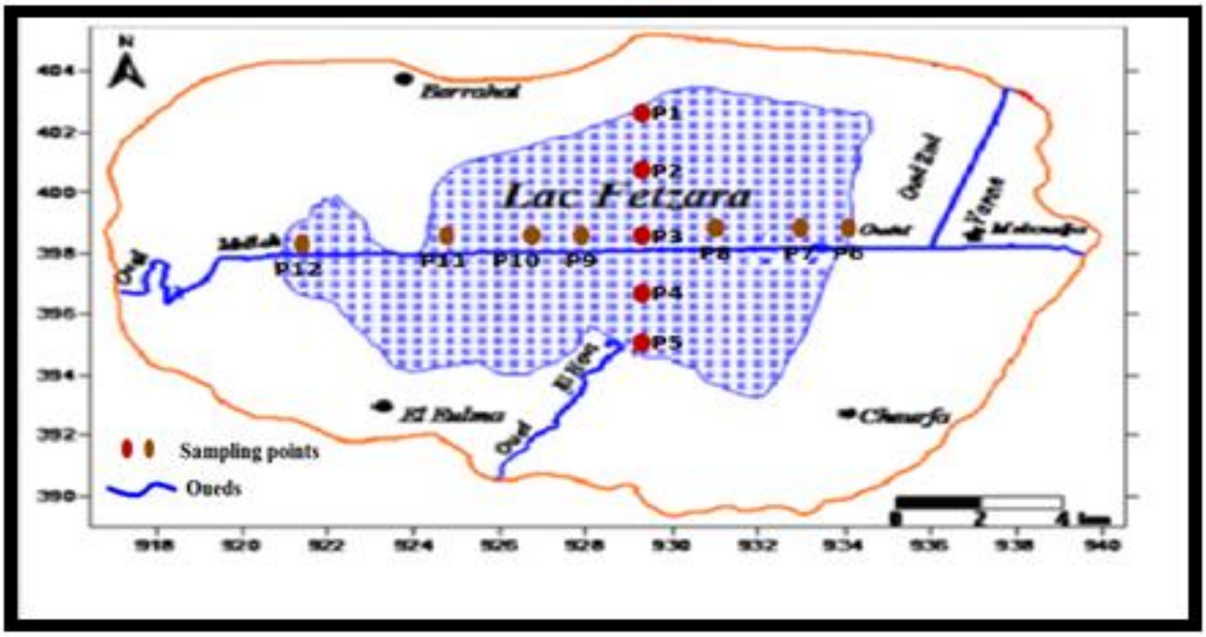

Fig. 2. Location of the modern pollen samples in the study area.

The Fetzara lake is composed mainly of Quaternary formations. The topography is relatively simple, consisting of three groups, the plain (10-20m), the low ground (<10m) and the terraces (20-40m), with 63%, 31% and 6% of the total area, respectively (AJCI, 1985).

The Fetzara lake is fed by a series of wadis from the surrounding massifs. However, the majority of the waters are collected by three main wadis which are: Zied wadi, El-Hout and El-Melah wadis.

Concerning climate, the region of Annaba receives an average of 686 mm/year of rain (Annaba les Salines from 1982 to 2011), with 80% of data available during six months of the year (October to March). Annual evaporation is very important because of its high average equal to 1220 mm/year, adding to this a summer dryness of 6 months (from April to September) which characterizes the region. This situation will generate a huge water deficit (P < ETP), which the consequences will have an impact on the water concentration, the accumulation and redistribution of salts before the opening of the outflow channels, hence, the accentuation of the phenomenon of salinization, will affect behavior and the redistribution of vegetation on Fetzara lake.

Experimental protocol

Sampling

The location of the sampling points was influenced by the importance given to insure a study on the center of the lake and its four corners in order to examine the models of palynomorphous deposits and to establish a homogeneous ecological and geographical context.

Floral and pollen inventory

The vegetation inventory was carried out on the edges of the lake and completed with two transects.

The objective was to identify all plant species found in the Fetzara lake basin, either near the water body or at its edges. Coverage and frequency of all plant species were estimated using the Braun-Blanquet method (1932).

The taxa were identified from several works carried out on the flora of Algeria and North Africa (Quézel & Santa, 1962-1963; Mayor, 1952-1987) on the one hand and the flora of Italy (Pignatti , 1982) on the other hand. The new nomenclature has been updated for the species inventoried taking into account the recent work compiled in the synonyms and bibliographic index of the flora of North Africa (Dobignard & Chatelain, 2010-2013).

For the pollen study, 12 samples of surface sediments were collected; 5 stations along the North/South transect and 7 stations on the East/West transect supplemented by qualitative vegetation data using a GPS (Fig. 2).

Laboratory study

Surface sediment samples were chemically treated according to the standard technique proposed by Ybert *et al.* (1992) for the separation and purification of pollen from quaternary sediments. It consists in using HCl (concentrate) for the removal of carbonates, HF (10%) for the removal of the silicates, and finally acetolysis and separation of the heavy liquid using $ZnCl_2$ (Density 2).

The determination and the pollen count were carried out with a magnification microscope (×40), with the support of an identification key from the Pollen Atlas collection (Reille, 1992-1998). A minimum of 200 grains of pollen were counted, excluding damaged and undefined pollen grains, spores of ferns and mosses.

Results and discussion

For the survey carried out on the study area, the floristic inventory identified 264 species, belonging to 164 genera and 54 families; On the other hand pollen analysis recognizes 86 families or pollen types along the two transects studied (North/South and East/West).

Table 1. List of herbaceous species having little pollen-producing (<1%).

Families	Taxa (Dobignard & Chatelain, 2010-2013)
Asparagaceae	*Drimia numidica* (Jord. & Fourr.) J.C.
Asphodelaceae	*Asphodelus ramosus* subsp. ramosus L.
Boraginaceae	*Cerinthe major* L., *Echium sabulicolum* subsp. *decipiens Klotz*, *Heliotropium europaeum* L., *Heliotropium supinum* L.
Brassicaceae	*Raphanus raphanistrum* L., *Sinapis arvensis* subsp. Arvensis, Capsella bursa-pastoris (L.) Medik., *Rapistrum rugosum* L. All. ssp. Rugosum, *Lepidium squamatum Forsskål*
Convolvulaceae	*Convolvulus arvensis* L. subsp. Arvensis, *Convolvulus althaeoides* L., *Convolvulus siculus* L., *Convolvulus tricolor* L., *Cressa cretica* L., *Cuscuta epithymum* L.
Lamiaceae	*Stachys ocymastrum* L. Briq, *Mentha pulegium* L., *Mentha suaveolens* subsp. *suaveolens* Ehrh, *Stachys arvensis* L.
Malvaceae	*Malva sylvestris* L.
Plantaginaceae	*Plantago lanceolata* subsp. *lanceolata L.*, *Plantago serraria* L., *Kickxia commutata* (Reichenb.) Fritsch, *Veronica arvensis* L., *Linaria reflexa* L. Desf., *Kickxia spuria* L. Dumort, *Veronica polita* Fries, *Plantago coronopus* L., *Plantago lagopus* L., *Veronica anagalloides Guss.*
Polygonaceae	*Rumex conglomeratus* Murray, *Rumex pulcher* L, *Rumex bucephalophorus* L, *Rumex crispus* L., *Polygonum aviculare* L.
Ranunculaceae	*Clematis cirrhosa* L.
Scrophulariaceae	*Scrophularia laevigata* Vahl subsp. *laevigata*, *Parentucellia viscosa* (L.) Caruel

Descriptive analysis showed that the arboreal stratum is present with 22% of pollen grains (Fig.3),*Quercus* dominates by 8%, Ericaceae by (4%) and *Pinus* by (2%), *Eucalyptus* by (2%) and *Pistacia by* (2%).

Pollen from herbaceous species dominates assemblages, reaching high percentages in all samples with 52%. In this stratum, Poaceae is the dominant type of pollen (11%) followed by families of Asteraceae (9%), Fabaceae (7%), Chenopodiaceae and Liliaceae (5%). The percentage of other taxa is relatively low (Fig. 4).

The hygrophyte stratum's pollen represents 25% of the total pollen (Fig.5). The dominant assemblages are Cyperaceae (11%) and Typhaceae (10%).

Table 2. List of herbaceous species not represented by their pollen.

Families	Taxa (Dobignard & Chatelain, 2010-2013)
Araceae	*Arum italicum* Miller
Campanulaceae	*Solenopsis laurentia* L. C. Presl
Ceratophyllaceae	*Ceratophyllum demersum* L.
Euphorbiaceae	*Euphorbia helioscopia* L.subsp. helioscopia, *Euphorbia exigua* L.
Gentianaceae	*Centaurium erythraea* Raf.
Geraniaceae	*Geranium molle* L.
Iridaceae	*Moraea sisyrinchium* (L.) Ker Gawl.
Lythraceae	*Lythrum junceum* Banks & Solander
Molluginaceae	*Corrigiola littoralis* subsp. littoralis L.
Oxalidaceae	*Oxalis corniculata* L.
Papaveraceae	*Papaver rhoeas* L., *Fumaria capreolata* L.
Portulacaceae	*Portulaca oleracea* L.
Primulaceae	*Anagallis arvensis* L. subsp. arvensis L., *Anagallis monelli* subsp. linifolia L. Maire
Resedaceae	*Reseda alba* L.subsp. *alba* L.
Rubiaceae	*Sherardia arvensis* L., *Galium viscosum* subsp. *viscosum* Vahl
Rutaceae	*Ruta angustifolia* Pers
Solanaceae	*Nicotiana glauca* Graham
Verbenaceae	*Verbena officinalis* L.

The comparative study between the floristic surveys and the pollen assemblages makes it possible to distinguish three ecological situations.

Pollen present-vegetation present

The inventory of field vegetation was confirmed by the presence of pollen grains in the sediments:

Arboreal stratum

Eucalyptus

According to the floristic inventory carried out in the southern part of the lake, a reforestation of Eucalyptus dating from 1954 was noticed, planted by the Mokta El-Hadid company on the outskirts of Fetzara lake (Gaffarel, 2004).

This plantation was part of a project to develop the region by drying the lake and at the same time to provide shade (Travers, 1958). Eucalyptus pollen is present in most surface sediments with a percentage > 2% (Fig. 3).

Tamarix

Tamarix grows in saline habitats, along streams and wadis. *Tamarix africana* Poiret and *Tamarix gallica* subsp. *Gallica* sensu lato are found only on the banks of the wadi El-Melah.

Tamarix pollen is relatively uncommon on transects with a maximum percentage of 1% (Fig.3).

Oleaceae

Oleae uropaea L. pollen is found on virtually all surfaces irrespective of altitude (Davis & Fall, 2001), which shows a significant atmospheric dispersion of this type of pollen.

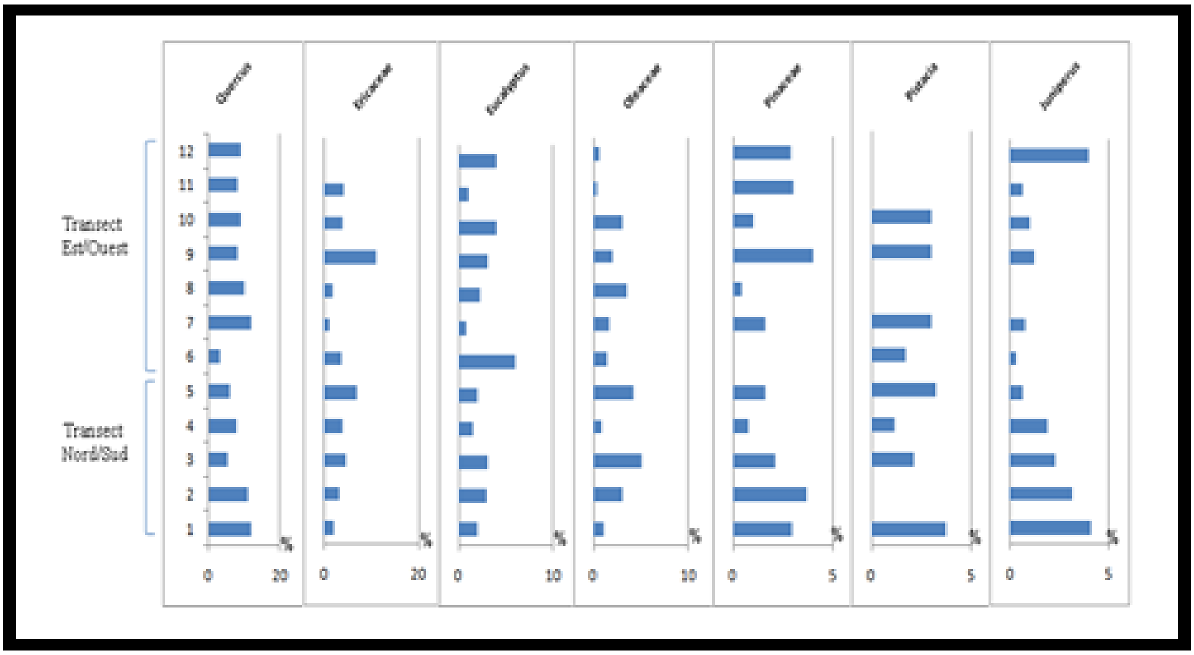

Fig.3. Percentage of pollen grains in the arboreal stratum.

Olea europaea is the most widespread species in the Annaba region, particularly in the mountain range of the Edough peninsula (Hamel, 2013).

Long life and *Olea*'s vegetative reproduction strategy make it difficult to distinguish between wild populations and individuals from abandoned orchards (Liphschitz *et al.,* 1991). The wild variety *Olea europaea* var. Oleaster is very similar to the cultivated variety *Olea europaea* (Zohary, 1973).

Oleaceae pollen is present in all samples with a percentage > 2% on the North/South transect and < 1.5% on the East/West transect (Fig.3).

Non-arboreal stratum

This stratum is dominated by xerophytic plants adapted to drought, but also, under certain conditions, live in a humid environment, exposed and open; they are the witnesses of a strong anthropization.

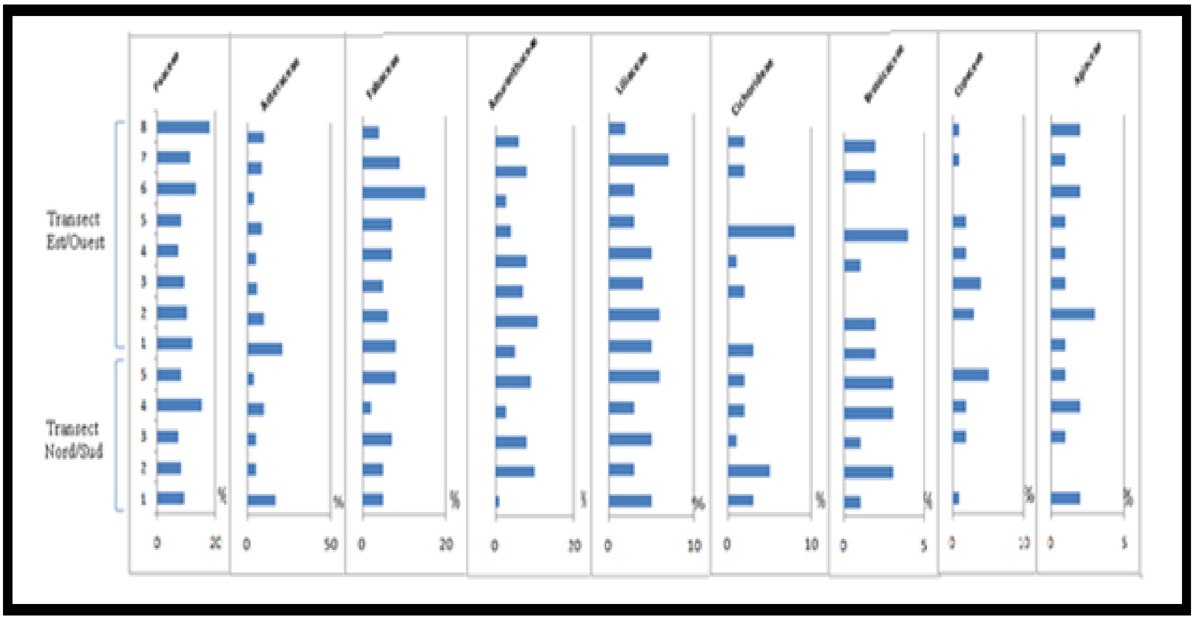

Fig. 4. Percentage of pollen grains in the non-arboreal stratum.

Asteraceae

The most frequent species of Asteraceae recorded on our study site are: *Anacyclus clavatus* (Desf.) Pers., *Carlina involucrata* Poir. subsp hispanica, *Acanthoxanthium spinosum* (L.) Fourr., *Centaurea napifolia* L., *Cichorium intybus* subsp. *Glabratum* arcang., *Cladanthus mixtus* (L.) Oberpriele & Vogt, *Crepis vesicaria* L. *subsp. vesicaria*, *Dittrichia viscosa* L. Greuter, *Galactites mutabilis* Durieu, *Galactites elegans* (All.) Soldano, *Hyoseris radiata* L., *Scolymus hispanicus*, *Dactylis glomerata* L., *Bellis annua* L. This family is most dominant in the Edough peninsula with 67 species (Hamel, 2013).

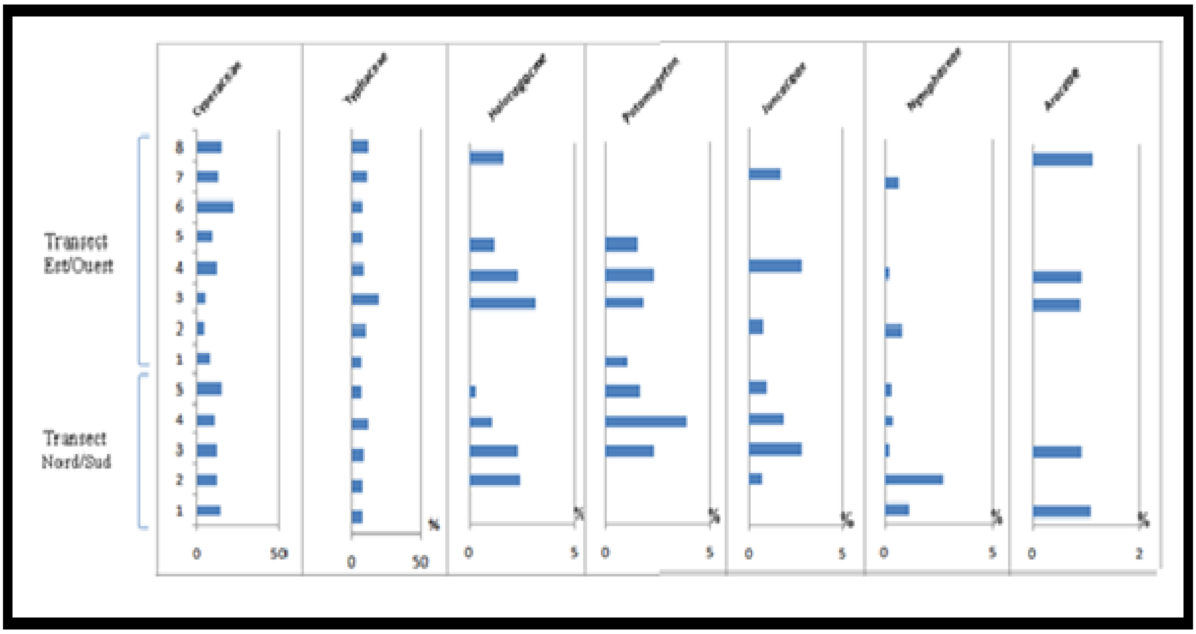

Fig. 5. Percentage of pollen grains in the hygrophyte stratum.

The list is complemented by the inventories carried out by de Bélair (GDB 1982-2008) and Faurel (1947); the species described are the following: *Carduus pycnocephalus* (L.) ssp. *pycnocephalus, Carlina lanata* L., *Andryala integrifolia* L., *Chamaemelum fuscatum* (Brot.) Vasc., *Coleostephus myconis* (L.) Reichenb. fil, *Filago vulgaris* Lam., *Filago gallica* L., *Filago pygmaea* L., *Jacobaea delphiniifolia* (Vahl) Pelser & Velk, *Leontodon tuberosus* L., *Otospermum glabrum* (Lag.) Willk, *Silybum marianum* (L.) Gaertner*, Xanthium brasilicum* Velloso.

Asteraceae pollen is common in all surface sediments on both transects with percentages of 7% on the North/South transect and 9% on the East/West transect and variable concentrations (Fig. 4).

The presence of the genus *Artimisia* (2%) may indicate the opening of the medium (Subba-Reddi & Reddi, 1986), while the subfamily Cichorideae with a percentage> 2.5% may indicate signs of degradation.

Poaceae

The Poaceae family is represented by a large number of species, the most abundant *Arundo donax* L., *Cynodon dactylon* L. Pers. and *Hordeum leporinum* Link. Almost the entire center of the lake is covered by *Phragmites domingensis* (Pers.) Steudel. Poaceae pollen is found in all samples with percentages exceeding 11% (Fig. 4).

Chenopodiaceae

The family Chenopodiaceae groups with a large number of species includes nine different plants (*Chenopodium vulvaria* L., *Sarcocornia fruticosa* (L.) A.J. Scott, *Suaeda maritima* L. Dumort, *Beta vulgaris* L, *Salsola soda* L., *Atriplex prostrata* DC, *Atriplex halimus* L. and *Salicornia ramosissima* J. Woods) Which denotes the ability of these species to withstand the salinity that prevails in these wetlands (Boulos, 1991; Chenchouni, 2012; Adi *et al.*, 2016).

Chenopodiaceae pollen is present in all samples with a minimum of 6% in both transects (Fig. 4).

Fabaceae

The percentage of Fabaceae surface pollen reflects the vegetation in the lake, with 8% and 5% compliance on the East/West transect and the North/South transect (Fig. 4). Among the species encountered are: *Trifolium angustifolium* L, *Medicago murex* Willd., *Scorpiurus muricatus* subsp. *muricatus*L., *Trifolium campestre* Schreber, *Trifolium glomeratum* L., *Viciasativa* L., *Astragalus sesameus* L., *Lathyrus ochrus* L. DC, *Medicago truncatula* Gaertner, *Melilotus infestus* Guss, *Tetragonolobus biflorus* (Desr.) DC, *Lotus corniculatus* L. etc...(de Bélair, GDB 1982-2008; Faurel, 1947).

Apiaceae

Several species of Apiaceae are developed in the study area: *Eryngium pusillum* L., *Ammi visnaga* L. Lam., *Ammi majus* L., *Daucus carota* L. var. *mauritanicus*, *Eryngium tricuspidatum* L. subsp. *tricuspidatum*, *Oenanthe globulosa* L., *Torilis nodosa* (L.) Gaertner, *Helosciadium nodiflorum* (L) W. D. J. Koch, *Torilis arvensis* (Huds.)Link, *Bupleurum tenuissimum* L., *Krubera peregrina* (L.) Hoffm, *Oenanthe silaifolia* M. Bieb., *Thapsia garganica* L., *Bupleurum lancifolium* Hornem.

Apiaceae pollen is relatively less expanded compared to the floristic diversity present in the study area, less than 2% are recorded on both transects (Fig. 4).

A low (<1%) representation of some unshaped pollen taxa was also recorded on both transects:

Hygrophyte stratum

This stratum occupies saturated or semi-permanent saturated media and consists of the following families:

Typhaceae and Juncaceae

This family is present in the lake in abundance with the species *Typha domingensis* (Pers.) Steudel, *Juncus acutus* L. and *Juncus bufonius* L.

The presence of the genus Juncus is a good indicator of salty wet habitats. Several authors have noticed the diversity and abundance of this family in areas characterized by saline and moist soils (Chehma *etal.,* 2005).

Typhaceae pollen is widespread in both transects with a percentage > 10% (Fig.5).

Cyperaceae

This family has recorded the largest pollen intake > 11% on both transects (Fig. 5). Based on the current inventory on the study area, the following species were reported: *Schoenoplectus lacustris* (L.) Palla subsp. *lacustris*, *Carex divisa* Hudson, *Cyperus rotundus* L. subsp. *rotundus*, *Eleocharis palustris* (L.) Roemer & Schultes, *Schoenoplectus supinus* (L.) Palla, *Schoenoplectus litoralis* (Schrader) Palla, *Bolboschoenus glaucus* (Lam.) S.G. Smith, with a dominance of *Cyperus longus* L. subsp. *Badius* (Desf.) Asch.

Haloragaceae

The species *Myriophyllum spicatum* L. et *Myriophyllum verticillatum* L. are very abundant in flooded areas of the Fetzara lake. *Myriophyllum* pollen is present with a percentage of < 2% (Fig. 5).

Pollen present - vegetation not present

Pollen analysis revealed pollen from regional vegetation.

Arboreal stratum

Pinus

Although no *Pinus* trees are found on sampled sites, their pollen is found to be averaged between 0.5 and 3.5% in all samples demonstrating its long-range dispersal capabilities (Davis, 1963).

In general, most of the Pinaceae are located in the vicinity of our study site. In the Annaba region, there are mainly artificial *Pinaster aiton*,*Pinus pinea* L. and *Pinus halepensis* on the El-Hadjar side (Ketfi, 1998). The North/South transect (2.5%) is richer than that of the East/West one (1.7%) (Fig. 3).

Quercus

The Edough peninsula is dominated by the cork oak (*Quercus suber* L.) and deciduous oak zeen forests (*Quercus canariensis* Willd) (Hamel, 2013).

Quercus pollen is present in most samples in relatively high percentages 9% for the North/South transect and 7% for the East/West transect (Fig. 3).

Pistacia

Pistacia pollen is present in most samples in relatively low percentages, 2% in the North/South transect and 1% in the East/West transect (Fig. 3).

The species *Pistacia lentiscus* L. and *Pistacia atlantica* Desf. are widespread in North Africa and the Middle East, but their surfaces have been greatly reduced by anthropogenic activities (Zohary, 1973). On the Edough peninsula, *Pistacialentiscus* is present from the seashore up to 400 m (Hamel *et al.,* 2013).

Alnus

According to (Belouahem *et al.,* 2012), *Alnus glutinosa* occurs in the Guerbes Senhadja wetland, which is less extended in the North/West of Fetzara lake. *Alnus* pollen is present in surface samples with a very low percentage < 1% recorded on both transects (Fig. 3).

Ericaceae

Arbutus unedo L., *Erica arborea* L. and *Erica multiflora* L. Grow on the Mediterranean buches in the region of Annaba (Hamel & Boulemtafes, 2017).*Erica scoparia* subsp. *scoparia* L. is also reported in the Guerbes-Senhadja zone, on the marshy scrub of the Sidi Fritis station (Ibncherif, 2012).

Ericaceae pollen is produced at relatively average percentages (about 4%) on both transects (Fig. 3).

Non arboreal stratum

Although *Ruppia* pollen is observed on both transects, the presence of this species is not reported in the study area, but is present in the neighboring territories of Fetzara Lake. The maximum pollen taxon of *Ruppia* is recorded in assemblages with 1% on the North/South transect (Fig. 4).

Hygrophyte stratum

This stratum is linked to the presence of a permanent water body, it accomplishes its vegetative cycle during the period when the lake is occupied by water, and then disappears during the dry season, which explains why it is absent in the floristic surveys.

It is present in the pollen surveys (Fig.5). In the region, this group is represented by the *Nymphaea* and *Lemna minor* L. according to (Quezel & Santa, 1962), white Nunuphar (*Nymphaea alba* L.) is reported as very rare on Annaba lakes.

Pollen not present - vegetation present

It appears from this inventory that some species belonging to the different strata are present on the site, but there are no traces of pollen, this may be due to 3 possibilities: either low pollen production or pollen fragility or still the flowering period coincides with the dry season, which exposes the pollen to the process of decomposition.

Hygrophyte stratum

Zygophyllaceae: *Tribulus terrestris* L. Alismataceae: *Alisma lanceolatum* With., *Damasonium alisma* MillerThe study has focused on a particular comparison between current vegetation and that revealed by palynology; it is intended to determine the extent of changes in plant assemblages as a result of the various disturbances that have occurred in recent years. It is therefore possible to establish a precise and objective diagnosis on the level of stability of the site under study.

The determination of the amount of pollen in the surface sediments of Fetzara lake remains influenced by the opening of the environment during the construction of hydraulic structures such as drainage channels allowing the lake to maintain a certain level of water and thus avoid flooding.

This opening of the medium was reflected in the diagrams established by a decrease in pollen grains of the arboreal stratum (22%) *Alnus, Pinus, Pistacia* in favor of an increase in heliophilic and pioneer plants non arboreal (52%), dominated by Poaceae, Asteraceae, Chenopodiaceae and Fabaceae.

However, the interpretation of the results of this single index has long been questioned (Jalut, 1991; Galop, 1998; Sugita *et al.,* 1999; Gaillard, 2007; Favre *et al.,* 2008). Many other factors may influence the arboreal pollen/nonarboreal (AP/NAP) pollen relationship, such as vegetation's structure, distant pollen's intake, pollen's dispersal, production of each species, pollen's quality, etc… Some studies have shown the variability and fluctuations of this ratio in identical contexts but subject to different constraints (Jackson, 1990; Favre *et al.,* 2008; Stebich *et al.,* 2005). Moreover, the only apprehension of the degree of openness of the medium is not sufficient to produce hypotheses and interpretations, a detailed observation of the composition of the assemblies is necessary (Faure, 2012).

On the Fetzara lake, we have observed that the AP/NAP ratio increases along the North/South transect, it is the most important on points P1, P2, P3, P4, P5. This can be explained by the presence of a very dense forest cover on the Edough peninsula north of the lake producing a large amount of pollen, which is transported by air, water or even by some animals to allow its deposit in the sediments of the center of the lake.

According to Jacobson and Bradshaw (1981), in a large aquatic environment, pollen's assemblages tend to be influenced by regional elements, which are not the case for the majority of pollen's grains deposited in small basins; Domination is ensured by elements of local origin. Bennett (1986) has suggested that most pollen grains arriving in a basin are transported by waters flowing through existing drainage channels rather than by wind; this result confirms the observations recorded in this study. However, pollen's analysis of surface sediments in Lagoa Salgada in Brazil has showed a strong influence of wind direction in pollen's grain deposition (Toledo *et al.*, 1994; Luz *et al.,* 2005).

On the east/west transect, the AP/NAP ratio is in favor of the herbaceous stratum which covers a large part of the study site, that is why Fetzara lake is still considered as a large grazing area.

The weak result obtained for the arboreal stratum occurs despite the fact that this transect carries a larger number of sampling points than the North/South.

The use of salt marsh soils as livestock grazing is once a widespread practice in North America (Hatvany, 2003) and in Europe (Jensen, 1985; Kiehl *et al.,* 1996; Bos *et al.,* 2002; Schroder *et al.,* 2002; Tessier, 2003) or in Africa (Ouattara & Louppe, 1998).

This practice has the effect of disturbing the soil by trampling livestock. This has probably facilitated the establishment of exotic species that do not grow in wetlands (Eucalyptus sp, *Oxalis corniculata* L.) On the other hand, the herd can also facilitate the dissemination of the grains of certain species by transporting them to the animal's coat or intestinal transit (Bakker *et al.,* 1985; Malo & Suazer, 1995).

Trampling and grazing, as well as land improvement and development work, can have an impact not only on the characteristics of a marsh (hydrology, salinity, erosion, etc.), but also on competitive interactions which exist between the different plant species (Bourgon-Desroches, 2010).

As for pollen's grain conservation in lake surface sediments, abundance of pollen has been observed, this may be related to palynomorph transport collisions and especially surface conditions (Tyson, 1995).The highest level of deterioration has been recorded in most samples on the east side, particularly the point P6 near the main drainage canal (Baretto *et al.*, 2012).

According to Campbell (1991), pollen's grains and spores damaged by erosion have been found in many sedimentary basins and can be interpreted as the result of a new deposit after a period of exposure to air, including wet and dry climate cycles. It should be recalled that the process of corrosion of pollen's grains and spores usually occurs sometime after release by the source vegetation (Wilmshurst & Mc Glone, 2005).

Conclusion

The study has made it possible to evaluate the different pollen messages in relation to the existing flora on Fetzara lake.

The floristic inventory carried out in view of obtaining a current image of the lake shows that the vegetation cover is more or less abundant with a dominance of the xerophyte vegetation, witnessing a strong anthropization and environmental degradation.

The halophyte vegetation consists of the Chenopodiaceae, which confirms the salinity of the environment. Hgrophyte vegetation is represented by species, *Typha domingensis* (Pers.) Steudel, *Juncus acutus* L., Et *Myriophyllum verticillatum* L. It is indicative of a permanent or seasonal hydromorphic environment.

The pollen's assemblages distributed on both transects in surface sediments have showed the dominance of (NAP) reflecting the current state of vegetation. It is useful to report the relative increase in arboreal pollen on the North/South transect; this is certainly due to the very dense vegetation cover on the forest of the Edough located North of the lake. In general, except for this difference in the amount of (AP), the results obtained on the North/South transect are roughly similar to those observed on the East/West transect, confirming the homogeneity of the species in study area.

The observation of damaged pollen grains can be explained by the phenomena of soil moistening and desiccation can also be considered as a factor of production of these micro-remnants of which a very important quantity appeared to have been damaged. The results obtained in this study will certainly help to explain the evolutionary dynamics of this wetland and the preparation of a predictive model for the analysis of fossil pollen by improving the comparison of recent and Holocene data very important for monitoring and conserving the biodiversity of Fetzara lake.

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