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Medieval coastal Syrian vegetation patterns in the principality of Antioch

D. Kaniewski,^{1,2,3} E. Van Campo,^{1,2} E. Paulissen,⁴ H. Weiss,⁵ T. Otto,^{1,2}
J. Bakker,³ I. Rossignol^{1,2} and K. Van Lerberghe⁶

Abstract

The coastal area of Jableh, in the vicinity of the Saladin and Al-Marquab castles, is a fertile alluvial plain located on the northwestern part of Syria, in what was once the crusader Principality of Antioch. In order to detail the coastal environment during the crusader period in the Middle East, palynological analyses have been conducted on the underlying coastal-alluvial deposits. The recovered sediments represent a continuous record of the environmental history of the area spanning a c. AD 850–1850 cal. yr period, from the Muslim Era up to and including the late Ottoman times. During the local crusader period (AD 1100–1270), the area was dominated by an arborescent matorral mixed with a xerophytic shrub-steppe. The alluvial plain was slightly waterlogged and colonized by a wetland meadow with an open vegetation of steppe-like character on bare surfaces and fresh arable soils. The riparian and open deciduous riverine forests were weakly developed. Signs of agricultural activities are mainly recorded for the High Medieval period (AD 1000–1300), with an increase of vineyards in the coastal area. Since c. AD 1250 cal. yr until the end of the crusader period, agricultural activities never reached the same intensity as during the Mameluke Sultanate and the Ottoman Empire.

Keywords

crusades, Middle Ages, numerical analyses, pollen, Syria

Introduction

The northern Levantine vegetation dynamics have not been intensively studied despite the complex and fascinating history of interactions between the environment and past societies in this region. The Medieval history of Syria starts with the Muslim conquest of the Roman-Byzantine army and the beginning of the Islamic overlordship in AD 638 (Sharon, 2002). Muslim control over the Levant remained unchallenged from the early and through part of the high Middle Ages until the arrival of the first European crusaders in AD 1097 (Lebédel, 2004). The crusades were first launched by the Pope Urban II in AD 1095 after the Council of Clermont. This was in response to a plea for assistance from the Byzantine Emperor of Constantinople, Alexios I Komnenos, who requested for aid to repel the invading Muslim Seljuk Turks from Anatolia (Riley-Smith, 1998). European historical reports related to the Medieval Levant mainly emphasise the nine successive crusades (Lebédel, 2004; Madden, 1999; Riley-Smith, 1998, 1999). These religious military campaigns, leading to the conquest of Jerusalem on 15 July 1099 and to the temporary re-establishment of the Christian control over the Holy Land (Tyerman, 2005), were at the basis of the foundation of crusader states (Figure 1) in Eastern Mediterranean during the twelfth and thirteenth centuries AD (Muir, 1962). The crusader period lasted until the Siege of Acre and the fall of the Kingdom of Jerusalem in AD 1291. The last crusaders, the Knights Templar, still maintained a fortress at the northern city of Tartus, but no longer controlled any of the Holy Land following the Siege of Ruad in AD 1302 (Barber, 2006). The Mamelukes (AD 1291–1517), the political and military power who defeated the last crusaders, subsequently ruled over

the Levant during the late Middle Ages; this period being known as the Mameluke Sultanate (Behrens-Abouseif, 2008). The rise of the Ottomans in AD 1517 marks the end of the Middle Ages in the Middle East and the beginning of the early Modern Era (İnalçık and Quataert, 1994). However, despite the high historical interest of the northern Arabian Peninsula for the crusader period, the environmental reconstructions are still scarce and only few studies encompass the Middle Ages in the Levant (Bottema, 1987; Leroy, 2010; Neumann *et al.*, 2007, 2010; Schwab *et al.*, 2004; Yasuda *et al.*, 2000).

The alluvial plain near the harbour town Jableh in northwest Syria (Figure 1) was selected to investigate the pollen-based

¹Université de Toulouse, UPS, INPT, EcoLab (Laboratoire d'Ecologie Fonctionnelle), France

²CNRS, EcoLab (Laboratoire d'Ecologie Fonctionnelle), France

³Center for Archaeological Sciences, Katholieke Universiteit Leuven, Belgium

⁴Physical and Regional Geography Research Group, Katholieke Universiteit Leuven, Belgium

⁵Department of Anthropology and Environmental Studies Program, Yale University, USA

⁶Near Eastern Studies Unit, Katholieke Universiteit Leuven, Belgium

Corresponding author:

David Kaniewski, Université de Toulouse, UPS, INPT, EcoLab (Laboratoire d'Ecologie Fonctionnelle), 29 rue Jeanne Marvig, 31055 Toulouse, France
Email: kaniewsk@cict.fr

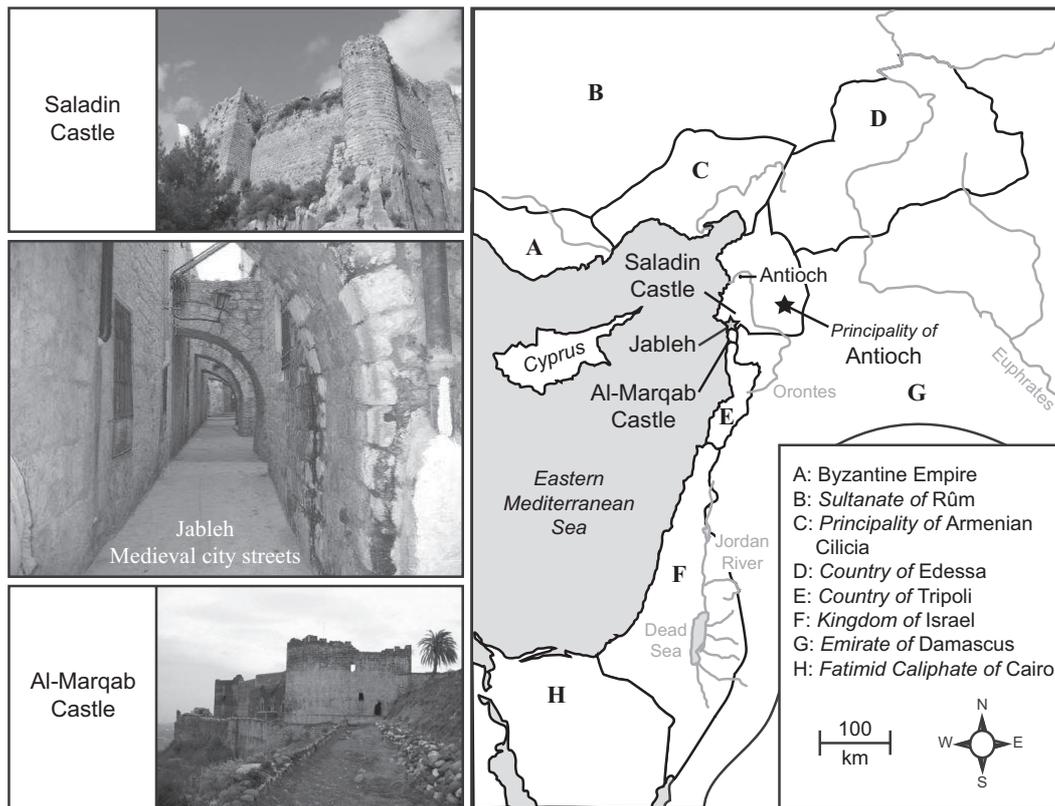


Figure 1. Middle Ages Near Eastern Mediterranean map (twelfth century AD) (adapted from Muir, 1962) with overviews of the modern harbour town Jableh, the Saladin Castle, the Al-Marqab Castle and the crusader states

vegetation patterns during the crusader period in the northern Levant. During the high Middle Ages, Jableh was part of the Principality of Antioch (Figure 1), a state created in AD 1098 during the first crusade (Richard, 1999) and several important historical sites occupy the region. The city of Latakia, c. 28 km north of Jableh, was incorporated into the Principality in AD 1103 (Richard, 1999); Jableh itself followed in AD 1103. Latakia was re-conquered by the Arabian commander Saladin in AD 1188 and developed into a well-fortified and wealthy city. The city was briefly re-conquered during the third crusade in AD 1197 (Riley-Smith, 2005). Again under Ayyubid-Muslim control, the city was rebuilt and its citadel restored. In AD 1255, Bohemond VI took possession of the town with the Knights Hospitallers, and controlled Latakia until the Mameluke conquest of Antioch in AD 1268. In the year of 1287 (22 March), a violent earthquake occurred in Latakia and devastated the town (Ring *et al.*, 1994; Sbeinati *et al.*, 2005). At c. 28 km northeast from Jableh lies Saladin Castle (Salah Ed-Din citadel, Soane Castle), built during the tenth century AD by the Byzantines, and conquered by Saladin in AD 1188. At c. 25 km south of Jableh lies Al-Marqab Castle, built during the eleventh century AD and conquered by the Mameluke Sultan Qalaoun in AD 1285.

This record presents the first reconstruction of the vegetation dynamics, fire activity and human occupation in coastal Mediterranean Syria from c. 880 to 1870 cal. yr AD, from the Muslim era to late Ottoman times. Our aim is to outline new detailed data on the environmental context accompanying the crusades in the Middle East. Pollen and charcoal analysis of the coastal alluvial deposits of the Ain Fawar spring complex near Jableh in the time interval encompassing the crusades can help us to elucidate whether the crusaders had to deal not only with societies and

political structures very different from those with which they were familiar, but also with major changes in their immediate natural environment. Insights into past environmental variability during historical periods are of major concern, as pre-twentieth century economies were largely based on agriculture and so fell naturally subject to the natural fluctuations of their environment (Stothers, 1999).

Historical and geographical setting

The 7 km long west–east fertile alluvial plain near Jableh is delimited towards the east by the Jabal an Nuşayrīyah (Alawite mountains), a 140 km long north–south mountain range parallel with the coast with peaks above 1200 m a.s.l. (Hardenburg and Robertson, 2007) and towards the west by the Mediterranean Sea. This area has recorded a long human occupation (Kaniewski *et al.*, 2008, 2009). The ancient Jableh, Gibala-Tell Tweini, was the southernmost harbour town of the Ugarit Kingdom (Bretschneider and Van Lerberghe, 2008). It was occupied since the early Bronze Age (c. 2600 BC) and flourished during the middle and late Bronze Age. Commercial routes connecting Gibala-Tell Tweini to the Syrian heartland, Anatolia, and Mesopotamia were at the basis of the wealth of the ports of the Ugarit Kingdom. The written sources and epigraphic finds for Gibala ceased as soon as Ugarit was destroyed. Gibala-Tell Tweini flourished again after the late Bronze Age collapse (1194–1175 BC) and the Dark Age (1175–825 BC), and Jableh was once again a wealthy city during the Hellenistic and Roman times (Boiy, 2008). Since AD 638–640, the Muslim conquest of Syria marks the end of Antiquity for Jableh and the beginning of Islamic control of Syria.

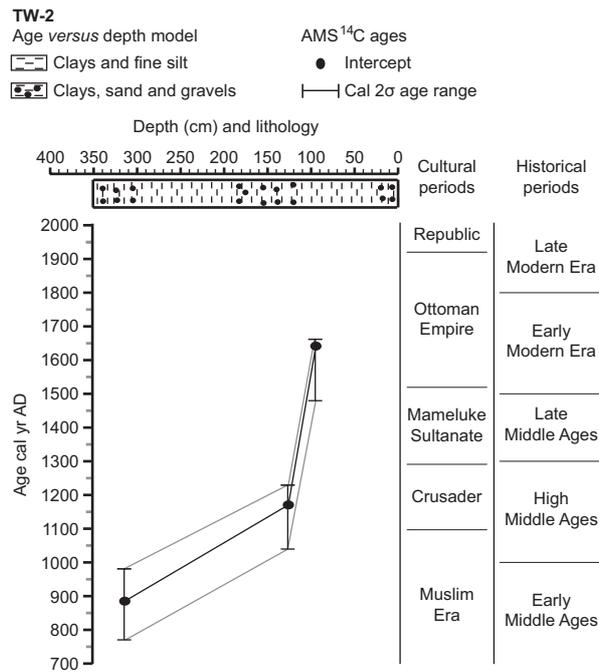


Figure 2. AMS ¹⁴C calibrated ages and suggested age–depth curves

Table 1. Details of the ¹⁴C age determinations for the TW-2 core

Samples	Depth (cm)	Laboratory codes	Material	Conventional ¹⁴ C age (yr BP ± 1σ)	Cal. (2σ) age range rounded (AD/BC)	Cal. (1σ) age range rounded (AD/BC)	Intercept (AD/BC)
TWEO8 EP21	94	Beta-261720	charcoals	290±40 BP	AD 1480–1660	AD 1630–1650	AD 1640
TWEO8 EP27	127	Poz-28164	charcoals	875±30 BP	AD 1040–1230	AD 1150–1220	AD 1168
TWEO8 EP59	315	Poz-28589	charcoals	1170±35 BP	AD 770–980	AD 770–900	AD 885

Materials and methods

Core lithology and chronology

The 315 cm core TW-2 was retrieved from alluvial deposits of a first order small spring-fed valley, at 1.70 km from the coast. The core consists of a continuous sedimentation of carbonate-rich clays, fine silt, and sand with sporadic gravel concentrations (Figure 2). No gaps or unconformities were observed in the core log and laboratory data (pollen data). The core chronology relies on three accelerator mass spectrometry (AMS) ¹⁴C ages (Table 1; Figure 2) at 315 cm (1170±35 ¹⁴C yr BP), 127 cm (875±30 ¹⁴C yr BP), and 94 cm (290±40 ¹⁴C yr BP) depth. The rare plant macroremains in the TW-2 core limit an extended chronology. The 2 sigma confidences give a range of, respectively, 770–980 cal. yr AD (intercept: 885 cal. yr AD), 1040–1230 cal. yr AD (intercept: 1168 cal. yr AD), and 1480–1660 cal. yr AD (intercept: 1640 cal. yr AD) for the radiocarbon dates (calibrated with Calib Rev 5.1.0; last intercept by Beta Analytic). Compaction corrected deposition rates have been computed between the intercepts of adjacent ¹⁴C ages. The values are from bottom to top: 6.65 mm/yr during 280 yr (885–1168 cal. yr AD), 0.75 mm/yr during 470 yr (1168 and 1640 cal. yr AD), and 2.90 mm/yr during 360 yr (1640 cal. yr AD–AD 2000). Because samples have been taken at regular intervals on the 315 cm sediment column, the time resolution is directly dependent on

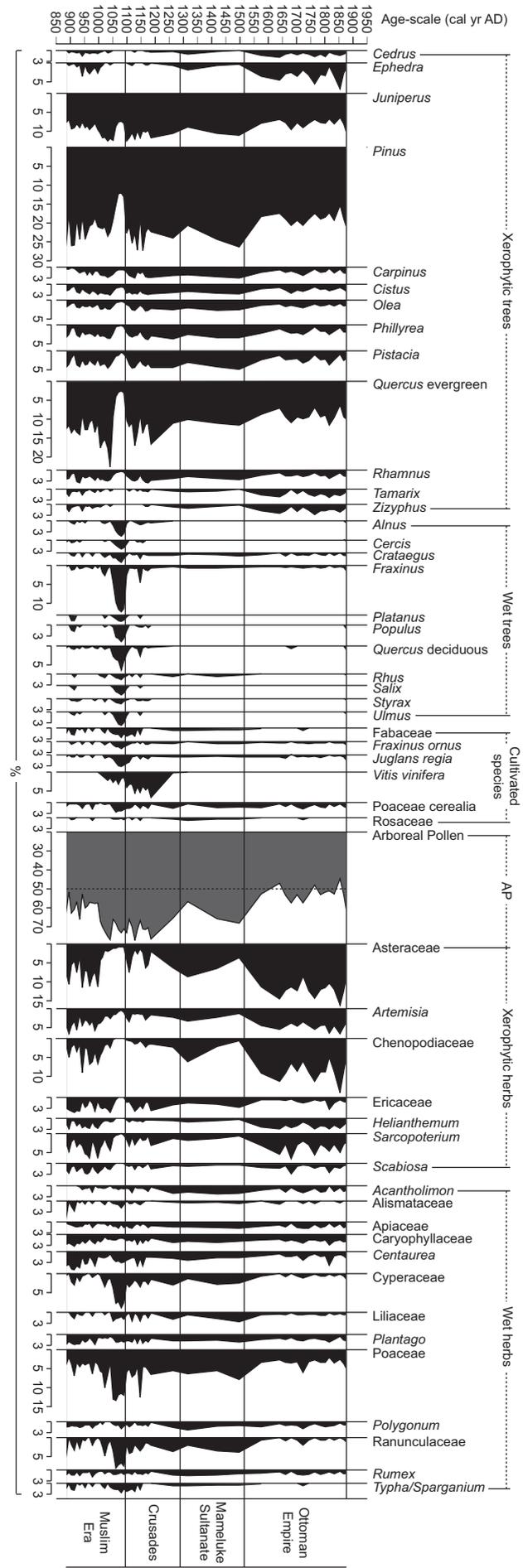
the sedimentation rate. The calculated time resolution between two samples is less than 10 yr (32 samples) from 885 to 1168 cal. yr AD, about 70 yr (7 samples) from 1168 to 1640 cal. yr AD, and about 20 yr (12 samples) from 1640 to 1870 cal. yr AD.

Pollen, pollen-slide charcoal and charcoal analyses

A total of 51 samples were prepared for pollen analysis using standard palynological procedures for clay samples, allowing an average time resolution of *c.* 20 years. Pollen grains were counted under ×400 and ×1000 magnification using an Olympus microscope. Pollen frequencies are based on the terrestrial pollen sum excluding local hygrophytes and spores of non-vascular cryptogams. Aquatic taxa frequencies are calculated by adding the local hygrophytes-hydrophytes to the terrestrial pollen sum. The Eastern Mediterranean primary anthropogenic indicators scores (*Fraxinus ornus*, *Juglans regia*, *Vitis vinifera*, Poaceae cerealia) were calculated by summing the corresponding taxa and termed as cultivated species. The historical pollen data have been drawn according to a linear age-scale (Figure 3).

The fire history of the coastal alluvial plain (Figure 3) was achieved by counting charcoal particles (50–200 μm) from the 51 slides prepared for pollen analysis as well as from larger charcoal remains (>200 μm) (Gavin *et al.*, 2006; Higuera *et al.*, 2007; Parshall *et al.*, 2003). The 50 μm size criterion was chosen to avoid

Figure 3. TW-2 core simplified pollen diagram with historical zones



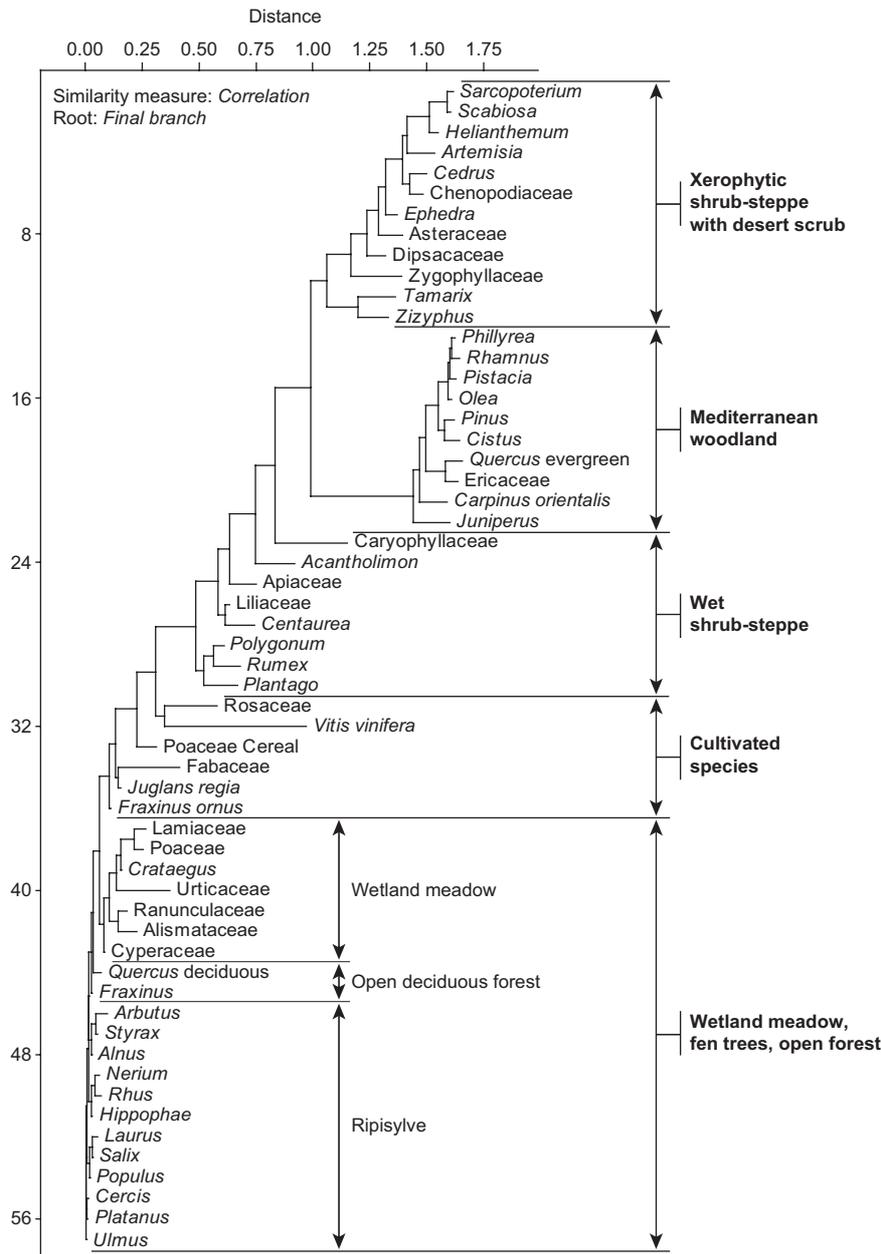


Figure 4. Neighbour Joining analysis of the main taxa from the core TW-2 computed with correlation as similarity measure and final branch as root

confusion of microscopic charcoal with opaque minerals, which are typically $< 50 \mu\text{m}$ (Parshall and Foster, 2002; Pederson *et al.*, 2005). Macroscopic charcoals, extracted with Na_2HPO_4 , were sorted and counted under a binocular microscope (at $\times 36$). Apart from identifying fire events, these macroremains have not been used in the present study as more amounts of sediments are required to provide a reliable study of environmental change based on charcoals. The identification of charcoal macroremains and an environmental study based on these macroremains corresponds to the next step of study in the Jableh area.

Numerical analyses

Pollen data were analysed using Neighbour Joining (NJ), Cluster Analysis (CA), and principal component analyses (PCA). The Neighbour Joining (NJ) method is a process initially based for reconstructing phylogenetic trees. The NJ technique was adjusted and used in this study to compute the lengths of the branches of a

tree, using branches as potential ecological distances (or similarities) between taxa or groups of taxa. In each stage, the two nearest nodes of the tree are chosen and defined as neighbours in the tree. This was done recursively until all of the nodes are paired together (Figure 4). NJ was computed using *correlation* as similarity measure and *final branch* as root. NJ was applied to group the observed data into palynological assemblages by categorizing the various taxa in such a way that the degree of association between two taxa is maximal when they have similar occurrences and minimal when they are dissimilar. The pollen-types from each cluster were summed to create pollen-derived vegetation patterns.

CA was computed to link numerically the pollen-derived vegetation patterns and charcoals (pollen-slide charcoals and macroremains). CA was computed using *paired group* as algorithm and *correlation* as similarity measure (Figure 5). Pollen-derived vegetation patterns were drawn according to a linear age-scale (Figure 6).

PCA, a linear method, was chosen to provide a two-dimensional representation of high-dimensional geometric distances between

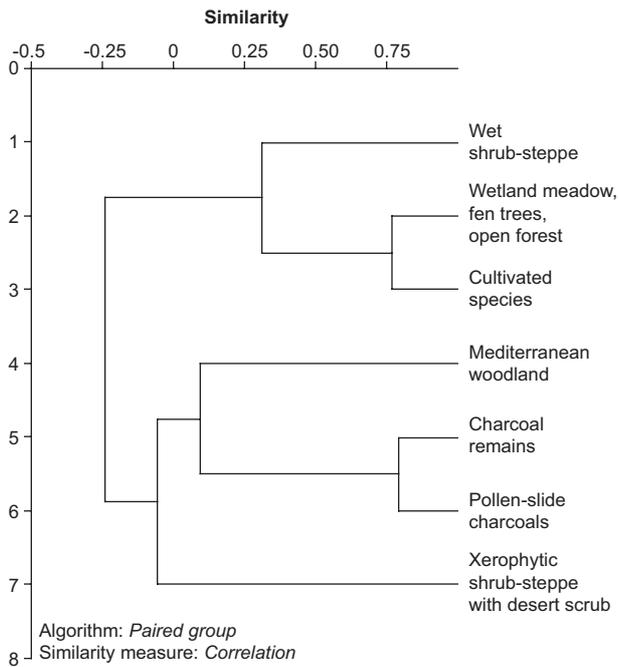


Figure 5. Cluster analysis of the pollen-derived vegetation patterns computed with paired group as algorithm and correlation as similarity measure

samples. PCA has frequently been applied to pollen frequencies as the analysis is easy to implement on large data sets and the results can be displayed graphically. In this study, PCA was based on a covariance matrix calculated from data that have been centred to the origin of the coordinate system. A biplot PCA graph was constructed to characterise the numerical distribution of samples according to pollen-derived vegetation patterns and charcoals (Figure 7). The samples were named according to the historical period from which they originate.

In order to elucidate wild (*Olea europaea* var. *sylvestris*) or cultivated (*Olea europaea* var. *europaea*) origin of olive trees, linear detrended cross-correlations ($P=0.05$) were computed. Linear detrended cross-correlation concerns the time alignment of two time series by means of the correlation coefficient (CC) (Kaniewski *et al.*, 2008, 2009). The *Olea europaea* time-series have been cross-correlated with the pollen-derived vegetation patterns (where *Olea* pollen-type values have been deleted) to ascertain the maximal match in time and the potential delay between the two time-series. The CC is then plotted as a function of alignment position. This numerical approach is well-adapted to detect and quantify potential links between *Olea europaea* pollen-type and the other vegetation patterns. Positive correlation coefficients are considered, focusing on the Lag 0 value (with +0.50 as significant threshold). Negative correlations are also assessed to test the inverse- or non-correlation between the two time-series (with -0.50 as significant threshold). Null values indicate a complete lack of correlation.

Results

The pollen diagram is subdivided into four historical zones (Figure 3) in order to facilitate the presentation of results and further discussion. The CA (Figure 5) shows that the cultivated species and the wetland vegetation assemblages are correlated,

and secondarily linked with the wet shrub-steppe. This 'wet' group is inversely correlated with the fire activity, the Mediterranean woodland, and the xerophytic shrub-steppe groups.

Muslim era (AD 638–1098)

The basal clay sediments of the TW-2 core, corresponding with the Muslim era, contain mainly pollen indicative of Mediterranean woodland with *Pinus*, *Juniperus* and evergreen *Quercus* (Figures 3–5). *Cistus*, *Olea*, *Phillyrea*, *Pistacia*, and *Rhamnus* are also well developed, suggesting that a diversified thermophilous open forest-shrubland surrounds Medieval Jableh, with arboreal pollen (AP) values reaching 51–65% of the total pollen sum. In the coastal area, a sandy-saline tolerant xerophytic shrub-steppe dominates with Asteraceae, *Artemisia*, Chenopodiaceae, and *Sarcopoterium*. Since *c.* 1050 cal. yr AD and until the end of the Muslim era, an important change in local hydrology is indicated by the strong development of fen trees (*Alnus*, *Populus*, *Salix*, *Ulmus*), open deciduous forest (*Fraxinus*, *Platanus*, deciduous *Quercus*), and wetland meadow (Cyperaceae, Poaceae, Ranunculaceae). During this wetter phase, AP values attain 77% of the total pollen sum, and the cultivated species show a strong increase, reaching their highest scores.

The fire activity in the area (Figure 6) oscillates with peaks of macro- and pollen-slide charcoals at *c.* 885, 960, 1000, and 1030 cal. yr AD. Each peak of charcoals corresponds to a strong decrease of the wetland meadow/fen trees vegetation assemblage after peaks at 945, 995, and 1020 cal. yr AD.

Crusader period (AD 1098–1291)

The onset of the crusade period is marked by a peak of charcoals at *c.* 1100 cal. yr AD and the following drop of the wetland meadow/fen trees vegetation assemblage (Figure 6). Throughout the crusader period, the pollen record continues to be dominated by Mediterranean woodland, and the AP values oscillate around 65–76% of the total pollen sum (Figure 3). The vegetation is also characterized by the presence of a wet shrub-steppe (Figure 6) loaded by a mixed Apiaceae, *Centaurea*, *Plantago*, and *Rumex* assemblage (Figure 3), which may correspond to secondary anthropogenic indicators. The xerophytic shrub-steppe decreases to lower values whereas the cultivated species scores remain at higher values until *c.* 1150 cal. yr AD, and decrease gradually until *c.* 1250 cal. yr AD. *Vitis* develops throughout this period before disappearing at the end of the high Middle Ages. A last peak of charcoals (Figure 6) is recorded at *c.* 1155 cal. yr AD, following a peak of wetland meadow/fen trees vegetation assemblage at *c.* 1145 cal. yr AD.

Mameluke Sultanate (AD 1291–1517)

During the Mameluke Sultanate, the area of Jableh was still dominated by Mediterranean woodland, and by a xerophytic shrub-steppe which redeveloped after the crusader period (Figures 3, 6). The AP values still fluctuate around 57–68% of the total pollen sum (Figure 3). The wet shrub-steppe and wetland meadow/fen trees vegetation assemblages decrease to low values. The cultivated species scores stay low throughout this time period (Figure 6). The vegetation recorded during the Mameluke Sultanate is similar to that recorded during the Muslim era. A single peak of charcoals (Figure 6) is recorded at *c.* 1315 cal. yr AD.

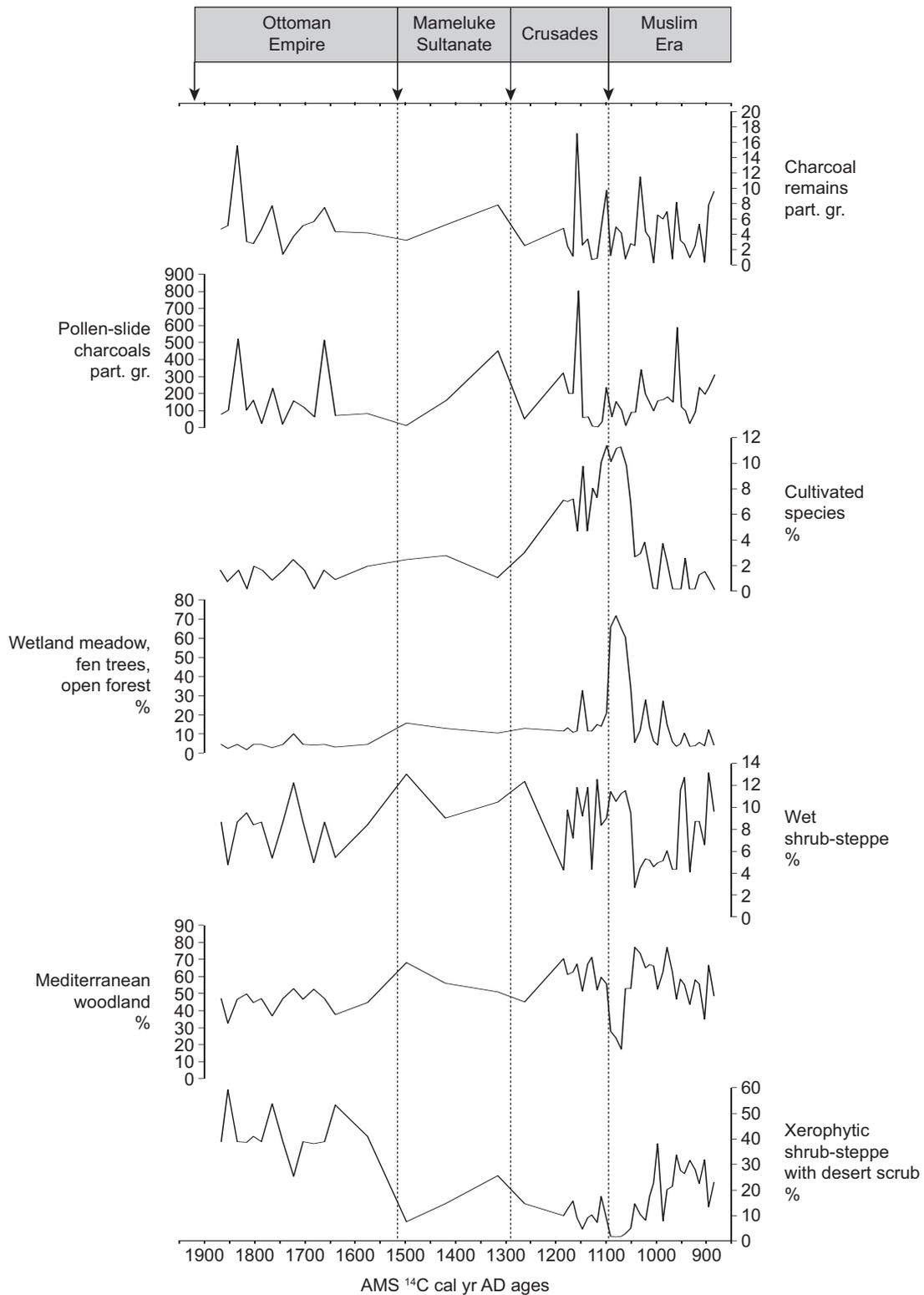


Figure 6. Pollen-derived vegetation patterns, pollen-slide charcoals, and macrocharcoals remains drawn according to a linear age-scale

Ottoman Empire (AD 1517–1917)

The Ottoman Empire corresponds with a strong development of xerophytic shrub-steppe and a decrease in Mediterranean woodland. At *c.* 1640, 1765, and 1850 cal. yr AD, xerophytic shrub-steppe dominates the area (Figure 6), while AP values decrease to 44% of the total pollen sum (Figure 3). Wetland meadow/fen trees and cultivated species vegetation assemblages show low values.

The fire activity (Figure 6) increases with peaks in macro- and pollen-slide charcoals at *c.* 1660, 1765, and 1830 cal. yr AD.

Discussion

The TW-2 core provides the first detailed paleoenvironmental reconstruction in the coastal part of the former territory of the Principality of Antioch from the Muslim era to the Ottoman Empire.

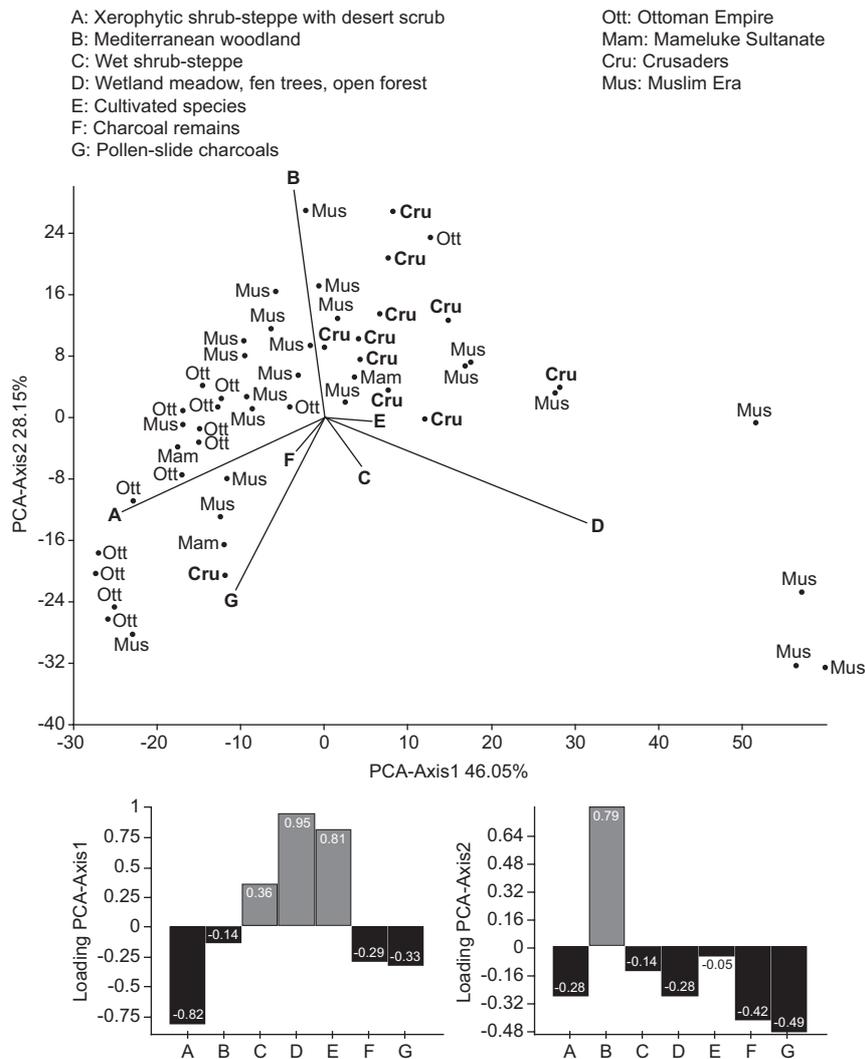


Figure 7. Biplot PCA graph based on a covariance matrix calculated from data centred to the origin of the coordinate system. Samples were named according to their cultural reference

The coastal zone of Syria, a strategically located gateway to the Mediterranean, provides important economic, transport, and residential functions, all of which depend on its landscape characteristics, natural resources, and terrestrial biodiversity since the early Bronze Age (Bretschneider and Van Lerberghe, 2008).

Pollen-derived vegetation patterns

From the Muslim conquest of the Roman-Byzantine army in AD 638 (Sharon, 2002) to the absorption into the Ottoman Empire, the vegetation dynamics of the Syrian coastal region has been controlled by fluctuating climatic conditions, and modified by human activity.

Mediterranean woodland. The main vegetation pattern isolated by numerical analyses (Figure 4) for the Middle Ages is a Mediterranean woodland with pollen-types of *Pinus* (*Pinus brutia*, *P. halepensis*), *Juniperus* (*Juniperus oxycedrus*, *J. excelsa*), and evergreen *Quercus* (*Quercus calliprinos*) (Figure 3). Nowadays, Aleppo pines (*Pinus halepensis*) are rare in the Eastern Mediterranean with small stands located in Greece, Turkey, Lebanon, and Israel (Lipshitz and Biger, 2001). Near Jableh, *Pinus halepensis* is present, but in degraded forest or maquis located on the lower slopes of the Jabal an Nuşayrīyah.

During the Middle Ages and the Modern Era, *Pinus* pollen-type may originate from the two species as no study has previously determined when *P. Brutia* overlapped the diffusion area of *P. halepensis* in coastal Syria. *Olea europaea* and *Pistacia* pollen-types are also included in the pollen-derived Mediterranean assemblage. NJ analysis suggests that olive and pistachio trees were not cultivated near Jableh (*Olea europaea* var. *sylvestris*; *Pistacia atlantica*, *P. palaestina*), and were part of a maquis with *Cistus*, Ericaceae, and *Rhamnus* (Figure 4). The cross-correlations further show that *Olea europaea* is significantly correlated with the Mediterranean woodland ($CC_{lag0} +0.739$), with *Pistacia* ($CC_{lag0} +0.913$), and inversely correlated with the cultivated species assemblage ($CC_{lag0} -0.156$), the xeric shrub-steppe ($CC_{lag0} -0.2427$), and the wetland formations ($CC_{lag0} -0.4249$). Similar hypotheses were suggested for the late Bronze Age-Iron Age Gibala-Tell Tweini (Kaniewski *et al.*, 2009). *Olea* probably result from the wild varieties (*Olea europaea* var. *sylvestris*), possibly mixed with abandoned cultivated varieties (*Olea europaea* var. *europaea*) resulting from the Roman and Byzantine arboriculture, which developed in areas of coastal maquis. The presence of *Pistacia* as a cultivated or a wild plant may remain a problem in pollen sequences. Behre (1990) has suggested that this shrub is a secondary anthropogenic indicator that took advantage of the primary forest destruction whereas Eastwood *et al.* (1998,

1999) have included *Pistacia* among the cultivated plants in Turkey. In the alluvial plain of Jableh, *Pistacia* is considered to be a colonizing shrub that has naturally spread in the area.

The numerically defined Mediterranean woodland assemblage, mainly composed of Mediterranean and Irano-Turanian floras (Danin, 1999; Davies and Fall, 2001; Zohary, 1973), may correspond to a Medieval Eastern Mediterranean pre-steppic forest or an arborescent matorral (Quézel, 1999). The latter is a degraded form of a semi-deciduous oak-pine forest mixed with xerophytic and thermophilous shrubs, and sparse occurrences of *Carpinus orientalis*. Throughout all the Middle Ages, this vegetation assemblage was probably affected by fire activity in the area (Figure 6). Most of the pollen-types encountered in the arborescent matorral are pyrophytic species that have proven to be remarkably resilient to fire and many other disturbances (Buhk *et al.*, 2006; Gracia *et al.*, 2002; Kaniewski *et al.*, 2008; Naveh, 1975; Retana *et al.*, 2002). This arborescent matorral may correspond to the resilient form of the coastal ecosystems.

Xerophytic shrub-steppe. The second pollen-derived vegetation pattern, which co-occurred with the Mediterranean woodland during the Middle Ages and which dominates the area during the Modern era, corresponds to a xerophytic shrub-steppe with components of the Irano-Turanian, Saharo-Arabian and Sudanian floras (Davies and Fall, 2001). This group is linked with the Mediterranean woodland and the fire activity (charcoals) in the CA (Figure 5). The xerophytic shrub-steppe is composed of desert scrubs (*Ephedra*, *Artemisia*, Chenopodiaceae, *Tamarix*, Zygophyllaceae), steppic components (Asteraceae, Dipsacaceae, *Helianthemum*, *Scabiosa*), xeric dwarf-shrubs (*Sarcopoterium spinosum*), and sparse remnants of a degraded mountainous cedar woodland (*Cedrus*) (Figure 4). The presence of *Cedrus* in the pollen assemblages is probably due to long-distance transport from remnants of degraded cedar woodland colonizing surrounding mountains. A similar xeric steppe with desert scrubs and thorny-shrubs (*Artemisia herba-alba*, *Ephedra fragilis*, *Juniperus oxycedrus*, *Noaea mucronata*, *Prosopis stephaniana*, *Sarcopoterium spinosum*, *Zizyphus lotus*) nowadays grow in the drier, rain-fed spots of the Jableh area. The other woods/shrubs (*Ceratonia siliqua*, *Crataegus azarolus*, *Pistacia atlantica*, *Styrax officinalis*, *Tamarix*) are concentrated in the wetter valley bottoms.

The xerophytic shrub-steppe is dominant in the pollen sequence at c. 1600–1650, 1755–1775, and 1840–1865 cal. yr AD, with peaks at c. 1640, 1765, and 1850 cal. yr AD (Figures 3, 6). These periods correspond with the ‘Little Ice Age’ (LIA) (Briffa, 2000; Jacobeit *et al.*, 2001; Jones *et al.*, 2001; Kuhlemann *et al.*, 2008; Osborn and Briffa, 2006; Richter *et al.*, 2009), a period (1580–1850 cal. yr AD) of widespread cold identified in a number of temperature-sensitive proxy records from the Northern and Southern Hemispheres, and also recognized in the Eastern Mediterranean (Hassan, 2007; Griggs *et al.*, 2007; Schilman *et al.*, 2001, 2002; Yavuz, 2007).

Fire is defined as a key ecological disturbance in Mediterranean-type ecosystems (Colombaroli *et al.*, 2007; Wittenberg *et al.*, 2007). The positive correlation in the CA (Figure 5) between the Mediterranean woodland and the xerophytic shrub-steppe suggests that fire may have contributed shaping the coastal Syrian landscapes into their present mosaic-like patterns, with different levels of regeneration and degradation. Following fire events, the arborescent matorral and the xerophytic shrub-steppe may have

colonized the bare surfaces and the lower slopes of the Jabal an Nuşayrīyah.

Wet shrub-steppe. The third pollen-derived vegetation pattern identified in the numerical analyses is a wet shrub-steppe (Figure 4), which is inversely correlated with the two previously defined clusters and the charcoals in the CA (Figure 5). This group with pollen types from the Irano-Turanian, and Mediterranean floras (Danin, 1999; Davies and Fall, 2001), includes meadow herbs (*Plantago lanceolata*, *P. major*, *Centaurea solstitialis*) and field plants (*Polygonum aviculare*, *Rumex acetosa*, *R. acetosella*), which are traditionally considered as Eastern Mediterranean indicators of agro-pastoral activities (Behre, 1990; Bottema and Woldring, 1990). This group also includes common forbs such as *Acantholimon*, Apiaceae, Caryophyllaceae, and Liliaceae (Danin, 1999). The development of this open, steppe-like vegetation, may be driven by clearance, extension of pasture, crop cultivation and rural infrastructures but also by increased water availability, which may have benefited from both climatic and anthropogenic factors.

Wetland meadow, fen trees, open forest. The fourth pollen-derived vegetation pattern, linked with the wet shrub-steppe (Figure 5), includes three subgroups (Figure 4). The wetland meadow component is loaded by swamps and reed thickets (Alismataceae, Cyperaceae, Ranunculaceae), grassland (Poaceae, Lamiaceae, Urticaceae), and thorny shrubs (*Crataegus*). The increase of these components may indicate a local above- or near-ground water-table, water impoundment, or an active floodplain (Cordova and Lehman, 2003; Magyari *et al.*, 2001). This first group is linked with a close azonal-type riparian-alluvial forest, composed of Nemoral-Submediterranean and Mediterranean elements (Meusel and Jäger, 1989; Quézel, 1999), with fen trees (*Alnus*, *Platanus*, *Populus*, *Salix*, *Ulmus*), and wet open forest (*Arbutus*, *Cercis*, *Hippophae*, *Laurus*, *Nerium*, *Rhus*, *Styrax*). The last ecological stage of the riparian forest succession is represented by an open deciduous forest with *Fraxinus* and deciduous *Quercus*. This suggests that a wooded-to-forested vegetation (average value of the riverine formations: 15.5% of the total pollen sum; max. value: 71% of the total pollen sum), fully developed when the area was waterlogged (e.g. c. 1050–1100 cal. yr BC). These riverine formations are linked with the wet shrub-steppe and the cultivated species assemblages, and were probably located on well-irrigated, fine, alluvial deposits still used today for arbori-, horti- and agriculture.

Peaks of fire activities associated with higher representation of the wetland meadow, fen trees, open forest vegetation patterns can be human-induced, fires being used as a clearing process of the fertile plots in the alluvial plain to enlarge the cultivable zone by burning local stands of riverine vegetation. If the fires are of natural origin, for instance caused by prolonged drought and lightning strikes, they would have caused a destruction of the marsh ecosystems with little influence on human activities.

Main indicator of Medieval arboriculture: *Vitis vinifera*

Even though *Vitis* pollen-type only appears in the pollen diagram (Figure 3) at the end of the Muslim era and during the crusades, the use of grapes as indicator of agriculture should be employed with care. The distinction between the wild (*Vitis sylvestris*) and domesticated grapes (*Vitis vinifera*) is difficult through pollen

analysis. The NJ analysis (Figure 4) suggests that *Vitis* pollen-type is closely linked with all the cultivated species (e.g. Poaceae cerealia, *Juglans regia*, Fabaceae) and may be integrated with a Medieval arbori-, horti- and agriculture, peaking from c. 1050 to 1250 cal. yr AD.

The potential surface covered by *Vitis* cultivation during the Middle Ages cannot be estimated as vineyards are absent nowadays in coastal Syria, but high percentages (up to 7% of the total pollen sum, Figure 3) indicate a strong presence of these cultivars near the site (Bottema and Woldring, 1990; Cordova and Lehman, 2003; Huntley and Birks, 1983). The highest values indicate that vineyards were best developed from c. 1100 to 1250 cal. yr AD. Columelle (2002), a writer of the first century AD, mentioned the need of maintaining plantations of wet trees (e.g. *Alnus*, *Populus*, *Ulmus*) to support vine ranks. Some fen trees, integrated in the riverine pollen-derived vegetation pattern and correlated with the cultivated species, may have been planted during wetter phases for the use of wood in the vineyard.

The vegetation of the Medieval Levant

In Northwest Syria, a pollen record from the Ghab Valley (Yasuda *et al.*, 2000) shows that during the last 1000 years, Arboreal Pollen (AP) include mainly *Pinus*, evergreen *Quercus*, *Olea*, and secondarily *Juniperus*, *Carpinus* and *Rhamnus*, suggesting the occurrence of an arborescent matorral. Non-arboreal pollen (NAP) is dominated by steppe-like grasslands (Apiaceae, *Centaurea*, Poaceae, *Plantago*, *Polygonum*), mixed with xerophytic shrub-steppe (Asteraceae, *Artemisia*, Chenopodiaceae). The AP/NAP ratio highlighted in the Ghab Valley over the last millennium together with the Jableh AP/NAP ratio for the same time period are very similar. Unfortunately, the time resolution of the Ghab Valley pollen record is too low to allow further comparison for the last 1000 yr. In the Dead Sea (Leroy, 2010; Neumann *et al.*, 2007, 2010), and Lake Birkat Ram (Schwab *et al.*, 2004) pollen records, despite higher occurrence of *Quercus calliprinos*, the entire assemblage termed as arborescent matorral can also be identified. The NAP is mainly composed of xerophytic steppe taxa, but a steppe-like grassland also occurred. A high occurrence of *Quercus calliprinos* is also recorded at the southeastern Syrian site of Bosra, near the Jebel Druze, where charcoal analyses for the period AD 1400–1900 show that the Mediterranean component of the vegetation is still present despite a distance of 170 km from the coast (Willcox, 1999).

The environment during the crusades

Since the council of Clermont in AD 1095 and until the fall of the Jerusalem Kingdom in AD 1291, the crusaders have marked the history of the Middle East. The first crusaders reached Latakia in AD 1097, with 28 ships from Cyprus, under the command of Guynemer of Boulogne. They sacked the town, made it part of the Principality of Antioch, and gave the governance to the Byzantine officials Robert of Normandy and Raymond of St. Gills (Riley-Smith, 2005). After a troubled period (AD 1099–1102), Tancred's army arrived in the coastal city in AD 1102, and fought against a Danishmend-Seljuk alliance. The victory of the crusaders in AD 1103 marks the definitive incorporation of Latakia and the northern coastal cities to the Principality of Antioch (Richard, 1999). This war, leading to the western expansion of the Principality's borders, and the emergence of discontinuous crusader settlements

in coastal Syria until AD 1268, has never been related from an environmental point of view. This study suggests that the first appearance of the crusader armies in AD 1097 and the later AD 1102–1103 battle took place in an Eastern Mediterranean arborescent matorral, mainly composed of *Pinus*, *Juniperus* and evergreen *Quercus*. The sandy coastal area was colonized by a xerophytic shrub-steppe with Asteraceae, *Artemisia*, and Chenopodiaceae. In the Jableh area, a wet shrub-steppe colonized the extended bare surfaces and fresh arable soils. The alluvial plain surrounding the northern Rumailiah river and the southern Al Fawar spring complex were slightly waterlogged, and a well developed riverine ecosystem (wetland meadow, azonal-type ripisylve-alluvial forest, open deciduous forest) occupied this area. The dominance of these landscapes during the Crusader period clearly appears in the numerical distribution of crusader samples in the PCA analysis (Figure 7).

A period of relative landscape stability is recorded during the period of crusader rule in northern Syria. The main elements of the crusader arbori-, horti- and agriculture were grape wine (*Vitis vinifera*), ornamental trees (*Fraxinus ornus*), walnut (*Juglans regia*), Rosaceae (e.g. *Prunus*, *Rosa*), cereals (e.g. *Barley*, *Hordeum*, *Triticum*), and Fabaceae (e.g. *Lens*, *Pisum*, *Vicia*). These taxa, already present during the Muslim era, develop in its final part, partly because of wetter conditions. The following strong development of vineyards was probably oriented to wine-production by the crusaders.

Following the fall of the city of Antioch by the Mamluke's army in AD 1268, the crusader rule over coastal Syria ended. The defeat of the crusaders is followed by a strong decrease of arbori-, horti- and agriculture, and the disappearance of *Vitis vinifera*.

Conclusions

The Principality of Antioch played a major role in the history of the crusades, as it was created since the late eleventh–early twelfth century AD and lasted until the Mameluke conquest of Antioch (AD 1268). Here we show that the expeditions of the crusaders in Syria, with the aim of regaining the territories regarded as unlawfully occupied by the infidels, did not suffer from dramatic environmental hazards. Obviously, the crusaders did not face major challenges in having to adapt their logistics systems to dramatic shifts in their natural environment during their two-century presence in Syria. The crusader period, bracketed in northern coastal Syria from AD 1097 to AD 1268, is centred on the 'Medieval Climate Anomaly' (MCA) (AD 900–1300), an episode of widespread temperature and hydrological anomalies in different areas over the world (Briffa, 2000; Briffa and Osborn, 2002; Keller, 2004). In coastal Syria, the MCA episode (c. 1000–1250 cal. yr AD) was warmer and wetter than the 'Little Ice Age' (c. 1500–1870 cal. yr AD) and slightly cooler but still wetter than the present-day. Only three peaks of positive anomalies centred on c. 1115, 1130 and 1170 cal. yr AD suggest similar or warmer temperatures compared with AD 2000 (Kaniewski *et al.*, unpublished data, 2010).

The strong decrease of arbori-, horti- and agriculture, and the disappearance of *Vitis vinifera* at the end of the crusader period are mainly linked with a cultural change brought by the rise of the Mamelukes in the Levant. The Mamelukes developed a new agro-production (Behrens-Abouseif, 2008), based on pastoral activities and crop cultivation (cereals) around Jableh. This type of subsistence has lasted throughout the Mameluke and Ottoman times in coastal Syria without major change.

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