Poplar trees in Israel’s desert regions: Relicts of Roman and Byzantine settlement

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ABSTRACT

The Euphrates poplar (Populus euphratica), can be found in the arid regions of the Negev highlands, the Judean desert, and the northern Arava in a number of clustered populations located near permanent water sources. The trees’ distribution in the desert regions is not continuous, being disconnected from its major area of distribution along the Jordan River, where its distribution is uninterrupted. It is unclear how and when this disjunctive distribution occurred, and what were the initial ecological conditions for this poplar’s original establishment and success. In this article we present a study of the current distribution of these trees within an arid environment, and of their various traditional uses. A strong relationship is demonstrated between the present location of the trees and settlements from the Roman and Byzantine periods (between the 1st century BCE to 7th century CE). Euphrates poplars are abundant today near early Christian monasteries, which could have been the main factor responsible for their present-day distribution.

1. Introduction

The Euphrates poplar (Populus euphratica; family Salicaceae) is an Irano-Turanian element whose range of distribution stretches from northwest Africa to central Asia (Browicz, 1977). In the southern Levant this species grows along the Jordan rift valley, from the Hula valley in the north to the Sodom salt flat in the Dead Sea basin in the south. In the Mediterranean region, with the exception of the coastal plain, the distribution of the tree is relatively continuous, occurring in the Jordan valley on either side of the River Jordan, along its tributaries, and near permanent water sources. In the desert regions of the southern Levant, located to the south and east of the aridity line (<200 mm of rainfall annually), the tree can also be found in the northern Arava and the Negev highlands. Its distribution thus ranges from the Mediterranean to the Saharo-Arabic region and the Sudanese enclaves in the south (Danin, 1983). The Euphrates poplar distribution in the arid environment is fragmented and the trees are isolated from their main distribution area.

Two major concentrations of this species are known from the Negev highlands: one at Ein Avdat spring (Ein means spring in Arabic and Hebrew) and the other at Ein Shaviv spring (Fig. 1). The average annual precipitation in the Negev highlands ranges from 80 to 130 mm (Morin et al., 1998; Bruins, 2012). The Ein Avdat poplars share a 98% genetic identity, indicating a low genetic variability and attesting to a vegetative reproduction characterized by minor genetic differentiation (Brosché et al., 2005).

The Euphrates poplar is tolerant of the higher salinity level of the semi-desert regions of the Middle East, particularly in its distribution areas along the banks of streams and beside springs, desert oases, and sand dunes (Brosché et al., 2005). The tree is resistant to high temperatures as long as its roots can reach water from underground sources. Along the Euphrates river in Turkey the tree can grow up to a diameter of 30 cm and a height of 30 m (Richardson et al., 2014). Poplars planted near Olympia, WA in the United States, for example, grew to heights of 13–16 m within a period of eight years (DeBell et al., 1997). Poplar trees

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can live for up to 200 years (Dickmann et al., 2014). In traditional societies and in all of the poplars’ areas of distribution, they are commonly used for a variety of construction purposes.

The presence of pollen from *Populus euphratica* of the Pleistocene, as noted in the regional palynological records, confirms that this species is part of the southern Levant natural vegetation. The ancient palynological evidence was found in sediment of the Ubeidiya Formation, dated to the Early Pleistocene (Horowitz, 1979). Grains of pollen from the Middle Pleistocene (Van zeist and Bottema, 2009) and the Late Pleistocene (Horowitz, 1968; Kadosh et al., 2004; Weinstein-Evron et al., 2015) have also been documented. The presence of poplar trees in the region is also evidenced in the occurrence of wood and charcoal remains recovered from archeological sites (detailed in Appendix 1).

The tree could have been easily disseminated by humans in Antiquity, mainly due to the rapid growth of its seedlings in flooded alluvial soils and on river banks, and because the tree reproduces easily from seeds and root cuttings (Dickmann et al., 2014; Marron et al., 2014; Richardson et al., 2014). Consequently, we suggest that documentation of the species’ distribution and arid areas can offer evidence of its establishment in desert regions, especially near isolated bodies of water separated by large distances, beyond its natural dispersal range. In such discontinuous sites, it is probable that the trees were introduced there as seeds or root cuttings by humans. Based on our findings, we assume that a spatial correspondence exists between the settlement history and the distribution of the poplar trees in our research area. These findings contribute to our understanding of the development of the historical cultural landscape of arid environments through the introduction of new plant species commonly exploited by humans for different purposes.

The Early Roman period (2nd century BCE and 1st century CE) witnessed an expansion of settlement around the Dead Sea and the Judean desert. Kings and other rulers, as well as the wealthy, established themselves in this desert region, with their presence evidenced in such prominent constructions as Herod’s building projects and palaces at Jericho and Masada, and the establishment of additional sites such as Qumran (Goodman, 1987; Netzer, 1987, 1991, 2001; Nielsen, 1990; Roller, 1998; Hirschfeld, 2004a). In the 2nd century CE, the Negev came under control of the Roman Empire. During the 3rd-beginning of the 4th century CE, military camps and settlements were established and Imperial roads were paved. Consequently, and for the first time in many years, the region experienced a thriving development that also involved the establishment of permanent settlements, requiring raw materials and knowledge of building technologies (Bauersock, 1970, 1971; Negev, 1977; Tsafir, 1983). During the period following the rise of Christianity (4th century CE), the Land of Israel became the “Holy Land” and the focus of pilgrims from throughout the Byzantine world. As a result, substantial capital was invested in the region, particularly in sites related to the New Testament and the life and works of Christ. This period was characterized by large-scale settlement activity, which reached its height in the Byzantine period (between the 4th and 7th centuries CE), and gradually declined in the 8th and 9th centuries CE, in conjunction with the onset of Islamic rule in the region.

In about 106 CE Rome abolished the semi-independent Nabataean kingdom, and the Negev, parts of Sinai, and modern Jordan became a Roman province. During the Roman period the Negev witnessed the establishment of sites such as Mamshit, Elusa, Avdat, and Shivta, which developed during the Byzantine period into large thriving settlements, surrounded by a developed rural agricultural system (Evenari et al., 1982; Ashkenazi et al., 2012; Bar-Oz et al., 2015; Tepper et al., 2019; Fuks et al., 2020). Beginning in the 2nd century CE, the Negev underwent a major political and socio-cultural change (Tsafir, 1983), as also reflected in agricultural developments (Avni et al., 2019). Archeological studies have suggested that the changes may have started even earlier than the 2nd century CE (Hirschfeld and Tepper, 2006; Tepper et al., 2020). These involved a change from small-scale agriculture (ibid) to a system based on harvesting and distributing rainwater over an area of at least 2000 km². Earthworks associated with that enterprise created 4000 ha of arable fields (Kedar 1957a, 1957b, 1967; Erickson-Gini, 2012). During the 4th century CE, a movement of ascetics also flourished in the Judean desert, the Negev, and the Sinai Peninsula (Hirschfeld, 2002, 2013; Patrich, 2013). These migrant populations probably possessed the agronomic knowledge to grow new plant species such as myrtle and cedar (Langvat et al., 2020) and (improved the agricultural systems and technologies of the time which, among other things, facilitated the establishment of a sustainable farming livelihood in the desert. During the peak of the Byzantine establishment, the region’s population reached its height, with thousands of inhabitants living in permanent settlements, including ascetics dwelling in monasteries both inside and outside the settlements (Avni, 2014; Rubin, 1982). Several of the smaller settlements and monasteries were erected beside permanent water sources and engaged in small-scale agriculture, based on vegetable gardens and horticulture (Rubin, 1982; Hirschfeld, 2002). In the present study, we examine the spatial distribution of the Euphrates poplar in desert areas of the southern Levant in relation to the ancient settlement sites and the human activity that took place in them.

2. Methods

In this study, we mapped the sites at which Euphrates poplar trees are growing today in the desert regions of Israel: the Judean desert and the Dead Sea valley, from the Jericho region in the north to the northern Arava and the Negev highlands in the south (Fig. 1, Appendices 2-3). We did not include the areas located farther north in the Mediterranean region, where the tree’s distribution is continuous, or areas beyond Israel’s desert regions. We determined the distance from the locations of the trees to sites of human settlement during the Roman and Byzantine periods.

Most of the data on the growth sites of the Euphrates poplar are based on information posted on the Israel Nature and Parks Authority’s “Endangered Plants of Israel” website. This site contains a map of lookout points and the trees’ locations (see: https://redlist.parks.org.il). Most of the data on the archeological sites were obtained from the archeological survey of the Israel Antiquities Authority (see: http://survey.antiquities.org.il). We also examined the geographical sub-strate in which the trees are located, based on the existing map surveys (Hadas, 2012; Cohen and Prital, 2016; Sion, 2013a, 2013b). We then compiled the data onto ArcMAP 10.4 GIS software, and conducted spatial analyses to examine the connections between the permanent settlements and the trees’ distribution. These analyses enabled us to determine the distance between the archeological sites and the trees’ locations (Figs. 1–3, Appendix 2). We did not count the number of trees in each population, because a local rapid vegetative reproduction mode occurs along those sections of stream that offer conditions suitable for such growth, precluding population size from serving as an indication of that population’s age.

3. Results

Euphrates poplar trees were identified in ten specific locations in Israel’s desert regions (Fig. 1). At all the sites, the trees grow adjacent to ground-water springs and in areas with high levels of moisture in the soil; they are also located close together and grow in groups. The locations of the trees were all found to be in close proximity to archeological sites, mostly from the Roman and Byzantine periods. The features of each site are presented below, with an emphasis on their close proximity to the Roman and Byzantine sites. Datum points are provided in Appendix 2.

3.1. The Jericho area

A flat area consisting partially soft rocks of low Lisan Peninsula hills which are around 30 m high and builds from aragonite and detritus, and includes also gypsum and sulphur. The region is characterized by
relatively low flat area around 320–350 m under sea level. The average distribution of annual precipitation in the region is in the range of 120–180 mm. The area features five groves in which the poplar trees grow near monasteries and monastic seclusion alcoves dated to the Byzantine period, some of which are still in use today. The trees are adjacent to sites from the Byzantine period and to the monastic sites, at distances of 50 to 1500 m. The trees within this area are distributed between the modern city of Jericho to the west and the Jordan river to the east, and are disseminated among ca. 40 archeological sites from different periods. The most remarkable sites are dated to the Roman period and include the Herodian-period palaces in Jericho. In the general area surrounding these trees, we note the existence of additional Byzantine sites located further away from the trees, at distances of between 1500 and 5000 m (Figs. 1 and 2). Of the recognized Byzantine sites, nine are monasteries that also contain findings from later periods. These include Deir Hajla monastery, Petrus Monastery, another chapel with monastic booths, a monastery with a caravanserai, and the Lavra of Qalamin. Some, like Deir Hajla monastery, continue to operate to the present day.

3.3. Einot Tzukim (Ein Feshkha) springs

A deep, narrow canyon that flows through marine sediment rock from the Cenomanian and the Turonian ages – primarily solid, hard limestone and dolomite around 150 m under sea level – 100 m above sea level. The average distribution of annual precipitation in the area is in the range of 120–180 mm. The site is located in the region of Jericho (see above). During the Byzantine period, the St. George and the Paran monasteries were built into the cliffs of Wadi Qelt and both are still operating today. The caves in the cliffs overlooking the canyon hold many monastic cells. Three nearby springs – Ein Fara, which emerges beside the Paran monastery; Ein Fawar and Ein Qelt – are perennial, filling the stream all year round. Along the springs, east of the St. George monastery, is a group of Euphrates poplar trees. Three Byzantine monastic sites are located 600–800 m from the trees: St. George monastery, which, like Deir Hajla, also continues to operate today; 16 Byzantine monastic cells; and Kypros, which also contains a monastery from the Byzantine period. Five sites from the Byzantine period are located at a distance of 1500 m from the trees (Figs. 1 and 2, Appendix 2).

According to the archeological survey, the geographical area in which the trees are located features ca. 17 archeological sites: five are sites from the Byzantine period described above; nine are part of one large site containing an aqueduct from the Byzantine period; and three are sites that have not yet been dated (Sion, 2013a).

3.4. East of Avnat

This site is located on the Dead Sea’s flat coastal plain, which contains freshwater springs, under marine sediment rock from the Cenomanian and the Turonian ages – mostly hard limestone and dolomite around 380–410 m under sea level. The average distribution of annual precipitation in the area is in the range of 50–100 mm. It features five clusters of poplar trees, each of which comprises dozens of trees of various ages. One of these clusters is located adjacent to Ein Tanur spring, just north of the main area of springs (Fig. 1, Appendix 2). A farmhouse from the Roman period is located 1 km away from the trees (Hirschfeld, 2004a) and the Roman-period site of Qumran is located 2500 m away. As described below, an historic account from Byzantine times refers to a nearby vegetable garden belonging to the monks (Federlin, 1903; see also Rubin, 1982).

3.5. Einot Kane

A freshwater spring area located on the Dead Sea’s flat coastal plain, under marine sediment rock from the Cenomanian and the Turonian ages – mostly hard limestone and dolomite, around 380–410 m under sea level. The average distribution of annual precipitation in the area is in the range of 50–100 mm. One concentration of trees (Fig. 1) has been documented to date, but this area has not yet been extensively surveyed. The site of Khirbet Mazin, which features a boat anchorage and additional buildings from the Roman period, is located ca. 300 m northeast of the trees, and Qumran is located ca. 7 km to the north.

3.6. Ein Gedi

An oasis located at the foot of the Ha’etekim cliff, where the cliff meets the Dead Sea valley. The area features freshwater springs, such as Ein Gedi, Ein Shulamit, and Ein Arugot. The oasis is crossed by two permanent cliff-lined canyon streams: Nahal David in the north and Nahal Arugot in the south. The Ha’etekim cliff consists marine sediment rock from the Cenomanian and the Turonian ages – mostly hard limestone and dolomite. The area of Ein Gedi oasis is around 400-100 m under sea level. The average distribution of annual precipitation in the area is in the range of 50–100 mm. The site features two large clusters with dozens of Euphrates poplar trees. One cluster is located northwest of an agricultural village dating mostly to the Roman and Byzantine periods, but also before and after. Some of the trees are located on agricultural terraces adjacent to the Roman-Byzantine village. At least another 13 archeological sites dated to the Byzantine period are located within 1500 m of the village (Figs. 1 and 2). A second group of poplars, comprising seven clusters, is located along an approximately 700 m segment of Nahal Arugot located ca. 2–3 km southwest of the village. At least nine sites from the Byzantine period have been documented at a distance of between 100 and 1500 m from these trees (Figs. 1 and 2). The oasis of Ein Gedi, which is also the site of an agricultural village from the Roman period, features the remains of additional phases of occupation, preventing us from firmly concluding that the origins of the trees in this area are unequivocally linked to the Roman and Byzantine periods.

3.7. Ein Khamarmar spring

Located in an area of low Lisan Peninsula hills, near a saline-water spring, around 300–350 m under sea level. The average distribution of annual precipitation in the area is in the range of 40–70 mm. The site features a single group of Euphrates poplar trees. The location has no known archeological sites, but the spring is located approximately 6500 m north of Ein Tamar spring, described below (Fig. 1, 3), and 11 km from the Roman city of Tsohar.

3.8. Ein Tamar spring

An area of low Lisan Peninsula hills with saline-water springs in the northern Arava, around 300–350 m under sea level. The average distribution of annual precipitation in the area is in the range of 40–70 mm. The site features the remains of a caravanserai, burial caves, and structures from the Roman and Byzantine periods. The spring is located 13 km from the Roman city of Tsohar, in close proximity to monastic cells from the Byzantine period. Three clusters of Euphrates poplar trees
are located adjacent to one another, with each comprising several dozen trees. The trees are located ca 600–800 m south and southeast of the monastic cells (Figs. 1 and 3).

3.9. Ein Avdat spring

The site is located in a deep, narrow canyon cut into the soft chalk bedrock from the Eocene (Mor Formation) in the central Negev highlands, around 400–550 m above sea level. The average distribution of annual precipitation in the area is in the range of 80–130 mm, near the Roman and Byzantine period settlement at Avdat. Excavations at Avdat uncovered a Roman army camp (Erickson-Gini 2002; Fabian 2005) located near an Imperial Roman road (Ben-David and Isaac 2020). The poplar trees are located in the canyon’s bed in three clusters, each with a few dozen trees in close proximity to a perennial spring. Several Byzantine monastic seclusion alcoves are present just above the main cluster of trees, in the channel’s steep slope above (Meshel and Tsafrir, 1977) (Figs. 1, 3 and 4). Large-scale agricultural fields, most of which have been dated to the Roman and Byzantine periods, are located within 1500 m of the spring.

3.10. Ein Shaviv spring

A desert oasis in the Zin Valley, located approximately 7 km east of Avdat. The site is located at the bottom of Ramat Avdat, where the spring flows out of marlstone in a flat area. This area is around 350–400 m above sea level. The average distribution of annual precipitation in the area is in the range of 80–130 mm. The three clusters of trees found nearby, totaling dozens of trees, constitute the desert oasis. No Roman or Byzantine-period sites were found in proximity to the trees. A hewed well and the remains of structures and of stone terraces and fences that have yet to be dated are located approximately 1500 m away (Figs. 1 and 3). A site from the Middle Bronze Age (beginning of the second millennium BCE) is located 1600 m northeast of the trees.

4. Discussion

Of all the sites listed above, Ein Avdat most effectively reflects the strong connection between the Euphrates poplar trees and the Roman and Byzantine periods of occupation in the Negev. With regard to the two sites located close to Avdat (Eboda), we draw attention to the above-noted Roman Legion base established at the site. In this context, it is important to note the public construction that accompanied the Roman military presence, and the public structures from the Roman period erected at the base and in its environment. Consequently, despite the link between Avdat and the trees, and their proximity to monastic alcoves, we cannot rule out the possibility that the trees had already been planted or were at the site during the Roman period, when Avdat was founded (for the presence of the Roman army in the Negev see Isaac, 2000; Lewin, 2007). In addition to this, and also equivocal, the Byzantine monastic seclusion caves and the trees (Fig. 4) are contiguous with the settlement at Avdat. It is interesting to note that all the seclusion
caves at Ein Avdat belong to a single period – the Byzantine (Meshel and Tsafrir, 1977). The caves are situated on a tall cliff overlooking the permanent stream, which offers a regular source of water for drinking and subsistence agriculture. Several date palms also grow near the trees. Ein Tamar is another site of Roman occupation, alongside monastic seclusion caves that were established within a short walking distance from the poplar trees, in the much more arid and extreme desert conditions. At both sites, the principle appears to be the same: A Roman and Byzantine period site, with the Byzantine monastic seclusion caves located adjacent to a permanent water source featuring poplar trees. Nonetheless, the remains of the Roman-period settlements at Avdat and Ein Tamar prevent us from attributing the planting of these poplars to the monasteries. The ease with which this tree is cultivated, and the fact that the planks made of its wood are of a high quality for building furniture and for floors and ceilings, made it an important product for the construction of public structures and monuments. This made the poplar tree a valuable resource in desert areas during the Roman and the Byzantine periods.

A similar cultural relationship between Byzantine monasticism and the sites of Euphrates poplar trees has also been documented in the geographical region between Jericho and the Jordan river, an area that was intensively populated during the Roman period (see above). Concomitantly, at Qasr al-Yahud, located east of Jericho, numerous monasteries were built between the Byzantine period and the 20th century. In the Christian tradition, this site is believed to have been the site of Jesus’s baptism in the River Jordan. The area features sites with numerous Euphrates poplars, all of which are located adjacent to at least one monastic site: e.g., the poplars of Ein Hajla and their proximity to the remains of structures from both the Byzantine period and modern monastic complexes, many of which use planks of poplar wood for...
Another case worth noting, and found outside our research area, is the Byzantine monastery near the town of St. Catherine at Mt. Catherine in southern Sinai. The monastery is still active today and is a good example of the proximity between Byzantine monastic sites and the cultivation of the Euphrates poplar. The trees grow in the Sinai Peninsula between Mt. Musa and Mt. Catherine (Hart, 1885), in an area that was once mostly occupied by the monastery.

The genetic differentiation among the poplar trees in the Ein Avdat thicket was assessed and found to be quite low. Such differentiation is indicative of a small founding population that has expanded naturally over the years (Brosche et al., 2005), supporting the assumption that the trees were brought to the site (as seedlings or roots) on a single occasion (the “founder effect”). Lack of excavations and dating data prevent us from determining with much certainty the exact time of their planting and whether it took place during the Roman or the Byzantine period. At other sites, and particularly sites of multilayer settlement like those in the Jericho area or the clusters of trees near Ein Gedi, dating their planting is more complex. Moreover, the location of these poplars on Ein Gedi’s agricultural terraces seems to indicate a connection between local agriculture and the spread of the Euphrates poplar tree.

Among the clusters of poplars in the Dead Sea valley, and especially along the northern shore, a relationship with the permanent settlements of the Roman period, such as the prominent settlements of Qumran, Ein Gedi, and Masada – has been well established. At only two sites, Ein Avnat and Ein Khamarmar, was it not possible to relate the poplar trees to nearby occupation phases, although it can be reasonably assumed that they are indeed linked to Roman period settlements. Remains from Roman and Byzantine periods were found near the Einot Tzukim site (De-Vaux, 1973), including historical evidence of a vegetable garden used by monks there (Federlin, 1903, quoted by Rubin, 1982). It is interesting to note that, according to the markings on the PEF (Palestine Exploration Fund) stone found in close proximity to the poplar population of Einot Tzukim (at datum point 31.706103/35.449865), we learn that, in 1900, the surface level of the Dead Sea was 392.9 m below sea level. On this basis, it is perhaps reasonable to conclude that the poplar trees only became established in this area in more recent times, and particularly over the past 120 years.

The absence of local trees in the desert environment that are suitable for private and public building and furniture construction leads us to assume that a high demand existed for wood for building in the permanent settlements of the Negev during the Roman and Byzantine periods. Indeed, the archeological findings at these sites are indicative of the exploitation of a variety of types of wood for construction, including tamarisk and other local tree species, in addition to imported wood. In Shivta, for example, we note the use of non-local imported wood, with excavations there having documented the remains of planks made of Lebanese cedar (Hirschfeld and Tepper, 2006). It is interesting to note that charcoal and pollen from the cedar (as well as from the cypress and the pine) have been documented in excavations at other Byzantine settlements in the Negev, providing extensive evidence of the use of wood for construction (Langgut et al., 2020). Accordingly, we assume that the permanent settlers of the Negev had a concrete need to cultivate poplar trees for both building construction and furniture making.

The poplar tree possesses many advantages in comparison to the local desert trees. Not only are many of its branches straight, thick, and long (Fig. 5), but its wood is flexible, comfortable to work with, and therefore used by the lumber industry to cover walls and in the construction of a variety of wooden objects (Sitri, 2016). Sitri notes that the Euphrates poplar tree is light and, through directed cultivation, its wood can be used to produce straight planks that tend not to warp. This
combination is an advantage when producing transportable wooden furniture. In damp and dry conditions alike, the wood is easy to process, and especially to carve. A small number of archeological objects documented by Sitri (2006) at Jericho in the Dead Sea valley and at Moa in the Arava, were made of Euphrates poplar.

The ease with which poplar wood is processed enables its use for tall buildings like public structures and churches, as well as for monasteries erected on cliffs (Fig. 6). As the construction of public buildings was not characteristic of the indigenous nomadic population of the Negev, poplar trees should be regarded as a Roman and Byzantine cultural feature, supporting the claim that man artificially introduced their cultivation into the desert regions during this period.

Additional possible support for the Euphrates poplar’s cultural association with the Roman and Byzantine desert settlers can be found in the fact that no trees of this species have been documented near any desert water sources devoid of nearby sites of such settlement. Rather, date palms (*phoenix dactylifera*) have been identified, as at the Ein Akev spring, located between the two above-noted populations of Euphrates poplar. Relative to Ein Shaviv, Ein Akev is located close to the settlement of Avdat. Assuming that the inhabitants of Avdat cultivated the poplars at the desert springs near the settlements, it is unclear why the poplar trees are located at the more distant spring from the settlement. This may have been related to other local conditions at the two springs and/or the waning of the poplar tree population there. We found a similar regional picture at the springs of the northern Arava and Kikar Sodom. The entire geographical area stretching ca. 40 km south of Ein Tamar features numerous springs. The dominant tree in proximity to the springs is the date palm; as it is at Ein Tamar, where the adjacent archeological remains have been dated to the Roman and Byzantine periods. Historical accounts from the Byzantine periods, such as the Nesana papyri, also mention date palm cultivation (Kraemer, 1958).

To this day, in and around their monasteries, desert monks prefer to grow trees with straight trunks, which are good for construction. Additional species of trees used for this purpose include the *Populus alba* (commonly known as the “silver” or “white” poplar) and the *Cupressus sempervirens* (the Mediterranean cypress), which also has a straight trunk. The rarity of straight-trunk trees in the desert increases the value of the Euphrates poplar. The use of long, straight planks of wood continues to be an important aspect of construction work up to the present, including as auxiliary support frameworks for structures in general and for tall structures in particular. Accordingly, many of the Byzantine monasteries that are still active today – such as the Wadi Og monastery, the St. George monastery in Wadi Qelt, and Mt. Quarantania overlooking Jericho – are built on cliffs and therefore required vertical construction and scaffolding. Due to the need for long, straight planks of wood for the construction of various facilities, straight-trunk poplar trees are still common in the orchards of Mt. Catherine in the Sinai Peninsula, in St. Catherine village and the surrounding area, and in the monasteries of the Judean desert. In Sinai, white poplar planks were used for building *shadufs* for pumping water from the many wells that were dug on Mt. Catherine. The poplar’s long, sturdy planks facilitate the drawing of a large volume of water from a well (Fig. 7). Thus, as a result of their knowledge of species of trees with which they had become acquainted over the generations, the Jabaliya Bedouin tribe, which has close historical ties to the monks of the St. Catherine monastery, also began to cultivate *Populus alba* in their gardens and to use its trunk for many purposes: to build booths; to support beams for sheds, structures, and doors; and for water-hoist devices (Fig. 7). Its geographical isolation may explain why the St. Catherine monastery continues the tradition of growing *Populus alba* trees, which, like the *Populus euphratica*, do not grow naturally in Sinai and were brought to the region by monks from Greece and other Mediterranean regions. Similarly, fossilized grains of pollen of the Lebanese cedar (*Cedrus libani*) and *Corylus* have been identified in the garden next to the North Church of Shivta. All these trees, which are not part of the wild vegetation of the desert, were apparently planted in the region by the non-local elite clerics, who came to settle in the Negev from other parts of the Byzantine Empire (Langgut et al., 2020). The abundance of charcoal finds further strength the...
importance of poplar trees throughout the country and their arrival to the Negev Highlands and Judean deserts during the Roman and Byzantine times. Their remains are found during this time in settlements such as Shivta, Nitzana, Qasrawet, Mesad Tamar, Avdat, Massada, and En Bokek.

5. Conclusion

In the Early-Roman period agricultural settlement expanded to the arid environments of the Negev and Judean deserts. During the following centuries, and in particular in the ensuing Byzantine period, agricultural prosperity in these arid areas reached its peak (Evenari et al., 1982; Hirschfeld, 2004b; Avni, 2014). The present study accords with previous studies in highlighting the influence of Roman and Byzantine farmers on the cultural landscape of the Negev and Judean deserts (Ashkenazi et al., 2012; Avni, 2014). Whether through the initiatives of local inhabitants or through central government policy, the peoples of the Negev modified the landscape of the desert. This change found expression not only in the settlements, but also, and perhaps primarily, in the hinterland, in the form of the massive construction of agricultural systems to collect runoff, the cultivation of vineyards and orchards, and in the greening of the desert (Kedar 1957b; Ramsay and Tepper, 2010; Ashkenazi et al., 2012, 2019). The findings from the present study reinforce those of previous studies and suggest that the Euphrates poplar continues to grow near water sources and constitutes a dominant species in the environs of freshwater springs in the desert. The trees offer a living testimony to the ancient cultural modification of the desert vegetation landscape. This connection, between human settlements and exploitation of the Euphrates poplar tree, deserves additional examination through further research at other desert sites in the Middle East and of the water sources that serve them.

Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jarenv.2021.104574.

References


Fig. 7. A water-hoist for to pump water in the Sinai Peninsula. Its long pumping beam is made of poplar wood, Wadi Kid, Sinai, 1994 (above) and a structure used for storage. Its roof supports, visible in the upper right hand of the structure, are made of wood beams (marked with white arrows), Abu Sila, Sinai, 1996 (Photo: Eli Ashkenazi).


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