

Fossil Palm Woods of Egypt III. A New Site for *Palmoxylon aschersoni* Schenk and *P. wadiai* Sahni

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Petrified monocotyledonous wood specimens of *Palmoxylon aschersoni* and *P. wadiai* are reported and described for the first time from the Cairo-Baharyia Oasis Desert Road in Egypt. They are compared to earlier descriptions of specimens assigned to these species from Egypt and other parts of the world. Relevant comments regarding fossil palm remains in Egypt and Africa are given.

Key words: Arecaceae, Baharyia Oasis, Egypt, fossil wood, Miocene, *Palmoxylon*.

Introduction

Palmoxylon-Arecaceae, in Egypt, is represented by 12 species namely: *P. aschersoni*, *P. compactum*, *P. geometricum*, *P. indicum*, *P. lacunosum*, *P. libycum*, *P. pondicherriense*, *P. pyriforme*, *P. rewahense*, *P. stromeri*, *P. wadiai* and *P. zitteli* (Kräusel and Stromer, 1924; Kräusel, 1939; El-Saadawi *et al.*, 2002, 2004)⁽²⁾. These species had been reported from 24 sites (Kräusel and Stromer, 1924; Kräusel, 1939; Youssef, 1993; El-Saadawi *et al.*, 2002, 2004) (Fig. 1) concentrated mainly in the northern part of Egypt and are of Tertiary age ranging from Oligocene to Miocene except *P.*

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(2) There is reference to 4 more unpublished, new to science, *Palmoxylon* species recorded in Egypt (El-Saadawi *et al.*, 2004).

stromeri and *P. zitteli* which come from the southern part of the country (Road between Esna and Wadi Halfa, Dakhla and Kharga Oasis) and are of Cretaceous age. This is the first record of fossil palm wood; namely *P. aschersoni* and *P. wadiyai* from Cairo-Baharyia Oasis Desert Road. These two species, in Egypt, were reported earlier from the following sites:

***P. aschersoni*:** Desert area between Gebel Hadahid and Gebel El-Bahr in southern Sinai, Suez, Qattamiya, Giza pyramids, 40km west of Abu Roasch, Gebel El-Khashab "Northern Petrified Forest", north of Fayum, Qaret El-Raml, Gebel Ruzza, Garet El-Mulk, Wadi Faregh, Wadi Natrun, Garet Aujân, Bir Lebuk, Moghra (Kräusel and Stromer, 1924; Kräusel, 1939; El-Saadawi *et al.*, 2002) (see Fig. 2).

***P. wadiyai*:** Qaret El-Raml (site No. 7) and Gebel Ruzza (site No. 8) (El-Saadawi *et al.*, 2004) (see Fig. 2).

It is worthy to mention that, besides Egypt, *P. aschersoni* is known also from Libya and Algeria, i.e., only from Africa (Duperon-Laudoueneix and Dupéron, 1995), whereas *P. wadiyai* is known from India (Sahni, 1964) besides Egypt.

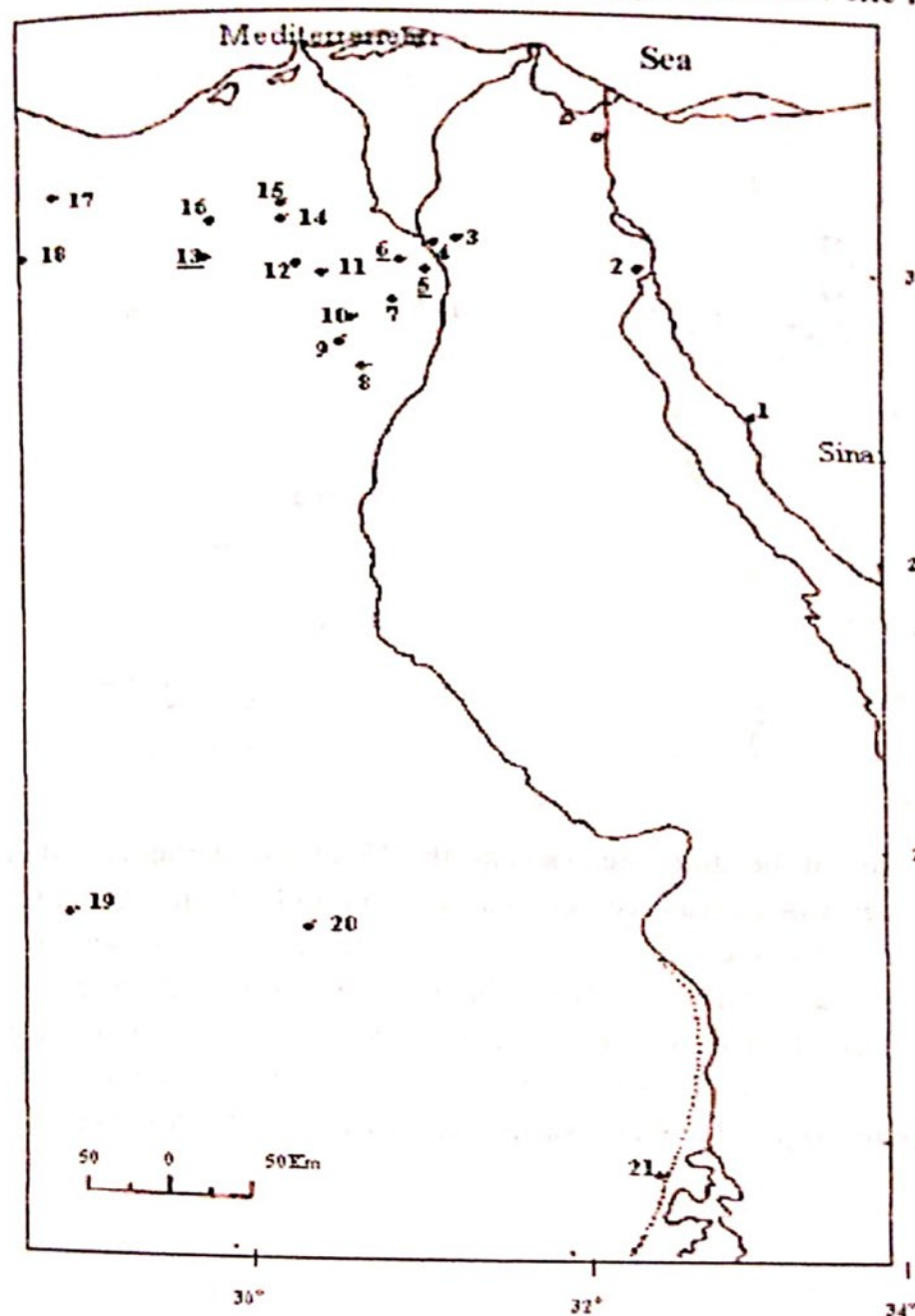


Fig. 1. Map showing the sites from which *Palmoxylon* was recorded from Egypt. Underlined numbers include 2 sites each.

1. Desert area between Gebel Hadahid and Gebel El-Bahr in southern Sinai,
2. Suez, 3. Qattamayia, 4. Gebel Ahmer, 5. Giza Pyramids and Abu Roasch, 6. Gebel El-Khashab (Northern Petrified Forest and Southern Petrified Forest), 7. Tall El-Zalat, 8. Fayum, 9. Birket Qarun,
10. Gebel Qatrani, 11. Qaret El-Raml, 12. Gebel Ruzza, 13. Wadi Faregh and Garet Aujân, 14. Garet El-Muluk, 15. Wadi Natrun, 16. Deir Baramûs,
17. Bir Lebuk, 18. Moghra, 19. Dakhla, 20. Kharga, 21. Road between Esna and Wadi Halfa

Study area

The area concerned in the present work lies along the Cairo-Bahariya Oasis Desert Road, at latitude $29^{\circ} 41'$ ($17''-41''$) N and longitude $30^{\circ} 19'$ ($29''-52''$) E, (Fig. 2). It is an Early Miocene site of Gebel El-Khashab Formation (Said, 1962; Map of the Geological Survey of Egypt, 1981). The lithostratigraphic section of the study area is shown in Fig. (3). From almost this study area [at lat. 29° ($30'-32'$) N, long. 30° ($5'-10'$) E] Mostafa (2009) reported 6 dicot wood species namely: *Bombacoxylon langstoni*, *B. owenii* (Bombacaceae), *Afzelioxylon welkitii*, *Cynometroxylon tunesense*, *Tetrapleuroxylon acaciae* and *T. ingaeforme* (Leguminosae).

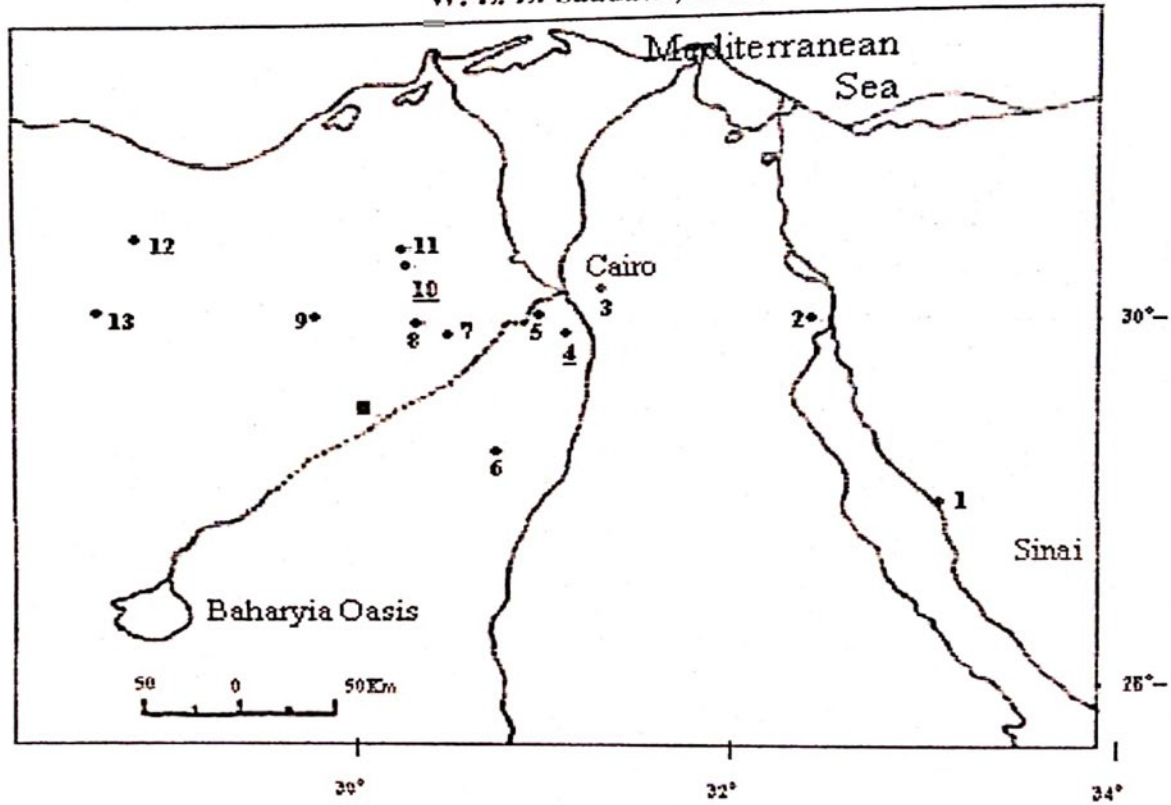


Fig. 2. Map showing the location of the study area (■) and the 15 sites of earlier record of *Palmoxyton aschersoni*. *P. wadii* was recorded earlier from only 2 sites; Qaret El-Raml and Gebel Ruzza. Underlined numbers include 2 sites each. 1. Desert area between Gebel Hadahid and Gebel El-Bahr in southern Sinai, 2. Suez, 3. Qattamaya, 4. Giza Pyramids and Abu Roasch, 5. Gebel El-Khashab (Northern Petrified Forest), 6. Fayum, 7. Qaret El-Raml, 8. Gebel Ruzza, 9. Garet El-Muluk, 10. Wadi Faregh and Garet Aujân, 11. Wadi Natrun, 12. Bir Lebuk, 13. Moghra.

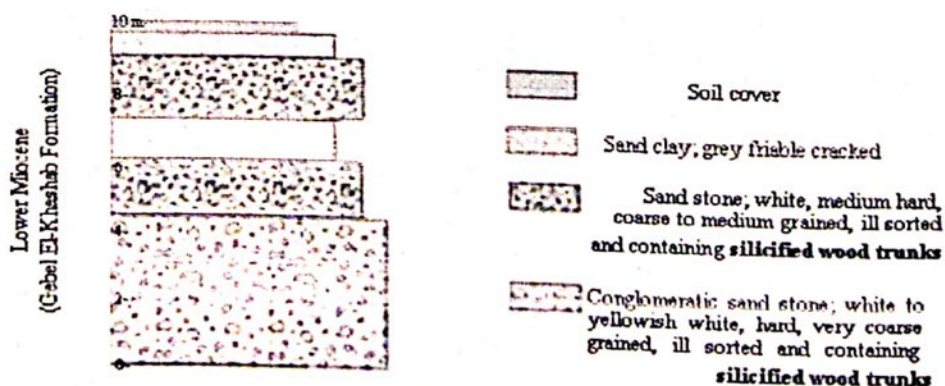


Fig. 3. Stratigraphic section of Cairo-Baharyia Oasis Desert Road (supplied by Prof. Dr. Rifaat Osman, Geology Department, Faculty of Science, Benha University, Egypt).

Material and Methods

Forty silicified wood specimens were collected by the authors from the study area during a field trip on 6-2-2009. The majority (38) of the specimens were chopped off from silicified large trunks that were found lying on sand surface and ranging in length from 0.5 to 30m except two small specimens that were found loose at the locality. The massive silicified trunks and smaller wood fragments are the only plant remains found in the study area.

The majority of the collected specimens range between 5–10cm in width and 10–20cm in length, with brown to reddish brown color. Only two of the specimens obviously belonged to the Palm family with clear scattered fibrovascular bundles and were taken from two trunk fragments (50×10cm and 60×12cm), with reddish brown color and rough texture.

Thin ground sections of cross and longitudinal surfaces were prepared according to the method described by Andrews (1961). The specimens and the prepared slides were photographed, numbered and deposited in the palaeobotanical collection of the Department of Botany, Ain Shams University, Cairo.

Results

Careful microscopic examination showed that the two Palm specimens belonged to *Palmoxylon aschersoni* and *P. wadii* while the rest were dicots (32 specimens Bombacaceae, one Combretaceae, one Leguminosae and 4 specimens were difficult to refer to any family). This paper deals only with the two palm specimens. The dicot specimens will be the subject of a forthcoming publication.

Systematic description

The quantitative data and descriptive terminology, used here, follow the descriptions of Stenzel (1904), Sahni (1943, 1964), Kaul (1960).

Group: Launaria Stenzel

Palmoxylon aschersoni Schenk

Specimen No. 27ZN; Plate I, 1–4

Parts available: central zone

Description:

Fibrovascular bundles irregular in distribution, average size 1.18×0.92mm, average frequency 18–20 per cm², f/v ratio 1.3/1.

Schlerenchyma: lunate, orbicular, rarely more or less reniform, auricular lobes angular, rarely rounded, medium sinus rounded. Fibrous bundles absent. Diminutive fibrovascular bundles present, average size 0.76x0.53mm.

Xylem: one large vessel or bivasal, average diameter 0.31x0.37mm. Leaf traces present.

Phloem: poorly preserved in two masses.

Ground tissue: slightly lacunar with small air spaces, tabular parenchyma 1–2 layers over schlerenchyma or around the fibrovascular bundle, radiate parenchyma absent. Idioblasts absent.

In longitudinal section: parenchyma cells appear in contiguous vertical rows, separated by small air spaces at intervals. Other features are poorly preserved.

Group: Reniformia Stenzel

Palmoxylon wadii Sahni

Specimen No. 38ZN; Plate II, 1–4

Parts available: central zone

Description:

Fibrovascular bundles irregular in distribution, average size 1.09x0.88mm, average frequency 19–22 per cm², f/v ratio 1.4/1.

Sclerenchyma: reniform, auricular lobes rounded, medium sinus deep rounded. Fibrous bundles absent. Diminutive fibrovascular bundles scattered, average size 0.57x0.4mm.

Xylem: one large vessel or bivasal, average diameter 0.19x0.25mm. Leaf traces present.

Phloem: poorly preserved in two masses.

Ground tissues: lacunar, interspaces angular, tabular parenchyma two layers over sclerenchyma, occasionally around the whole bundle, radiate parenchyma absent. Idioblasts present in the ground tissue.

In longitudinal section: parenchyma cells appear in contiguous vertical rows. Other features are poorly preserved.

Systematic discussion

1. Affinities and comparisons.

The anatomical features of the two present fossil woods i.e., presence of numerous fibrovascular bundles scattered in a matrix of unspecialized ground tissue indicate that both belong to the genus *Palmoxylon* of the family Arecaceae.

The diagnostic features of the present wood specimen number 27ZN i.e., lunate-shaped schlerenchyma, angular auricular lobes, rounded medium sinus, absence of fibrous bundles, presence of scattered diminutive fibrovascular bundles, one large xylem vessel, absence of radiate parenchyma and idioblasts concur quite well with the description of *Palmoxylon aschersoni* Schenk provided in Kräusel and Stromer (1924), Youssef (1993) and El-Saadawi *et al.* (2002). However, in the description of *P. aschersoni*, Kräusel and Stromer (1924) did not mention which zone(s) they described; in Youssef (1993) and El-Saadawi *et al.* (2002) only subdermal zone was described. So we cannot make a critically fair comparison with their specimens since we have only the central zone.

The diagnostic features of the present second wood specimen number 38ZN i.e., reniform-shaped sclerenchyma, rounded auricular lobes, deep rounded medium sinus, absence of fibrous bundles, presence of scattered diminutive fibrovascular bundles, one large xylem vessel, absence of radiate parenchyma, presence of idioblasts in the ground tissue concur quite well with the description of *P. wadiai* provided in Sahni (1964) and El-Saadawi *et al.* (2004), with only slight differences in quantitative features as shown in Table (1).

Table (1). Comparison between central zone of specimens of *Palmoxylon wadiai* from India and Egypt (including the present work). fv= fibrovascular.

Features	<i>P. wadiai</i> Sahni		
	India Sahni, 1964	Egypt	
		El-Saadawi <i>et al.</i> , 2004	The present work
average size of fv bundles	–	1.1x0.8mm	1.09x0.88mm
average frequency of fv bundles	20/cm ²	24/cm ²	19–22/cm ²
f/v ratio	–	1.5/1	1.4/1

According to Stenzel's classification, the two *Palmoxylon* species recorded in this work can be related to Cocos-like group of modern palms. These two species are not the only representative of the Cocos-like group in Egypt; other records are *P. libycum* (group Reniforma), *P. pyriforme* (group Sagittata), *P. stromeri* (group Vaginata) and *P. zitteli* (group Lunaria).

2. Geographic distribution and Palaeoclimate.

Genus *Palmoxylon* comprises 158 species (Mahabalé, 1959; Kaul, 1960; Sahni, 1964; Dupéron-Laudoueneix and Dupéron, 1995; Cevallos-Ferriz and Ricalde-Moreno, 1995; Kamal El-Din, 1999; Bera and Banerjee, 2001; El-Saadawi *et al.*, 2002; Conran and Rozefelds, 2003; El-Saadawi *et al.*, 2004; Zucol *et al.*, 2004; Ottone, 2007), which are spread in 6 continents

(Asia, Europe, Africa, North America, South America and Australia). Asia is the richest continent (having 74 species), followed by Europe (42 species), then Africa and North America (20 species each), South America (9 species) and Australia (one species). Geographic distribution of *Palmoxylon* species in Africa is presented in table (2).

It is worthy to mention that every continent has its own species of *Palmoxylon*, but Asia and Africa have 8 species in common (El-Saadawi *et al.*, 2004) (i.e., species typed in bold face, Table 2). However, careful future investigation may alter this picture and reduce the number of *Palmoxylon* species known from the world.

Data presented in Table (2) show that:

- I. The African *Palmoxylon* species were spread in 7 countries (12 species in Egypt, 4 in Libya, 3 in Somalia, one in each of Algeria, Ethiopia, South Africa and Tunisia) (Fig. 4).
- II. *Palmoxylon* species in Africa had long vertical extension from Cretaceous to Tertiary age but they are most widespread in the Tertiary age.
- III. *P. aschersoni* is the most wide spread species in Africa being reported from 3 countries (Algeria, Egypt and Libya). Other species are reported from only one country each, except *P. libycum* which is known from Egypt and Libya.

There is close resemblance between fossil palm flora of Egypt and Indian subcontinent (including India, Myanmar and Pakistan) because there are 8 *Palmoxylon* species namely; *P. compactum*, *P. geometricum*, *P. indicum*, *P. lacunosum*, *P. pondicherriense*, *P. pyriforme*, *P. rewahense* and *P. wadaii* common to both. Furthermore, there are other fossil remains common to Egypt and India such as *Cynometroxylon schlagintweitii* described by Kamal El-Din and El-Saadawi (2004) from Egypt and by Müller-Stoll and Mädler (1967) from India; *Dipterocarpophyllum* (a dicot leaf impression) described by Seward (1935) from the Nubian sandstone of Egypt and by Lakhanpal (1970) from India. These similar floras are due to migration of floral elements between Africa and India which were close together before "Indian plate migration" during "Continental drift" (see El-Saadawi *et al.*, 2004).

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Table (2). Age and geographic distribution of *Palmoxylon* species in Africa. Based on: 1- Dupéron-Laudouencix and Dupéron, 1995; 2- El-Saadawi *et al.*, 2004; 3- Kaul, 1960. Bold typed species names indicate their presence in Asia as well.

Taxa	Age			Country						Reference	
	Cretaceous	Tertiary	Unknown	Algeria	Egypt	Ethiopia	Libya	Somalia	S. Africa		Tunisia
<i>Palmoxylon:</i>											
<i>P. aethiopicum</i> Lemoigne		+				+					1
<i>P. aschersoni</i> Schenk		+		+	+		+				1
<i>P. benadirensis</i> Chiargui	+							+			1
<i>P. compactum</i> Shani		+			+						2
<i>P. cossonii</i> Fliche		+								+	1
<i>P. dutoitti</i> Kaul			+						+		3
<i>P. geometricum</i> Sahní		+			+						2
<i>P. giarabubense</i> Chiargui		+					+				1
<i>P. Indicum</i> Shani		+			+						2
<i>P. lacunosum</i> (Unger) Felix		+			+						1
<i>P. libycum</i> (Stenzel) Kräusel		+			+		+				1
<i>P. aff. libycum</i> (Stenzel) Kräusel		+					+				1
<i>P. pondicherriense</i> Sahní		+			+						2
<i>P. pyriforme</i> Shani		+			+						2
<i>P. rewahense</i> Sahní		+			+						2
<i>P. scebelianum</i> Chiargui	+?							+			1
<i>P. somalense</i> Chiargui	+?							+			1
<i>P. stromeri</i> Kräusel	+				+						1
<i>P. wadiat</i> Sahní		+			+						2
<i>P. zitteli</i> Schenk	+?				+						1

The palaeoclimate under which the two reported *Palmoxylon* species lived must have been tropical or subtropical based on comparison with climates under which modern palms live today (El-Saadawi *et al.*, 2004). Likewise 5 out of the 6 species reported by Mostafa (2009) from almost the same study area also indicate tropical climate.

3. Fossil remains of Arecaceae in Egypt.

To date, the number of Egyptian fossil wood species assigned to the Arecaceae is 12 species belonging to one genus (*Palmoxylon*). This genus is not the only representative of the family in Egypt; another genus is *Palmocaulon* (a sheathing leaf base) reported from the Miocene of Qaret El-Raml by Kamal El-Din (1999) but without reference to any particular species due to bad preservation, in addition to that, a structure related to the extant *Hyphaene thebaica* (L.) C. Martius reported from the Miocene of Moghra by Fourtau (1918). Other fossil records belonging to Arecaceae in Egypt are: 4 fruits, 3 leaves and one rhizome as detailed below.

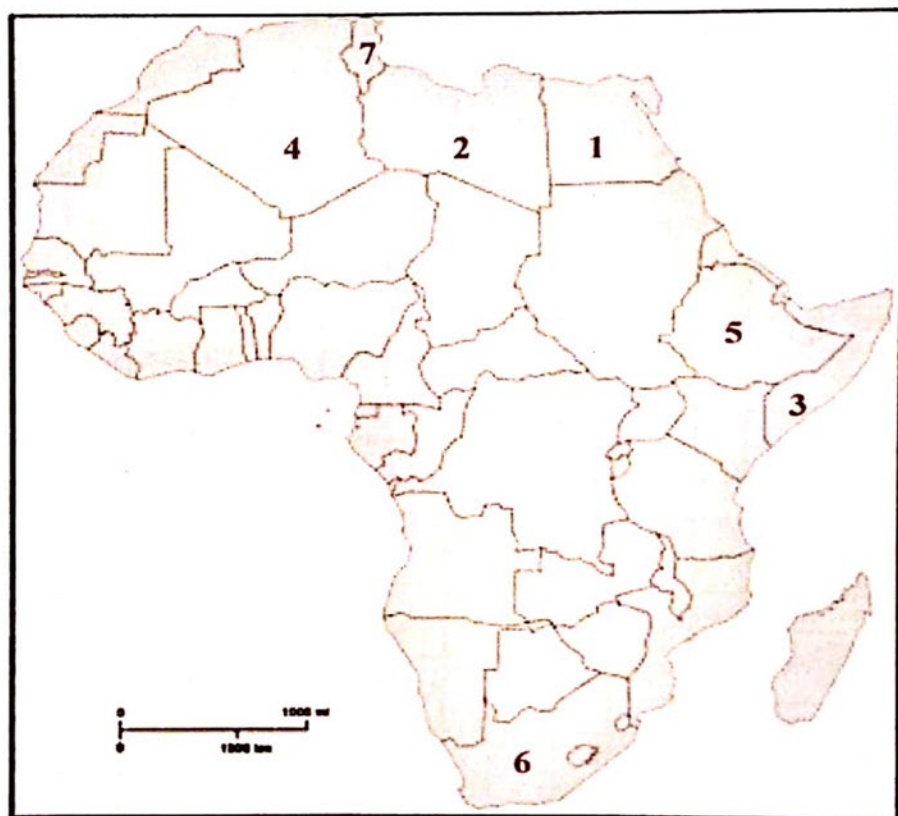


Fig. 4. Map showing the geographic distribution of *Palmoxylon* in Africa. 1: Egypt, 2: Libya, 3: Somalia, 4: Algeria, 5: Ethiopia, 6: South Africa, 7: Tunisia.

1. cf. *Coryphoicarpus globoides* Koch; a fruit cast reported from the Cretaceous-Palaeocene boundary of Danian-Abu Munqar, Farafra-Dakhla Road by Gregor and Hagn (1982).
2. *Hyphaeneocarpon aegyptiacum* Vaudois-Miéja and Lejal-Nicol; silicified endocarp of a fruit reported from the Cretaceous of Aswan area by Vaudois-Miéja and Lejal-Nicol (1987).
3. *Nipa burtini* (Brongniart) Ettingshausen (= *Nipadites sickenbergeri*); a fruit cast reported from the Cretaceous-Palaeocene boundary of Danian-Abu Munqar, Farafra-Dakhla Road and from the Middle Eocene of Gebel Giuschi (chain of Mokattam mountain, east of Cairo) by Bonnet (1904), Frass (1867) and Gregor and Hagn (1982).
4. *Palmacites rimosus* Heer; a fruit cast reported from the Cretaceous of Kharga Oasis by Heer (1876).
5. ? *Phoenix sylvestris* Rosch; a leaf impression reported from the Pleistocene of Kharga Oasis by Gardner (1935).
6. *Sabalites* sp.; a palmate leaf impression reported from the Middle to Late Cretaceous of Aswan area by Fritel (1926).
7. Fan shaped leaves of palms reported from the Oligocene of Gebel Qatrani Formation by Wing and Tiffney (1982).

8. A rhizome cast probably of *Nipa fruticans* reported from the Late-Middle Eocene Camp White Layer at the top of Gehannam Formation in Wadi Hitan, west of Fayum Depression by El-Saadawi (2005).

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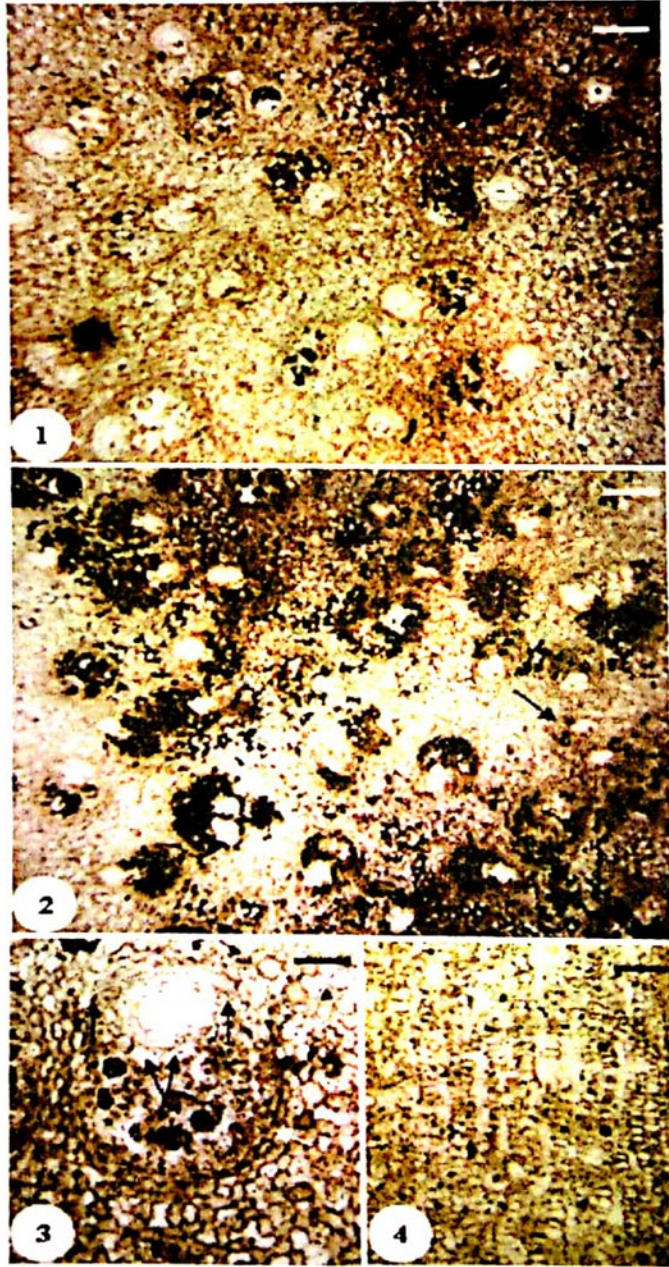


Plate I. *Palmoxylon aschersoni* Schenk. 1: Cross-section showing irregular distribution of fibrovascular bundles in central zone; 2: Cross-section showing diminutive fibrovascular bundle (arrowed); 3: Cross-section magnified to show launate shaped sclerenchyma, angular auricular lobes (black arrows), rounded median sinus, phloem masses (forked arrow), tabular parenchyma (white arrow), one large vessel per bundle, compact ground tissue with small air spaces; 4: Longitudinal-section showing vertical rows of parenchyma cells. — Scale bar = 78 μ m for 1, 87 μ m for 2, 36 μ m for 3, 37 μ m for 4.

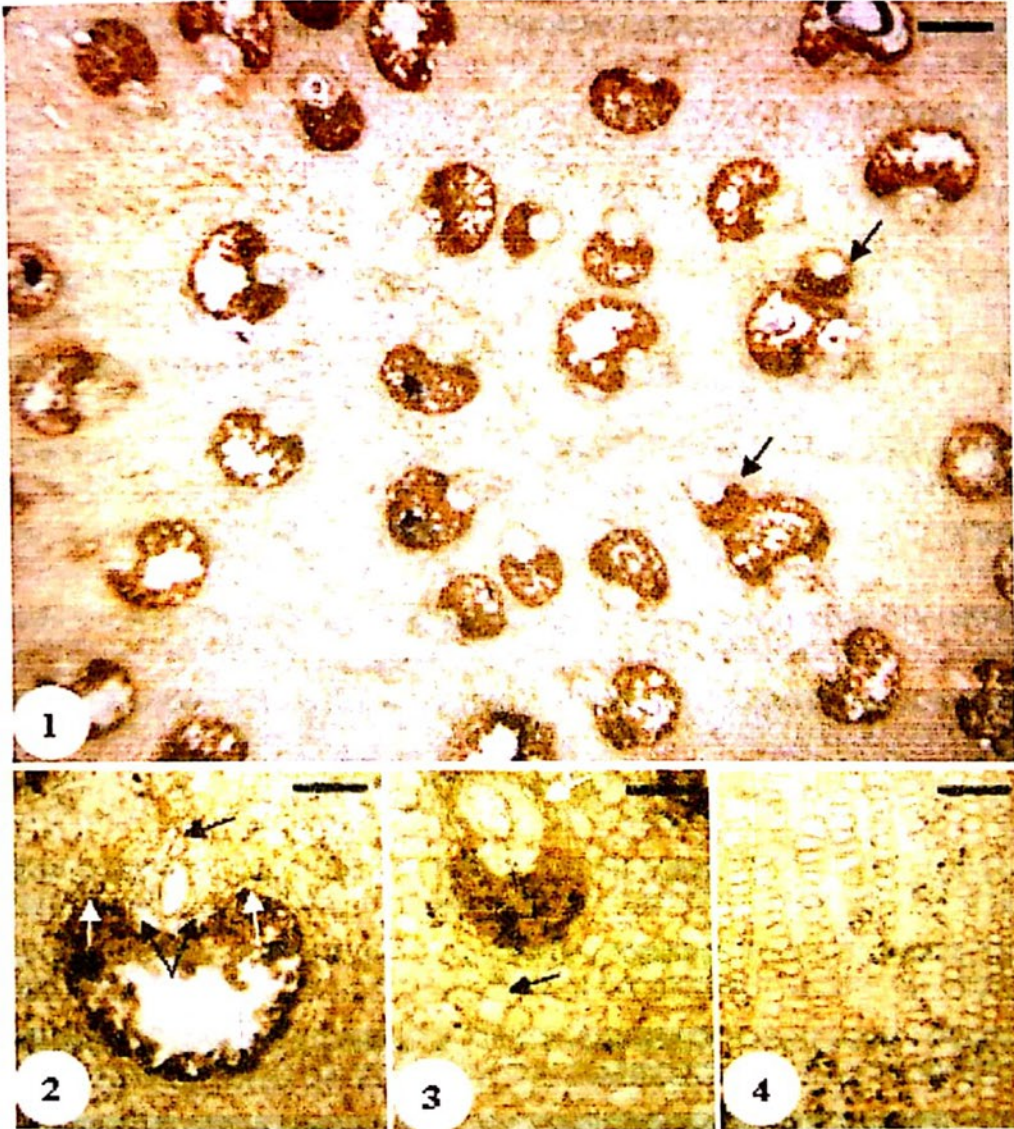


Plate II. *P. wadii* Sahnii. 1: Cross-section showing irregular distribution of fibrovascular bundles in central zone, diminutive fibrovascular bundle (arrowed); 2: Cross-section magnified to show reniform shaped sclerenchyma, rounded auricular lobes (white arrows), deep rounded median sinus, phloem masses (forked arrow), leaf trace (a group of protoxylem vessels) (black arrow), one large vessel per bundle; 3: Cross-section magnified to show tabular parenchyma (white arrow), lacunar ground tissue with angular interspaces (black arrow); 4: Longitudinal-section showing vertical rows of parenchyma cells separated by small air spaces. — Scale bar = 89 μ m for 1, 44 μ m for 2 and 3, 25 μ m for 4.