Fossil palm woods of Egypt. I- *Palmoxylon aschersoni* Schenk and *P. libycum* (Stenzel) Kräusel

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Palmoxylon aschersoni and *P. libycum*, were described, based on investigation of specimens collected from new sites in Egypt, these were compared with earlier finds and differences noted. Distribution of the two species in Africa and their affinities are given.

***Key words*:** *Palmoxylon aschersoni*, *P. libycum*, Tertiary, Egypt.

Introduction

There are about 130 *Palmoxylon* species reported worldwide: Asia, Europe, Africa and the New World, of which only five species have been reported, up till now, from Egypt. The five species are:

i- *Palmoxylon aschersoni* Schenk: from Tertiary of the Eastern Desert, Western Destert and Sinai (Stenzel, 1904; Kräusel & Stromer, 1924; Kräusel, 1939; Kaul, 1960; Louvet, 1973; Boureau *et al.*, 1983; Youssef, 1993; Dupéron-Laudoueneix & Dupéron, 1995). Reference had been made to two varieties of *P. aschersoni*: var. *verum* and var. *schweinfurthi* (see Stenzel, 1904; Kaul, 1960; Dupéron-Laudoueneix & Dupéron, 1995).

ii- *P. lacunosum* (Unger) Felix: from Tertiary of the Western Desert (Kräusel & Stromer, 1924; Kräusel, 1939; Kaul, 1960; Dupèron-Laudoueneix & Dupéron, 1995).

iii- *P. libycum* (Stenzel) Kräusel: from Tertiary of the Eastern Desert, Western Desert and Sinai (Stenzel, 1904; Kräusel & Stromer, 1924; Kräusel, 1939; Youssef, 1993; Dupéron-Laudoueneix & Dupéron, 1995).

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iv- *P. stromeri* (Kräusel) Kräusel (=*P. lacunosum* var. *stromeri* Kräusel): from Late Cretaceous of the Eastern Desert (Stenzel, 1904; Kräusel & Stromer, 1924; Kräusel, 1939; Kaul, 1960; Dupéron-Laudoueneix & Dupéron, 1995).

v- *P. zitteli* Schenk: from Late Cretaceous of the Western Desert (Stenzel, 1904; Kräusel & Stromer, 1924; Kräusel, 1939; Kaul, 1960; Dupéron-Laudoueneix & Dupéron, 1995).

Palmoxylon stromeri and *P. zitteli* are of Cretaceous age and come from the southern part of Egypt, while *Palmoxylon aschersoni*, *P. lacunosum* and *P. libycum* are of younger age and come from the northern parts of the country. In general the age of *Palmoxylon* in Egypt extends from Late Cretaceous (Senonian) to Late Tertiary (Pliocene) and its remains come mainly from sites in the Western Desert (Fig. 1). There is however, a much earlier report on the occurrence of a specimen of palm trunk in Aswan area (Upper Egypt) by Roziére (1813-24), but without reference to any particular taxon.

Other palm remains reported from Egypt include four fruits (cf. *Coryphoicarpus globoides* Koch., *Hyphaeneocarpon aegyptiacum* Vaudois-Miéja & Lejal-Nicol, *Nipa burtini* (Brongniart) Ettingshausen and *Palmacites rimosus* Heer); one leaf (*Sabalites* sp.) and one sheathing leaf base (*Palmocaulon*). These remains are of similar age to the stems of Middle-Late Cretaceous to Miocene reported by Heer, 1876; Bonnet, 1904; Kräusel & Stromer, 1924; Fritel, 1926; Kräusel, 1939; Chandler, 1954; Kaul, 1960; Gregor & Hagn, 1982; Boureau *et al*. 1983; Vaudois-Miéja & Lejal-Nicol, 1987; Kamal El-Din, 1999). In addition to these remains a Miocene structure referred to *Hyphaene thebaica* (L.) C. Martius was reported by Fourtau (1918), a Pleistocene leaf of ? *Phoenix sylvestris* Rosch by Gardner (1935) and Oligocene fan-shaped leaves of palms by Wing & Tiffney (1982).

The aim of this paper is to describe specimens of *Palmoxylon aschersoni* and *P. libycum* collected from new as well as old sites in Egypt and to compare them with earlier descriptions.

Materials and Methods

Fifty-two (48 well-preserved and 4 ill-preserved) specimens of fossil palms were collected between the years 1995-1997 from seven sites (Qaret EL-Raml, Gebel Ruzza, Tall EL-Zalat, Gebel Qatrani, Gebel El-Khashab (Southern Petrified Forest), Qattamiya, and Wadi Natrun, Fig. 1)

The first five sites are new (no palms reported earlier from them) while the other two sites are old (cf. Stenzel, 1904; Kräusel & Stromer, 1924; Kräusel, 1939). The specimens were taken from small or large trunk fragments reaching 3m in length and 0.5m in diameter (see Fig. 3).

Ground thin sections (T.S. & L.S.) were prepared from all collected specimens (cf. Lacey, 1963). The specimens and slides are deposited in the palaeobotanical collection of the Department of Botany, University of Ain Shams, Cairo, Egypt.

A large number of microphotographs have been taken to show fine details of cross and longitudinal sections prepared form the collected specimens using a light microscope, Minolta XEII camera and Kodak films.

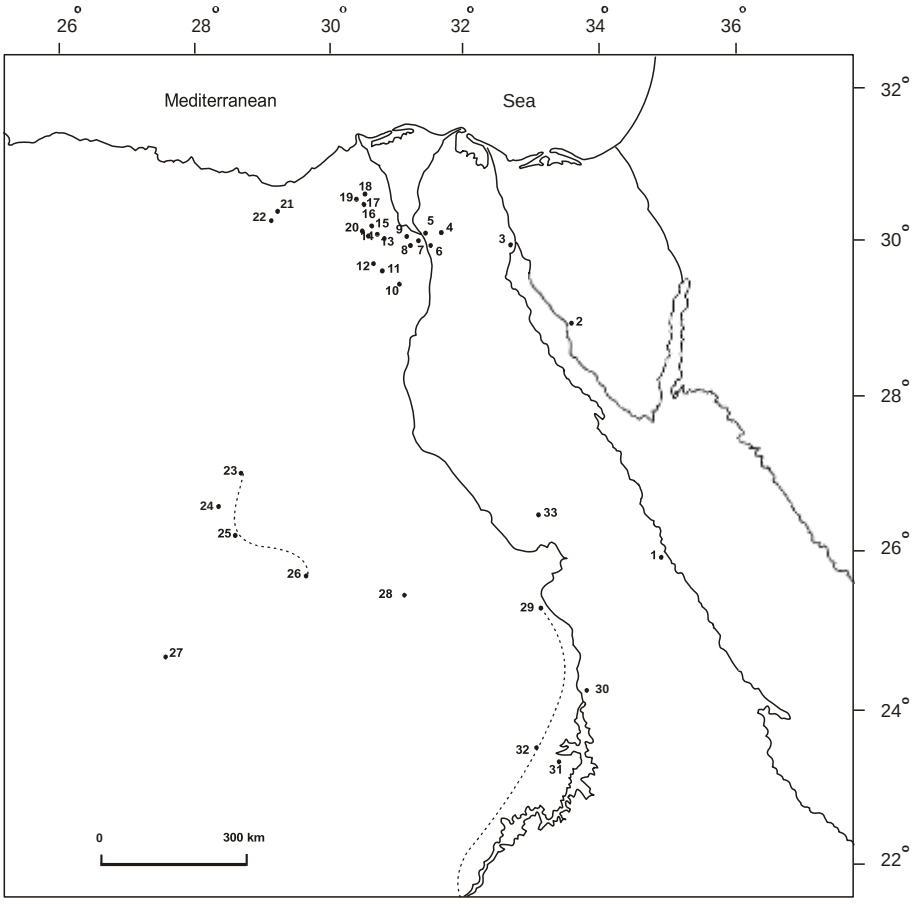

Fig. 1. Map showing sites from which fossil palm remains (leaves, fruits & stems) were recorded in Egypt. Names of the five new sites of collection are bold typed below.
1-Quseir, 2- Gebel Hadahid and Gebel El-Bahr in Sinai, 3- Suez, 4- Qattamiya, 5- Gebel Ahmer, 6- Gebel Giuschi and Gebel Mokattam, 7- Giza Pyramids and Abu Roasch, 8-Gebel El-Khashab (Northern Petrified Forest & **Southern Petrified Forest**), 9 -**Tall El-Zalat**, 10- Faiyum, 11- Birket Qarun, 12- **Gebel Qatrani,** 13- **Qaret El-Raml,** 14- **Gebel Ruzza**, 15- Wadi Faregh, 16- Deir Abu Makâr, 17- Garet El-Muluk, 18- Wadi Natrun, 19- Deir Baramûs, 20- Garet Aujân, 21- Bir Lebuk, 22- Moghra, 23- Farafra, 24- Abu Munqar, 25- Road between Farafra and Dakhla, 26- Dakhla, 27- Regenfeld, 28- Kharga, 29- Esna, 30- Aswan, 31- Lake Nasser Abu Simbel, 32- Road between Esna and Wadi Halfa, 33- Wadi Hammamat.

Identification

Careful study of the anatomy of the 48 well-preserved *Palmoxylon* specimens and following Stenzel's 1904 scheme of classification (see Fig. 2); the 48 specimens proved to belong to 13 distinct species. Ten specimens belonged to *Palmoxylon aschersoni* and four specimens to *P. libycum*; both are old records while the remaining 34 specimens were not described earlier from Egypt and will be the subject of forthcoming publications.

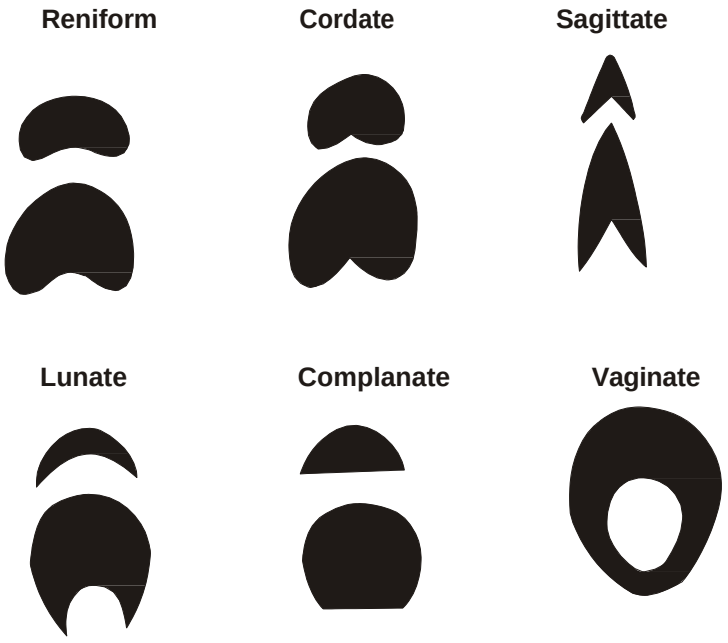

Fig. 2. Different forms of sclerenchyma in palm stems, according to Stenzel's classification scheme (after Sahni, 1964).

Palmoxylon aschersoni and *P. libycum* belong to groups Lunaria and Reniformia respectively (Fig. 2). In this aspect, we have to indicate the number of specimens collected from each site.

Palmoxylon aschersoni: Qaret EL-Raml (Early Miocene, specimens Nos. 129, 130, 130`, 132, 139), Gebel Ruzza (Early Miocene, specimen No. 21), Wadi Natrun (Miocene, specimens Nos. 1, 3, 4, 11). *P.libycum* : Wadi Natrun (Miocene, specimens Nos. 5, 12), Gebel El-Khashab Southern Petrified Forest (Early Miocene, specimens Nos. 3, 4).

Description

Group: Lunaria Stenzel

***Palmoxylon aschersoni* Schenk, (Figs. 4-7)**

Parts available: Subdermal zone.

Fibrovascular bundles mainly regular in distribution, average size 1.3x0.9mm, average frequency 26-35 per cm^2, f/v ratio (the ratio between areas occupied by the sclerenchyma and the vascular part as seen in cross section) 2/1 (Fig. 4).

Sclerenchyma lunate (Fig. 5), orbicular, rarely more or less renifrom (Fig. 6), auricular lobes angular (Fig. 5), rarely± rounded (Fig. 6), median sinus rounded (Figs. 5, 6). Fibrous bundles absent. Diminutive fibrovascular bundles present. Xylem one large vessel (Fig. 6) or bivasal (Fig. 5). Phloem ill-preserved in two masses (Fig. 6). Ground tissue compact with small air spaces, tabular parenchyma 1-2 layers around the fibrovascular bundle (Fig. 6), radiate parenchyma absent. Leaf traces present.

In longitudinal section: parenchyma cells appear in contiguous vertical rows, separated by small air spaces at intervals. Perforation plates with oblique end walls (Fig. 7), intervessel pits alternate (Fig.7).

Fig. 3. A palm trunk at Gebel El-Khashab, x 0.2 one of the sites of collection.

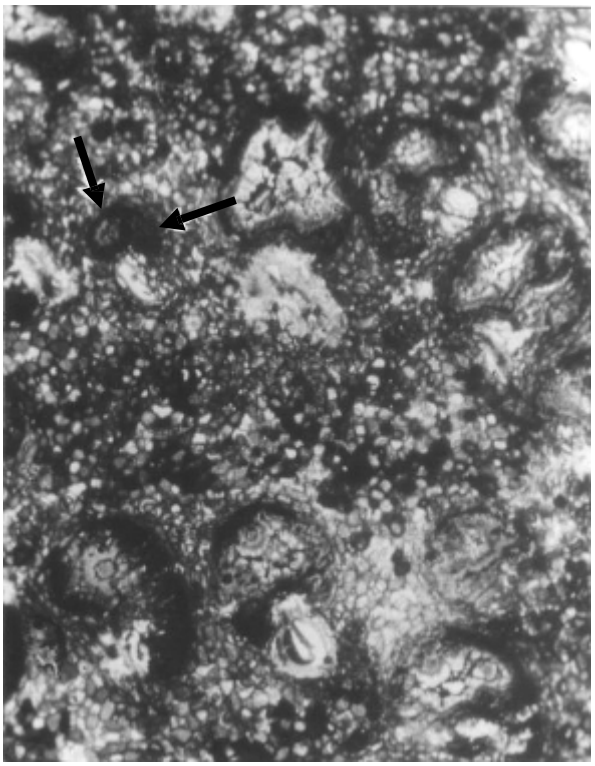

Fig. 4. *Palmoxylon aschersoni*, cross section showing distribution of fibrovascular bundles, and diminutive fibrovascular bundle (arrows),x 15.

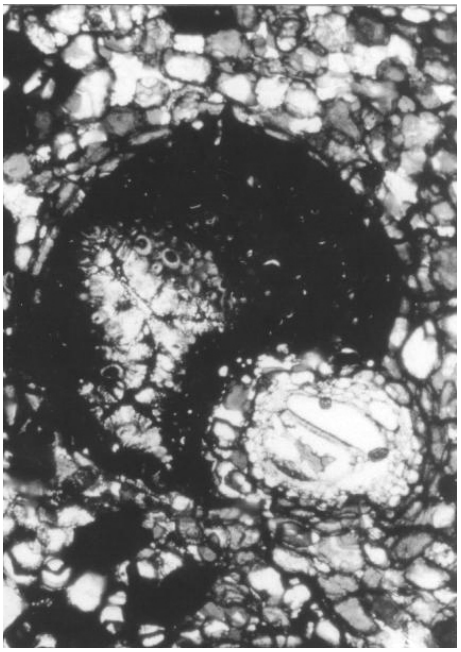

Fig. 5. *Palmoxylon aschersoni*, part of a cross section magnified to show lunate shaped sclerenchyma, auricular lobes, median sinus, and xylem vessels, x70.

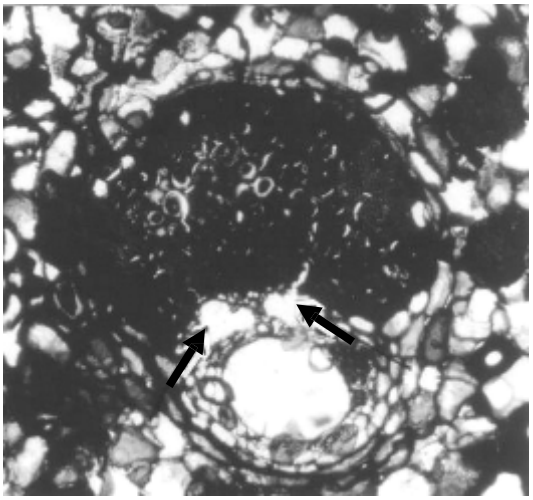

Fig. 6. *Palmoxylon aschersoni*, part of a cross section magnified to show xylem vessels, phloem masses (arrows), and tabular parenchyma around the whole bundle, x70.

Fig. 7. *Palmoxylon aschersoni*, part of a longitudinal section magnified to show alternate intervessel pits and oblique end walls, x130.

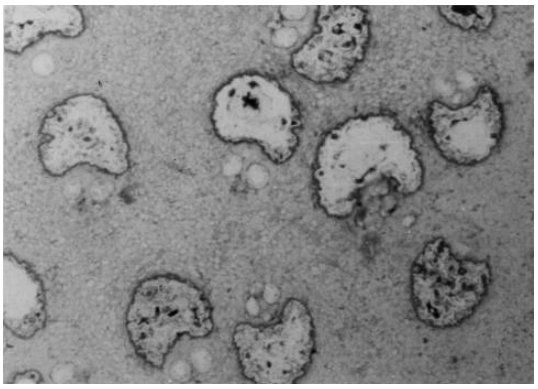

Fig. 8. *Palmoxylon libycum*, cross section showing irregular distribution of fibrovascular bundles, and reniform sclerenchyma, x20.

Group: Reniformia Stenzel

***Palmoxylon libycum* (Stenzel) Kräusel, (Figs. 8-10)**
Syn. *P. cottae* Unger var. *Libycum* Stenzel.
Parts available: Central zone

Fibrovascular bundles irregular in distribution, average size 1.4x1mm, average frequency 29-41 per cm^2, f/v ratio 1.5-2/1 (Fig. 8). Sclerenchyma reniform (Fig. 8), auricular lobes rounded (Fig. 8), median sinus rounded and shallow (Fig. 8). Fibrous bundles absent. Diminutive fibrovascular bundles absent. Xylem two rounded vessels 0.26 x 0.36 mm (Fig. 9). Phloem ill-preserved in 1-2 masses. Ground tissue compact, cells thin-walled and small, tabular parenchyma 1-2 layers over sclerenchyma (Fig. 9), radiate parenchyma absent. Leaf traces absent.

In longitudinal section: parenchyma cells appear in contiguous vertical rows (Fig. 10). Perforation plates simple, intervessel pits alternate and spiral (Fig. 10).

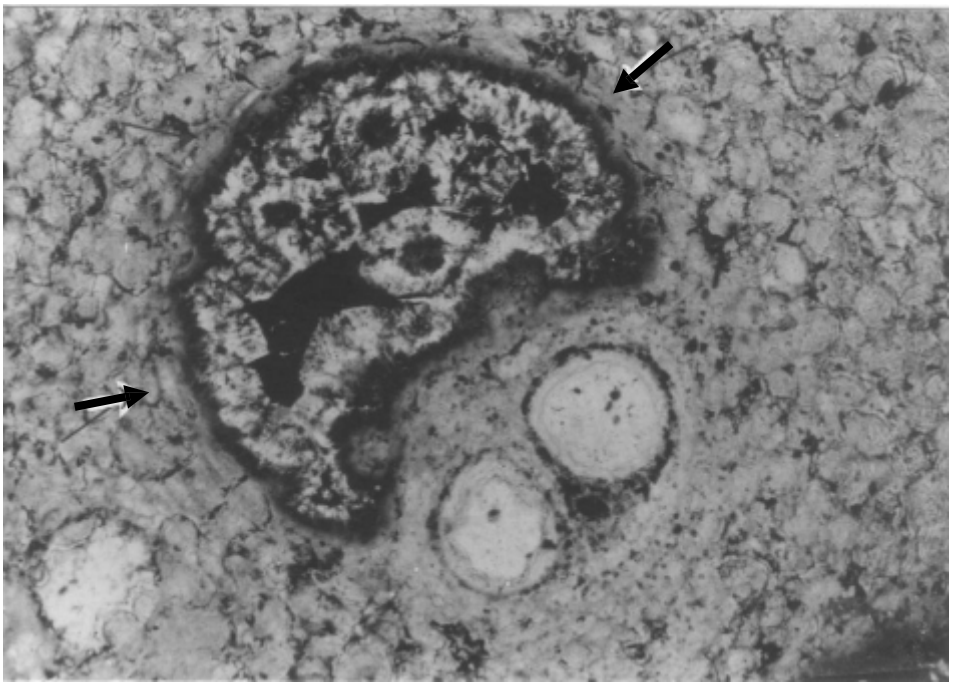

Fig. 9. *Palmoxylon libycum*, part of a cross section magnified to show reniform sclerenchyma, auricular lobes, median sinus, xylem vessels, ground tissue, and tabular parenchyma (arrows), x70.

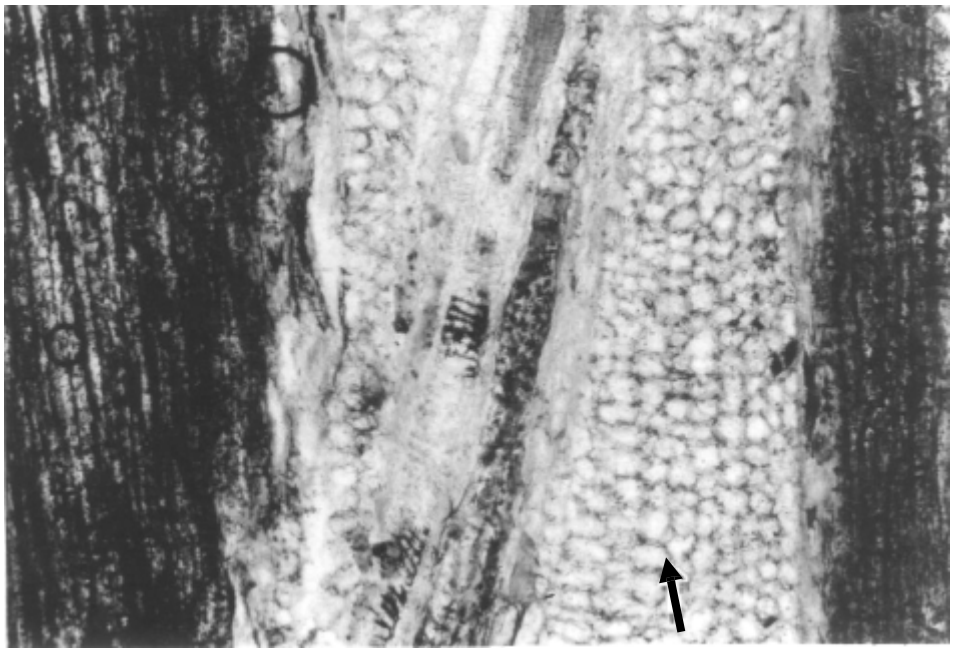

Fig. 10. *Palmoxylon libycum*, longitudinal section showing compact parenchyma cells (arrow) and other anatomical features, x65.

Comparisons and Affinities

There are some slight differences in the description of *P. aschersoni* and *P. libycum* as given by Kräusel and Stromer (1924) and as observed in present work (Table 1).

Table 1. Wood features of *Palmoxylon aschersoni* and *P. libycum* as given by Kräusel & Stromer (1924) and as observed in present work.

Features	*P. aschersoni*	
	Kräusel & Stromer, (1924)	Present work
Parts available	Not mentioned	Subdermal zone
Average size of bundles	2x0.75mm	1.3x0.9mm
Average frequency of bundles	23-38 per cm^2	26-35per cm^2
P. libycum		
Parts available	Not mentioned	Central zone
Average size of bundles	1.5x0.8mm	1.4x1mm
Average frequency of bundles	22-40 per cm^2	29-41 per cm^2

The present results indicate that *P. aschersoni* (10 specimens) was not only more common in Egypt than *P. libycum* (4 specimens) but as reported also by Kräusel & Stromer (1924) and Youssef (1993) it was more widespread; being reported from 15 sites (Gebel Hadahid-Gebel El-Bahr, Suez, Qattamiya, Giza Pyramids, Abu Roasch, Gebel El-Khashab (Northern Petrified Forest), Fayum, Qaret El-Raml, Gebel Ruzza, Garet El-Muluk, Wadi Faregh, Wadi Natrun, Garet Aujân, Bir Lebuk, Moghra) compared to eight sites (Gebel Hadahid-Gebel El-Bahr, Qattamiya, Gebel El-Khashab (Southern Petrified Forest), Giza Pyramids, Birket Qarun, Wadi Faregh, Wadi Natrun, Deir Baramus) for *P. libycum.*

Furthermore *P. aschersoni* was more widespread in Africa being reported from the Early Miocene of Libya, Tertiary of Algeria and Tertiary of the Sudan (Chiarugi, 1929a; Louvet, 1973; Delteil-Desneux & Koeniguer, 1974; Boureau *et al*. 1983; Dupéron-Laudoueneix & Dupéron, 1995) while *P. libycum* was reported from only the Tertiary of Libya (Chiarugi, 1929b; Boureau *et al*. 1983; Dupéron-Laudoueneix & Dupéron, 1995).

Many authors worked on the anatomy of the modern palms as Karsten (1847), Mohl (1849), Eichler (1886), Stenzel (1904), Strasburger (1906), Solereder & Meyer (1928), Kaul (1960), Tomlinson (1961a, b) and others. Only Mohl (1849), classified modern palms on the basis of the stem anatomy; his artificial classification is hitherto the best available scheme of grouping palm stems (cf. Sahni, 1964). He recognized five types namely: 1- Geonoma-like (Corypha-like) forms, 2- Calamus-like forms, 3- Mauritia-like forms, 4- Coccos-like forms and 5- Stemless-palms forms.

Stenzel (1904) used Mohl`s (1849) scheme in his work on fossil palm species and accordingly the main fossil types recognized by the first are grouped only under Corypha-like and Cocos-like. Anatomical features of the two studied species in this work (*Palmoxylon aschersoni* of group Lunaria and *P. libycum* of group Reniformia) show that they are related to Cocos-like forms, extant representatives of which are widely distributed in Africa including Egypt (cf. Mabberley, 1990; Bebawi & Neugebohrn, 1991; El-Hadidi & Fayed, 1994/1995).

It must be mentioned that *P. stromeri* (group Vaginata) and *P. zitteli*(group Lunaria) which were reported earlier from Egypt by Kräusel & Stromer (1924) and Kräusel (1939) belong also to Cocos-like forms (cf. Kamal El-Din, 1999) whereas *P. lacunosum* of group Complanta (reported earlier from Egypt by Kräusel & Stromer, 1924 and Kräusel, 1939) belongs to the Corypha-like forms (Stenzel, 1904).

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