

A study on
THE POLLEN FLORA OF SUDAN
with special reference to pollen identification

by

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Thesis submitted for the award of Dr.Scient. degree

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June 1989

Acknowledgement

This work has been financially supported by a grant from the Norwegian Agency for International Development (NORAD) to whom I am grateful. I am also deeply grateful to the National Council for Research, Khartoum, Sudan, for releasing me to pursue this research and providing additional support. My thanks are also due to the Botanical Institute, University of Bergen for various facilities.

I would like to express my appreciation and gratitude to my supervisor Knut Krzywinski who introduced me to the subject and has given me much of his time.

Professor Knut Fægri showed constant interest throughout the course of this work and willingly provided much of his knowledge and experience. I would like to thank him for his assistance with microscope work, his critical review and comments.

Equally appreciated is the help of Dr. Hilary Birks who solved many of my linguistic barriers in addition to giving her advice and suggestions.

I also wish to thank Professor Peter Emil Kaland together with Knut Krzywinski for providing me with the practical and theoretical basis for this work, and running some courses only for me. My thanks are also due to Professor John Birks (University of Bergen), Dr. E.A. Bari and Dr. Babiker F. Mohamed (University of Khartoum) for making comments on earlier drafts of this work, Professor Jim Ritchie (University of Toronto, Canada) for comments and suggestions on the list of the species examined, and Professor Wim Punt (State University, Utrecht) for fruitful comments on endoaperture morphology.

I am particularly indebted to Professor Raymonde Bonnefille for the use of various facilities and offering reference slides as part of exchange programme from the Laboratoire de Geologie du Quaternaire (CNRS, Marseille, France), Dr. A.M. Lezine, Guy Riollet for comments and suggestions on earlier drafts of the manuscript and to other members of the laboratory for hospitality.

Sincere thanks are due to the directors and curators of BG, K, KHF, KHU and LD herbaria for providing polliniferous material from their collections, with special reference to Dagfinn Moe (University of Bergen), Professor Sven Snogerup and Dr. Annette Carlström (University of Lund), and Dr. John Dransfield and Dr. Carl Furness (Royal Botanic Garden, Kew).

The technical assistance of Jan Berge with scanning electron microscopy and micrographs, and Siri Herland for some of the line illustrations is gratefully acknowledged.

My colleagues and friends Aage Paus, Jan Berge and Sverre Sivertsen were my "unofficial supervisors" for most of my microscopical work. Our discussions on various aspects have broadened my thinking and increased my enthusiasm for the subject.

Lastly, I would like to dedicate this work to my family, Sarra, Mayada and Mo'ayad who have given me a lot of their time, patience and endless encouragement when my fighting spirit tended to fail.

Abstract

The study illustrates , using both light and scanning electron microscopy , 320 Sudanese plant species of which the pollen grains of more than $\frac{1}{4}$ are described for the first time. The material examined is selected among the recognised ecological indicators , endemic species , and taxa recorded in Quaternary deposits of Sudan.

Notes on habit , habitat and distribution (with maps where possible) for each of the species examined is included. In pollen identification , an illustrated master key comprising 20 pollen classes was constructed , followed by a detailed illustrated key to the pollen types.

Comments related to previous descriptions are also included and discussed.

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1

CHAPTER I

Introduction

The study of pollen morphology, being dependant on the use of microscopes, is the direct consequence of the inventions and advancements in optical technology in the middle of the seventeenth century. From this date onwards, various pollen morphological studies have been made to advance knowledge in morphological botany, or to supplement the taxonomic description of plants.

Pollen grains, with their special morphology, offer many characters of taxonomic value at the family, generic or specific level. Pollen identification is important in various fields of science such as historical phytogeography, Quaternary palynology, Quaternary geology, palaeobotany, palaeoecology, archaeology, aeropalynology, melissopalynology etc.

Regional and local pollen floras and pollen identification for some parts of the Africa are very well established: Central Africa (Assemien 1966), East Africa (Bonfille & Rioulet 1980), Tropical Africa (A.P.L.F. 1974), South Africa (Van Zinderen Bakker 1953, 1956; Van Zinderen Bakker & Coetzee 1959), Ethiopia (Bonfille 1971 a, b), Nigeria (Sowunmi 1973), Ivory Coast (Ybert 1979), Tchad (Maley 1970) and Africa (Van Campo 1957, 1958, 1960; Van Campo & Halle 1959; Van Campo *et al.* 1964, 1965; Bronckers 1967, Guinet 1968, Lobreau *et al.* 1969, Guers 1970, Guers *et al.* 1971).

Fossil pollen grains are valuable indicators of conditions in the past and can be used in the reconstruction of past floras and past plant populations (Birks 1973), and past plant communities (Reyment 1963, Iversen 1964, Andersen 1961, Davis 1967), as well as past environments (Birks 1979, Grichuk 1969, Webb & Clark 1977).

Although the importance of vegetation history had been recognized since the 19th century, little progress had been made until Lennart von Post (1918) laid out the fundamental approach of quantitative pollen analysis. Though the techniques and equipment have been developed and improved since then, the basic methods remain the same (Birks & Birks 1980). However, the subject gained momentum and hence recognition some five decades ago in North-West Europe and North America. Through time, results have become more accurate and detailed, leading to new dimensions in our knowledge of vegetation history. The interaction of man and his environment and the vegetation response to climatic changes through time have now been traced in many parts of the world (Howe & Webb 1983, Bartlein *et al.* 1984, Sabatier & Van Campo 1983).

Sudan, a large tropical, subsaharan country approaching one million square miles in area, has received very little pollen analytical attention. Evidence and / or data of climatic and vegetational changes in Sudan has been obtained from studies on: movement of former vegetational belts (Wickens 1975a); paleo-lakes (Pachur & Kropelin 1987; Haynes *et al.* 1979); sand dune trends (Warren 1970); fluctuations of water levels in Blue and White Nile (Adamson *et al.* 1980, Williams & Adamson 1973, 1974); fossil plants, fruits, seeds and impressions (Wickens 1975b, Colchester 1927, Arkell 1949, Mehringer 1982); sub-fossil aquatic and land snails (Haynes & Mead 1987, Pachur & Kropelin 1987), and fossil savanna and domestic faunas (Pachur & Kropelin 1987, Shaw 1936).

Pollen analytical evidence in Sudan is represented by the work of Mehringer (1982), Haynes (1987), Ritchie (1987), Ritchie *et al.*

(1985) and Ritchie & Haynes (1987). All these studies were done on the fossil-bearing Holocene lake sediments from Northwestern Sudan (Bir Artun , Selima oases and Oyo).

Although this evidence has established that changes in climate and vegetation have occurred , a firm pollen analytical background for the vegetational history of the whole country is not yet available.

a- Aim of the study :

The present study was designed and conducted to fulfill the following aims : 1- to provide a preliminary survey as a basis for future studies in this field in Sudan , 2- to document the morphology of Sudan's pollen grains to provide a pollen reference material for both pollen analysis of Quaternary deposits and aeropalynology , 3- to construct illustrated keys to facilitate the recognition of the species under study , and 4- to provide additional or confirmatory characters to be used in plant taxonomy.

The application of this study is not , however , limited to the Republic of Sudan , because of the wide floristic regions it includes. According to White (1983) fig. 1 , the following floristic regions exist in Sudan :

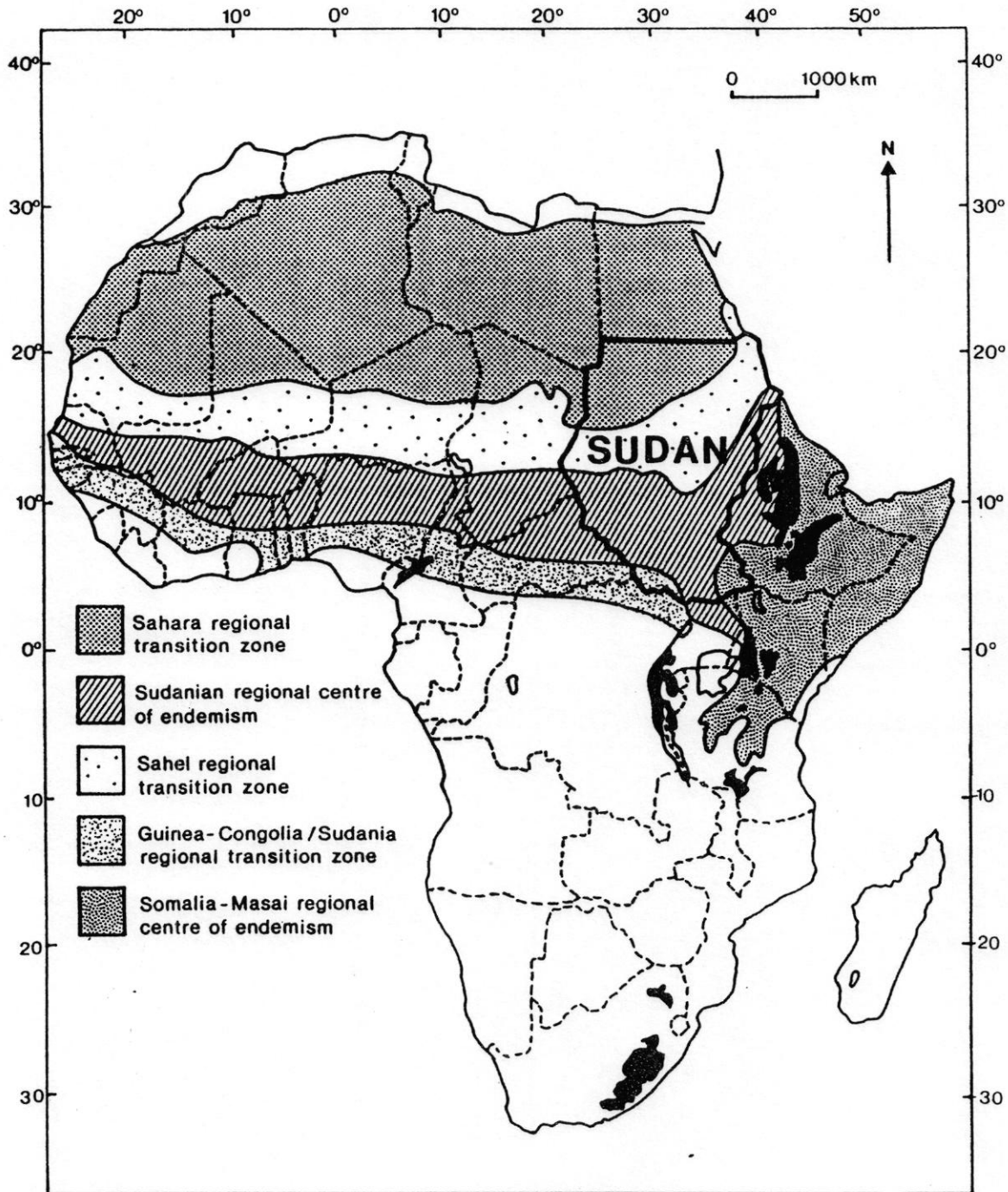
- a- Sudanian Regional Centre of Endemism.
- b- Sahel Regional Transition Zone
- c- Saharan Region Transitional Zone.
- d- Guinea-Congolia / Sudania Regional Transition Zone.
- e- Somalia-Masai Regional Centre of Endemism.

b- Previous Work :

Pollen morphological studies in Sudan are few. El Amin (1972) recognized 4 pollen types in Sudan Acacias correlated with the presence/absence and dimensions of the stipitate glands.

Other previous work done on Sudanese plant species is outlined in chapter VI , under the morphologic description of each taxon. Reference is given only to sources dealing with pollen morphology.

Fig. 1 Main floristic regions of Sudan and other African countries sharing the same regions after White 1983



CHAPTER II

Area of study

a- Geography :

Sudan is the largest country in Africa with an area of 967,498 square miles (2,496,138 km²). It is bounded by Egypt in the North ; by the Red Sea in the North-East ; by Ethiopia in the East ; by Kenya and Uganda in the South ; by Central Africa in the South-West ; by Chad in the West ; and by Libya in the North-West.

The study area (fig. 2) , lies approximately between latitude 21⁰ 55' and 3⁰ 53' N , and longitude 21⁰ 54' and 39⁰ 30' E. It represents a substantial portion of the transition between the drought-devastated Sahel and the fragile dry savanna belt in Central Sudan.

b- Climate :

The climate of the Sudan (fig. 3) is wholly tropical and varies from complete desert north of 18⁰ N through regions of semi-desert with rainfall of varying intensity and duration , passing southwards into a continental equatorial type of climate with a considerable dry season , even in the extreme south (Lebon 1965 , Whiteman 1971). The Red Sea introduces certain maritime characteristics , but these are confined to the narrow coastal plain and the eastern slopes of the Red Sea Hills (Ireland 1948).

c- Flora and Vegetation :

The flora of Sudan is relatively rich in species corresponding to the wide range of ecological habitats and vegetational zones. The flora of Sudan has been studied by Broun and Massey (1929) , and Andrews (1950 , 1952 , 1956). Other contributions towards regional floras include Crowfoot (1928) ; Andrews (1947) ; Obeid & Mahmoud (1968) ; Ahti *et al.* (1973) ; Hassan (1974) ; and Wickens (1976). Other aspects of the flora such as trees and shrubs , soil and vegetation were studied by Sahni (1968) , and Willimott (1957) respectively.

The vegetation of Sudan has been described by Andrews (1948) , Smith (1949) , Jackson (1953-54) , Harrison & Jackson (1958) , Lebon (1965) and Wickens (1976).

Harrison & Jackson 's (1958) work still remains the most comprehensive study. According to variations in rainfall and soil , they recognized 5 main vegetational types (fig. 4).

I- Desert :

The average rainfall is less than 75 mm/annum. The vegetation is

Fig. 2 Republic of Sudan Relief and general locality map

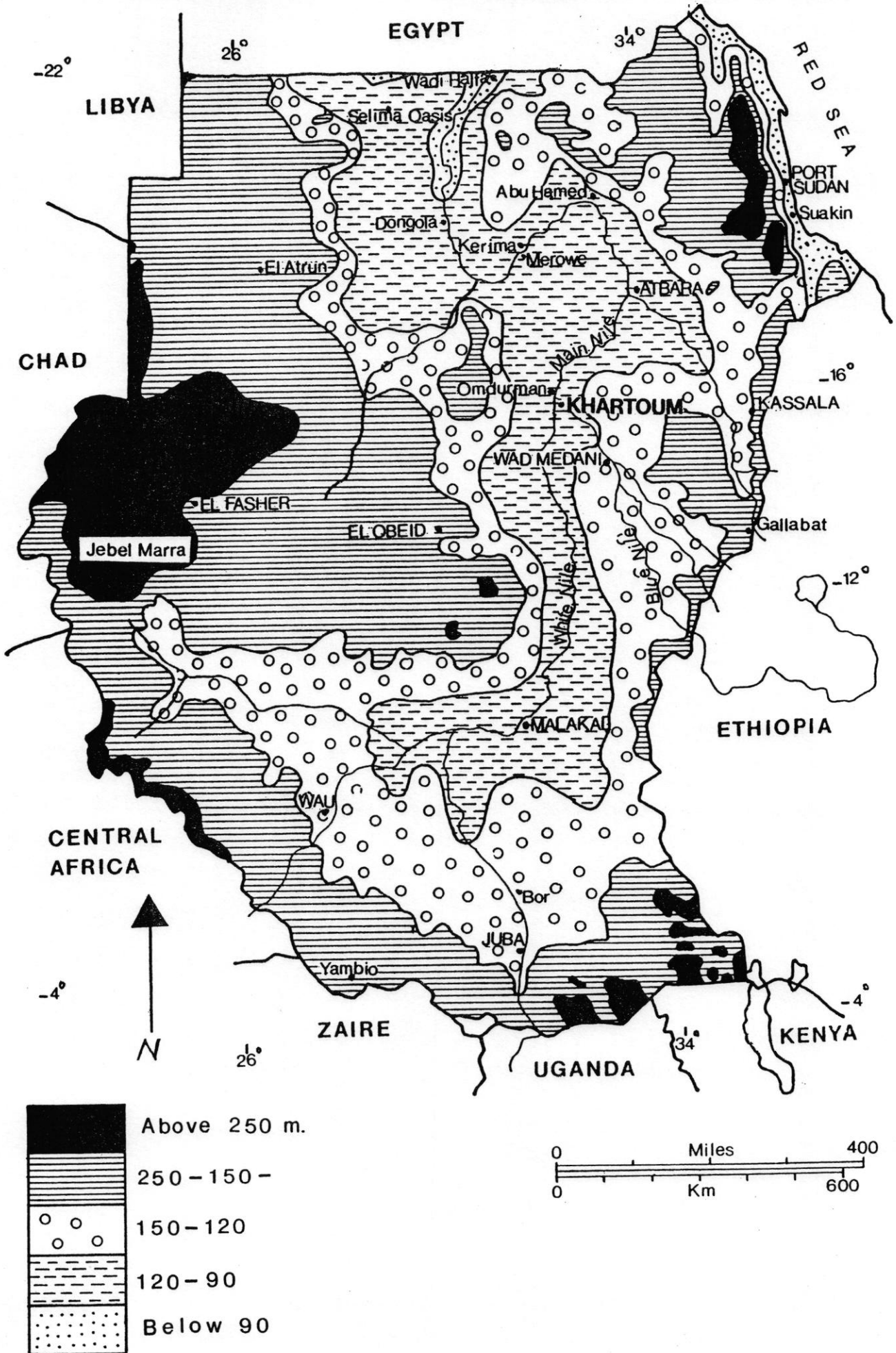


Fig. 3 Climate at selected meteorological stations in Sudan.
(after Walter & Lieth 1960)

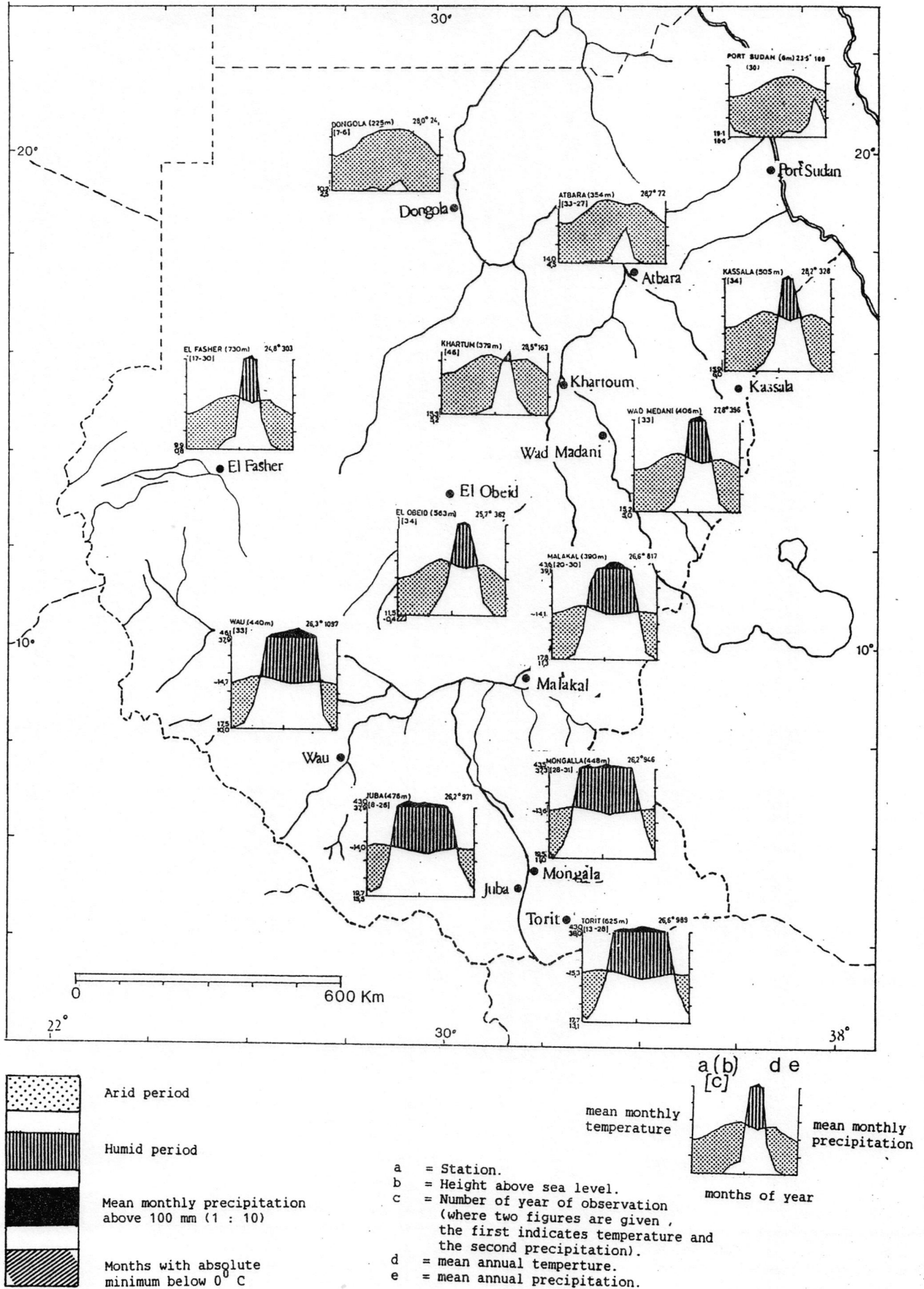
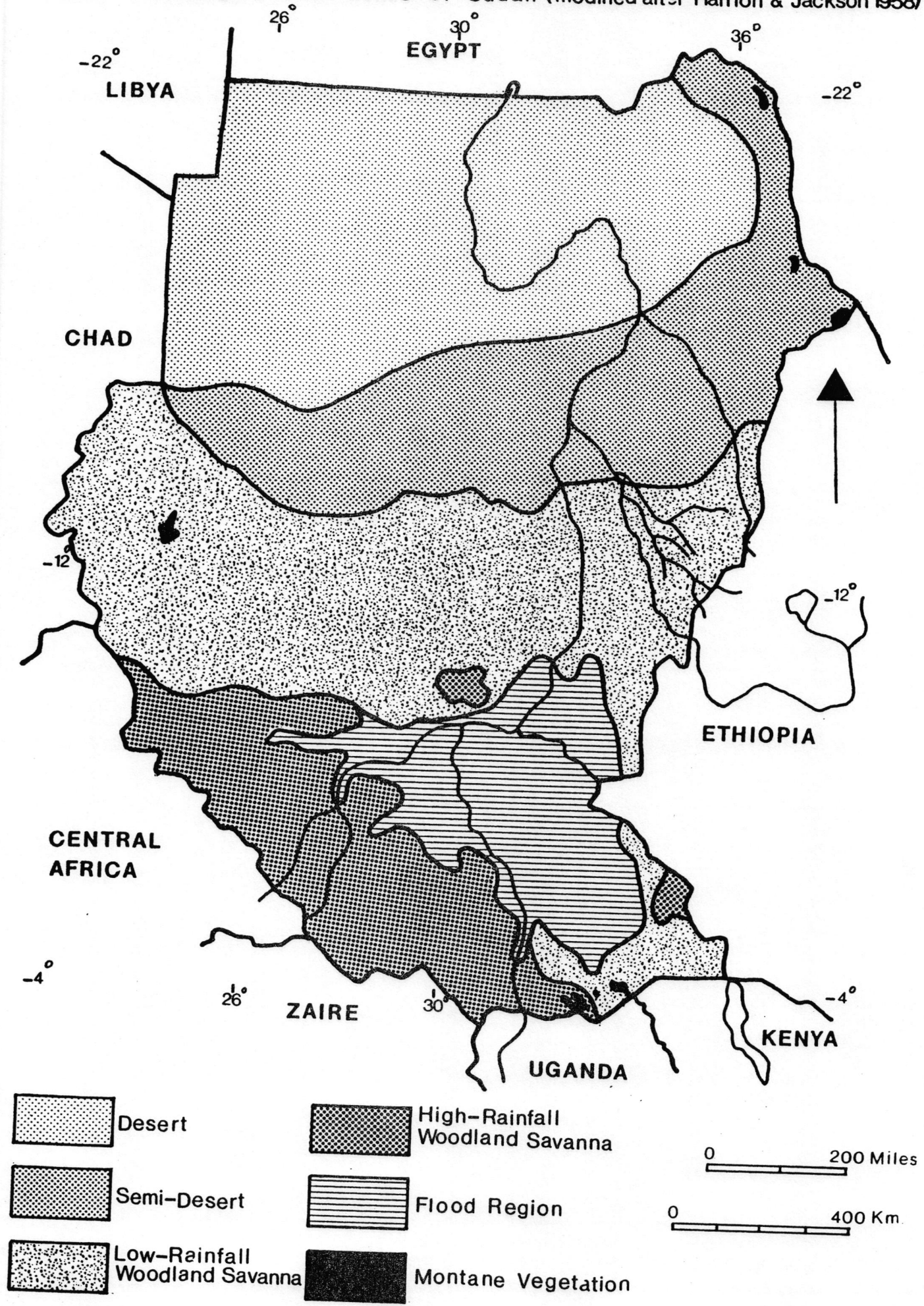


Fig. 4 The vegetational zones of Sudan (modified after Harrion & Jackson 1958)



virtually nil except for the comparatively few ephemeral herbs and grasses that germinate after the rare rain showers and are localized along watercourses.

II- Semi-Desert :

The average rainfall is 75-300 mm/annum and is confined almost entirely to July and August. This region has been divided into five subdivisions :

a- Acacia tortilis - Maerua crassifolia Desert Scrub :

This subdivision is found mainly in the east. Maerua crassifolia is usually present in considerable amounts and in some places becomes abundant. Acacia tortilis, Leptadenia pyrotechnica and Salvadora persica are locally abundant on sandy drainage lines while Capparis decidua, Ziziphus spina-christi and Balanites aegyptiaca occur on clay drainage lines. In some areas Acacia ehrenbergiana replaces A. tortilis.

The Red Sea coastal plain differs very little from the rest of the A. tortilis-M. crassifolia Desert Scrub. Lycium persicum is a characteristic shrub of the area together with few halophytes on the coast.

At the delta of River Gash (near Kassala) dense stands of Acacia nilotica, Tamarix aphylla and Ziziphus spina-christi occur.

b- Semi-Desert Grassland on Clay :

The main area of this subdivision is the Butana, which lies between the River Atbara and the Blue Nile. Most of the Butana is completely without trees or bushes. Areas with Acacia mellifera, though considerable, are confined to the soils around "Jebels" and along "Khors". The typical cracking clay supports A. mellifera. Other associates include mainly A. nubica, Blepharis edulis, Cymbopogon sp. and Sorghum spp.

c- Semi-Desert Grassland on Sand :

Bushes and trees are generally absent. In some places, a thin scatter of A. tortilis occurs near "Jebels" or along "Khors", whereas A. mellifera and Commiphora spp. are particularly frequent in hollows between undulating sand-hills ("qozes").

d- Acacia mellifera-Commiphora Desert :

This subdivision occurs in the west. Commiphora spp. and Acacia mellifera are the most abundant bushes. Other bushes occurring in varying quantities are Maerua crassifolia, Boscia senegalensis, Acacia tortilis and Lannea humilis.

e- Acacia glaucophylla-A. etbiaca Scrub :

This is found on the lower slopes of the southern part of the Red Sea Hills. A. glaucophylla and A. etbiaca are dominant together with A. tortilis along the "wadis". Other associates include Euphorbia cuneata, E. thi and Delonix elata.

III- Woodland Savanna :

The average rainfall is 300-1500 mm/annum. The main constituent of the vegetation is grasses and hence fires are the limiting factor in determining the climax vegetation. Most species are fire resistant and the vegetation is of mixed grasses and bushes with or without trees.

According to the amount of rain , this region has been divided into :

A- Low Rainfall Woodland Savanna :

This covers most of the central Sudan. In the drier parts , the trees are nearly all thorny and small , dominated by Acacia spp. In the wetter parts , broad-leaved deciduous trees become predominant.

This region is sharply divided into two extreme soil types :

A-1- Low Rainfall Woodland Savanna on Clay :

This covers most of the east central Sudan and the areas surrounding the flood region. It has been divided into three subdivisions :

A-1-a- Acacia mellifera Thornland :

i- on dark cracking clays , alternating with grass areas.

ii- on hill-soil formed in situ associated with Commiphora africana and Boscia senegalensis.

iii- A.mellifera-Commiphora Desert Scrub.

b- Acacia seyal-Balanites Savanna alternating with grass areas.

c- Anogeissus-Combretum hartmannianum Savanna Woodland.

A-2- Low Rainfall Woodland Savanna on Sand :

This covers the greater part of the established sand dunes of Kordofan and Darfur in west central Sudan.

It has been divided into :

A-2-a- Acacia senegal Savanna

b- Combretum cordofanum-Albizzia sericocephala-Dalbergia Savanna Woodland.

c- Terminalia-Sclerocarya-Anogeissus-Prosopis Savanna Woodland.

B- High Rainfall Woodland Savanna :

This occupies most of Bahr al-Ghazal and Equatoria Provinces. The trees are mostly broad-leaved species , and thorn trees are relatively infrequent.

This type is divided into :

B-a- Anogeissus-Khaya-Isoberlinia Woodland :

The dominant species , Anogeissus schimperi , Khaya senegalensis and Isoberlinia doka do not generally occur mixed together but in separate patches on different soil types.

B-b- Woodland Savanna derived from Rain Forest :

Characteristic species of larger trees are Terminalia glaucescens , Albizzia zygea , Vitex doniana , Acacia campylacantha and Anogeissus schimperi. Small trees include Combretum binderianum , Grewia mollis , Annona chrysophylla , Bridelia scleroneuroides and Dombeya

quinqueseta.

IV- Flood Region :

This region has been divided into :

a- High land :

The high land is rarely flooded ; the soil is sand and sandy loams. Four types of forests are distinguished :

a-1- Palm type : dominated by Hyphaene thebaica and Borassus aethiopicum.

2- Poorly developed Broad-leaved type : similar to that of the High Woodland Savanna (see above).

3- Mixed Acacia-dominated type : Acacia sieberiana is the dominant species.

4- Acacia seyal-Balanites occurring on clay soils.

b- Intermediate land :

This consists of land flooded during the rainy season and dry during the dry season. It is dominated with grasslands together with small areas of Acacia seyal-Balanites Savanna.

c- Swamp :

This is flooded from the rivers and inland "Khors" so that the flooding is deeper and lasts longer than it does on intermediate land. Permanent swamp is dominated by Cyperus papyrus , while in seasonal swamps the dominant species include Echinochloa stagnina and E.pyramidalis.

V- Montane Vegetation :

This differs from the vegetation of the surrounding plains due to the effect of altitude and sometimes of high rainfall. The four main mountain areas are the Imatong , Didinga and Dongotona Mountains in Equatoria , the Red Sea Hills in Eastern Sudan , and "Jebel" Marra in Darfur.

CHAPTER III

Material and methods

a- Collection of the pollen material :

This work involves a study of 320 phanerogams (20 monocotyledonous and 300 dicotyledonous species) belonging to 209 genera and 79 families collected either as fresh material in the field or taken from different herbaria.

In selecting the material , special attention was given to the following :

- ecological indicator species or characteristic species recognized by Andrews (1948) , Harrison & Jackson (1958) and Wickens (1976) to dominate the different vegetational belts present in Sudan.
- endemic species existing in the different floristic regions occurring in Sudan as recognized by Brenan (1978) , Takhtajan (1986) and White (1983).
- species recorded in Quaternary deposits of Sudan as recognized by Ritchie (1987) , Ritchie et al. (1985) and Ritchie & Haynes (1987).

After consideration of the works by Bonnefille & Riollet (1980) , Van Zinderen Bakker (1953 , 1956) , Van Zinderen Bakker & Coetzee (1959) , Maley (1970) , Erdtman (1971) and Faegri & Iversen (1975) some additional species were included. They were chosen so that all the existing pollen types would be represented and also to enrich and diversify some parts of the keys. Some genera such as Cassia , Combretum , Hibiscus , and to a lesser extent Indigofera , Polygala and Polygonum were intensively studied.

On the other hand , only a few representatives of the four pollen types of the genus Acacia (El Amin 1972:115 cf. Appendix table A) were taken into consideration. In addition , since members of the family Gramineae (Poaceae) have more or less similar pollen grains (Faegri & Iversen 1964:253) , only a few representatives of the main genera occurring in Sudan were taken into consideration.

The fresh polliniferous samples were collected mainly from Khartoum Province and Ed-Dinder (Blue Nile Province) in the period from February to April 1987. Besides native species , these also include cultivated crops and a few species that were previously planted and later have become naturalized. Herbarium materials include specimens from all parts of the Sudan ranging from the desert in the North , the High Rainfall Woodland Savanna to the South and the Montane vegetation in the West , Centre and East. The herbarium samples were obtained from :

- BG : Herbarium , Botanical Institute , University of Bergen , Bergen , Norway.
- EA : East African Herbarium , Nairobi , Kenya.
- K : Royal Botanical Gardens , Kew , U.K.
- KHF : Herbarium , Forest Research and Education Institute , Soba , Khartoum , Sudan.

- KHU : Herbarium , Khartoum University , Faculty of Science , Botany Department , Khartoum , Sudan.
- LD : Botanical Museum , University of Lund , Lund , Sweden.
- NCRH : Herbarium , National Council for Research , Institute of Medicinal and Aromatic Plants , Khartoum , Sudan.

In cases where no Sudanese specimens could be located , pollen samples from neighbouring countries have been used. These are labelled with an asterisk (*) in the descriptions.

To avoid pollen contamination and to ensure that the pollen sacs are not empty , flowers or inflorescences were collected as far as possible at the bud-stage or just at the point of their opening.

b- Pollen preparation :

For a comparison with fossil material , the extra-exinous oil and other interstitial inclusions , cytoplasm and intine of modern pollen grains should be removed. Therefore , the pollen grains were chemically treated with 10% KOH and acetolysed so as to get rid of all superfluous matter which obscures the exine characters. Acetolysis was carried out according to the standard acetolysis method for recent pollen grains (Erdtman 1934 , 1960 ; Faegri & Iversen 1964 , 1975) and Corylus avellana was used as a marker pollen. The procedure is summarized in the Appendix (fig. A).

After chemical treatment and staining with basic fuchsin the sample was stored in water in a small stock vial. This stock pollen sample was then used partly to make the voucher slides for light microscopic (LM) examination and partly for the preparation of the Aluminum stubs for the scanning electron microscopic (SEM) examination. All the samples prepared (vials and voucher slides) have been deposited at the Botanical Institute , University of Bergen and Botany Department , Faculty of Science , University of Khartoum , Sudan.

Voucher slides were mounted in 85% glycerol and sealed with paraffin wax. LM examination was done with a Zeiss microscope using phase contrast (ph) objectives X 100 magnification , eyepiece X 10 magnification and phase contrast condenser lenses (NA = 1.4). LM photographs were taken with a Zeiss axiomatic.

SEM examination was done with a Jeol JSM-T200 microscope with 25 kv accelerating voltage and 8 mm working distance. SEM photographs were made with a (6X7) Mamiya Camera.

c- Measurements :

The dimensions of the polar axis (P) , equatorial axis (E) or the diameter (D) of all the pollen grains investigated were measured. The mean value (X) of 20 counts , and the range for each parameter , standard deviations and the ratio of polar and equatorial axes (P / E) were calculated. The measurements were taken from different parts of the slide , since smaller grains tends to move towards the edges when the cover-slip is put on (Brookes & Thomas 1967).

The number of pores on isodiametric, periporate pollen was estimated from the ratio of the distance between centres of two adjacent pores (Chord) (C) to the diameter of the grain (D) (McAndrews & Swanson 1967). The graphic correlation between the ratio of C/D and the number of pores is given in the Appendix (fig. B).

The diameter of 20 grains of Corylus avellana were measured for each preparation and averaged. Since the size of the pollen grains varies according to the chemical treatments (Faegri & Iversen 1965 :221; Andersen 1960 ; Christensen 1946) , the measurements taken were converted to the "standard size". This is achieved by dividing the sizes measured (P , E , D) by a conversion factor (k). This conversion factor (k) , is the ratio of the measured size of C.avellana for each preparation to the standard mean size of C.avellana (= 37 μ m) (Faegri & Iversen 1964:221 , 222) and Faegri & Iversen (1989 in press).

d- Species description and terminology :

A uniform system of pollen morphological description was followed for all the specimens examined. In such a study , standard description and terminology of the features describing the rang of all propable variation are needed so that descriptions can be meaningfully compared. The definitions and terminology , listed in the glossary , follow various authors : Erdtman (1952 , 1947) for shape classes (table B Appendix) , Kuyle et al. (1955) for shape in polar view (fig. C , Appendix) , Faegri & Iversen (1950 , 1964 , 1975) for pollen classes , apertures , exine , and columellae , Faegri & Iversen (1975) and Praglowski & Punt (1973) for sculpturing.

During this study , a wide diversity of endoaperture morphology was noticed , but its description was not possible using previously published definitions. Therefore , it was necessary to reassess endoaperture description and then to construct a key applicable throughout the rang of variation (El Ghazali - submitted for publication- , Appendix). Other pollen morphological features have been adapted from various other sources. A glossary of these terms followed by their citation is given in chapter VII.

For each species in addition to pollen morphological description , the synonym(s) , vernacular name(s) , habit , habitat (if known) , distribution , previous work , material examined , determinative (when specified) and the site of deposition are included. The nomenclature , synonym(s) , habit and distribution are after Andrews (1950 , 1952 , 1956). Up-dating of names and synonyms in addition to habitats (unless otherwise specified) follows Wickens (1976) and El Ghazali (1985).

e- Micrographs :

Both light microscopic and scanning electron microscopic micrographs are included in this study. Unless otherwise specified , horizontal lines below the scanning electron micrographs are equivalent to 10 μ m each and those below light microscopic micrographs are equivalent to 25 μ m.

f- Literature :

Relevant previous work on each of the species investigated was obtained after an extensive literature survey of the indices of bibliography by Thanikaimoni (1972 , 1973 , 1976 , 1980) , and the journals Grana , Pollen et Spores , and Review of Palaeobotany and Palynology. A list of these references is given on page 349.

g- Abbreviations used in the text :

- Ar. : Arabic language.
- D : Diameter.
- Det. : Determinative/s.
- Engl. : English language.
- G. : Greek.
- k : Conversion factor.
- LM. : Light microscope.
- Mts. : Mountains.
- P : Polar axis.
- SEM. : Scanning electron microscope.
- Syn. : Synonym/s.
- Tr. : Translated.
- Vern. name/s : Vernacular name /s.

h- English equivalents of Arabic words used in the text :

- "Harig" : Fire.
- "Jebel" : Mountain.
- "Khor" : Seasonal stream.
- "Qoz" : undulating sand-dunes.
- "Wadi" : valley.

CHAPTER IV

Species description

320 species belonging to 209 genera and 79 families are described here. They fall into 20 pollen morphological types. Most of the pollen grains are tricolpate or tricolporate.

Pollen morphological characters in the descriptions follow the sequence : shape class , shape in polar view , dimensions , pollen class , apertures (ectoapertures and endoapertures) , exine , columellae and sculpturing. These criteria are then followed by the description of ecological characters such as habit , habitat , distribution and where possible the flowering and fruiting seasons , and pollinating agent/s.

The collector's name and number , date and place of collection , determinative and date of determination and the place/s of deposition of the herbarium material of the specimens examined are also given.

Several pollen grains are described here for the first time. The families are arranged alphabetically, the species and the genera are also arranged alphabetically within families.

Family : ACANTHACEAE

*

Barleria acanthoides Vahl.

Shape Class : subprolate.

Shape in polar view : circular.

Dimensions : P = 155.9 μm (120.5-160.5),
 E = 128.8 μm (120.1-135.7) , P/E = 1.21 , k
 = 0.88.

Pollen Class : tricolporate.

Apertures : composite.

Ectoapertures : colpi ovate-oblong ,
 tapering at both ends , apices acute to
 rounded ; endexinous membrane smooth.

Endoapertures : pores distinct ; with
 closed costae , diameter \pm equal to the
 width of the endoapertures.

Exine : semi-tectate ; tectum
 thickness $8.9 \pm 0.7 \mu\text{m}$, undulating ;
 ectexine thicker than endexine.

Columellae : distinct , arranged in a
 reticulate pattern , widely spaced.

Sculpturing : per-reticulate ; hetero-
 brochate ; reticulum continuous all over
 the surface ; muri simpli-columellate ,
 having a general wavy appearance , with
 columellae in the corners and along the
 sides ; lumina slightly angular , of varying
 shapes, $\geq 10 \mu\text{m}$ in diameter , diameter
 larger than the width of the separating
 muri, bottom smooth at the middle and with 1
 or 2 rows of isolated ectexinous elements
 running adjacent to the collumellae.

Habit : harsh prickly undershrubs.

Distribution : Northern and Central Sudan.

Previous Work : Bonnefille & Riollot (1980:
 31 , Pl. 5 , figs. 1-10).

Material Examined : Dag Olav Ovstedal , July
 1979. Coastal Province , Kenya. Deposited at
 BG.

Comments :

Bonnefille & Riollot (1980) described
 the pollen grains of this species as having
 a verrucate ectoaperturate membrant.

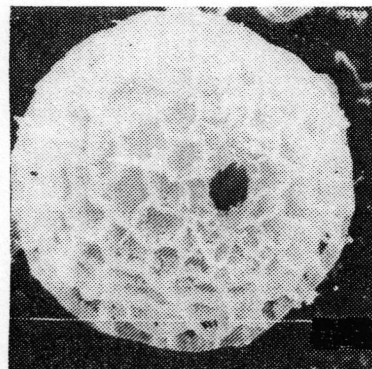


Fig. 5 , SEM ,
 equatorial view , each
 horizontal line
 equivalent to 75 μm .

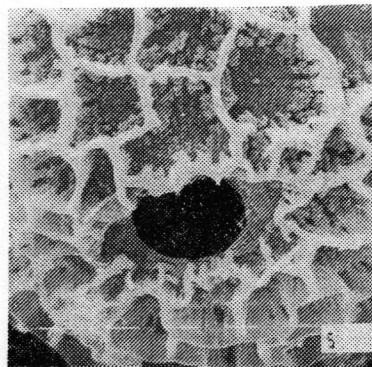


Fig. 6 , SEM , close-up
 view at the aperture ,

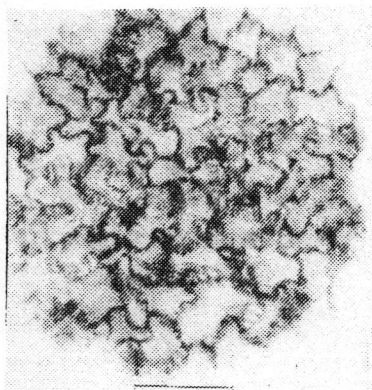


Fig. 7 , LM , polar
 view , horizontal line
 equivalent to 50 μm .

*

Barleria ventricosa Hochst. ex Nees.

- Syn. B. grantii Broun & Massey.

Shape Class : prolate-spheroidal.

Shape in polar view : circular.

Dimensions : P = 148.3 μm (142.3-160.9),
E = 133.6 μm (123.7-145.4) , P/E = 1.11 , k
= 0.89.

Pollen Class : tricolporate.

Apertures : composite.

Ectoapertures : colpi elliptic ,
tapering at both ends , edges ill-defined ,
apices acute to rounded ; endexinous
membrane smooth.

Endoapertures : pores distinct ; with
closed costae , diameter \pm equal or slightly
less than the width of the ectoapertures.

Exine : semi-tectate , tectum
thickness $14.5 \pm 0.7 \mu\text{m}$, undulating ;
ektexine thicker than endexine.

Columellae : distinct , thicker at
the top , arranged in a reticulate pattern ,
widely spaced.

Sculpturing : per-reticulate ; homo-
brochate ; reticulum continuous all over the
surface ; muri simpli-columellate , smooth ,
with columellae in the corners and along the
sides ; lumina \pm circular to slightly
angular , of varying shapes , $> 10 \mu\text{m}$ in
diameter , diameter larger than the width
of the separating muri , bottom smooth.

Habit : erect strigose herbs. Distribution : Nuba Mts. , Eritrea.
Material Examined : A. Papp 4904 , Sept. 1902 , Eritrea-Amasen. Det.
E. Chiovenda. Deposited at BG.

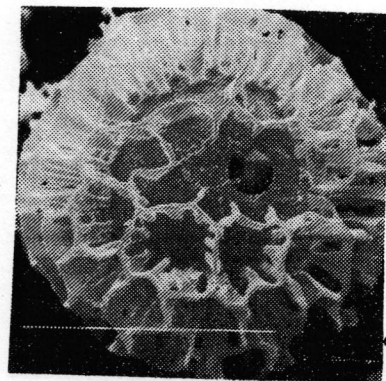
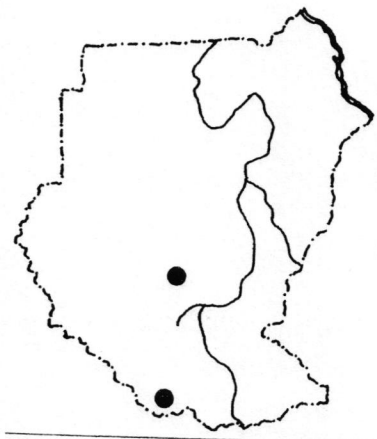


Fig. 8 , SEM ,
equatorial view , the
horizontal line is
equivalent to 75 μm .



Distribution map

*

Blepharis persica (Burm. f.) Kuntze.
- Syn. B. edulis (Forsk.) Pers.

Shape Class : per-prolate.

Shape in polar view : intersub-angular.

Dimensions : P = 62.2 μm (55.6-75.4) ,
E = 30.2 μm (26.2-36.1) , P/E = 2.06 , k =
0.84.

Pollen Class : tricolpate.

Apertures : simple , colpi slit-shaped , with parallel sides , apices rounded , sunken ; endexinous membrane smooth ; costae colpi present along the whole colpi , of uniform thickness.

Exine : semi-tectate , tectum of uniform thickness ; ectexine thicker than endexine.

Columellae : distinct , of uniform length , regularly distributed , widely spaced.

Sculpturing : micro-reticulate ; homobrochate ; reticulum continuous all over the surface ; muri simpli-columellate , smooth , with columellae in the corners and along the sides ; lumina circular , of uniform shape , $\leq 1 \mu\text{m}$ in diameter , diameter \pm equal or slightly larger than the width of the separating muri , bottom with one columella per each lumen.

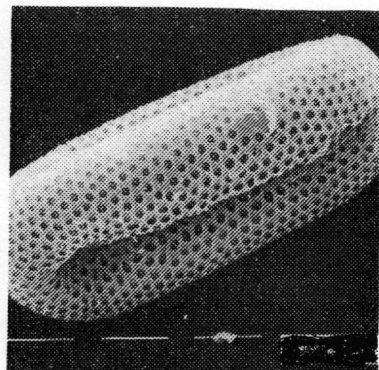


Fig. 9 , SEM , oblique equatorial view.

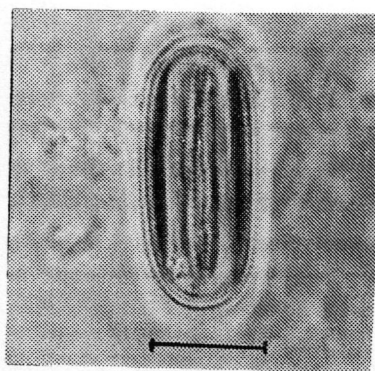


Fig. 10 , LM , equatorial view.

Habit : grey-pubescent woody herbs. Distribution : Northern and Central Sudan.

Previous Work : Raj (1961:41 , 73).

Material Examined : Tore Ouren 21205 , Sept. 1961 , Wallo Province , Ethiopia. Det. K.H. , Nov. 1973. Deposited at BG.

Comments :

This species is characteristic of the Semi-desert vegetational type (Harrison & Jackson 1958). Pollen identified as far as the genus Blepharis is commonly recorded in Quaternary deposits of Northwestern Sudan (Ritchie 1987 , Ritchie et al. 1985).

Hygrophila auriculata (Schumach) Heine.

- Syn. Asteracantha longifolia (L.) Nees ; Hygrophila spinosa T.Anders.
- Vern. names : (Ar.) Abu Shwaika , Hag el moya.

Shape Class : prolate-spheroidal.

Dimensions : P = 89.8 μ m (81.9-101.6) ,
E = 86.1 μ m (72.1-100.1) , P/E = 1.04 , k =
0.84.

Pollen Class : heterocolpate and / or
stephanocolpate.

Apertures : 16 , every 3 simple
apertures alternate with 1 composite one or
all simple.

Simple apertures : colpi tapering at
both ends , slightly longer than the
composite apertures , with margo ;
endexinous membrane smooth.

Composite Apertures :

Ectoapertures : colpi tapering at both
ends , undulating ; endexinous membrane
smooth.

Endoapertures : pores indistinct ,
diameter \pm equal to the width of the
ectoapertures.

Exine : tectate , tectum perforate ;
perforations \pm circular to slightly
elongated , in the lumina of the reticulum ;
ektexine thicker than endexine.

Columellae : distinct , of uniform
length , regularly distributed , closely
spaced.

Sculpturing : supra-reticulate ;
homo-brochate at the intercolpi ;
reticulum continuous all over the surface ;
lumina angular , of varying shapes , $\geq 2 \mu$ m
in diameter , diameter larger than the width
of the separating muri , bottom perforate ;
brochi smaller at the polar area.

Habit : hispid erect spinescent herbs. Habitat : weed of "Khor" banks,
watercatchment areas. Distribution : Central and Southern Sudan.
Previous Work : Cerceau-Larrival & Hideux (1983:2) , Maley (1970:38 ,
Pl. 23 , figs. 1-2) , Raj & Saxena (1966:50 , 51 , Pl. I , figs. 9-
12) , Raj (1961:29 , 81 , Pl. 31 , fig. 3).
Material Examined : R. Danielsen , Nov. 1986. Southern Kordofan , Lake
Abyad , Sudan. Deposited at KHU , BG.

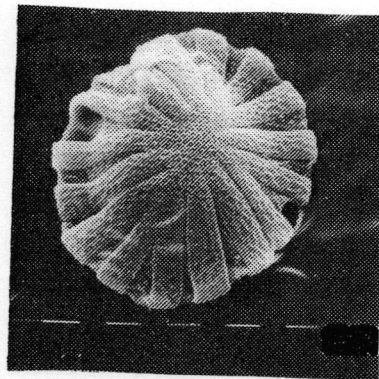


Fig. 11 , SEM , polar
view.

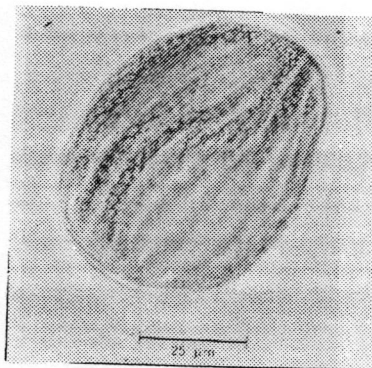


Fig. 12 , LM ,
equatorial view.

Hypoestes forskalei (Vahl) Soland. ex Roem. & Schult.

- Syn. Justicia forskalei Vahl ; Hypoestes verticillaris (L.f.) Soland. ex Roem. & Schult.
- Vern. name : (Ar.) Mahlab.

Shape Class : prolate.

Dimensions : P = 62.2 μm (51.8-74.5) ,
E = 39.5 μm (32.4-48.6) , P/E = 1.57 , k =
0.85.

Pollen Class : heterocolpate.

Apertures : 9 , every 2 simple apertures alternate with 1 composite one.
Simple Apertures : colpi slit-shaped , long (from pole to pole) , perforated at the bottom.

Composite Apertures :

Ectoapertures : colpi tapering at both ends , apices acute ; endexinous membrane smooth.

Endoapertures : pores distinct ; with closed costae , diameter \pm equal to the width of the ectoapertures.

Exine : tectate ; tectum perforate ; perforations \pm circular , in the lumina of the reticulum ; ectexine thicker than endexine.

Columellae : distinct , digitate , regularly distributed , closely spaced.

Sculpturing : micro-reticulate ; homo-brochate ; reticulum continuous all over the surface ; muri simpli-columellate , smooth , with columellae in the corners and along the sides ; lumina angular , of uniform shape , < 1 μm in diameter , diameter larger than the width of the separating muri , bottom perforated.

Habit : herbaceous undershrubs. Habitat : weed of "Khor" banks.

Distribution : Central and Southern Sudan.

Previous Work : Bonnefille & Riollot (1980:33 , Pl. 10 , fig. 1-7) , Bonnefille (1971 b:475 , Pl. 3) , Raj (1961:54 , 83).

Material Examined : El Ghazali G27/84 , Nov. 1984. Nuba Mts., Kaloro district , Sudan. Deposited at KHU , NCRH , BG.

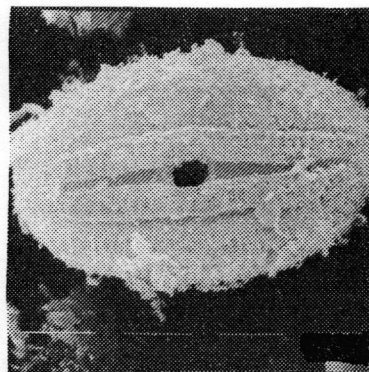


Fig. 13 , SEM , equatorial view.

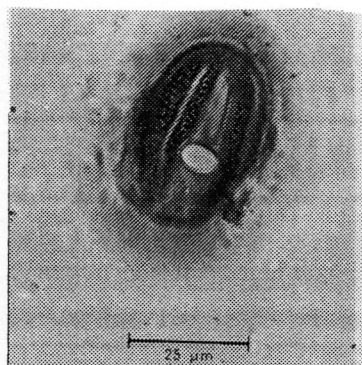


Fig. 14 , LM , equatorial view.

*

Justicia galeopsis T.Anders. ex C.B.Clarke.

Shape Class : prolate.

Dimensions : P = 73.6 μm (62.4-92.8) ,
E = 50.0 μm (35.2-57.6) , P/E = 1.47 , k =
0.86.

Pollen Class : dicolporate.

Apertures : composite.
Ectoapertures : colpi slit-shaped ;
endexinous membrane smooth.

Endoapertures : pores distinct ; with
closed costae , diameter \pm equal to the
width of the ectoapertures.

Exine : tectate , tectum perforate ;
perforations \pm circular , in the lumina of
the reticulum ; ectexine thicker than
endexine.

Columellae : distinct , shorter
towards the colpi , equatorially thickened.

Sculpturing :
"peripheral area" : micro-reticulate ;
homo-brochate ; muri simpli-columellate ,
smooth , with columellae in the corners and
along the sides ; lumina < 1 μm in
diameter , diameter larger than the width of
the separating muri , bottom perforated.
"trema area" : oblong , with micro-
reticulate insulae ; insulae 16-20.

Habit : hispid straggling herbs.
Distribution : Darfur , Nuba Mts. , Equatoria.
Material Examined : Tore Ouren 20859 , Aug.
1961 , Sidamo Province , Ethiopia. Det. K.H. ,
Feb. 1973. Deposited at BG.

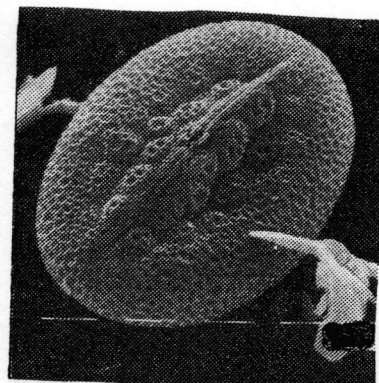


Fig. 15 , SEM ,
equatorial view.

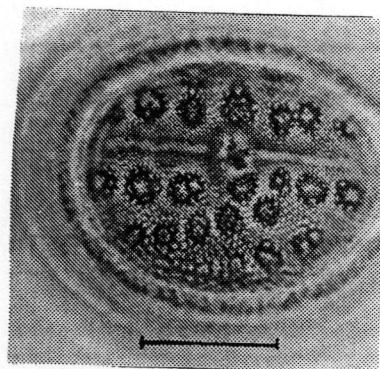


Fig. 16 , LM ,
equatorial view.



Distribution map

Comments :

Pollen identified as far as the genus Justicia is frequently recorded in Quaternary deposits of Northwestern Sudan (Ritchie 1987 , Ritchie & Haynes 1987).

*

Justicia matammensis (Schweinf.) Oliv.- Syn. J. anselliana Broun & Massey.

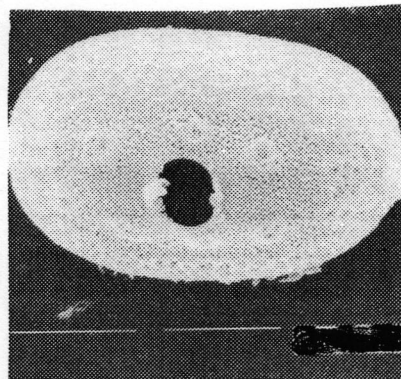
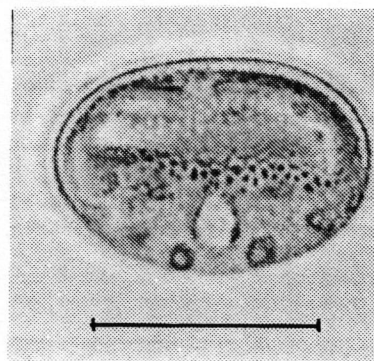
Shape Class : prolate.

Dimensions : P = 35.4 μm (31.6-38.0) ,
P = 21.8 μm (20.6-22.2) , P/E = 1.62 , k =
0.87.

Pollen Class : diporate.

Apertures : simple ; pores with well-
defined edges , operculate ; operculum
deciduous.Exine : tectate at the "peripheral
area" , tectum perforate ; perforations
 \pm circular , in the lumina of the
reticulum ; ectexine thicker than the
endexine.Columellae at the "peripheral area" :
distinct , regularly distributed , closely
spaced , equatorially thickened.
"trema area" without columellae.Sculpturing : "peripheral area" :
micro-reticulate ; homo-brochate ; muri
simpli-columellate , smooth , with
columellae in the corners and along the
sides ; lumina \pm circular , of uniform
shape , $< 1 \mu\text{m}$ in diameter , diameter larger
than the width of the separating muri ,
bottom with columellae."trema area" oblong , with \pm circular
insulae ; insulae 8-10 , micro-reticulate ,
with isolated ectexinous elements.Habit : erect or decumbent pubescent herbs. Distribution : Central and
Southern Sudan.

Previous Work : Raj (1961:63 , 73).

Material Examined : Tore Ouren 21001 , Aug. 1961 , Arussi Province ,
Ethiopia. Det. K.H. , Dec. 1975. Deposited at BG.Fig. 17 , SEM ,
equatorial view.Fig. 18 , LM ,
equatorial view.

*

Lepidagathis collina (Endl.) Milne-Redh.

- Syn. L. radicalis Hochst. ; L. schweinfurthii Lindau ;
Russegera collina Endl.

Shape Class : prolate.

Shape in polar view : circular.

Dimensions : P = 56.5 μm (48.6-64.8) ,
E = 39.7 μm (32.4-42.1) , P/E = 1.42 , k =
0.85.

Pollen Class : tricolporate.

Apertures : composite.

Ectoapertures : colpi elliptic ,
tapering at both ends , apices rounded ,
margo present ; endexinous membrane smooth.

Endoapertures : pores distinct ; with
closed costae , diameter \pm equal to the
width of the ectoapertures.

Exine : semi-tectate , tectum thicker
at the intercolpi ; ectexine thicker than
endexine.

Columellae : distinct , slightly
longer at the intercolpi , dimorphic ;
those forming the reticulum are larger than
those in the lumina , regularly distributed,
widely spaced.

Sculpturing : micro-reticulate ; homo-
brochate except for rows of 5-7 large brochi
on both sides of the colpi ; reticulum
continuous all over the surface ; muri
simpli-columellate , smooth , with
columellae in the corners and sometimes also
along the sides ; small lumina $< 1 \mu\text{m}$ in
diameter , diameter \pm equal or slightly
larger than the width of the separating
muri ; large lumina $\geq 5 \mu\text{m}$ in diameter ;
bottom of lumina with columellae ; brochi
generally decreasing towards colpi.

Habit : pubescent herbs with sessile leaves.

Distribution : Ingassana District.

Material Examined : A. Papp 225 , Oct. 1902 ,
Eritrea-Sarae. Det. E. Chiovenda. Deposited
at BG.

Comments :

Pollen identified as far as the genus Lepidagathis is
frequently recorded in Quaternary deposits in Northwestern Sudan
(Ritchie 1987 , Ritchie & Haynes 1987).

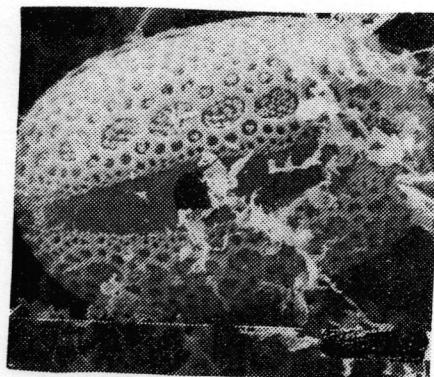


Fig. 19 , SEM ,
equatorial view.

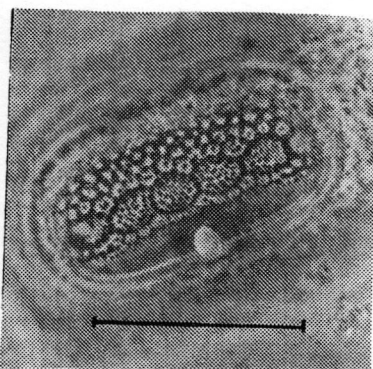


Fig. 20 , LM ,
equatorial view.



Distribution map

Nelsonia canescens (Lam.) Spreng.
- Syn. Justicia canescens Lam.

Shape Class : oblate-spheroidal.

Shape in polar view : semi-angular.

Dimensions : P = 38.6 μm (34.8-41.1) ,
E = 40.2 μm (39.6-44.3) , P/E = 0.96 , k =
0.87.

Pollen Class : tricolporate.

Apertures : composite.

Ectoapertures : colpi ovate-oblong ,
tapering at both ends , apices rounded to
slightly obtuse , margo present , endexinous
membrane smooth ; costae colpi present along
the sides , of uniform thickness.

Endoapertures : H-shaped , distinct.

Exine : semi-tectate ; tectum slightly
thicker at the intercolpi ; ectexine as
thick as the endexine.

Columellae : distinct , of uniform
length at the intercolpi , slightly shorter
near the colpi , irregularly distributed ,
closely spaced.

Sculpturing : micro-reticulate ;
hetero-brochate ; reticulum continuous all
over the surface ; muri simpli-columellate ,
smooth , with columellae in the corners
only ; lumina \pm circular to slightly
elongated , of uniform shape , < 1 μm in
diameter , diameter larger than the width of
the separating muri , bottom smooth ;
brochi decreasing towards colpi.

Habit : pubescent prostrate herbs. Habitat : weed of "Khor" banks.

Distribution : Central and Southern Sudan.

Previous Work : Raj (1961:23-24).

Material Examined : EL Ghazali G14/84 , Nov. 1984. Nuba Mts., Kaloro
district , Sudan. Deposited at KHU , NCRH , BG.

Comments :

Raj (1961) described the pollen grains of this species as
tricolpate and with a prolate shape class.

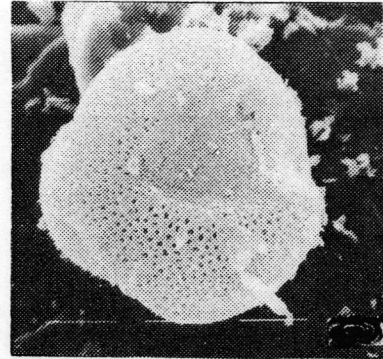


Fig. 21 , SEM , oblique
polar view.

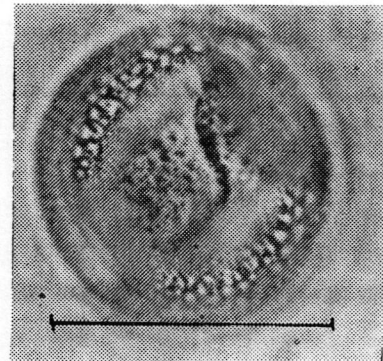


Fig. 22 , LM ,
equatorial view.

Peristrophe bicalyculata (Retz.) Nees.

- Syn. Dianthera bicalyculata Retz.
- Vern. name : (Ar.) El nadab.

Shape Class : prolate.

Dimensions : P = 52.1 μm (45.4-51.4) ,
E = 34.5 μm (24.2-42.4) , P/E = 1.51 , k =
0.91.

Pollen Class : heterocolpate.

Apertures : 9 , every 2 simple
apertures alternate with 1 composite one.
Simple Apertures : colpi slit-shaped ,
long (from pole to pole) , apices acute ,
perforate at the bottom.

Composite Apertures :

Ectoapertures : colpi tapering at both
ends , apices acute ; endexinous membrane
smooth.

Endoapertures : pores distinct ; with
closed costae , diameter \pm equal to the
width of the ectoapertures.

Exine : tectate , tectum perforate ;
perforations \pm circular , in the lumina of
the reticulum , indistinct ; ectexine
thicker than endexine.

Columellae : distinct , digitate , of
uniform length , regularly distributed ,
closely spaced.

Sculpturing : supra-reticulate ;
homo-brochate ; reticulum continuous all
over the surface ; muri simpli-columellate ,
smooth , with columellae in the corners and
along the sides ; lumina angular , \pm of
uniform shape , $\leq 1 \mu\text{m}$ in diameter ,
diameter larger than the width of the
separating muri , bottom perforate.

Habit : hispid erect much-branched herbs. **Habitat :** weed of "Khor"
banks. **Distribution :** widespread.

Previous Work : Bonnefille & Riollet (1980:36 , Pl. 13 , fig. 1-
14) , Chaubal & Deodikar (1966-67:87) , Raj (1961:85 , Pl. 34 ,
fig. 5).

Material Examined : El Ghazali G111/83 , Nov. 1983. Nuba Mts. , Sudan.
Deposited at KHU , NCRH , BG.

Comments :

Pollen identified as far as the genus Peristrophe is frequently
recorded in Quaternary deposits in Northwestern Sudan (Ritchie 1987).

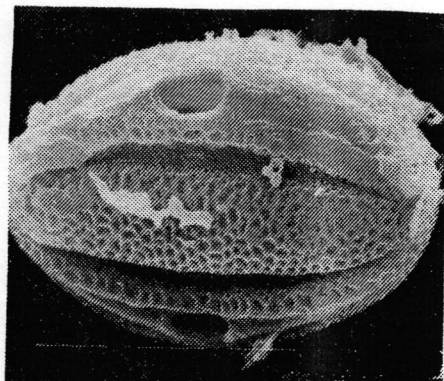


Fig. 23 , SEM ,
equatorial view.

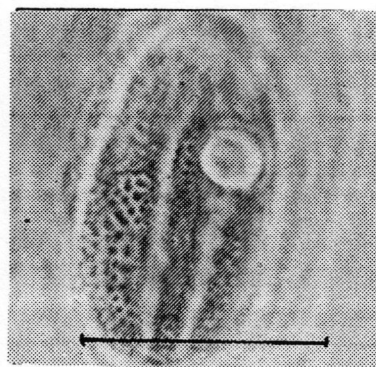


Fig. 24 , LM ,
equatorial view.

*

Thunbergia alata Boj. ex Sims.

Shape Class : spheroidal.

Dimensions : D = 68.8 μ m (58.6-84.9) ,
k = 0.94.

Pollen Class : syncolpate.

Apertures : simple , colpi spiral-shaped , made up of a single band or complex spirals ; edges irregular.

Exine : tectate ; tectum perforate ; perforations \pm circular , distinct , irregularly distributed , widely spaced ; of uniform thickness , ectexine thicker than the endexine.

Columellae : distinct , of uniform length , irregularly distributed , closely spaced.

Sculpturing : psilate.

Habit : pubescent herbaceous twiners.

Distribution : Equatoria.

Previous Work : Chaubal & Deodikar (1966-67:85) , Furness (1985:315) , Rao & Tian (1974:22 , fig. 59 ; Pl. III , 1) , Raj (1961:25 , 71).

Material Examined : Tore Ouren 20648 , Aug. 1961 , Shao Province , Koka Power Plant , Ethiopia. Det. K.H. , Jan. 1974. Deposited at BG.

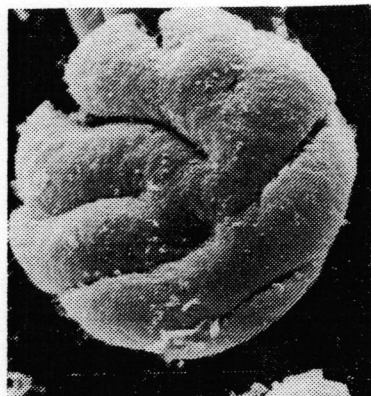


Fig. 25 , SEM

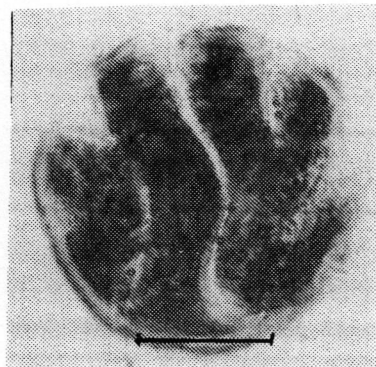


Fig. 26 , LM.



Distribution map

Comments :

According to Faegri & Iversen (1950) the term syncolpate is a broad one and includes also the term spiraperturate (Erdtman 1952). Furness (1985) classified this species under spiraperturate and regarded syncolpate as another phenomenon resulting from further development of the apertures. Kalis (1979) regarded the term syncolpate as misleading and to be avoided since several pollen classes may also be syncolpate.

The sculpturing is conformable with the description by Chaubal & Deodikar (1966-67). The reticulate surface as described by Rao & Tian (1974) was not recognized.

Family : AIZOACEAE

Aizoon canariense L.

- Vern. name :

Shape Class : prolate.

Shape in polar view : circular to semi-angular.

Dimensions : P = 40.5 μm (33.2-46.4) ,
E = 29.2 μm (26.5-39.8) , P/E = 1.39 , k = 0.83.

Pollen Class : tricolpate.

Apertures : simple ; colpi slit-shaped , apices rounded , slightly sunken ; with isolated ectexinous elements ; costae colpi present along the whole colpi , of uniform thickness.

Exine : tectate ; tectum perforate ; perforations \pm circular , distinct , regularly distributed , closely spaced ; of uniform thickness , ectexine as thick as the endexine.

Columellae : indistinct.

Sculpturing : micro-echinate ; spines uniform , sometimes 2 or 3 grouped together , irregularly distributed.

Habit : spreading herbs. Habitat : sandy soil and rocky crevices.

Distribution : Northeastern Sudan.

Material Examined : Mac Leay. May 1967 , Erkowit , Sudan. Deposited at KHU.

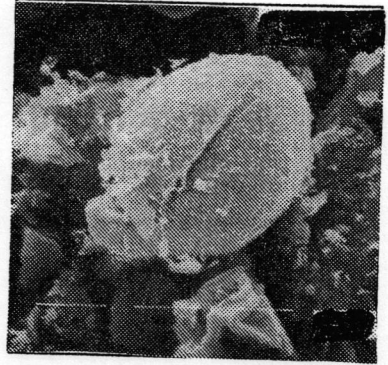


Fig. 27 , SEM , equatorial view.

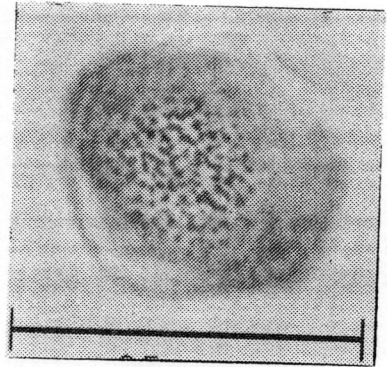
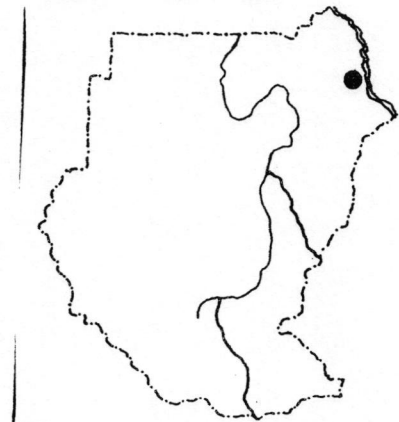


Fig. 28 , LM , equatorial view.



Distribution map

- Comments :

This species is characteristic of the eastern parts of the Acacia Desert Scrub Region on the sandstone slopes of the Red Sea Hills (Andrews 1948).

Glinus lotoides L.

- Syn. Mollugo glinus A.Rich.
- Vern. name : (Ar.) Remet.

Shape Class : oblate-spheroidal.

Shape in polar view : circular.

Dimensions : P = 30.2 μ m (25.6-32.9) ,
E = 32.5 μ m (31.1-35.2) , P/E = 0.93 , k =
0.86.

Pollen Class : tricolpate.

Apertures : simple ; colpi slit-shaped , apices acute , slightly sunken ; with isolated ectexinous elements ; costae colpi present along the whole colpi , of uniform thickness.

Exine : tectate ; tectum perforate ; perforations \pm circular , distinct , irregularly distributed , closely spaced , of uniform thickness ; ectexine as thick as the endexine.

Columellae : indistinct.

Sculpturing : micro-echinate ; spines uniform , sometimes 2-3 grouped together , irregularly distributed.

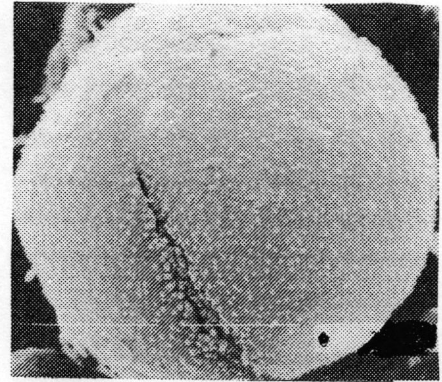


Fig. 29 , SEM , oblique polar view.

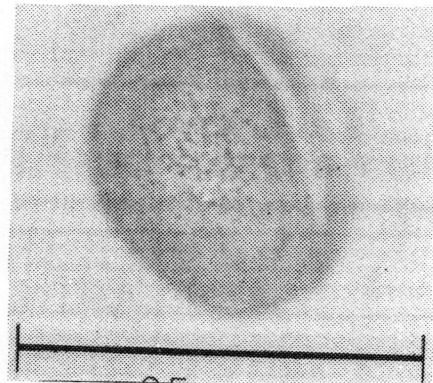


Fig. 30 , LM , equatorial view.

Habit : annual herbs. Habitat : silty Nile banks.

Distribution : widespread.

Previous Work : Rao et al. (1965:50 , fig. 1).

Material Examined : El Ghazali G56/87 , Feb. 1987. Khartoum Province , Main Nile bank , Sudan. Deposited at KHU.

Comments :

Rao et al. (1965) described the sculpturing of this species as smooth. In this study it is recognized as micro-echinate as revealed with both LM and SEM.

Family : ALISMATACEAE

Limnophyton obtusifolium (L.) Miq.- Syn. Sagittaria obtusifolia L.

Shape Class : spheroidal.

Dimensions : D = 51.1 μm (41.0-61.5) ,
k = 0.94.

Pollen Class : periporate.

Apertures : simple; pores \pm circular or slightly ovate , slightly sunken , edges illdefined , operculate ; operculum persistent , with smaller spines than the rest of the surface.

Exine : tectate ; tectum imperforate , of uniform thickness ; ectexine thicker than endexine.

Columellae : distinct , of uniform length , regularly distributed , closely spaced.

Sculpturing : echinate ; spines polymorphic , of various shapes and size , with broad base and pointed apices , irregularly distributed , larger in diameter than the columellae underneath.

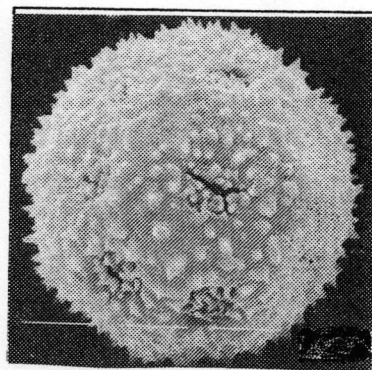


Fig. 31 , SEM

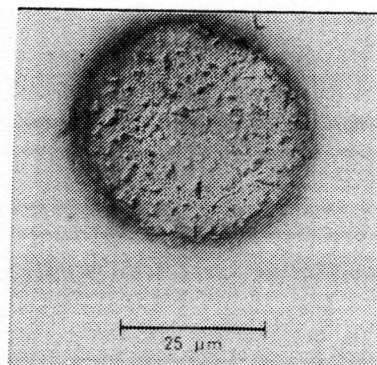


Fig. 32 , LM.

Habit : herbs with short rhizomes and radical leaves.

Habitat : aquatic. Distribution : Central and Southern Sudan.

Previous Work : Argue (1974 , figs. 3 , 17) , Argue (1976:172 , fig. 18) , Raj & Saxena (1966:54 , Pl. II , figs. 6-8).

Material Examined : R. Danielsen , Dec. 1986. Kordofan , Lake Sheirkeila , Sudan. Deposited at KHU , BG.

Comments :

Raj & Saxena (1961) described the sculpturing of the operculum as with dense granules. These granules are recognized in this study as spines with the same pattern as the rest of the surface , but rather smaller in size.

Family : AMARANTHACEAE

Achyranthes aspera L.

- Vern. names : (Ar.) Khasm el nasiba , Abu rukab.

Shape Class : spheroidal and sometimes subspheroidal.

Dimensions : D = 23.6 μm (19.9-27.5) ,
C = 5.8 , C/D = 0.25 , k = 0.90.

Pollen Class : periporate.

Apertures : simple ; pores ca. 60 (50-70) , \pm circular , with annulus , operculate ; operculum deciduous , sculpturing unlike that of the rest of the grain.

Exine : tectate , tectum perforate ; perforations indistinct (LM) , but distinct with SEM , circular , regularly distributed ; of uniform thickness , ectexine thicker than endexine.

Columellae : distinct , $\geq 1 \mu\text{m}$ in diameter , of uniform length , irregularly distributed , widely spaced.

Sculpturing : psilate.

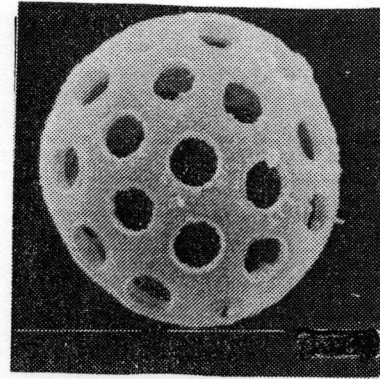


Fig. 33 , SEM.

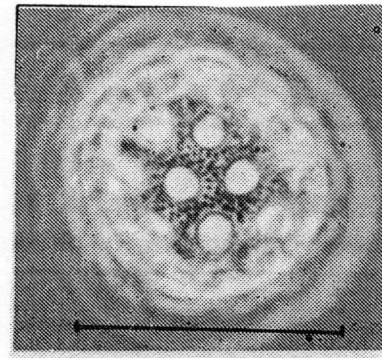


Fig. 34 , LM.

Habit : pubescent annual herbs or undershrubs. Habitat : weed of Nile and "Khor" banks. Distribution : widespread.

Previous Work : Bonnefille (1971 b:477 , Pl. 14) , Bonnefille & Riollet (1980:38 , Pl. 16 , figs. 12-17) , Nair & Rastogi (1966:6 , fig. 6) , Riollet & Bonnefille (1976:71 , Pl. IV , figs. 14-19) , Van Zinderen Bakker (1956:69) , Vishnu-Mittre (1963:89) , Zandonella & Lecocq (1977:133 , Pl. IV,A).

Material Examined : El Ghazali G34/87 , Dec. 1987. Khartoum Province, Blue Nile banks , Sudan. Deposited at KHU , BG.

Comments :

Amaranthaceae pollen is frequently recorded in Quaternary deposits of Northwestern Sudan. (Ritchie 1987 , Ritchie & Haynes 1987 , Ritchie et al. 1985).

Alternanthera nodiflora R.Br.

- Vern. name : (Ar.) Abu Tamra.

Shape Class : spheroidal.

Dimensions : D = 22.0 μm (18.9-25.3) ,
C = 12.6 , C/D = 0.57 , k = 0.87.

Pollen Class : periporate.

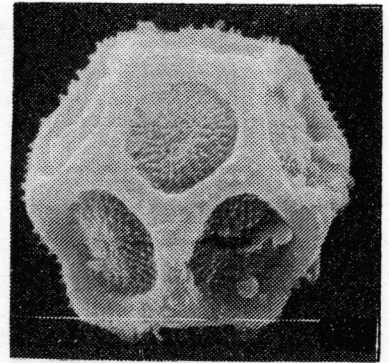
Apertures : simple ; pores ca. 8 ,
> 6 μm in diameter , with annulus,
operculate ; operculum persistent ,
sculpturing unlike the rest of the grain ,
with elongated ektexinous elements radiating
from the centre of the operculum.

Fig. 35 , SEM.

Exine : tectate ; tectum perforate
(SEM) , perforations indistinct (LM) , of
varying size and distribution ; ektexine as
thick as the endexine.

Columellae : indistinct.

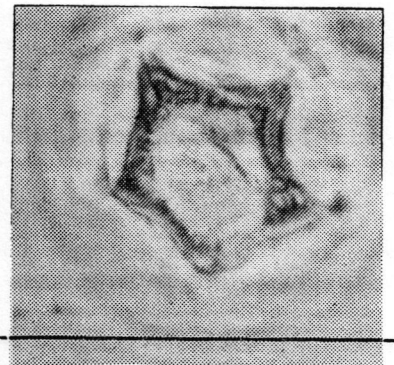
Sculpturing : micro-echinate ; spines
blunt , in one row , irregularly
spaced.

Fig. 36 , LM.

Habit : procumbent herbs. Habitat : weed of cultivation and water-
catchment areas. Distribution : Central and Southern Sudan.Previous Work : Maley (1970:33 , Pl. 6 , figs. 14-15) , Riollot
& Bonnefille (1976:85).Material Examined : Wickens 1131 , Feb. 1964. Jebel Marra , Zalingei,
Sudan. Deposited at KHU.**Comments :**Although the micro-spines present on the surface are distinct
both with LM and SEM , they were not reported by the previous
workers.

Celosia argentea L.

- Vern. names : (Ar.) Ras el shaeeb , Danab al-Kalib.

Shape Class : spheroidal.

Dimensions : D = 36.6 μm (32.4-42.1) ,
C = 13.2 , C/D = 0.36 , k = 0.85.

Pollen Class : periporate.

Apertures : simple ; pores 28 (10-50),
with annulus , present in depressions ,
operculate ; operculum deciduous ,
sculpturing unlike the rest of the surface ,
with isolated ektexinous elements.

Exine : tectate , tectum imperforate ,
of uniform thickness , ektexine thicker than
endexine.

Columellae : distinct , < 1 μm in
diameter , of varying size and distribution.

Sculpturing : scabrate ; scabrae
 \pm circular , < 1 μm in diameter , regularly
distributed.

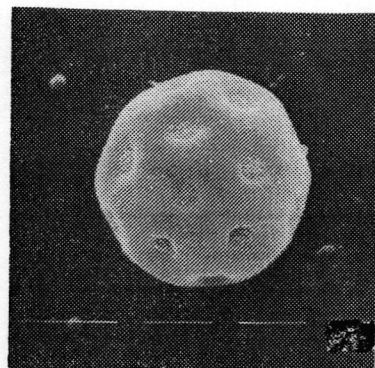


Fig. 37 , SEM

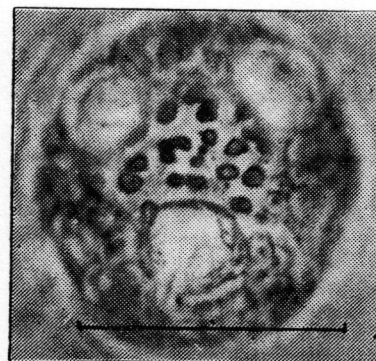


Fig. 38 , LM.

Habit : annual herbs. Habitat : lowland plains , weed of
cultivation and watercatchment areas. Distribution : Central and
Southern Sudan.

Agent of pollination : Wasps (Faegri & van der Pijl 1971).

Previous Work : Bonnefille (1971 b:479 , Pl. 4) , Bonnefille &
Riollet (1980:38 , Pl. 17 , figs. 21-25) , Maley (1970:35 , Pl. 6 ,
figs. 8-9) , Nair & Rastogi (1966:4 , fig. 1) , Nowicke (1975:53) ,
Riollet & Bonnefille (1976:71 , Pl. II , figs. 1-6) , Vishnu-Mittre
(1963:91) , Zandonella & Lecocq (1977:132 , Pl. II C).

Material Examined : El Ghazali G/84 , Nov. 1984. Nuba Mts. ,
Madgolin (North-west Rashad district) , Sudan. Deposited at KHU ,
NCRH , BG.

Comments :

This species is one of the commonest weeds of cultivation in
the Acacia Tall Grass Forest Region (Andrews 1948).

Celosia trigyna L.

- Vern. name : (Ar.) Bambit.

Shape Class : spheroidal.

Dimensions : D = 22.4 μ m (18.6-27.8) ,
C = 9.3 , C/D = 0.42 , k = 0.89.

Pollen Class : periporate.

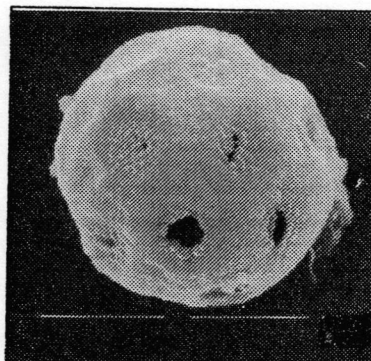
Apertures : simple ; pores 23 (18-45) ,
with annulus , present in depressions ,
operculate ; operculum deciduous ,
sculpturing unlike the rest of the grain.Exine : tectate , tectum imperforate
(LM) , perforations indistinct with the
SEM ; ectexine thicker than endexine.Columellae : distinct , < 1 μ m in
diameter , of \pm uniform length ,
regularly distributed, closely spaced.Sculpturing : scabrate ; scabrae
 \pm circular , < 1 μ m in diameter , regularly
distributed.

Fig. 39 , SEM

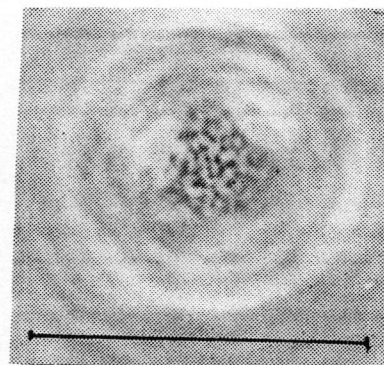


Fig. 40 , LM.

Habit : glabrous straggling herbs. Habitat : lowland plains.

Distribution : widespread.

Previous Work : Bonnefille & Riollot (1980:39 , Pl. 15 , figs.
13-17) , Maley (1970:35 , Pl. 6 , figs. 8-9) , Riollot & Bonnefille
(1976:71 , Pl. I , figs. 16-19).Material Examined : El Ghazali G74/83 , Nov. 1983. Nuba Mts. , Sudan.
Deposited at KHU , NCRH , BG.

Pupalia lappacea (L.) Juss.

- Syn. Achyranthes lappacea L.
- Vern. name : (Ar.) Abu el lusiag.

Shape : spheroidal.

Dimensions : D = 29.5 μm (24.7-34.0) ,
C = 7.8 , C/D = 0.26 , k = 0.89.

Pollen Class : periporate.

Apertures : simple ; pores 47 (30-80),
with annulus , operculate ; operculum
persistent , with peripheral pointed
radially-arranged processes.

Exine : tectate , tectum perforate ;
perforations \pm circular , irregularly
distributed , closely spaced ; ectexine
thicker than endexine.

Columellae : distinct , < 1 μm in
diameter , of varying size , irregularly
distributed , closely spaced.

Sculpturing : scabrate ; scabrae
 \pm circular , < 1 μm in diameter ,
irregularly distributed.

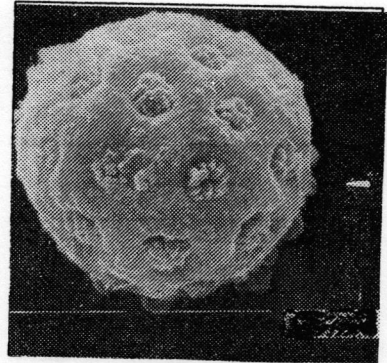


Fig. 41 , SEM.

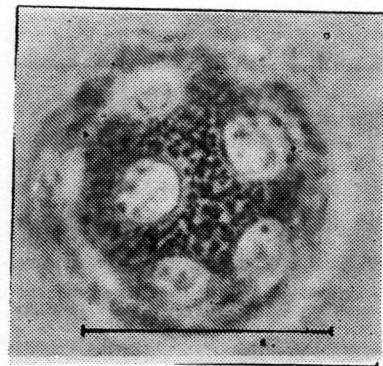


Fig. 42 , LM.

Habit : grey tomentose herbs. Habitat : weed of "Khor" banks and
damp grasslands. Distribution : widespread.

Previous Work : A.P.L.F. (1974:48 , Pl. 17) , Bonnefille & Riollot
(1980:40 , Pl. 17 , figs. 15-20) , Nair & Rastogi (1966:13) , Nowicke
(1975:53 , Pl. X , fig. 59) , Riollot & Bonnefille (1976:71 , Pl. V ,
figs. 1-6) , Vishnu-Mittre (1963:91) , Zandonella & Lecocq (1977:133,
Pls. IV , IX).

Material Examined : El Ghazali G51/83 , Nov. 1983. Nuba Mts., Kaloro
district , Sudan. Deposited at KHU , NCRH , BG.

Family : ANACARDIACEAE

Lannea humilis (Oliv.) Engl.

- Syn. Odina humilis Oliv.
- Vern. name : (Ar.) Layoun.

Shape Class : subprolate.

Shape in polar view : circular.

Dimensions : P = 48.0 μm (41.0-55.7) ,
E = 40.4 μm (32.2-49.8) , P/E = 1.19 , k =
1.19.

Pollen Class : tricolporate.

Apertures : composite.

Ectoapertures : colpi tapering at both
ends ; with isolated ektexinous elements ;
costae colpi present along the whole colpi ,
thicker at the equator.

Endoapertures : pores transversely
elongated ; with converging costae , length
 $\leq \frac{1}{2}$ the length of the ectoapertures.

Exine : tectate ; tectum imperforate ,
of uniform thickness , ektexine as thick as
the endexine.

Columellae : indistinct.

Sculpturing : striate , vallae clearly
marked , thicker than the lumina , short ,
running meridionally at the intercolpi and
changing direction by 90° at the poles ,
of uniform thickness , interweaving ,
concomitant with the columellae ; bottoms
of lumina imperforate.

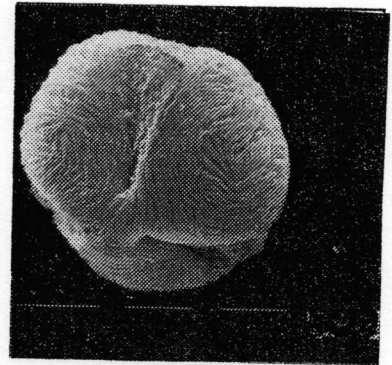


Fig. 43 , SEM , oblique
polar view.

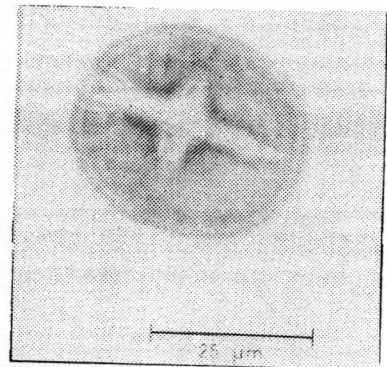


Fig. 44 , LM ,
equatorial view.

Habit : deciduous savanna trees or shrubs. Habitat : mixed Acacia
woodlands , lowland plains.

Distribution : Central and Southern Sudan.

Material Examined : Wickens 1511 , Apr. 1964. Jebel Marra , Zalingei,
Sudan. Deposited at KHU.

Comments :

This species is characteristic of the Semi-desert vegetational
type (Harrison & Jackson 1958). Pollen identified as far as the
genus Lannea is frequently recorded in Quaternary deposits of
Northwestern Sudan (Ritchie 1987 , Ritchie et al. 1985).

Rhus vulgaris Meikle.

- Syn. R. villosa sensu Lester-Garland.
- Vern. name : (Fur) Jawra.

Shape Class : subprolate.

Shape in polar view : semi-circular.

Dimensions : P = 30.4 μm (28.8-32.0) ,
E = 23.2 μm (19.2-25.6) , P/E = 1.31 , k =
0.86.

Shape Class : tricolporate.

Apertures : composite.

Ectoapertures : colpi slit-shaped , long
(from pole to pole) ; endexinous membrane
smooth ; costae colpi present along the
whole colpi , thicker at the equator.

Endoapertures : pores transversely
elongated , totally covered ; with parallel
costae , meridional edges lacking , length
< 1/2 the length of the ectoapertures.

Exine : tectate ; tectum imperforate ,
of uniform thickness , ectexine as thick as
the endexine.

Columellae : distinct , of uniform
length , regularly distributed.

Sculpturing : striate ; vallae clearly
marked , branched , thicker than the lumina,
running meridionally , anastomosing ,
concomitant with the columellae ; bottoms of
lumina imperforate.

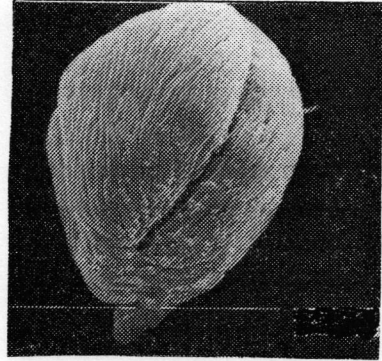


Fig. 45 , SEM , oblique
equatorial view.

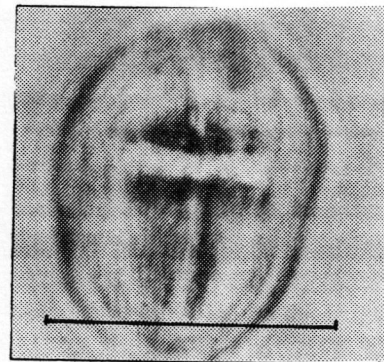


Fig. 46 , LM ,
equatorial view.

Habit : shrubs or small trees. Habitat : gallery forests , "Khor"
banks. Distribution : Central and Southern Sudan.
Material Examined : Kassas et al. 1154 , Dec. 1966. Jebel Dambobei ,
Sudan. Det. Collectors. Deposited at KHU.

*

Sclerocarya birrea (A.Rich.) Hochst.
 - Syn. *Spondias birrea* A.Rich.
 - Vern. name : (Ar.) Homeid.

Shape Class : prolate.

Dimensions : P = 33.7 μm (29.6-38.5) ,
 E = 23.7 μm (20.7-26.7) , P/E = 1.42 , k =
 0.93.

Pollen Class : tricolporate.

Apertures : composite.
 Ectoapertures : colpi slit-shaped ,
 endexinous membrane smooth ; costae colpi
 present along the sides , slightly thicker
 towards the equator.

Endoapertures : distinct , transversely
 elongated , meridional edges lacking or
 indistinct.

Exine : tectate ; tectum imperforate ,
 ectexine thicker than the endexine.

Columellae : distinct , of uniform
 length , regularly distributed , sometimes
 concomitant with the vallae.

Sculpturing : striate ; vallae thicker
 than lumina , long , running meridionally ;
 bottoms of lumina imperforate.

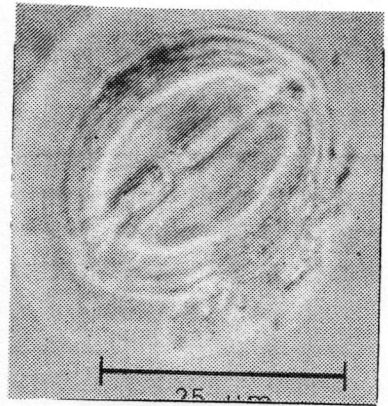


Fig. 47 , LM ,
 equatorial view.

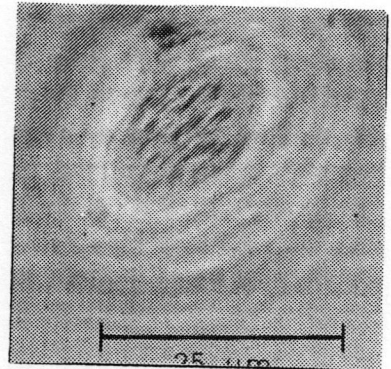


Fig. 48 , LM , surface
 view.

Habit : savanna trees with pale-green bark and leaves tufted at the
 end of branchlets. Habitat : lowland plains and "Khor" banks.
 Distribution : Central and Southern Sudan.
 Material Examined : reference slide 3509 , Lab. Geol. Quat. , CNRS ,
 Marseille , France. Herbarium material : C.Darskins 165 , Uganda.
 Deposited at EA.

Family : APOCYNACEAE

Adenium obesum Roem. & Schult.

- Syn. A.hongel A.DC. ; Nerium obesum Forsk.
- Vern. name : (Ar.) Shagar el ssim.

Shape Class : spheroidal.

Dimensions : D = 53.0 μ m (47.5-60.1) , k = 0.87.

Pollen Class : triporate or stephanoporate.

Apertures : simple , pores 3-4 , slightly protruding , with annulus , edges well-defined.

Exine : tectate ; tectum imperforate, of uniform thickness ; ectexine as thick as the endexine.

Columellae : distinct , of uniform length , dimorphic , irregularly distributed.

Sculpturing : psilate , smooth.

Habit : glabrous shrubs or small trees with smooth shiny trunks and fleshy branches.

Habitat : rocky hill-slopes.

Distribution : Jebel Marra , Nuba Mts.

Previous Work : Bonnefille (1971 b:480 , Pl. 4) , Bonnefille & Riollot (1980:43 , Pl. 18, figs. 16-20).

Material Examined : El Ghazali G87/83 , Nov. 1983. Nuba Mts. , Rashad district , Sudan.

Deposited at KHU , NCRH , BG.

Comments :

Bonnefille & Riollot (1980) described pollen grains with 4 (3 or 5) pores , whereas Bonnefille (1971b) described pollen grains with only 4 pores. In this study 3 or 4 pores were encountered.

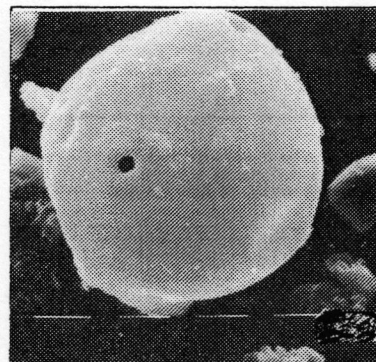


Fig. 49 , SEM

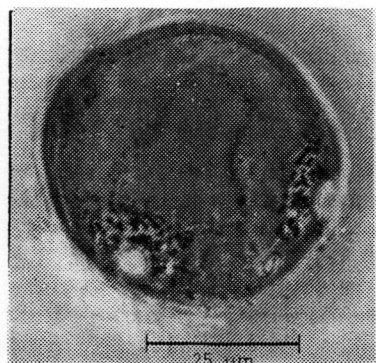


Fig. 50 , LM



Distribution map

Carissa edulis (Forsk.) Vahl.
- Vern. name : (Ar.) Alalli.

Shape Class : spheroidal.

Dimensions : $D = 46.6 \mu\text{m}$ (41.6-51.2) , $k = 0.86$.

Pollen Class : tricolporate.

Apertures : composite.

Ectoapertures : colpi slit-shaped or tapering at both ends ; apices acute ; with isolated ectexinous elements ; costae colpi present along the sides , thicker at the equator.

Endoapertures : pores slightly squared to transversely elongated , edges ill-defined or represented by interrupted costae colpi , slightly protruding.

Exine : tectate ; tectum perforate ; perforations \pm circular or elongated , distinct , irregularly distributed ; with elongated depressions and endocracks ; endexine as thick as the endexine.

Columellae : distinct , of uniform length , irregularly distributed.

Sculpturing : psilate , perforate ; perforations $< 1 \mu\text{m}$ in diameter , diameter smaller than the width of the separating tectum.

Habit : glabrous much-branched spinescent shrubs. Habitat : gallery forests , "Khor" banks. Distribution : widespread.

Previous Work : Bonnefille (1971 a :60 , Pl. 20 , figs. 1-6).

Material Examined : Wickens 987 , Jan. 1964. Jebel Marra , Saur 5800' , Sudan. Deposited at KHU.

Comments :

Bonnefille (1971a) described this species as with foveolate sculpturing. Nilsson (1986) interpreted that the endocracks of the exine are connected with the exine perforations.

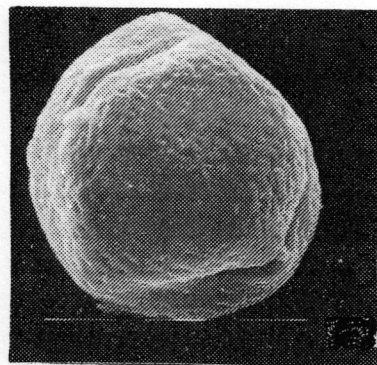


Fig. 51 , SEM , equatorial view.

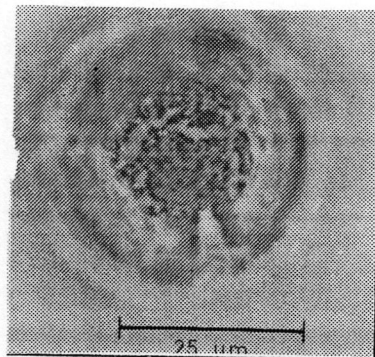


Fig. 52 , LM , surface view at the polar area.

Saba florida (Benth.) Bullock.

- Syn. Landolphia florida Benth. ; L.comorensis (Boj.) K. Schum. var. florida (Benth.) K. Schum.
- Vern. name : (Ar.) Erg el awaay.

Shape Class : spheroidal.

Dimensions : D = 46.5 μ m (41.1-57.0) , k = 0.87.

Pollen Class : heterocolpate.

Apertures : 3 ; 1 or 2 simple alternating with 2 or 1 composite.
Simple apertures : colpi oblong to slightly ovate , short , with rounded apices ; with isolated ectexinous elements.

Composite apertures :

Ectoapertures : colpi tapering at both ends , apices acute.

Endoapertures : pores distinct , slightly protruding ; with closed costae , diameter \pm equal to the width of the ectoapertures.

Exine : tectate ; tectum perforate ; perforations \pm circular , regularly distributed ; of uniform thickness , ectexine as thick as the endexine.

Columellae : indistinct.

Sculpturing : psilate , perforate ; perforations < 1 μ m in diameter , diameter smaller than the width of the separating tectum.

Habit : glabrous lianas with reddish-brown branches.

Habitat : "Khor" banks. Distribution : Central and Southern Sudan.

Previous Work : Bonnefille & Riollot (1980:43 , Pl. 18 , figs. 7-14) , Erdtman (1971:50-51 , fig. 16 C).

Material Examined : El Ghazali G58/83 , Nov. 1983. Nuba Mts. , Kaloro district , Sudan. Deposited at KHU , NCRH.

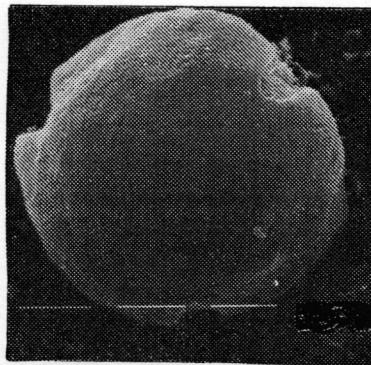


Fig. 53 , SEM , polar view.

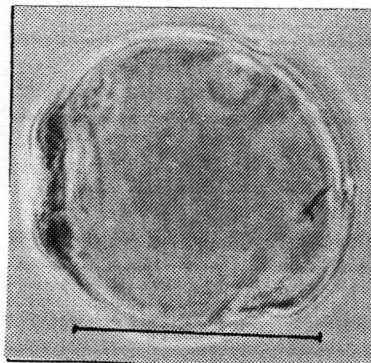


Fig. 54 , LM , optical section.