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Pollen identification multimedia software: a microtaxonomic palaeobotanical research tool

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ABSTRACT

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The utility of the graphically pollen identifiable software as a capacity building, microtaxonomic palaeobotanical research tool is briefly described. The software accompanying a user manual (a booklet) enables many levels of users to learn palynology "at the click of a mouse". The rationale and operation of the pollen identification system like the parent software IDAO is based on the principle of co-efficient of similarity and character weighting (*vide* Gower, 1971; Grard, 2000). A total of 145 selected genera belonging to 60 dicot and 2 monocot families have been listed. Out of selected genera, 14 are mangroves and most of the remaining genera come from the evergreen forests of Western Ghats. The vector drawings of weighted 136 pollen character states (in 30 character-interfaces) are also provided. The two major parts of this application, the Graphical Pollen Identification System and the Results are explained. A plate with the pollen digital images of 24 pollen types exemplifies palyno-diversity providing clues for parent-plant determination.

Key-words—Electronic pollen flora, Computer-aided identification, Trees, Micro-characters.

पराग अभिनिर्धारण बहुमीडिया सॉफ्टवेयर : एक सूक्ष्मवर्गिकीय पुरावानस्पतिक शोध सूत्र

जी. वसन्ती एवं पी. ग्रार्ड

सारांश

आलेखी रूप से पराग अभिनिर्धारणीय सॉफ्टवेयर की उपयोगिता क्षमता निर्माण, सूक्ष्मवर्गिकीय पुरावानस्पतिक शोध सूत्र के रूप में संक्षिप्त रूप से वर्णित की गई है। एक प्रयोक्ता नियम-पुस्तक (पुस्तिका) संगत सॉफ्टवेयर विभिन्न स्तरों के प्रयोक्ताओं को ''माउस के क्लिक करने पर'' परागाणुविज्ञान सिखा देता है। पराग अभिनिर्धारण प्रणाली का मूलाधार एवं प्रचालन जैसे कि मूल सॉफ्टवेयर आई डी ए ओ सदृश्यता एवं लक्षण महत्व (देखें गॉवर, 1971; ग्रार्ड, 2000) के गुणांक के सिद्धांत पर आधारित है। कुल 60 द्विबीजी एवं 2 एकबीजी परिवारों के 145 चिह्नित वंश सूचीबद्ध हैं। किंतु चिह्नित वंश में से 14 मैंग्रोव हैं तथा शेष अधिकांश वंश पश्चिमी घाटों के सदाहरित वनों से हैं। महत्वपूर्ण 136 पराग अभिलक्षण दशाओं (30 अभिलक्षण-अंतरापृष्ठ) के वेक्टर आरेख भी दिए गए हैं। इस अनुप्रयोग के दो प्रधान भाग, आलेखी पराग अभिनिर्धारण प्रणाली तथा परिणामों की व्याख्या की गई है। 24 पराग प्ररूपों के पराग अंकीय चित्रों सहित एक प्लेट मूल-पादप निर्धारण हेतु परागाणु-विविधता उदाहरण प्रदान करती है।

मुख्य शब्द—इलेक्ट्रॉनिक पराग पेड़-पौधे, कंप्यूटर-सहायक अभिनिर्धारण, वृक्ष, सूक्ष्म-अभिलक्षण।

Changing Scenario in Palaeobotany and Allied Subjects
Editor : J.S. Guleria

INTRODUCTION

THE parent plant taxa are determinable from the micro-taxonomic characters of spores and pollen. Their outer walls are sub-fossilisable in non-oxidizing depositional environments (Pocock *et al*., 1988: Fig. 1) because of their sporo-polleninous composition. The marker-value of these microfossils has been considered significant in palaeobotanical and palaeoecological investigations. The nomenclature of fossil pollen-spore types is mostly based on resemblances between fossils and their analogous pollen-spores of modern vegetation.

One of the "New Frontiers and Applications in Palynology" has been Computer and Palynology (Boyd & Hall, 1999). A few examples of computer-aided palynological research tools are: (i) Pollen identification system for Formosan pollen grains (Hsieh & Huang, 1983); (ii) Pollen-spores identification methods using XPER software for N. Europe (Lebbe *et al.*, 1987); (iii) *Dinium Alpha*: photomicrography database builder for Dinoflagellate cyst taxa (Williams, 1998); (iv) Application of multimedia in pollen analytical studies (Matthews, 1996); (v) Modelling pollen dispersal and deposition using *HUMPOL* software (Bunting & Middleton, 2005); (vi) OPENLAND3 Program for plant-pollen relationship (Eklöf *et al.*, 2004) and (vii) Mosaic I.I software for landscape simulation of pollen dispersal and deposition (Middleton & Bunting, 2004).

As a sequel to the south Indian pollen floras (Guinet, 1962; Vasanthy, 1976; Thanikaimoni, 1987; Tissot *et al*., 1994) a new palynological tool for computer-aided identification and self-training has been developed. It is an adapted version of the plant taxonomic tool IDAO ('Logiciel d'IDentification Assistée par Ordinateur' version II by Grard, 2000, Research Manual, CIRAD). The IDAO-based plant taxonomic tools by Grard *et al*., 1996; Le Bourgeois *et al.*, 1997; Bonnet *et al*., 2007; Prosperi *et al*., 2005 and the ongoing BIOTIK project by Grard *et al.* are the electronic plant floras facilitating computer-aided graphical identification: "Taxonomy at the click of a mouse" (Bisby *et al.*, 2002).

The objectives of the pollen identification software are: (i) to inspire young biologists, geologists and microscope-users to learn Palynology "at the click of a mouse" and (ii) to provide a computer-aided pollen identification tool to palaeo-ecologists appreciative of microtaxonomic "Palynological Diversity" (Blackmore & Barnes, 1991).

Trees are the principal components of forests and the ratio between the arborescent pollen and the total number of pollen counted per sample serve as an index in the interpretation of palaeopalynological results (Bonnefille, 1971). Hence, priority has been given to pollen grains of trees of the Western Ghats and mangroves that may be of greater ecological and palaeo-ecological importance in Late Quaternary and modern pollen analytical studies (e.g. Thanikaimoni, 1987; Vasanthy, 1988; Caratini *et al*., 1994; Sutra *et al*., 1997; Bonnefille *et al.*, 1999; Anupama *et al.*, 2000; Barboni & Bonnefille, 2001; Barboni *et al.*, 2003).

About 74% of the genera in this pollen identification software are "stenopalynous" [± same type of pollen characterizing all the species of a genus, a tribe, etc. (see Erdtman, 1952)]. These taxa, characterized by monotypic pollen, are mostly of wide geographic distribution (see Generic Distribution). A few examples of "stenopalynous" taxa are: *Ficus* pollen type / 800 spp.; *Ilex* pollen type / 400 spp.; *Myristica* type / 120 spp. and *Syzygium* pollen type / 500 spp. This fact implies that this software would serve as a research tool for Indian as well as International users.

This tool underscores the utility of Information Technologies in basic and applied palynological studies. As a multimedia self-tutoring tool, it would promote capacity-building in micro-taxonomic pollen science.

The Graphical Identification System combined with the Results providing legends included pollen images and pollen morphological descriptions, Tentative Typification, Generic References, Taxonomy, Ecology, Phytogeography and hyperlinked Bibliography and Pollen Terminology (mostly illustrated) is of palaeobotanic and taxonomic significance.

MATERIAL

The software is based on pollen of 152 tree species (Fig. 1) belonging to 145 genera encompassing 62 families. Out of the selected genera, 14 are mangroves and most of the remaining genera are found in Western Ghats. The chemically fossilized or acetolysed (*see* Erdtman, 1952) pollen mounted on slides are from the pollen-spores collection ("data-based" 22,000 specimens) of the Palynology Laboratory of the French Institute of Pondicherry.

METHODS

This pollen identification software is a product of Visual Basic 6.1.0 (© MacIntosh) and MS Access (© MacIntosh). Vector drawings of a composite picture and of 136 character states of selected tree pollen taxa (Fig. 2) have been designed with Coral Draw (V. 13). Information on the pollen morphology is organized in a database accessed by the identification system**.**

Pollen images were captured using Leitz Dialux 22 Microscope and Nikon Digital SLR Cameras. The digital images of the Leitz micrometer scale were superimposed on the pollen images (see Pl. 1) to enable users to assess different characters quantitatively at a glance before and after zooming (Fig. 9 in the User Manual in Vasanthy & Grard, 2007a).

THE USER–MANUAL

From the following subheadings included under the illustrated (6 screen-shots) *Presentation of the tool*, users

FAM	Genera
ANA	*Gluta, Holigarna, Mangifera, Nothopegia, Semecarpus*
ANN	*Goniothalamus, Meiogyne, Polyalathia*
APO	*Alstonia*
AQF	*Ilex*
ARE	*Bentinckia, Caryota, Pinanga*
ARL	*Schefflera*
AST	*Vernonia*
AVI	***Avicennia***
BIG	*Pajanelia*
BOM	*Cullenia*
BRR	***Barringtonia***, *Careya*[3]
BRS	*Canarium, Garuga*
CPP	*Capparis*[4]
CEL	*Bhesa, Elaeodendron, Euonymus, Lophopetalum, Microtropis*
CLU	*Calophyllum, Garcinia, Mesua, Poeciloneuron*
CMB	***Lumnitzera***
CPR	*Viburnum*
COR	*Mastixia*
CSL	*Bauhinia, Humboldtia, Kingiodendron*
DCH	*Dichapetalum*
DPC	*Dipterocarpus, Hopea,Vateria*
EBN	*Diospyros*
ELC	*Elaeocarpus*
ERI	*Rhododendron*
ERX	*Erythroxylum*
EUP	*Actephila, Agrostistachys, Baccaurea, Bischofia, Blachia, Croton, Dimorphocalyx, Drypetes, Excoecaria, Fahrenheitia, Glochidion, Macaranga, Mallotus*
FAB	*Ormosia*
FLC	*Casearia, Flacourtia, Hydnocarpus, Scolopia, Taraktogenos*
ICC	*Apodytes,Gomphandra, Nothapodytes*
LAU	*Litsea, Neolitsea*
LOG	*Fagraea*
MAG	*Michelia*
MAL	***Hibiscus*** *(tiliaceous)*
MEL	*Aglaia, Dysoxylum, Reinwardtiodendron, Toona, Trichilia, Walsura,* ***Xylocarpus***
MIM	*Acacia*[1], *Albizia*[1]
MLS	*Memycylon*
MOR	*Antiaris, Artocarpus, Ficus*
MRS	***Aegiceras***, *Ardisia, Rapanea*
MRT	*Eugenia, Syzygium*
MYS	*Gymnacranthera, Knema, Myristica*
OLC	*Strombosia*
OLE	*Olea*
PGL	*Xanthophyllum*
PIT	*Pittosporum*
POA	*Bambusa*[2]
RHZ	***Blepharistemma, Bruguiera, Carallia, Ceriops, Kandelia, Rhizophora***
ROS	*Prunus (Pygeum)*
RUB	*Gardenia*[3], *Ixora, Neonauclea, Octotropis, Psychotria, Tricalysia, Wendlandia*
RUT	*Atalantia, Clausena, Evodia, Murraya, Vepris*
SAB	*Meliosma*[5]
SAP	*Dimocarpus, Dodonaea, Filicium, Harpullia, Otonephelium, Thraulococcus*
SNN	***Sonneratia***
SPT	*Chrysophyllum, Isonandra, Madhuca, Mimusops, Palaquium, Xantolis*
STP	*Turpinia*
STR	***Heritiera,*** *Leptonychia, Pterospermum, Pterygota*
SYM	*Symplocos* (3 species: Eurypalynous)
TEA	*Eurya, Gordonia*
ULM	*Celtis*
URT	*Villebrunea*
VAC	*Vaccinium*
VRB	*Clerodendrum*
VIO	*Rinorea*

Note: Acronyms of families after Weber (1982, Taxon 31: 74-88).
The generic names (11) in bold letters are the Mangrove trees. Seven taxa (superscripted 1-5) distributed in other areas or regions (outside the Western Ghats) are from: [1]south India and Sri Lanka; [2] Sri Lanka; [3] India and Sri Lanka; [4]eastern south India and [5]Eastern Ghats. The remaining 127 genera are mostly from the evergreen forests of the Western Ghats. To assess the marker-values of the pollen taxa, the reader is referred to the pollen analytical study of the Late Quaternary (Caratini *et al.* 1994: 373-376).

Fig. 1—List of selected S.I. tree genera and their families.

can evaluate the user-friendly nature of the pollen identification software.

(i) The content and Structure: Principles. (ii) Selection of taxa. (iii) Computer-aided pollen identification. (iv) Pollen microscopy prior to identification. (v) Integrating characters to identify pollen types/taxa. (vi) Selecting and unselecting character states by clicking. (vii) Synthesis of pollen diagnostic characters in this taxa determination key. (viii) Changing percentage of similarity during identification. (ix) Appropriate method to choose the identification criteria. (x) Some suggestions for reliable identification. (xi) Identifying a pollen type: An example. (xii) Access to the results of identification. (xiii) The descriptive page. (xiv) Zooming micrographs. (xv) Detecting and correcting error(s). (xvi) Access to the terms via links.

THE RATIONALE AND OPERATION

The rationale and operation of IDAO applications are relying on the principles of coefficient of similarity and character weighting (Gower, 1971; Grard, 2000). A similarity co-efficient measures the resemblances between two individuals based on two logically distinct kinds of information pertaining to variables allowing for possible missing information (Gower, 1971). The simplified version of the similarity coefficient of Gower (*ibid*.) has been modified as given below for the IDAO-based pollen identification application.

$$\frac{\text{Number of common shared and weighted character states}}{\text{Total number of observed and weighted character states}}$$

In this application the character weights are given to character states (Fig. 2); the character weights (1 to 10) are given to them in increasing order from faintly to easily discernible ones. The diagnostic value of the latter is obviously greater than that of the former. We have given weights by approximate diagnostic evaluation of character states: (i) easily observable and of greater diagnostic value- 9.0; (ii) distinct but of rare occurrence (variation within a species)- 7.0; (iii) of moderate diagnostic value- 5.0 and (iv) faintly discernible and/or lesser diagnostic value or hardly observable- 1.0.

The system is supplied with the user-selected character states to calculate the best possible match. The number of the identifiable species depends on the number of layers that have been introduced in a particular application. The pollen identification software includes 26 layers (opening interface, 25 character-frames and 30 graphical interfaces with tool tip-texts for 136 character states (Fig. 2). It may be easily discerned by the reader from the illustrated character states from second through eighth interface are not simple but compound in nature as these are classified on the bases of **N**umber, **P**osition and **C**haracter of pollen apertural types (*cf.* **NPC** system of Erdtman, 1969).

The opening interface (Vasanthy & Grard, 2007a: Fig. 1) displays the initially accessible characters' frames labeled with tip-texts (15/25) linked to 3-colporate pollen in equatorial and polar views and 3-porate pollen in polar view. The two buttons at the top right read *Search* and *Results*. The percentage of similarity "box" is at the right bottom. Changing percentage of similarity during identification serves as a guide for user's interactive steps in framing the pictorial identification key or identikit.

In the opening Interface

150 species at 0%

>1 to <100% (with Errors)

'n' species at 65%

Reliable Identification

'n' species at 100%

The chosen character state appears upon validation in the character-frame. The number of species having a specific character state or a combination of them is displayed within the "box" at lower right of the screen. At every step of identification the user should note the values (percentage of similarity) displayed within the "box".

These values indicate: (i) The **number of species** covered by the graphically assembled identikit with the chosen characters. (ii) The **percentage of similarity** between one or some of the listed species and the assembled identikit. (iii) If the combination of user's identification criteria is unmatchable with any of the listed species of the pollen flora, then the percentage of similarity cannot reach **100%**.

IDENTIFICATION AND RESULTS

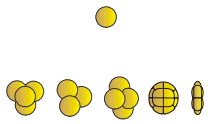
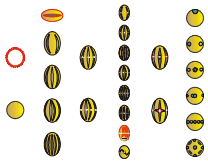
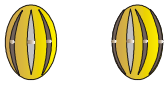
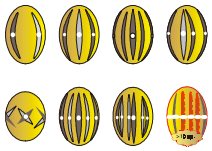
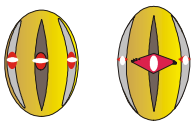
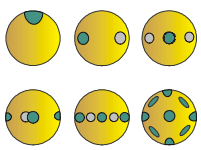
The two major interfaces of this software are the Identification interface and the Results interface. The Identikit interface enables the user to build the graphical pollen identification key to determine the parent plant taxon (Fig. 3). And the Result(s) interface serves as an electronic pollen flora (Fig. 4) during and after key framing. Users can access the results in 3 phases: prior to or during or on completion of identification. The pollen descriptive page of any of the included species could also be accessed by clicking on **View**→Species list→species→the chosen species.

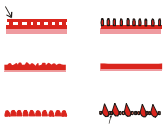
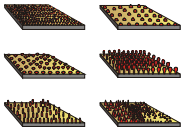
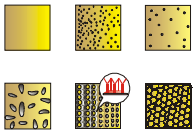
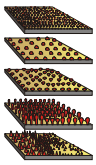
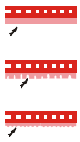
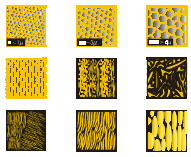
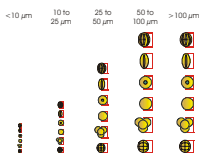
The Descriptive Page provides: 1. Binomial nomenclature of the species that produced a specific pollen type. 2. Detailed pollen morphological description together with remark, tentative pollen typification and references (Generic Palynology). 3. Origin of the pollen specimen studied. 4. Ecology and taxonomy of the species. 5. Distribution of the species. 6. Distribution of the genus. 7. Link for the bibliographic list (82 cited references). 8. A set of light microscopic digital pollen images for 150 taxa (with scale lines). 9. Complementary scanning electron micrographs for 47 taxa. When the mouse cursor is placed over these illustrations a brief description (Legend) appears (Fig. 4). Underlined and green-colored pollen morphological terms are linked to mostly illustrated definitions (Vasanthy & Grard, 2007a: Fig. 9 in the User manual).

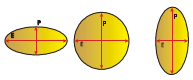
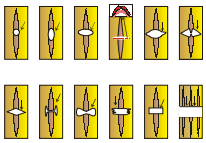
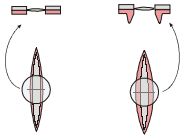
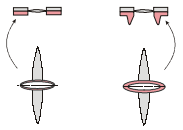
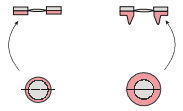
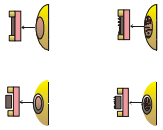
Information on ecology, taxonomy and distribution of species and genus has been provided from Gamble (1915-1936), Pascal and Ramesh (1987), Ramesh *et al.* (1997), Prosperi *et al.* (2005) and Willis (1988) enabling the user to assess approximately the marker-values of pollen types.

CONCLUDING REMARKS

The IDAO adapted pollen identification software is being used by young palynologists of the French Institute of Pondicherry since Nov. 2006 and two posters were presented at the International conferences held in India (Vasanthy & Grard, 2006; Vasanthy & Grard, 2007b). After its publication by the IFP, (www.ifpindia.org/pdfs/eco_pub.pdf) it has been demonstrated to many visiting palynologists and

Pollen Characters	Interfaces	Pollen Character States of Selected Taxa	Weights of Ch. States
Pollen Grouping		Single grain	9.00
		Grouped grains	9.00
Types of composite Pollen		Tetrad (4-celled) with composite apertures	9.00
		Tetrad (4-celled) with circular apertures	9.00
		Polyad (16-celled) with circular apertures	9.00
Types of simple Pollen		No aperture	9.00
		One to few furrows	9.00
		Diffused inner thinning of composite aperture	9.00
		Composite aperture with well-delimited inner opening	9.00
		Inner opening of composite aperture with two units	9.00
		Circular aperture	9.00
Types of colpate Pollen		Sulcate or monocolpate: with only one furrow	9.00
		2-Colpate	9.00
		3-Colpate	9.00
		4-Colpate	9.00
		5-Colpate	9.00
Types of colporoidate Pollen		3-Colporoidate	9.00
		4-Colporoidate	1.00
Types of colporate Pollen		2-Colporate	7.00
		3-Colporate	9.00
		3-Colporate and 3-Colpoidate (Heterocolpate)	9.00
		4-Stephano-colporate	9.00
		4-Pericolporate/4-Loxocolporate	7.00
		5-Stephano-colporate	7.00
		6-Stephano-colporate	1.00
		10 >= Stephano-colporate	9.00
Types of colpororate Pollen		Bipartite os Type 1	9.00
		Bipartite os Type 2	9.00
Types of Porate Pollen		Single pore	9.00
		Biporate	9.00
		Triporate	9.00
		Tetraporate	9.00
		Pentaporate	9.00
		Polyperiporate	9.00

Types of Tectum		With roof	9.00
		Without roof	9.00
		No tectum with areolae	9.00
		Intectate without positive sculpture	9.00
		Intectate, verrucae on nexine	9.00
		Intectate, spinulate / microgemmate	9.00
Types of positive sculpture (Intectate Exine)		Scabrate, granular	9.00
		Warty, verrucate	9.00
		Gemmate, spherical and constricted at base	1.00
		Clavate, club-shaped elements	1.00
		Baculate, rod-like elements	9.00
		Spiny to spinulate, pointed elements	9.00
Exine Surface		Smooth exine surface	9.00
		Very small pores	9.00
		Pits >= 1.0 micron	9.00
		Exine surface grooved	9.00
		Funnel-shaped depressions	9.00
		Linked grooves (negative reticulum)	9.00
Types of supratectal positive sculpture		Scabrate, granular	9.00
		Warty, verrucate	9.00
		Gemmate, spherical and constricted at base	9.00
		Clavate, club-shaped elements	9.00
		Spiny to spinulate, pointed elements	9.00
Nexine proximal surface		Nexine proximal surface smooth	1.00
		Nexine proximal surface with endocracks	1.00
		Nexine proximal surface with endosculpture	1.00
Elongated sculpture on Tectum		Micro-reticulate: network with small lumina (<= 1.0 µm)	9.00
		Reticulate: network with medium sized lumina (>1.0 - 3.0 µm)	9.00
		Coarsely reticulate: network with large-sized lumina (> 4.0 µm)	9.00
		Striato-reticulate: network intermediate between striate and reticulate	9.00
		Granulo-rugulate: elongated strips mixed with granules	9.00
		Rugulate: elongated strips irregularly distributed	9.00
		Finely striate: ± parallel thin ridges (width < 1.0 µm)	9.00
		Striate medium (> 1.0 µm width)	9.00
		Coarsely striate: ± parallel ridges (> 3.0 µm width)	9.00
Polar Axis/ Length/ Diameter		Polar axis / Length or Diameter < 10 µm	1.00
		Polar axis / Length or Diameter > 10 to 25 µm	1.00
		Polar axis / Length or Diameter > 25 to 50 µm	1.00
		Polar axis / Length or Diameter > 50 to 100 µm	1.00
		Polar axis / Length or Diameter > 100 µm	1.00

E Axis *vs.* P Axis		Equatorial axis longer than the Polar axis	1.00
		Equatorial axis equal to the Polar axis	1.00
		Equatorial axis shorter than the Polar axis	1.00
Os shape		Circular os	5.00
		Elliptic, vertical os	5.00
		Elliptic, horizontal os	5.00
		Elliptic, horizontal os with cavity	5.00
		Lens shaped os	5.00
		Rhombus os with constriction	1.00
		Rhomboidal os	5.00
		H shaped os	5.00
		Bow shaped os	5.00
		Irregularly shaped os	5.00
		Rectangular os	5.00
		Ringed os	5.00
Colpal costae		Non costate colpi	1.00
		Costa(e) colpi	1.00
Oral costae		Non costate os	1.00
		Costate os	1.00
Poral costae		Non costate pore	1.00
		Costate pore	1.00
Polar area(s) in colp(or)ate pollen		Polar areas (unbordered)	1.00
		Parasyncolpate (bordered polar areas)	1.00
		Syncolpate, no margo (polar area absent)	1.00
		Syncolpate, synmargo (polar area absent)	1.00
Types of Margo		Margo thick	1.00
		Margo thin or diffuse	1.00
		Margo undifferentiated	1.00
Types of Annulus		Annulus thick	1.00
		Annulus thin or diffuse	1.00
		Annulus undifferentiated	1.00
Types of Aperture membrane		Non-operculate, smooth	1.00
		Non-operculate, sculptured	1.00
		Operculate, smooth	1.00
		Operculate, sculptured	1.00

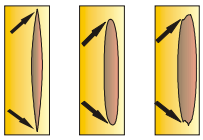
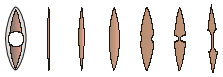
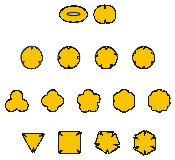
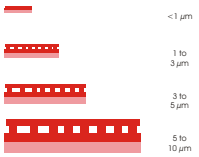
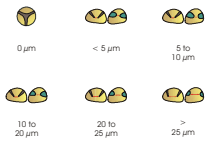
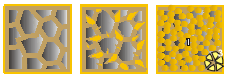
Types of colpus apex		Colpus Apex pointed	1.00
		Colpus Apex blunt	1.00
		Colpus Apex truncate or wavy	1.00
Colpus shape		With periapertural thinning	1.00
		Linear	1.00
		Elliptic	1.00
		Broadly Elliptic	1.00
		Equatorially constricted (Type A)	1.00
		Equatorially constricted (Type B)	1.00
		Equatorially constricted (Type C)	1.00
Polar view		Elliptic	1.00
		(Sub) Circular	1.00
		(Sub) Lobed	1.00
		(Sub) Angular	1.00
Exine thickness		Maximum Exine Thickness < 1 µm	1.00
		Maximum Exine Thickness > 1 to 3 µm	1.00
		Maximum Exine Thickness > 3 to 5 µm	1.00
		Maximum Exine Thickness > 5 to 10 µm	1.00
Distances between the adjacent apertural apices		0 µm apart / united	1.00
		< 5 µm apart	1.00
		> 5 to 10 µm apart	1.00
		> 10 to 20 µm apart	1.00
		> 20 to 25 µm apart	1.00
		> 25 µm apart	1.00
Elongated + Positive Sculptures		Macroreticulum smooth	9.00
		Crest-like reticulum	9.00
		"Beaded" reticulum	9.00

Fig. 2—The weighted pollen character states and the character interfaces.

palaeobotanists. Upon receiving the complementary copies from the IFP, palynologists have appreciated the software.

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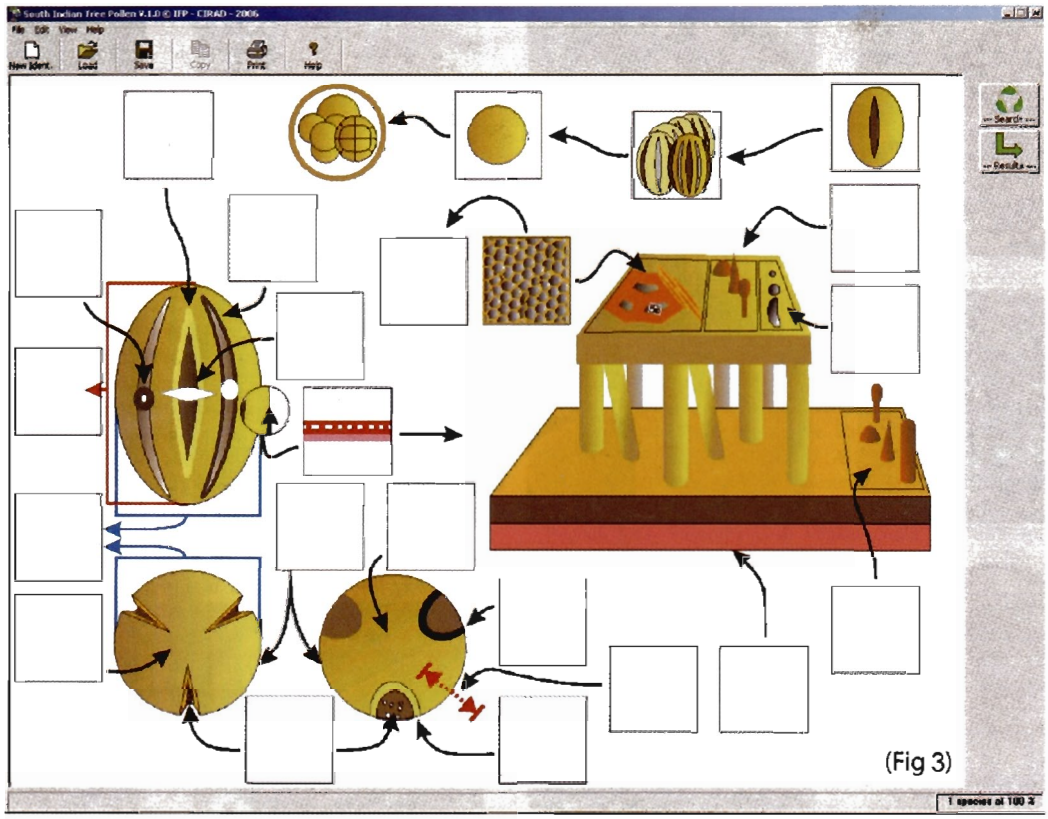

Fig. 3—The identikit with the user-selected 5 character states of *Knema attenuata* (Myristicaceae).

Fig. 4—The result of *Knema attenuata* pollen type. Note the legend of the pollen image(s) is provided as tip-text.

PLATE 1

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PLATE 1

1. *Acacia* subtype
2. *Rhododendron arboreum* type
3. *Croton* type. (*Dimorphocalyx*)
4. *Pinanga dicksonii* type
5. *Careya* type
6. *Dipterocarpus* type
7. *Leptonychia moacurroides* type
8. *Vateria indica* type
9. *Sonneratia alba* type
10. *Ilex* type
11. *Lumnitzera racemosa* type
12. *Agrostistachys* type
13. *Avicennia* type.
14. *Rhizophora* type
15. *Xantolis* type
16. Hibiscaceae subtype
17. *Humboldtia* type 1. (*H. brunonis*)
18. *Mesua* type
19. Hippocrateaceae type (*Micritropis*)
20. Rubiaceae type **x** (*Neonauclea*)
21. *Xanthophyllum flavescens* type
22. *Palaquium* type
23. *Pterospermum* type
24. *Clerodendrum* type

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