MEMÓRIAS
DA SOCIEDADE BROTERIANA
VOLUME X
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INSTITUTO BOTÂNICO DA UNIVERSIDADE DE COIMBRA

# MEMÓRIAS
## DA
# SOCIEDADE BROTERIANA

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# UMA NOVA ESPÉCIE PARA A FLORA DE PORTUGAL

## *ALTHAEA CANNABINA* L.

*por*

J. MALATO-BELIZ,
A. FONSECA RAIMUNDO *e* J. A. GUERRA
Estação de Melhoramento de Plantas, Elvas

MERCÊ da constante actividade de alguns Centros de Investigação que, entre nós, dedicam maior ou menor parte dos seus programas de trabalho e dos seus esforços a estudos florísticos, existe actualmente um crescente e marcado progresso no conhecimento da flora portuguesa. Os resultados globais dessa actividade, ainda há pouco postos em evidência por A. FERNANDES durante o VIII Congresso Internacional de Botânica (Progrès récents dans l'étude de la flore vasculaire du Portugal. *Rapp. et Comm. au VIII^e Congr. Intern. de Bot.* Paris, 1954), englobam a descrição de diversos *taxa* novos para a Ciência, a identificação de outros até então desconhecidos em Portugal e uma mais rigorosa delimitação das áreas de distribuição de numerosas espécies e de grupos infra-específicos da nossa flora.

Todavia, e apesar dos resultados já obtidos, as herborizações minuciosas continuam a fornecer elementos de valor para um mais perfeito conhecimento do elenco florístico do nosso País.

Um novo elemento surgiu com a recente herborização da *Althaea cannabina* L. nos arredores de Elvas, planta até agora desconhecida em Portugal. Em boa verdade, porém, o seu aparecimento nesta zona interior não deve surpreender se se atender a que a sua área de distribuição conhecida abrangia já, por assim dizer, todo o Sul da Europa, com excepção de Portugal. É, mesmo, de supor que a primeira localidade lusitana da espécie, de que agora se dá conta, não seja a única.

Aos Ex.^mos Senhores Directores dos Institutos Botânicos de Coimbra e de Lisboa o nosso profundo reconhecimento pela gentileza de nos haver sido facultado o material dos respectivos Herbários necessário à elaboração da presente nota.

## REFERÊNCIAS E DIAGNOSE

***Althaea cannabina* L.**, *Sp. Pl.*: 686 (1753); LE MAOUT et DECAISNE, *Fl. Élém. Jard. Champs* **2**: 518 (1855); WILLKOMM et LANGE, *Prodr. Fl. Hisp.* **3**: 585 (1880); BONNIER, *Fl. Compl. Fr. Suis. Belg.* **2**: 79 (1911-1934); JÁVORKA, *Magyar Fl.*: 715 (1925); FIORI, *Nuova Fl. Anal. Ital.* **2**: 156 (1925-1929); COSTE, *Fl. France* **1**: 240 (1937); CABALLERO, *Fl. Anal. Esp.*: 296 (1940); FOURNIER, *Les quatre Fl. France*: 609 (1946); BAILEY, *The Stand. Cyclop. Hortic.* **1**: 268 (1947); DIAPULIS, *Syn. Fl. Graec.*: 304 (1948); GISMONDI, *Prosp. Fl. Ligust.*: 584 (1950).

*Icon.* — BONNIER, *l. c., planche* 97: 512; FIORI, *Icon. Fl. Italicae*: 310 (1933); COSTE, *l. c.*; FOURNIER, *l. c.*

Planta vivaz, de 0.60 a 2.40 m, estrelado-puberulenta a subtomentosa, esbranquiçada, erecta ou, mais ou menos, difusa. Caule rizomatoso grosso, muito ramoso, roliço. Folhas pecioladas (as superiores com pecíolo curto), profundamente divididas, as inferiores palmatipartidas com 5 segmentos, e as superiores palmatissectas, apenas com 3 segmentos; segmentos ovais ou oblongo-lanceolados, irregularmente inciso-serrados ou, por vezes, subpinatífidos; estípulas persistentes, linear-assoveladas. Pedúnculos axilares maiores do que a folha, erecto-patentes, 1-2 floros. Flores com 1.8 a 2.5 cm de comprimento. Epicálice formado por 7-9 bractéolas linear-lanceoladas mais curtas que o cálice. Cálice constituído por 5 segmentos ovado-acuminados. Corola 2-3 vezes maior que o cálice, rosada com a base purpúrea. Pétalas obcordiformes. Aquénios acastanhados, glabros, transversalmente rugosos no dorso.

*Floração:* Junho-Setembro.

*Espécime*

Alto Alentejo: Elvas: junto à estrada para Campo Maior: margem da ribeira de Závil (24-Agosto-1954, *F. Raimundo e J. A. Guerra* 1699).

*Exsiccata*

ESPANHA: Corla, Aragon, Espagne (Juin-1884, *Bordère*. Herbarium Bordère).

Campos — Uclés (Julho-Agosto 1897, *J. S. Tavares*. Flora Hispanica, Museu de S. Fiel).

Valence: Segorbe, coteaux (16-VIII-1920, *Dr. C. Pau*. Herb. F. Sennen).

FRANÇA : Clermont-Ferrand (Puy-de-Dôme): haies, aux environs de la ville (13-août-1878, *Fre. Héribaud-Joseph*).

Toulouse (Haute-Garonne): coteaux de Pech-David (17--août-1879, *E. Timbal-Lagrave*).

(1894, *Ab. Marçais*. Herb. Société du Sud-Est).

ITÁLIA : Ad agrorum margines — Frazzanò (Julio, *Todaro*. Fl. Sicula Exsiccata n. 1556).

ÁUSTRIA : In fruticetis prope Zaule. Istria (21-Julii-1889, *V. Engelhardt*. F. Schultz, herbarium normale, nov. ser. Cent. 26: 2520).

HUNGRIA : Ofen: Schwabenberg in Schlagen (August-1872, *Lud. Richter*).

Ofen (Jun-1883, *Richter*)

In silvis: Schwabenberg ad Budam. Hungaria Centralis (23-Szept.-1883, *Hermann*).

Adlerberg bei Ofen (Juli, *W. Steinitz*).

*Distribuição geográfica*

Europa Meridional (Portugal, Espanha, Sul da França, Itália, Áustria, Hungria, Grécia e Cáucaso) e Ásia Ocidental (Ásia Menor, Síria e Pérsia).

## ECOLOGIA E FITOSOCIOLOGIA

A *Althaea cannabina* é apontada pela maior parte dos autores (cf. por ex. Bolós, 1950, pág. 404) como planta própria de terras húmidas e ensombradas. Tem sido assinalada nas margens dos cursos de água, em taludes, sebes e fossos. Mais raramente, encontra-se também em terras de cultura, tais como olivais e hortejos.

Parece habitar em solos neutros ou alcalinos de baixa altitude.

Sob o ponto de vista fitosociológico, tem sido indicada, no Sul da França, como característica de *Brachypodietum phoenicoidis* Br.-Bl. 1924, da classe *Thero-Brachypodietea* Br.-Bl. 1947 (Braun-Blanquet et collab.,

1952), associação própria de terrenos incultos, bordas dos campos, colinas e fundo de ravinas, em solos básicos.

Nos arredores de Elvas, encontrou-se nas margens de um ribeiro, numa pequena horta aonde se havia cultivado fava, e num talude marginal, em solo de pH 7. No primeiro destes locais, acompanhavam esta espécie:

*Elatinoides lanigera* (Desf.) P. Cout.
*Lactuca Scariola* L.
*Cichorium Intybus* L.
*Pulicaria uliginosa* Hoffgg. et Link
*Erigeron canadensis* L.
*Picris echioides* L.

No talude referido encontrava-se com:

*Equisetum ramosissimum* Desf.
*Carex hispida* Willd.
*Rubus* sp.
*Mentha rotundifolia* (L.) Huds.
*Lythrum Salicaria* L.
*Epilobium hirsutum* L.
*Jasminum fruticans* L.
*Elatinoides lanigera* (Desf.) P. Cout.
*Euphorbia androsaemifolia* (Schousb.) Willd.
*Euphorbia pubescens* Vahl
*Brachypodium phoenicoides* (L.) R. et Sch.
*Foeniculum vulgare* Miller
*Scrophularia aquatica* L.
*Inula viscosa* (L.) Ait.
*Tunica prolifera* (L.) Scop.
*Rosa canina* L.
*Centaurea salmantica* L.
*Saponaria officinalis* L.
*Thapsia garganica* L.

Embora não seja possível, por falta de elementos concretos, definir a posição fitosociológica que entre nós ocupa a *Althaea cannabina*, salienta-se o facto de algumas das espécies que coabitam no local referido, como *Brachypodium phoenicoides*, *Foeniculum vulgare*, *Tunica prolifera* e *Centaurea salmantica*, serem incluídas na classe *Thero-Brachypodietea* a que já fizemos referência.

## CHAVES PARA A DETERMINAÇÃO DAS ESPÉCIES DE *ALTHAEA* EXISTENTES EM PORTUGAL

Por só agora ser conhecida em Portugal, a *Flora* de PEREIRA COUTINHO (1939), como é óbvio, não faz qualquer referência a *Althaea cannabina*. Deste modo, para tornar possível a sua determinação, actualizando as chaves ali existentes, elaborou-se o seguinte novo esquema de identificação para as espécies do género *Althaea* L. até agora conhecidas no nosso País, tomando como base não só o citado trabalho daquele tão ilustre Mestre, mas também as já citadas obras de WILLKOMM et LANGE e de FIORI:

1 — Pedúnculos (pelo menos os inferiores) mais compridos que a folha correspondente . . . . . 2
Pedúnculos iguais ou menores que a folha; plantas vivazes . . . . . 4

2 — Plantas anuais; pedúnculos unifloros. . . . . 3
Planta vivaz, robusta, de 6-24 dm, estrelado-puberulenta a subtomentosa, esbranquiçada; estípulas persistentes, linear-assoveladas; pedúnculos uni-bifloros; segmentos do cálice ovado-acuminados; folhas inferiores palmatipartidas com 5 segmentos, as superiores palmatissectas apenas com 3; aquénios acastanhados, glabros, transversalmente rugosos no dorso . . . . . **A. cannabina** L.

3 — Planta delgada, de 1-4 dm, hirsuta, com pêlos patentes; estípulas persistentes, fundamente bi-quadrifendidas; segmentos do cálice longamente triangular-acuminados, erectos na frutificação; folhas superiores tripartidas; aquénios glabros, transversalmente rugosos, aquilhados no dorso . . . . . **A. longiflora** Bss. et Reut.
Planta de 1-4.5 dm, hirsuta, ramosa ou, raramente, simples; estípulas persistentes, cordado-ovadas, acuminadas; folhas superiores palmatipartidas, com 3-5 segmentos oblongos; aquénios glabros, arredondados no dorso, transversalmente rugosos . . . . . **A. hirsuta** L.

4 — Planta erecta, rígida, estreita, de 1-2 m, mais ou menos estrelado-tomentosa; estípulas caducas; folhas palmatilobadas; epicálice quase do tamanho do cálice ou sensivelmente menor; corolas grandes (cerca de 6 cm de diâmetro

ou mais); aquénios sulcados no dorso, sub-bimarginados, tomentosos . . . . . **A. rosea** (L.) Cav.

Planta robusta, de 5-15 dm, molemente aveludado-esbranquiçada; estípulas caducas, pequenas, inteiras; folhas superiores trilobadas; segmentos do cálice ovados, por fim aplicados sobre o fruto; corolas medíocres (cerca de 3 cm de diâmetro); aquénios não marginados, tomentosos . . . . . **A. officinalis** L.


## SUMÁRIO

No presente trabalho, os autores dão notícia do aparecimento da *Althaea cannabina* L. em Portugal. Apresentam a sua diagnose, apontam a distribuição geográfica e fazem algumas referências à sua ecologia e fitosociologia. Incluem, ainda, chaves para a determinação das espécies de *Althaea* de cuja existência, presentemente, se tem conhecimento no País.

## RÉSUMÉ

Dans la publication présente, les auteurs mentionnent, pour la première fois, l'existence de l'*Althaea cannabina* L. au Portugal. Après avoir donné la description de l'espèce et sa distribution géographique, ils ont fait des références à l'écologie et à la phytosociologie de cette plante. Finalement, ils ont présenté des clefs pour la détermination des espèces du genre *Althaea* connues au Portugal.

## SUMMARY

In this paper, the authors notice, for the first time, the existence of *Althaea cannabina* L. in Portugal.

Diagnosis and the geographical distribution of the plant as well as some considerations on the ecological and phytosociological position of this species are presented. Keys to the determination of the Portuguese species of the genus *Althaea* are given.


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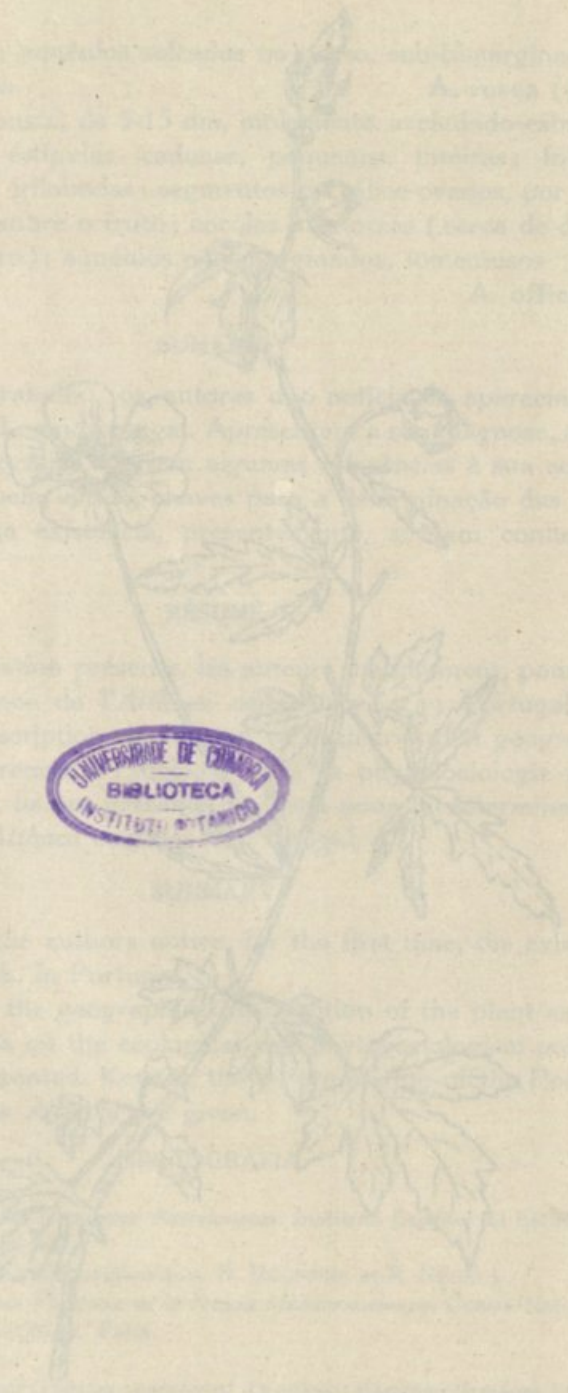
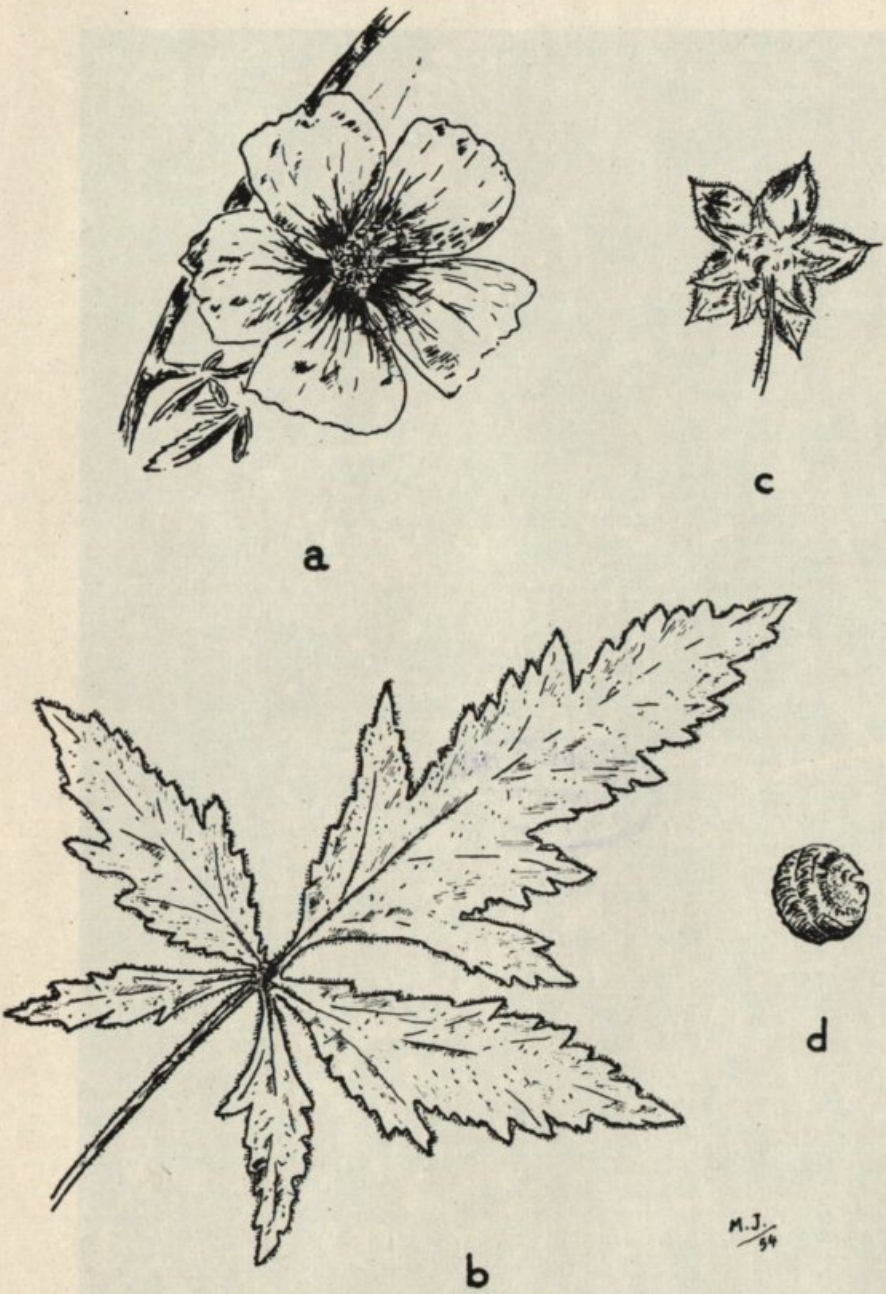
1952 *Les Groupements Végétaux de la France Méditerranéenne.* Centre National de la Recherche Scientifique. Paris.

COUTINHO, A. X. PEREIRA

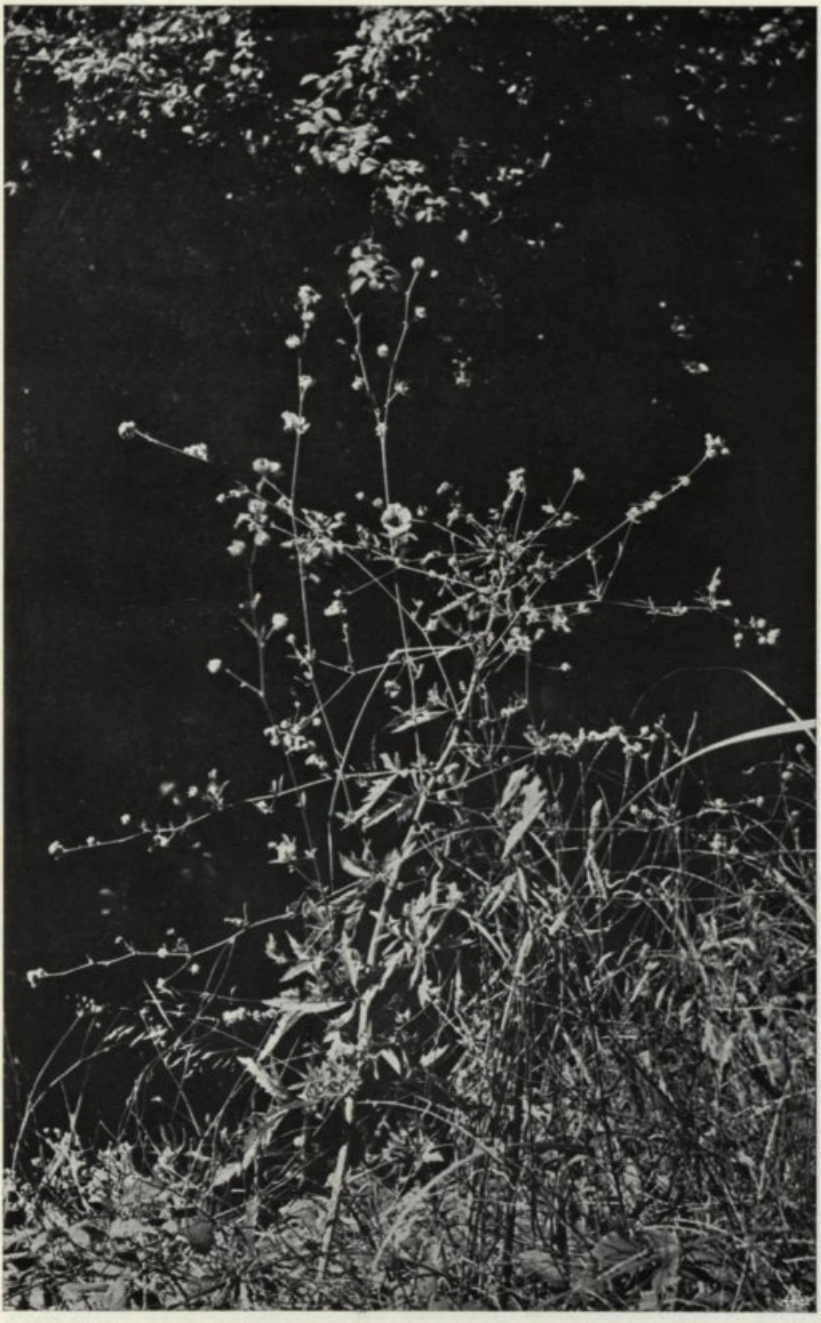
1939 *Flora de Portugal (Plantas vasculares)* 2.ª edição. Bertrand (Irmãos), Lt.ª Lisboa.

*Althaea cannabina* L.: ramo florido.






*Althaea cannabina* L.: *a*, flor (×1.5); *b*, folha (t. n.); *c*, cálice e epicálice (×1.5); *d*, aquénio (×3).



*Althaea cannabina* L. na margem da Ribeira de Zável (Elvas).

Pormenor de *Althaea cannabina* L.

# NOTAS DE FLORÍSTICA

## IV

*por*

J. MALATO-BELIZ e J. P. ABREU

Estação de Melhoramento de Plantas, Elvas

**Scirpus setaceus** L.

Esta espécie que tem sido assinalada no Norte do País, sobretudo nas regiões montanhosas, é considerada rara no Centro e no Sul (COUTINHO, 1939). Contudo, foi herborizada na Serra de Ossa (FERNANDES e FERNANDES, 1948) e, mais recentemente, por nós, na mesma província do Alto Alentejo, nas cercanias da Serra de S. Mamede. Dada a natureza acidentada das localidades em que a planta tem sido colhida ao Sul do Tejo, o seu *habitat* parece estar ligado ao carácter montanhoso pelas condições de meio por este criadas.

*Espécime:* Alto Alentejo: Castelo de Vide: Tapada dos Cavalinhos: pousio de um ano em solo muito húmido (18-Maio-1953, *Malato-Beliz, A. Alves e Ruivo* 1493).

**Carex helodes** Link

Indicada já para a região de Vendas Novas, do Alto Alentejo (FERNANDES e GARCIA, 1947), herborizámos esta ciperácea na Serra de Ossa. Contudo, a existência da espécie nesta província alentejana não se limita às localidades indicadas; antes, a planta é aí frequente como se verificou pelos espécimes observados no herbário da Faculdade de Ciências de Lisboa.

*Espécimes:* Alto Alentejo: Castelo de Vide: Ribeira do Prado: nas margens (Junho-1882, *R. da Cunha* LISU 7484); Portalegre: Boi d'Água (Junho-1882, *R. da Cunha* LISU 7483); entre Reguengos e o Guadiana: Cotovia (Abril-1908, *Dr. R. Palhinha e F. Mendes* LISU 7504); de Marvão a Portalegre (Maio-1913, *Dr. R. Palhinha e F. Mendes* LISU 7503); Serra de Ossa: junto à berma da estrada Estremoz-Redondo (13-Abril-1954, *Malato-Beliz et al.* 1624)

*Distribuição:* Minho, Beira, Estremadura, Alto Alentejo e Alentejo Litoral.

**Biarum tenuifolium** (L.) Schott

Após a recente herborização da espécie em diversas localidades da Beira Litoral (R. FERNANDES, 1953), a sua área de distribuição deve incluir também o Alto Alentejo, pois foi recentemente herborizada na região de Elvas.

*Espécime:* Alto Alentejo: Elvas: Santo Ildefonso: Herdade da Alagada: junto à linda da Herdade da Calada (17-Novembro-1953, *J. A. Guerra* 114).

*Distribuição:* Beira Litoral, Estremadura, Alto Alentejo e Algarve.

**Nothoscordum fragans** Kunth

Além dos locais indicados por COUTINHO (1939), encontra-se também próximo de Elvas, junto ao rio Guadiana.

*Espécime:* Alto Alentejo: Elvas: Alagada: lezíria do rio Guadiana (29-Abril-1952, *Malato-Beliz e Ruivo* 1195).

*Distribuição:* Beira Litoral, Estremadura e Alto Alentejo.

**Narcissus Jonquilla** L. var. **Henriquesii** Samp.

Esta interessante planta, rara em Portugal, era, até agora, conhecida apenas de Castelo de Vide e Torrão (cf. COUTINHO, 1939 e FERNANDES, 1951). Ùltimamente, porém, encontrámo-la com abundância na lezíria do Guadiana, próximo de Juromenha, onde vive no meio das moitas de *Securinega buxifolia*.

*Espécime:* Alto Alentejo: Elvas: Freguesia da Ajuda: Herdade de S. Rafael: na lezíria do rio Guadiana (4-Abril-1954, *J. A. Guerra* 161).

*Distribuição:* Alto Alentejo (Castelo de Vide e Elvas) e Baixo Alentejo (Torrão).

**Amaranthus blitoides** Wats. var. **scleropoides** Thell.

Referida pela primeira vez para a flora portuguesa em 1939 por ROTHMALER e P. SILVA, esta planta americana apenas havia sido assinalada

Fig. 1. — *Narcissus Jonquilla* L. var. *Henriquesii* Samp.
na lezíria do Guadiana (Elvas).


Fig. 2. — *Narcissus Jonquilla* L. var. *Henriquesii* Samp.: exemplar de herbário.

na Estremadura. Contudo, últimamente, foi herborizada por J. A. Guerra nos arredores de Elvas, o que está de acordo com a opinião de uma maior área de dispersão desta amarantácea então apresentada por aqueles autores.

*Espécime:* Alto Alentejo: Elvas: Santo Ildefonso: Herdade da Calada: em restolho de trigo (1-Setembro-1954, *J. A. Guerra* 8).

*Distribuição:* Estremadura e Alto Alentejo (Elvas).

**Minuartia tenuifolia** (L.) Hiern ssp. **tenuifolia** var. **hybrida** (Vill.) Briquet

À área de distribuição desta cariofilácea, recentemente indicada por R. Fernandes (1953), deve acrescentar-se o Alto Alentejo, onde foi há pouco herborizada.

*Espécime:* Alto Alentejo: Elvas: Varche: olival junto à Herdade da Amada (4-Maio-1954, *Malato-Beliz et al.* 1641).

*Distribuição:* Trás-os-Montes e Alto Douro, Douro Litoral, Estremadura e Alto Alentejo.

**Ononis pinnata** Brot.

Já conhecida do limite ocidental do Alto Alentejo, esta leguminosa existe também na zona NE da província.

*Espécime:* Alto Alentejo: Castelo de Vide: próximo à Tapada dos Cavalinhos (30-Maio-1953, *Malato-Beliz* 268).

**Astragalus Glaux** L.

Esta pequena leguminosa, muito pouco frequente no País, foi por nós herborizada no interior da fortificação que rodeia Elvas, sobre a plataforma das muralhas.

*Espécime:* Alto Alentejo: Elvas: no interior das muralhas: ruderal (25-Abril-1952, *Malato-Beliz, Abreu e Ruivo* 1187).

*Distribuição:* Estremadura (Lisboa), Alto Alentejo (Elvas), Baixo Alentejo (Beja) e Algarve (Castro Marim).

**Oxalis corniculata** L. var. **villosa** Hohen.

Encontrámos esta planta, com certa frequência, nos muros, nas proximidades de Marvão, pelo que o Alto Alentejo deve figurar na área da sua distribuição.

*Espécime:* Alto Alentejo: Marvão: Portagem: nos muros do caminho para a ribeira (6-Abril-1953, *Malato-Beliz* 282).

Fig. 3. — *Ononis pinnata* Brot. nos arredores de Castelo de Vide.

*Distribuição:* Beira Alta (Penalva do Castelo) e Alto Alentejo (Marvão).

**Euphorbia androsaemifolia** (Schousb.) Willd.

Esta espécie, até agora apenas mencionada nas margens do Douro, do Sorraia e no Algarve, existe, também, nos arredores de Elvas.

*Espécime:* Alto Alentejo: Elvas: Rosal: Ribeira do Závei: junto à ponte da estrada para Campo Maior (14-Setembro-1954, *F. Raimundo, J. Abreu e J. A. Guerra* 1722).

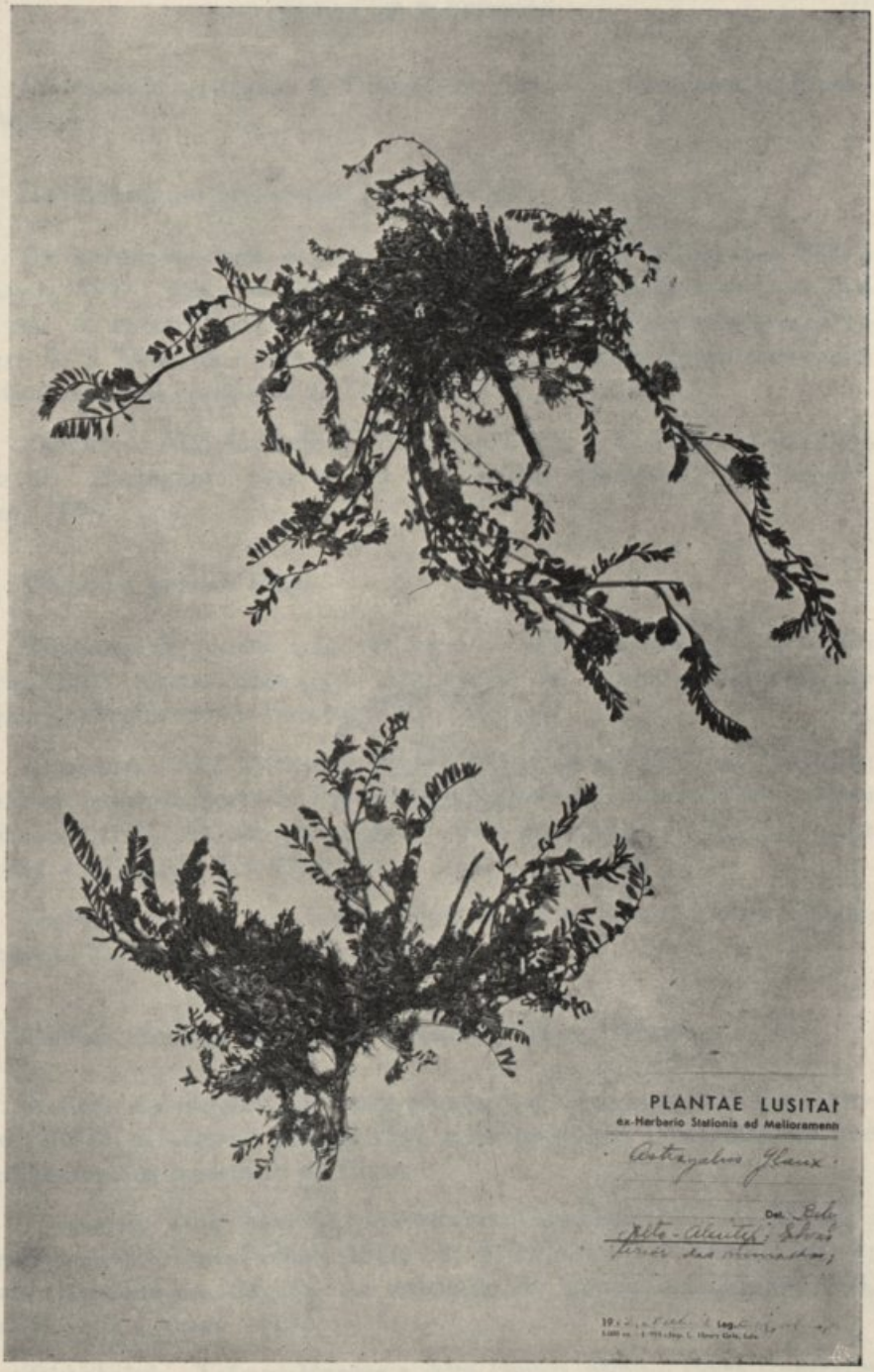



Fig. 4. — Exemplares de *Astragalus Glaux* L. herborizados em Elvas.

*Distribuição:* margens do Douro e do Sorraia, Alto Alentejo (Elvas) e Algarve.

**Helianthemum alyssoides** (Lam.) Vent.

Da indicação dada pelas duas *Floras* do País (Coutinho, 1939 e Sampaio, 1947) sobre a distribuição desta espécie, pode deduzir-se que ela não se encontra a Sul do rio Tejo. Ora, certo é que a colhemos na Serra de S. Mamede e que também, em época mais recuada, havia sido herborizada nos arredores de Elvas por J. C. Silva Senna.

*Espécime:* Alto Alentejo: Elvas (Maio-1886, *J. C. Silva Senna* COI); Marvão: Portagem: nos matos sob pinhal (6-Abril-1953, *Malato-Beliz* 289).

**Veronica persica** Poir.

Esta espécie parece não ser rara no Alto Alentejo, pois a temos herborizado várias vezes junto aos muros de hortas e caminhos, em lugares ensombrados e frescos.

*Espécimes:* Alto Alentejo: Elvas: berma da estrada para Badajoz: junto ao muro da horta do Paraíso (21-Março-1952, *Malato-Beliz, Abreu e Ruivo* 1116); Marvão: Portagem: junto aos muros do caminho para a ribeira (6-Abril-1953, *Malato-Beliz* 284).

*Distribuição:* Minho, Trás-os-Montes e Alto Douro, Douro Litoral, Ribatejo, Estremadura e Alto Alentejo.

**Galium erectum** Huds. ssp. **Gerardi** (Villars) Briquet

A área de distribuição desta planta deve alargar-se ao Alto Alentejo, pois foi aí herborizada em 1911 e, de novo, em 1953, data em que a colhemos nos arredores de Elvas.

*Espécimes:* Alto Alentejo: margens do Guadiana: Moínho do Gato: confluência do Azavel (Maio-1911, *Dr. R. Palhinha e F. Mendes* LISU); Elvas: Herdade da Alagada: na lezíria do rio Guadiana (22-Maio-1953, *Malato-Beliz e Ruivo* 1516).

*Distribuição:* Trás-os-Montes e Alto Douro, Minho, Beira Central e Meridional e Alto Alentejo.

**Valerianella echinata** (L.) DC.

Esta interessante planta, apenas conhecida de Barca de Alva, foi agora herborizada por J. A. GUERRA nos arredores de Elvas. Colheu-se num olival em que a terra é habitualmente cultivada com uma leguminosa ou com uma gramínea anual, onde se encontrava com as seguintes espécies:

*Nigella damascena* L.
*Tunica prolifera* (L.) Scop.
*Biscutella auriculata* L.
*Valerianella discoidea* (L.) Loisel.
*Sherardia arvensis* L.
*Anchusa italica* Retz.
*Asperula arvensis* L.
*Scandix Pecten-Veneris* L.
*Lithospermum arvense* L. e
*Bupleurum lancifolium* Hornem.

*Espécime:* Alto Alentejo: Elvas: Varche: olival junto à Herdade da Amada (30-Abril-1954, *J. A. Guerra* 232).

*Distribuição:* Beira Alta (Barca de Alva) e Alto Alentejo (Elvas).

**Inula viscosa** (L.) Ait.

Confirmando a opinião expressa por FERNANDES e FERNANDES (1949) quanto à distribuição desta espécie, encontrámo-la com frequência na região NE do Alto Alentejo.

*Espécimes:* Alto Alentejo: Elvas: Herdade da Alagada: junto à lezíria do rio Guadiana (20-Outubro-1953, *Malato-Beliz e Ruivo* 1533); Castelo de Vide: Ribeira de Niza: junto à ponte do Panasco (19-Setembro-1954, *Malato-Beliz e Ruivo* 1735).

**Taraxacum obovatum** DC.

Depois de se haver assinalado, pela primeira vez em Portugal, a presença desta espécie (cf. MALATO-BELIZ e ABREU, 1951), publicou J. L. VAN SOEST (1954) um estudo em que a taxonomia deste grupo de *Taraxaca* aparece com maior detalhe. Entretanto, novas colheitas de exemplares deste grupo, amàvelmente determinados por aquele ilustre

Fig. 5. — *Valerianella echinata* (L.) DC. herborizada nos arredores de Elvas.

especialista, permitem esclarecer a presença desta espécie em Portugal, do modo seguinte:

a) ssp. *obovatum*

*Espécime:* Alto Alentejo: Elvas: berma da estrada para o Caia (19-Março-1952, *Malato-Beliz, Abreu e Ruivo* 1615 e 1616).

b) ssp. *ochrocarpum* v. Soest

*Espécime:* Alto Alentejo: Elvas: talude da estrada para a Alagada (14-Março-1950, *Malato-Beliz, Abreu e Ruivo* 302).

Como se vê, as duas subespécies de *Taraxacum obovatum* DC., até ao presente, apenas se conhecem dos arredores de Elvas.

**Taraxacum duriense** van Soest

Até agora apenas assinalada no Douro Litoral, Beira Litoral e Estremadura (van Soest, 1951), esta espécie existe também no Alto Alentejo, onde recentemente a herborizámos.

*Espécime:* Alto Alentejo: Marvão: Portagem: caminho para a ribeira (6-Abril-1953, *Malato-Beliz* 261).

*Distribuição:* Douro Litoral, Beira Litoral, Estremadura e Alto Alentejo.

**Sonchus tenerrimus** L.

Deve incluir-se o Alto Alentejo na área de distribuição desta espécie, pois foi herborizada em Elvas.

*Espécime:* Alto Alentejo: Elvas: nos muros do pátio interior da igreja de S. Domingos (2-Maio-1954, *Malato-Beliz* 310).

*Distribuição:* Alto Alentejo, Baixo Alentejo e Algarve.

**Hieracium onosmoides** Fries ssp. **cadyense** Zahn

Em qualquer dos estudos de J. L. van Soest (1948 e 1950) sobre *Hieracia* de Portugal, não se encontra citada esta subespécie, pelo que deve considerar-se nova para a flora portuguesa.

*Espécime:* Beira Alta: Serra da Estrela: floresta de *Quercus pyrenaica*, junto à estrada para o Poço do Inferno: ca. 1050 m. s. m. (22-Julho-1952, *Malato-Beliz, Gonçalves e Ruivo* 1347).

*Distribuição:* Beira Alta (Serra da Estrela).

## SUMÁRIO

No presente conjunto de notas sobre a flora portuguesa, — o 4.º de uma série iniciada em 1950 — mencionam-se diversos *taxa* novos para a província do Alto Alentejo e acrescentam-se algumas novas localidades de outras plantas que eram ali consideradas raras.

Refere-se, pela primeira vez em Portugal, a existência da ssp. *cadyense* Zahn de *Hieracium onosmoides* Fries, e destacam-se, como plantas mais raras no País: *Narcissus Jonquilla* L. var. *Henriquesii* Samp., *Astragalus Glaux* L., *Oxalis corniculata* L. var. *villosa* Hohen., *Valerianella echinata* (L.) DC. e *Sonchus tenerrimus* L.

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## RÉSUMÉ

Les auteurs mentionnent un groupe de nouvelles plantes dans la province du Alto Alentejo et une sous-espèce de *Hieracium onosmoides* Fries (ssp. *cadyense* Zahn), nouvelle dans le Pays.

Parmi les plantes rapportées, on met en évidence, par sa rareté au Portugal, les suivantes: *Narcissus Jonquilla* L. var. *Henriquesii* Samp., *Astragalus Glaux* L., *Oxalis corniculata* L. var. *villosa* Hohen., *Valerianella echinata* (L.) DC. et *Sonchus tenerrimus* L.

## SUMMARY

A group of plants new to the province of Alto Alentejo and a subspecies of *Hieracium onosmoides* Fries (ssp. *cadyense* Zahn) new to the Portuguese flora are presented by the authors.

Among the rare plants recorded are the following: *Narcissus Jonquilla* L. var. *Henriquesii* Samp., *Astragalus Glaux* L., *Oxalis corniculata* L. var. *villosa* Hohen., *Valerianella echinata* (L.) DC. and *Sonchus tenerrimus* L.


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# THE COMPARATIVE MORPHOLOGY OF THE *OLACACEAE, OPILIACEAE* AND *OCTOKNEMACEAE*

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## INTRODUCTION

MANY studies emphasizing the significance of salient phylogenetic modifications of the cambium and its derivatives have been presented in the last decade or so. Some workers have dealt with the relationships and classification of families of dicotyledonous plants in a general way, while others have dealt specifically with some family or genus, or some small group of same.

This paper provides an intensive study of the *Olacales*, setting forth the types of morphological specializations in the various organs and tissues, the extent of such modifications and the significance and correlation of vascular morphology to foliar and floral morphology. Materials for these studies were obtained from (1) the ordinary herbarium sheets from various herbaria and (2) the wood collections at Yale and Harvard Universities. The studies include those of the anatomy of the node and internode, the pith of the young twigs, the wood parenchyma and rays, the vessels and tracheary elements and the comparative morphology of the leaves, cotyledons, integuments, pollen and floral structures.

### I. GENESIS OF THE *OLACALES*

The *Olacaceae* and related families have been a continuous source of phylogenetic confusion. The genera have been variously placed in one family and then another. Some of the genera have originated in

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various other families and then have been transferred to the *Olacaceae* or to some closely related family. Also the families and tribes within the families have been variously treated or disposed of from time to time.

Because of this complex situation which has grown out of various attempts to classify the *Olacaceae* and the related families, a brief survey of the genesis of the *Olacales* is given to orient the reader with this situation of grouping the genera in these families.

The family *Olacaceae* received its name from the genus *Olax*. This genus was originally used as the type by MIRBEL (Bull. Philom., n. 75, 377. 1813) for the order *Olacineae* and later by LINDLEY (Nat. Syst., ed. 2, 32 (partim). 1836) for the order *Olacaceae*. BENTHAM (Trans. Linn. Soc. London 18 (4): 676. 1841) divided the order into three tribes, the *Olacineae*, the *Opilieae* and the *Icacineae*, suggesting that each might be a distinct order. LINDLEY (The Vegetable Kingdom, pp. 443-444. 1847) transferred the three tribes to his order *Olacaceae: Olaceae* Benth. *(Heisteria, Ximenia, Hypocarpus, Olax, Schoepfia), Opilieae (Opilia* and *Cansjera)* and *Icacineae* (14 genera, of which *Liriosma, Lepionurus, Anacolosa, Pseudaleia,* and *Pseudaleioides* with Olacaceous affinities have since been removed and placed in the *Olacaceae* or *Opiliaceae).* In his supplement (p. 910) LINDLEY added to his *Olacaceae, Strombosia* (from the *Rhamnaceae*), *Lopadocalyx* (= *Olax*) and *Bursinopetalum* (later placed in *Cornaceae*).

MIERS (Ann. Mag. Nat. Hist. II. 8: 174. 1851; II. 9: 221. 1852; Contrib. Bot. 1: 34. 1851-61, and in other papers up to 1859) raised BENTHAM's tribes to family status, using LINDLEY's ordinal name, *Olacaceae*. The actual difference between the three families were first pointed out by MIERS and their true relationships and affinities established. However, MIERS (Jour. Linn. Soc. Bot. 17: 68-78. 1880) established the tribe *Schoepfieae* for *Schoepfia* and *Schoepfiopsis*, but he placed it in the *Styracaceae. Minguartia* of Aublet (really *Minquartia* Miers, l. c., 17: 338-339. 1880) was placed in the family *Crescentiaceae* along with *Crescentia* and *Parmentiera.*

BAILLON (Adansonia 3: 89, 367-370. 1862) substantiated MIERS' separation of the *Olacaceae* and the *Icacinaceae*, but in his treatment of the *Loranthaceae* (1863) he divided that family into two series: *Loranthineae* and *Santalineae*. The first series included two suborders or tribes, the *Loranthaceae* (*Visceae* and *Lorantheae*) and the *Anthoboleae*, both of which have superior ovaries. The second series having the ovules descending is also made up of two suborders or tribes, the *Santalaceae* (*Myzodendreae* and *Santaleae*) and the *Olacineae* (excl. *Icacineis* and

*Phytocreneis*) (*Olaceae, Opilieae, Cervantesieae, Aptandraceae, Ximenieae*), both of which have inferior to nearly inferior ovaries. However, the *Santaleae* included such genera as *Erythropalum, Schoepfia, Anacolosa* and *Liriosma; Agonandra* was placed in the *Olaceae.*

BENTHAM and HOOKER in their Genera Plantarum (1862) did not recognize the families as MIERS had presented them, but instead they followed BENTHAM's treatment of three tribes. MIERS retaliated in 1864 (Seem. Jour. Bot. 2: 257-266) with a restatement of the important factors distinguishing the *Icacinaceae* from the *Olacaceae.*

VALETON (Crit. Overz. Olacin, 24, 136. 1886) established the *Olacaceae* and the *Opiliaceae* as distinct families. Then, again in 1888, DURAND (Index Genera Phanerogamorum, pp. 62-65. 497) reverted to BENTHAM's *Olacineae* and set up four well-defined tribes: *Olaceae, Opilieae, Icacineae* and *Phytocreneae.* With the *Icacinaceae* removed ENGLER (in ENGLER u. PRANTL, Pfl.-fam. 3 (1): 233. 1889) first divided the *Olacaceae* into four tribes (*Schoepfieae, Anacoloseae, Agonandreae* and *Opilieae*), but later (Pfl.-fam. Nachtr. 143-144) treated the *Agonandreae* and *Opilieae* as tribes of VALETON's *Opiliaceae* and divided the *Olacaceae* (revised) into three subfamilies with seven tribes: *Schoepfioideae* (*Schoepfieae*), *Olacoideae* (*Olaceae, Aptandreae*) and *Dysolacoideae* (*Ximenieae, Anacoloseae, Heisterieae, Couleae*). This system was followed by DALLA TORRE and HARMS (Genera Siphonogam., pp. 137-138. 1900-1907).

An extreme treatment of the plants of Olacaceous affinity was presented by GAGNEPAIN (1910) in which eight families were recognized: *Opiliaceae, Olacaceae, Aptandraceae, Schoepfiaceae, Erythopalaceae, Icacinaceae, Phytocrenaceae* and *Cardiopteridaceae.* The first remains the *Opiliaceae* (SLEUMER, Nat. Pfl.-fam. 16 B, 1935); the next four were treated by SLEUMER (l. c., 1935) as the *Olacaceae*, in its broader sense, although SLEUMER treated *Erythropalaceae* separately in 1942 (Nat. Pfl.-fam. 20 B); and the last three have been treated by HOWARD (1941-42) in the *Icacinaceae*, in its broader sense. The revision of the *Olacaceae* and the *Opiliaceae* for the second edition of Natürlichen Pflanzenfamilien was done by SLEUMER (l. c., 16 B: 5-34. 1935), who used in the *Olacaceae* the same three subfamilies and seven tribes of ENGLER, reorganizing the genera under the tribes and adding a new genus here or there.

In every treatment of the *Olacaceae* there have been several genera of dubious Olacaceous affinity appended. In DALLA TORRE and HARMS, *Bracea* King, *Erythropalum* Blume, *Drebbelia* Zoll., *Octoknema* Pierre and *Petrusia* Baill. are listed. By 1935 *Bracea* and *Erythropalum* still

remained in SLEUMERS's list of extra genera; *Drebbelia* had become a synonym of *Olax; Petrusia* did not appear. However, SLEUMER added the following genera of dubious affinity: *Ctenolophon* Oliv., *Fissipetalum* Merrill, *Petalocaryum* Pierre, *Schoepfianthus* Engl., *Stolidia* Baill. and *Vasea* F. All. Of these *Ctenolophon* has more recently been treated in the *Linaceae; Fissipetalum* has been shown to be congeneric with *Erycibe* Roxb. *(Convolvulaceae)* by AIRY-SHAW (1947), who at the time refrained from making any transfers since VAN OOSTROM was revising *Erycibe* at the time (Blumea 3 (2): 267. 1939); *Schoepfianthus* Engl. is a nomen (Index Kew. 4th. Suppl.); *Stolidia* has become *Badula insularis* A. Dec. (*Myrsinaceae*, Engl., Pflanzenr. IV. 236. Heft 9: 282. 1902). Eventually, both *Erythropalum* and *Octoknema* have been placed in families each unto itself. *Okoubaka* has recently been added to the *Octoknemaceae*. Perhaps the other genera of dubious Olacaceous affinity should more properly be placed in a category suggested by BAILEY (Chronica Botanica, 14: 125. 1953) the «Incognitales», similar in status to the Fungi Imperfecti, at least until their true relationships can be established.

The placing of the family *Olacaceae*, as well as of the order *Olacales*, has been quite variable, as indicated from the various treatments of the genera and tribes of the *Olacaceae* mentioned above. Of recent years there have been several contentions as to the phylogenetic relationships of this family and other closely related families to each other, and of the order to other orders of the flowering plants.

WETTSTEIN (1911, Handbuch der Systematischen Botanik, II, p. 500) placed the *Santalales* between the *Proteales* and the *Piperales*. In the *Santalales* were placed the *Santalaceae, Grubbiaceae, Opiliaceae, Octoknemataceae, Olacaceae, Myzodendraceae*, and then *Loranthaceae, Balanophoraceae* and *Cynomoriaceae*.

HUTCHINSON (1926, The Families of the Flowering Plants, I. Dicotyledons) established the order *Olacales* to include the families *Olacaceae* and *Opiliaceae* and placed it between the *Celastrales* and the *Santalales*. He considered the *Olacales* as the advanced type of the *Celastrales* and the *Santalales* as the more parasitic representatives of the *Olacales*.

HEINTZE (1927, Cormophyternas Fylogeni, Lund, p. 157) placed the *Santalales* as the last group of the Dicotyledons next to the *Ebenales*. Thus, *Olacaceae* → *Sannalaceae* → *Loranthaceae*.

↙ ↘

*Myzodendraceae* *Balanophoraceae*

According to HEINTZE, the OLACACEAE have more common factors with the *Styracaceae*, than with other groups. On the other hand the *Santalaceae* have nothing to do with the *Proteaceae* which are far removed in his system from the *Santalales* in the *Myrtiflorae*. Thus, HEINTZE organized the orders, as *Primulales* → *Ebenales* → *Santalales*, stating that the three orders can be placed without difficulty into a closely related group.

HUTCHINSON & DALZIEL (1938, Flora of West Tropical Africa 1 (2): 457-464) grouped the families of the *Olacales* as *Olacaceae*, *Pentadiplandraceae*, *Opiliaceae* and *Octoknemataceae*. *Pentidiplandra* Bailll. was placed in the *Tiliaceae* in DALLA TORRE and HARMS, Gen. Siphonogam., p. 306, 620. 1900-1907), and is usually treated as being there.

WARMING-MOEBIUS (1929, Systematische Botanik, p. 396) placed the order *Hysterophyta* between the *Passiflorales* and the *Saxifragales*, and included in this order the following families: *Aristolochiaceae*, *Santalaceae*, *Myzodendraceae*, *Grubbiaceae*, *Olacaceae*, *Loranthaceae*, *Balanophoraceae*, *Rafflesiaceae* and *Hydnoraceae*. «They are mostly parasitic, except *Olacaceae*». R. BROWN (1810, Prod. Fl. N. Holl. et Insulae Van-Diemen, p. 357) had been the first to point out a relationship between the genera which are now placed in the *Olacaceae* and the *Santalaceae*.

SCHELLENBERG (1932, Festschrift der D. Bot. Ges. L. a., p. 136) presented a new approach to the proposition of the phylogeny of the *Santalales*, based upon the number of integuments. In the *Olacaceae* there are two, one or none in the various tribes (*Couleae* and *Heisterieae*, 2; *Anacoloseae* and *Ximenieae*, 1 or 2; *Olaceae*, *Aptandreae* and *Schoepfieae*, none). *Octoknemaceae* have one (at least in *Octoknema*). *Opiliaceae*, *Grubbiaceae*, *Santalaceae*, *Myzodendraceae* and *Loranthaceae* have none.

ANSELMINO (1934, Repert. Spec. Nov. Fedde 33: 285-297) presented a brief survey of the history of the *Olacaceae* up to SCHELLENBERG's paper, giving the various concepts concerning the disposition of the genera of the *Olacaceae* and of the family to other families in various orders. The most pertinent papers have been reviewed above in order to familiarize the reader with the situation as it is to date.

METCALFE and CHALK (1950, Anatomy of the Dicotyledons, 1: 362-381) treated the *Olacales* as being between the *Geraniales* and the *Celastrales*. The following families were included in the order *Olacales*: *Olacaceae*, *Icacinaceae*, *Octoknemataceae*, *Opiliaceae*, *Aquifoliaceae* and *Cyrillaceae*. The other parasitic families which had usually been associated with the *Olacaceae* are placed in the *Achlamydosporeae* (*Lorantha-*

*ceae, Santalaceae, Grubbiaceae, Myzodendraceae* and *Balanophoraceae*) between the *Daphnales* and the *Unisexuales*. They state that the «anatomical evidence at present available is not sufficiently comprehensive to give any clear indication of how closely related the *Olacaceae* and the *Icacinaceae* may be», (l. c., p. 365). MIERS, HOWARD and BAILEY and others have definitely stated that the two groups are distinct as discussed earlier in this paper.

In the *Opiliaceae*, as presented by SLEUMER in 1935, there were three tribes. The status of the first of these, the *Aveledoeae*, needs some explanation. First, the use of the generic names, *Aveledoa* and *Metteniusa*, needs to be reviewed. Then an evaluation of the genus *Metteniusa*, based upon comparative anatomy with the *Olacaceae* and the *Opiliaceae*, needs to be made.

The genus *Metteniusa* had been proposed by KARSTEN (Fl. Columb. 1: 79, t. 39. 1859) as the type of a family near the *Convolvulaceae* or *Borraginaceae*. ENGLER (Nat. Pfl.-fam. Nachtr. 226. 1893) placed the genus in the *Icacinaceae*. DALLA TORRE and HARMS (Gen. Siphonogam. p. 809. 1900-1907) also placed the genus in the *Icacinaceae*.

In 1925, PITTIER (Bol. Cient. Tecn. Mus. Con. Venez. Nr. 1: 45) described the genus *Aveledoa* from Venezuela and placed it in the tribe *Opilieae* of the *Olacaceae*.

In 1934 SLEUMER (Notizbl. Bot. Gart. Berlin 12: 148) described another species in *Aveledoa* Pittier from southern Peru, suggesting its affinity with the *Icacinaceae*. In the following year PITTIER (Bol. Soc. Venez. Cienc. Nat. 3: 22-23. 1935) reconsidered the position of his genus and suggested following SLEUMER's disposition of the genus by placing it in *Icacinaceae*. Then, SLEUMER confused the issue thoroughly by establishing the tribe *Aveledoeae* in the *Opiliaceae* in 1935 (Nat. Pfl.--fam. 16B: 35) for the genus *Aveledoa* and then in 1936 combining *Aveledoa* with *Metteniusa* (Notizbl. Bot. Gart. Berlin 13: 359) and placing *Metteniusa* in the *Icacinaceae*.

Because of this last disposition of the genus *Metteniusa* (= *Aveledoa*) HOWARD studied it and came to the conclusion that it was to be excluded from the *Icacinaceae*, leaving the genus free again (Jour. Arnold Arboretum 21: 485. 1940).

One disposition for the genus *Metteniusa* is to return it to KARSTEN's family status, and then to place the family between the *Olacaceae* and the *Opiliaceae*. Many anatomical structures bear out a relationship with the *Olacaceae*. For example, of *Metteniusa nucifera* (Pittier) Sleumer has laticiferous tubes accompanying the veins, as in *Heisteria*, *Minquar-*

*tia* and *Ochanostachys*, at times these tubes lying free in the mesophyll, as in *Heisteria*. Druses are present in the leaves, similar to those found in many genera of the *Olacaceae*. Cystoliths, so characteristic of the *Opiliaceae*, are totally absent. However, there are many other anatomical features which are similar to those found in the *Opiliaceae*. The stomata in *Metteniusa* are similar to those found in various species of *Agonandra*. There is a single anatropous ovule pendent by a short funiculus at the apex of the cavity (apical placentation), like that found in the *Opilieae*. Further, the wood anatomy bears interesting relationships to both the *Olacaceae* and the *Opiliaceae*. As a point of difference with the *Opiliaceae*, the flowers in the other two tribes, *Opilieae* and *Agonandreae*, are quite small, a few millimeters in length, whereas those of *Metteniusa* have a total corolla length from 3.5 to 4 cm.

Another disposition of *Metteniusa* would be to place it in a tribe or subfamily unto itself in either the *Opiliaceae* or the *Olacaceae*. The tribal name *Aveledoeae* would be available for this purpose. However, studies which will be brought out later in this paper, the genus more properly belongs in the *Olacaceae* than in the *Opiliaceae*, and in the *Olacaceae* is more nearly related to the tribe *Olaceae*.

In conclusion the *Olacales* of METCALFE and CHALK (1950) are about where they were in BENTHAM's classification of the group in 1841, where the Olacaceae (as an order) was divided into three tribes, *Olacineae*, *Opilieae* and *Icacineae*. METCALFE and CHALK have raised these tribes to families and have added the *Octoknemataceae*, *Aquifoliaceae* and *Cyrillaceae* to make the order *Olacales*.

Since the *Icacinaceae* have been well treated in the studies of HOWARD and BAILEY, and since the *Aquifoliaceae* and *Cyrillaceae* differ considerably in floral and other anatomical features from the rest of the families mentioned above, the following families of the *Olacales*-complex will be treated herein: *Olacaceae*, *Opiliaceae* and *Octoknemaceae*, with some notes on the *Erythropalaceae*.

## II. GENERAL COMPARATIVE MORPHOLOGY

The *Olacales* display in their vegetative organs no outstanding peculiarities, unless it be the general presence of solitary or clustered crystals in the leaves and wood. The twigs and leaves are usually hairy only in the young stages, becoming glabrous later. The leaves are always simple and entire-margined. The petiole is semicircular, frequently twisted. The leaves of the semi-parasitic representatives are often cha-

racteristically greenish-gray or olive-green and somewhat fleshy. Stipules are always absent.

Among the anatomical specializations present in this order are (1) the reduction from two to one to no integuments, (2) predominately anatropous ovules, with a few atropous ones, (3) transitions from superior to semi-inferior to inferior ovaries, (4) the stamens free to stamens fused to the petals or to one another, (5) the petals free to petals fused or absent, (6) the presence of resin canals or latex tubes in the leaves and bark of some of the genera, (7) the transition from autophytism to root-parasitism, and (8) the full range of anatomical variation in the vascular tissues.

## OLACALES

Fruit drupaceous, with a single seed; seeds with copious to slightly ruminate endosperm; embryo small, usually straight; ovary superior to semi-inferior to inferior, 1-3 celled; ovules 1-5, anatropous rarely atropous (*Schoepfia*) and apotropous.

### Families of the *Olacales*

*Olacaceae:* Ovary superior or slightly immersed in the disc, inferior in *Schoepfia*, 1-3-celled; style 1, with 2-5 lobed stigma; ovules 1-5 from the apex of a central placenta in the 1-celled ovaries, or pendulous from the inner angle of the 2- or more-celled ovaries; fruit drupaceous, sometimes inferior by concrescence with the calyx; seeds with copious endosperm, and a small or medium-sized straight embryo; cotyledons 2, 3 or 4.

*Opiliaceae:* Ovary superior or semi-inferior, 1-celled; style slender, stigma sessile; ovule solitary, pendulous or erect; fruit drupaceous, often fleshy; seeds with copious endosperm and a rather small embryo; cotyledons 3 or 4, rarely 2.

*Octoknemaceae:* Ovary inferior, 1-celled; style very short, 3-5 lobed stigma, lobes bifid; ovules 3, at the apex of a basal thread-like placenta which reaches and is adnate to the top of the ovary; fruit drupaceous, with a single seed; endosperm slightly ruminate; embryo small, the radicle much longer than the cotyledons; cotyledons 2 to 6.

### Subfamilies and tribes of the *Olacaceae*

The studies reported herein for this family will follow the classification of Sleumer (Nat. Pfl.-fam. 16 B: 5-33. 1935), in which three subfamilies and seven tribes are outlined, based primarily upon the

structural and anatomical differences of the flowers, upon the number of integuments, the position of the ovules and the position of the ovary with respect to the other floral parts.

Subfamily I. *Dysolacoideae* — Ovules with two or one integument, anatropous; ovary superior.

Tribe I. *Couleae* — Trees and shrubs with schizogenous resin canals and latex tubes in the leaves and in the bark; endosperm of seeds containing fatty oils and starch; fruit-calyx not enlarged.

Tribe II. *Heisterieae* — Trees and shrubs with only latex tubes in the leaves and in the bark; endosperm of seeds containing fatty oil only, no starch; fruit-calyx strongly enlarged.

Tribe III. *Anacoloseae* — Trees and shrubs without resin canals or latex tubes in the leaves or bark; stamens as many as or doubly as many as, the petals and always situated in front of these.

Tribe IV. *Ximenieae* — Small trees and thorny shrubs, semi-parasites, without resin canals or latex tubes; stamens double as many as petals, in two circles, one in front of the sepals, one in front of the petals.

Subfamily II. *Olacoideae* — Ovules without integuments, anatropous; ovary superior to semi-inferior; fruit-calyx more or less enlarged; root-parasites.

Tribe V. *Olaceae* — Trees and shrubs, sometimes scrambling or climbing; stamens free.

Tribe VI. *Aptandreae* — Trees; stamens fused into a ring; endosperm containing fatty oils and starch.

Subfamily III. *Schoepfioideae* — Ovules without integuments, atropous; ovary inferior; root-parasites.

Tribe VII. *Schoepfieae* — Trees and shrubs, with characters of the subfamily.

**Tribes of the *Opiliaceae***

The studies reported herein for this family will follow the classification of Sleumer (Nat. Pfl.-fam. 16 B: 33-35. 1935), in which three tribes are set down. Until some further disposition of the genus *Metteniusa* is made, I shall treat the genus in the tribe *Aveledoeae* of the *Opiliaceae*.

Tribe I. *Aveledoeae* — Trees up to 25 m and shrubs; flowers large, in axillary racemes, 7-12 flowered, monoecious; calyx 2-6 mm long, 5-lobed; corolla 3-4 cm long; bracteoles about 1 mm long; ovary superior, sessile; ovule solitary, anatropous, apical placentation, pendent from the apex of the cavity by a short funiculus; fruit a drupe.

Tribe II. *Opilieae* — Trees, shrubs and climbing or twining shrubs; flowers small, in racemes or spikes, monoecious; calyx very small and indistinctly 4-toothed or united with the cup-shaped flower axis and without a definite fringe; bracts occasionally large and at least more or less imbricate, identical with the flower; ovary with one pendent ovule at the apex of the placenta.

Tribe III. *Agonandreae* — Trees; flowers small, dioecious, the floral parts reduced to tepals, with petals and stamens lacking in female flowers; calyx short, 4-lobed (rarely 5-lobed), cup--shaped; male flower with as many stamens as petals; ovary with a sessile upright ovule.

### A. *Integuments and Cotyledons*

The number of integuments vary considerably in the *Olacales* from two to one to none. SLEUMER made use of this character in setting up his subfamilies. In the *Olacaceae*, the subfamily *Dysolacoideae* possesses anatropous ovules with two or one integument; the tribes *Couleae* and *Heisterieae* having two; the *Anacoloseae*, except *Strombosia* having one, having two; the *Ximenieae* having one, or two according to SCHELLENBERG (1932). The subfamily *Olacoideae* possesses anatropous ovules without any integuments. The subfamily *Schoepfioideae* possesses atropous ovules without integuments. The *Opiliaceae* have no integuments. The *Octoknemaceae* have one.

There seems to be a correlation between the number of integuments present and the degrees of semi-parasitism to root-parasitism in the tribes of the *Olacaceae*. The tribes *Couleae*, *Heisterieae* and most of the *Anacoloseae* are self-sustaining trees and shrubs, all possessing two integuments, except *Strombosia*. The *Ximenieae* are semi-parasites, having one or two integuments. The *Olaceae*, *Aptandreae* and *Schoepfieae* are root-parasites, without any integuments.

The Angiosperms have been grouped into two large categories based upon the supposition that they all had either one or two cotyle-

dons in the seed. Thus we have the Monocotyledons and the Dicotyledons. Of course, other anatomical characters have been added to cotyledony to substantiate these divisions of the Angiosperms, as parallel leaf venation, trimerous flowers, lack of cambium and lack of stelar arrangement of the vascular bundles in the Monocotyledonous members. Even these characters do not fit all the Monocots, since some families do not have parallel venation (some *Araceae*) and a good many do not have trimerous flowers. Some of the dicotyledonous plants have either the pair of cotyledons fused together or else they are seemingly single. A survey of this character needs to be made to establish the soundness of cotyledony as a sole factor separating the «monocots» from the «dicots».

The *Olacales* present a problem here since the number of cotyledons varies from two to three to four and even to six in the various tribes, genera and families. In the *Olacaceae*, the *Couleae* and *Heisterieae* have either three or four cotyledons, rarely two. The *Anacoloseae*, *Ximenieae* and *Aptandreae* have two cotyledons. The *Olaceae* and *Schoepfieae* have two or three cotyledons. Recently, BLACK told the author that his seedlings of *Curupira tefeensis* had three cotyledons. The *Opiliaceae* have from two to four cotyledons, usually three. In the *Octoknemaceae* there may be as many as six. In the *Loranthaceae*, which has been variously associated with the *Olacaceae*, from two to three to six cotyledons have been reported; this family is also highly parasitic and possesses no integuments. Three cotyledons are not uncommon in the *Juglandaceae (Carya pecan)*. Many of the Gymnosperms possess as many as twelve cotyledons.

A study is being made of the germination of the seeds of the *Olacales* and closely related groups and of the subsequent anatomy of the seedlings.

### B. *Floral Anatomy*

*Olacaceae:* Flowers mostly monoecious, except in *Worcesterianthus* and *Harmandia*, which are dioecious; actinomorphic; borne in short axillary clusters, racemes or panicles, usually closely clustered in the axils of the leaves; in the *Olaceae* the flowers single or inishort spikes or racemes. Calyx small, usually 6-3 parted margin, with its cup-shaped basal portion free or fused to the disc or to the ovary, frequently considerably enlarged about the mature fruit and enveloping the fruit; sometimes (in *Schoepfia*) the basal part of the calyx fused with the sunken ovary, which it eventually encloses, as in the *Loranthaceae*, and becomes

connected about the floral axis as in that family; in *Tetrastylidium* the cup-shaped axis barely distinguishable between the calyx and the ovary, and due to this position this axis grown into many depressions of the calyx after fertilization, even frequently overtopping the fruit (*Chaunochiton*). Petals 3-6, free or fused together, sometimes fused in pairs, twisted in the bud, only exceptionally imbricate; varying in size from a few millimeters in length to several centimeters, the majority being less than one centimeter in length. Disc sometimes present, persisting as separate lobes or cup-shaped. Stamens in a perfect diagram of three circles, whereby the center ring is doubled and three stamens stand in front of each petal, mostly one or two rings fallen out, sometimes simply the middle ring remaining; stamens usually all fertile, sometimes some of them staminoides; sometimes fused together by an antheral corona (in *Aptandreae*), or fused to the petals throughout the length of their filaments; anthers oval to oblong, usually opening through a longitudinal slit, rarely opening by a theca valve. Ovary free, superior or more or less inferior, only 2-5 loculate in the lower part and rarely up to the apex, with usual free placenta, a thin long ovule hanging down from it in the compartment; ovule rarely straight (orthotropous) with the micropyle turned under it, usually anatropous with the micropyle turned over or in toward it, either with one integument, or with two integuments, or without integuments; style with small, sometimes 3-parted, often nearly sessile stigma. The subfamilies *Dysolacoideae* and *Olacoideae* have superior ovaries with a tendency to semi-inferior ovaries in some genera of the *Olaceae*. The *Schoepfioideae* have inferior ovaries. The ovaries may by incompletely loculate, with two to five locules, or even be uniloculate. Genera with five lobes or divisions of the ovary are *Strombosia* and *Minquartia* (including *Endusa*); those with four, *Tetrastylidium* and *Ximenia;* those with three, *Olax, Liriosma, Ongokea, Schoepfia, Eganthus, Ochanostachys, Coula, Heisteria,* and *Scorodocarpus;* those with two, *Chaunochiton, Cathedra, Anacolosa, Worcesterianthus, Aptandra* and *Harmandia;* that with one, *Ptychopetalum*. Fruit a drupe, either by fusion with the cup-shaped axis or with an enlarged fruit-calyx, then forming a fleshy outer covering, a spurious fruit, almost monospermous inside; placenta half-way imbedded in a furrow of the seeds. Seed with a thin seed coat and a rich nutritive tissue, the little embryo imbedded in the apex of it. Mostly tricotyledonous, some dicotyledonous, some tetracotyledonous.

*Opiliaceae:* Flowers monoecious in the *Aveledoeae* and *Opilieae*, dioecious in the *Agonandreae;* actinomorphic; borne in racemes or in

single or complex spikes or in a panicle situated together in a cluster; usually small, a few millimeters in length, up to 4 cm in the *Aveledoeae*. Calyx usually not distinct, but occasionally developed faintly, rarely large, not enlarged in the ripe fruit; calyx may be united with the cup--shaped flower-axis, without a definite toothed margin. Bracts of the flower occasionally large, more or less imbricate, identical with the floral parts. Floral parts reduced to tepals in the *Agonandreae*. Petals (or tepals) 4-5, free, or more or less united. Stamens as many as the petals and situated nearly always in front of the petals, rarely with alternating disc lobes either united with the petals at the edge of each petal, or inserted at the base of the petals. Disc lobes 4-5, free or fused ring-shaped and then nearly entirely margined or growing up into a 4-5 short lobed proliferation fused with the stamens. Ovary free or in the floral axis and embedded half in the disc, more or less cup-shaped. Ovule one, anatropous, pendent from the apex of a more or less central, basally situated and more or less upright slender placenta *(Opilieae)*, rarely basal and upright at the same time *(Agonandreae)*, always without integuments. Fruit a drupe, with a thin sarcocarp and mostly a crusty endocarp. Seed without a shell, with a rich, oily nutritive tissue. Embryo terete, as long as the nutritive tissue or shorter, usually with linear cotyledons, barely separated from each other and with the plumule sweeping up on top. Mostly tricotyledonous, some tetracotyledonous.

*Octoknemaceae:* Flowers through abortion dioecious; male flowers in a long clustered raceme, the stalked flowers axillary in few-flowered cymose clusters; perianth through complete reduction of the calyx apparently simple with 5 valvate segments fused at the base; stamens 5 in front of the segments of the perianth; filaments broad, short; anthers short, very broad, dithecal, introrse, sessile at the top of the filaments; ovary rudimentary without compartments and stigma, fused at the base with 5 broad disc lobes alternate with the stamens. Female flower with the calyx sometimes clearly perceptible in the form of 5 short teeth at the rim of the receptacle fused with the inferior ovary, sometimes wholly suppressed; petals as in the male flower; staminoides without anthers; disc as in male; ovary wholly inferior, 3-loculate close up to under the apex, where the septa do not meet, soon through tearing of the septa unilocular with a thin central column; one ovule in the chamber, pendent from the apex, anatropous with the raphe sweeping outwardly, with one integument; style short, thick, stigma 3-lobed, broad, cleft irregularly, prostrate shield-shaped. Fruit a drupe, ellipsoidal

to spherical, crowned by the persisting petals; pericarp with 3 layers, the outer parenchymatous, the middle hard stone-like, the inner softer, then the inner prominently 6-10 ridged. Ovule one per seed, which becomes deeply grooved in the ridges of the endocarp; seed coat thin, nutritive tissue rich, thin-walled, full of small round starch granules and fatty oil; embryo small, at the apex, cotyledons flat, shorter than the plumule. Cotyledons two to six.

### C. *Foliar Anatomy*

Besides the general statements about the leaves mentioned in the discussion of the general comparative morphology of the *Olacales*, there are some peculiarities in the various tribes and genera which are worthy of mention at this time.

I. *Stomata.* The stomata are of the ordinary type being surrounded by epidermal cells. The following genera have stomata which are accompanied by two to several subsidiary cells parallel to the pore, often designated as the rubiaceous type: *Coula*, one species of *Olax*, *Curupira* and the *Opiliaceae (Metteniusa, Opilia, Agonandra, Cansjera, Melientha, Champereia).* The rubiaceous type of stomata is very frequent in the *Santalaceae.* The stomata are usually on the lower surface of the leaf only. The following genera have stomata on both sides of the leaf: *Ximenia, Olax, Chaunochiton (obovatum* and *angustifolium*, but not in *brevifolium* and *mourioides), Opiliaceae (Cansjera parvifolia).* In *Octoknema* the stomata are confined to the lower surface and are of the ranunculaceous type (also represented in the *Santalaceae* in *Comandra*).

II. *Hairs.* The hairy covering of the young leaves and twigs usually consists of simple unicellular hairs of varied lengths. Multicellular hairs are found in *Opiliaceae (Cansjera);* staghorn-branched hairs are known in *Ximenia caffra;* and dendritic types of hairs are found on the leaves and twigs in *Coula, Ochanostachys, Minquartia* and *Strombosiopsis.* In *Octoknema* the hairs of the leaves are tufted and stellate *(O. affinis* and *O. klaineana).*

III. *Leaf specialities.* There is a *development of the hypodermis* on the upper side of the leaf in *Anacolosa, Cathedra* and *Schoepfia.* There is a *papillose differentiation of the epidermis* on the lower side in *Liriosma,* many species of *Olax, Erythropalum* and *Apodytes (Icacinaceae).* The leaf tissue is mostly bifacial; it is centric in *Ximenia coriacea, Olax stricta* (and perhaps in other microphyllous Australian species) and in

the *Opiliaceae (Opilia amentacea)*. There are *strongly developed terminal tracheids* on the small veins in *Ximenia, Schoepfia, Worcesterianthus, Ptychopetalum, Cathedra (rubricaulis), Chaunochiton, Opiliaceae (Agonandra)* and *Phlebocalymna* (*).

A branching anastomosing system of bundles composed of reticulately or spirally thickened, lignified cells between the veins, similar to those found in *Cycas* and *Podocarpus*, are found in the *Opiliaceae (Agonandra, Cansjera, Lepionurus* and *Opilia)*, and in *Octoknema*. The palisade tissue in *Octoknema* is not clearly differentiated, but the mesophyll is more compact on the adaxial than on the abaxial side.

IV. *Internal secretory organs. Mucilage cells* situated in the spongy mesophyll have been found in *Opiliaceae (Agonandra* and *Opilia)*. *Secretory cells* with finely granular contents, readily stained with iodine, are found in the lowermost layer of mesophyll of *Opilia amentacea*. *Secretory cells* with resinous contents are found in the palisade and spongy parenchyma of *Cathedra, Anacolosa, Chaunochiton, Ximenia, Strombosiopsis (rigida), Lavalleopsis (Strombosia grandifolia)* and *Schoepfia*. *Schizogenous secretory cavities* with resinous contents are found in the mesophyll of *Endusa, Coula, Minquartia, Eganthus, Ochanostachys, Heisteria*. *Laticiferous tubes* which may be branched and non-septate accompanying the veins are found in *Minquartia, Ochanostachys, Heisteria* (also found free in the mesophyll of the leaf) and *Worcesterianthus magallensis*. *Articulate laticiferous tubes* are found accompanying the veins and are also found free in the mesophyll in *Endusa* and *Cardiopteris (Icacinaceae)*. *Silicified cells*, either solitary or in groups, are found in the mesophyll of *Ximenia, Olax, Liriosma, Cathedra, Schoepfia, Strombosia* (also has stone cells in the leaves). *Spicular cells*

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(*) *Phlebocalymna* is treated by METCALFE and CHALK (l. c., pp. 363-365) as being in the *Olacaceae*, instead of being in the *Icacinaceae* as treated by HOWARD, who in turn regarded *Phlebocalymna* synonymous with *Gonocaryum* of that family. The $\frac{T}{V}$ ratio from two samplings of *Gonocaryum melanocarpum* is 2.4, or 58 % shortening, with the vessels averaging 926 and 703 mu and the tracheids, 2230 and 1693 mu in length, respectively. In *Phlebocalymna griffithiana* the $\frac{T}{V}$ ratio is 3.35, or 71 % shortening, with V about 620 mu and T about 2080 mu in length. This would place the genus *Phlebocalymna* between *Aptandra* and *Ongokea* in regard to the wood anatomy, and not too far from *Liriosma* and *Olax*. *Phlebocalymna* has in the wood diffuse vessel arrangement as in *Liriosma, Ongokea* and *Heisteria;* has small intervascular pittings as in *Olax, Ongokea, Anacolosa, Schoepfia* and *Ximenia;* has rays similar to those of *Liriosma, Olax* and *Ongokea*, except that they are wider (up to 9 cells, instead of 2 or 3); has fibres with distinct and numerous bordered pits as in *Heisteria, Liriosma, Ongokea* and *Ximenia*.

(or sclerenchymatous fibres or idioblasts), which may be branched or unbranched, are found free in the mesophyll of *Endusa, Minquartia, Eganthus, Ochanostachys, Heisteria, Scorodocarpus, Strombosiopsis, Strombosia, Ptychopetalum, Cathedra, Anacolosa, Metteniusa* and in *Desmostachys* and *Discophora* of the *Icacinaceae*. There are three types of crystals found in the mesophyll or arranged along the veins of the genera of the *Olacaceae* and the *Opiliaceae* and their close relatives. *Clustered crystals* of the druse type, often accompanied by rhombic type crystals are found in *Heisteria, Strombosia, Strombosiopsis, Olax, Anacolosa, Cathedra, Worcesterianthus, Minquartia* and *Metteniusa*. Those genera having druses only are *Liriosma, Lavalleopsis, Aptandropsis, Ximenia, Ptychopetalum* and *Erythropalum*. *Ongokea* (in veins only) and *Aptandra* have rhombics only. No crystals were observed in *Chaunochiton* (4 species), *Schoepfia* (15 species), *Curupira* and *Tetrastylidium*. All the genera of the *Opiliaceae* have cystoliths, or compound crystal clusters, arranged in groups of two to several in special cells in the mesophyll of the leaf, except *Metteniusa* which possesses crystals of the druse-type only. The *Octoknemaceae* have crystals in the endodermis of the leaves.

## III. LACUNAR AND NODAL ANATOMY

The vascular bundles from a leaf make either a single gap, three gaps or many gaps in the stele corresponding to unilacunar, trilacunar or multilacunar conditions, respectively. The vascular bundle may divide after leaving the stele, but before reaching the node and leaf scar where three or five, or more, bundle scars may be present. The trilacunar condition is generally accepted as being the primitive one, and the unilacunar and multilacunar conditions are derived from this trilacunar condition, the former in a reduction, the latter in an addition, of lateral gaps in the stele.

The lacunar condition of a leaf-trace refers to the number of breaks or gaps made in the stele by the vascular tissue going to one leaf. Often the laterals leave the stele far down in the internode and travel upward in the cortex toward the node, where the median emerges from the stele. Then all progress to the leaf as one leaf-trace, even though they be separate vascular bundles of different stelar origins. The lacunar condition is not always obtained from a single cross-section, even though the nodal condition may be. Each break in the stele constitutes a single gap.

Ordinarily a unilacunar trace consists of a single bundle of fibre-

-vascular tissue. This trace is recognizable from the stele up to the leaf--scar of the leaf. At other times a single gap is made in the stele, but in the internode between where this trace has left the stele and where it leaves the stem through the leaf-scar the single bundle may divide

LACUNAR CONDITION IN THE *OLACACEAE*

| Trilacunar | Unilacunar | Pentalacunar |
|---|---|---|
| **Subfamily *Dysolacoideae*** | | |
| *Couleae* | | |
| Coula | | |
| Ochanostachys | | |
| Endusa | | |
| Minquartia | | |
| Eganthus | | |
| *Heisterieae* | *Heisterieae* | |
| Heisteria | Chaunochiton (*) | |
| Aptandropsis | | |
| *Anacoloseae* | *Anacoloseae* | *Anacoloseae* |
| Strombosia | Anacolosa | Scorodocarpus |
| Strombosiopsis | Cathedra | Lavalleopsis |
| Worcesterianthus | | |
| Tetrastylidium | | |
| **Subfamily *Olacoideae*** | | |
| *Olaceae* | *Olaceae* (3-1) | |
| Liriosma | Olax | |
| Ptychopetalum | *Aptandreae* (5-1) | |
| Curupira | Aptandra | |
| | Ongokea | |
| | *Aptandreae* (1-1) | |
| | Harmandia | |
| **Subfamily *Schoepfioideae*** | | |
| | *Schoepfieae* (3-1) | |
| | Schoepfia | |

(*) Although SLEUMER treated *Chaunochiton* in the tribe *Heisterieae*, there is evidence to the effect that the genus best belongs in the *Anacoloseae* along with *Cathedra* and *Anacolosa*, which are also unilacunar. Additional substantiating evidence will be provided when the wood anatomy is considered.

into three or five distinct vascular bundles. Thus, there may be one, three or five bundles at the node.

The lacunar types in the *Olacaceae* are just as diverse as are the other anatomical structures, as will be pointed out in the studies of the vessels, the wood parenchyma and the rays. The range in all the anatomical characters in this family is from the generally accepted primitive to the highly specialized types. The tri- and unilacunar tipes cut across the first subfamily, *Dysolacoideae*, with the result that the *Couleae* with their schizogenous resin canals and latex tubes in the leaves and bark and the *Heisterieae* with only latex tubes are trilacunar. In the more diversified *Anacoloseae* are found (1) the trilacunar type in *Strombosia*, *Strombosiopsis* (fig. 4) and *Worcesterianthus*, (2) the unilacular type in *Cathedra*, *Anacolosa* (fig. 1) and *Chaunochiton* and (3) the pentalacunar type in *Scorodocarpus* (fig. 2) and *Lavalleopsis*. The *Ximenieae* are trilacunar. In the subfamily *Olacoideae*, some of the *Olaceae* are trilacunar, as *Liriosma*, *Ptychopetalum* and *Curupira*, while *Olax* is unilacunar with three traces at the node; the *Aptandreae* (fig. 3) are unilacunar with five vascular bundles to a single gap. The subfamily *Schoepfioideae* are unilacunar with three vascular bundles to a single gap.

## IV. SECONDARY XYLEM

### OLACACEAE

The secondary xylem in the *Olacaceae* varies from the primitive to the more specialized on all counts. Usually there are five categories considered: vessel grouping based upon the types of perforations on the walls of the vessels (scalariform, scalariform-porous, porous, transverse); pore distribution (diffuse, pore chains, tangential); imperforate elements (tracheary, fibre-tracheids, libri-form fibres); wood parenchyma (diffuse, diffuse-aggregate, apotracheal, paratracheal); ray types (Heterogeneous I, II, III and Homogeneous I and II). All of these conditions exist in the various genera of the *Olacaceae* in various combinations. Metcalfe and Chalk (l. c., pp. 363-365) give a brief survey of the wood anatomy of this family. Most of the subsequent information verifies their findings but more often adds considerably to what was already known about the wood anatomy of the family.

In studying the tracheids and vessels in the various genera of *Olacaceae*, it was found that the ratio of the length of tracheids to that of the vessels seemed useful as an indicator of the primitiveness of the wood as a whole. Further, the information this ratio imparted

correlates with the floral and other anatomical structures in this family. The higher the ratio, the shorter the vessels, the more specialized the elements and the less primitive the genus. The tracheids and vessels were measured from macerations, stained with hemotoxylin. Correlation of the wood characters of the *Olacaceae* with the respective $\frac{T}{V}$ ratios are tabulated below to substantiate this fact.

| Vessel markings | T/V Ratio | % Shortening | Ray Type |
|---|---|---|---|
| Scalariform . . . . . | 1.2 to 2.0 | 20.3 to 49.9 | Het. I to Het. III |
| Scalariform-porous. . . | 1.7 to 2.3 | 41.8 to 55.2 | Het. II |
| Porous . . . . . | 2.0 to 4.8 | 49.9 to 73.0 | Het. I to Het. III |
| Porous . . . . . | 3.8 | 71.5 | Hom. I |
| Transverse . . . . . | 2.8 to 3.1 | 64.0 to 64.8 | Het. II |
| Transverse . . . . . | 4.3 to 5.3 | 76.9 to 81.1 | Hom. I & Hom. II |

**Subfamily *Dysolacoideae***

Tribe 1. *Couleae: Coula, Ochanostachys, Minquartia, Endusa, Eganthus.*

These genera are trilacunar at the node. The intervascular pitting of the vessels is scalariform-porous (figs. 58-61). The vessels appear in pore-chains in transverse sections (figs. 10-13). There are fibre-tracheids varying to libriform fibres. The wood parenchyma in *Coula* and *Minquartia* is diffuse to diffuse-aggregate, but varies from diffuse-aggregate to apotracheal in *Ochanostachys*. *Coula* (fig. 32) and *Ochanostachys* (fig. 35) have Het. II ray type, while *Minquartia* (fig. 33) and *Endusa* (fig. 34) have from Het. II to Het. III ray types. *Minquartia* and *Endusa* have been treated synonymous lately, and the study of the wood anatomy seems to bear out this relationship.

The $\frac{T}{V}$ ratios for these genera are:

*Coula edulis:* 1.4-1.5 with T from 1880 to 2152 mu and V from 1120 to 1554 mu.

*Ochanostachys amentacea:* 1.7-1.8 with T from 2140 to 2480 mu and V from 1140 to 1470 mu.

*Minquartia guianensis:* 1.7-1.8 with T from 2048 to 2900 mu and V from 1144 to 1228 mu.

*Endusa punctata:* 1.7 with T about 2090 mu and V about 1208 mu.

Tribe 2. *Heisterieae: Heisteria, Aptandropsis.*

The genus *Aptandropsis* has been placed close to *Heisteria* by DUCKE (Bol. Tecn. Inst. Agron. Norte, Belem, Brazil No. 4: 5-7. 1945) on the basis that the flowering specimens of the two species have the aspect of *Heisteria*, even though the fructifying specimens are very much like *Aptandra*. The nodes are trilacunar, but since no mature wood has been available the details of the wood anatomy have not been studied,

In the genus *Heisteria* the following species have been studied: *H. cauliflora, cyanocarpa, densifrons, duckei, flexuosa, longipes, parvifolia, spruceana.* The nodes in all are trilacunar. The intervascular pittings on the vessels are scalariform (figs. 56-57) with up to 20 bars or more. The wood has diffuse pore distribution (fig. 9). The imperforate elements are tracheary. The wood parenchyma varies from diffuse to diffuse-aggregate. The Het. I ray type permeates the genus (fig. 31). Truly this is the most primitive genus in the *Olacaceae*. The average $\frac{T}{V}$ ratio in nine species of the genus is 1.48, ranging from 1.2 to 2.1. This ratio is low, hence the tracheids should be long and the vessels long. Lengths of the tracheids vary from 1950 to 2470 mu; the vessels vary from 900 to 1734 mu.

Tribe 3. *Anacoloseae: Strombosia, Strombosiopsis, Tetrastylidium, Lavalleopsis, Scorodocarpus, Worcesterianthus, Anacolosa, Cathedra, Chaunochiton.* The genera in this tribe vary considerably and those which seem to resemble each other more closely will be treated together.

A. *Strombosia, Strombosiopsis* and *Tetrastylidium.* The intervascular pitting of the vessels of these genera varies from scalariform (fig. 62) to scalariform-porous. The vessels are in pore chains in all in transverse section (figs. 14-17, and fig. 4). The imperforate elements are fibre-tracheids in *Strombosia* and *Tetrastylidium* and tracheary in *Strombosiopsis.* The wood parenchyma varies from diffuse to diffuse--aggregate. The ray types vary from Het. I to Het. III in *Strombosia* (figs. 37-39), but are only Het. III in *Strombosiopsis* and *Tetrastylidium janeiriensis.* The woods of six species of *Strombosia* have been studied: *S. javanica, membranacea, philippinensis, rotundifolia, pustulata, zeylanica.* The $\frac{T}{V}$ ratio varies from 1.5 to 2.0. Thus, the ratio is increasing in its magnitude, perhaps indicating some specializations. For, besides the scalariform-porous vessels of the more primitive genera of the family, there are indications of slight modifications, as the pore-chains, the fibre-tracheids, the diffuse-aggregate wood parenchyma and the varying

to Het. III ray type. The nodes of these genera are trilacunar, with some indications that some species of *Strombosia* are unilacunar (3-1).

B. *Lavalleopsis.* This genus has been placed by SLEUMER in *Strombosia*, with which genus it shares the following similar characteristics of the wood anatomy: scalariform-porous vessels (fig. 63), in pore-chains and rays varying from Het. I to Het. III. The vessels are extremely narrow (fig. 36), and the rays look very different from those in *Strombosia.* However, the node in *Lavalleopsis densivenia* is pentalacunar.

C. *Scorodocarpus* and *Worcesterianthus.* These two genera have several characteristics of their wood similar. The intervascular pittings are scalariform-porous (figs. 64-65). The vessels are in pore-chains (figs. 18-19) in transverse sections. The ray type is Het. II (figs. 40-41). However, *Scorodocarpus borneensis* is pentalacunar (5-5) and *Worcesterianthus magallensis* is trilacunar (3-3). The $\frac{T}{V}$ ratio for *Scorodocarpus* is 1.7, with tracheids about 2490 mu and vessels about 1450 mu in length. In *Worcesterianthus* the ratio is 2.3, with the tracheids about 1636 mu and the vessels only 734 mu in length. Specializations in the wood are responsible for the shorter tracheids and vessels, and inversely to the greater ratio.

D. *Anacolosa, Cathedra* and *Chaunochiton.* These three genera are unilacunar. The intervascular pittings are porous (figs. 67-69). The vessels are arranged in pore-chains in transverse section (figs. 20-22). *Cathedra* and *Chaunochiton* have Het. II ray type (figs. 43-44); *Anacolosa* has Het. III ray type (figs. 42 and fig. 1). The wood parenchyma is diffuse-aggregate in all, but the imperforate elements in *Anacolosa* and *Chaunochiton* are libriform-fibres, whereas they are tracheary in *Cathedra.* The $\frac{T}{V}$ ratio for *Anacolosa* is 3.2 with tracheids from 1036 to 2082 mu and vessels from 402 to 526 mu in length. *Anacolosa lutea* and *A. arborea* were studied. For *Cathedra*, the ratio is 2.3, the tracheids varying from 800 to 860 mu and the vessels from 300 to 420 mu in length. *Cathedra rubricaulis* and *C. acuminata* were studied. For *Chaunochiton*, the ratio is 2.5, with the tracheids varying from 1100 to 1400 mu and the vessels from 430 to 700 mu in length. The wood anatomy of a single species of *Chaunochiton* has been studied, *Ch. breviflorum.*

*Chaunochiton* has usually been placed along with *Heisteria* in the tribe *Heisterieae.* However, a comparison of the wood characters and some of the floral characters of the genera *Heisteria, Chaunochiton, Cathedra* and *Anacolosa* reveals a different relationship.

| *Heisteria* | *Chaunochiton* | *Cathedra* | *Anacolosa* |
|---|---|---|---|
| 1. Trilacunar | Unilacunar | Unilacunar | Unilacunar |
| 2. Scalariform perforations in vessels | Porous | Porous | Porous |
| 3. Diffuse pore distribution | Pore-chains | Diffuse pore | Pore-chains |
| 4. Tracheary imperforate elements | Libriform fibres | Tracheary | Libriform fibres |
| 5. Het. I ray type | Het. II | Het. II | Het. III |
| 6. $\frac{T}{V}$ ratio — 1.48 | 2.5 | 2.3 | 3.2 |
| 7. Ovary 3-loculate | 2-loculate | 2-loculate | Uniloculate or indistinctly compartmented |
| 8. Stamens 10 (12), rarely 5-6 | 5 | 5-6 | 6 |
| 9. Fruit-calyx more or less leathery | Fruit-calyx thin membranous | Calyx fleshy | Calyx small |

Tribe 4. *Ximenieae: Ximenia.* This genus is trilacunar. The intervascular pittings of the vessels are transverse (fig. 66). The pore distribution is diffuse in transverse sections (fig. 23). The rays are of the Het. II type (figs. 45-46). The $\frac{T}{V}$ ratio average for the two species studied (*X. americana* and *X. elliptica*) is 3.0, the tracheids varying from 850 to 950 mu and vessels from 300 to 310 mu in length.

**Subfamily *Olacoideae***

Tribe 5. *Olaceae: Ptychopetalum, Olax, Liriosma, Curupira.* The genera of this tribe cut across several lines of specialization in the wood anatomy. *Ptychopetalum, Liriosma* and *Curupira* are trilacunar, but *Olax* is unilacunar (3-1). The intervascular pittings in *Curupira* are scalariform-porous, whereas they are porous (figs. 70-75) in the other genera. The wood parenchyma is diffuse-aggregate in all the genera. The distribution of the vessels in transverse section is different in each genus: *Ptychopetalum* has pore-chains, *Olax* has tangential pore distribution (figs. 24-25); *Liriosma* has diffuse pore distribution (fig. 26); and *Curupira* has diffuse to short pore-chains. Thus all three types of pore distribution are exhibited in the tribe *Olaceae* of Sleumer. *Ptychopetalum* (figs. 47-49) and *Olax* (fig. 50)

have Het. I ray type, with a tendency for there to be Het. II ray type in some species of *Olax*; *Curupira tefeensis*, from a study of twig material, has Het. III ray type; and *Liriosma* (fig. 51) has Hom. I ray type. The $\frac{T}{V}$ ratio for three species of *Ptychopetalum* (*Pt. anceps*, *Pt. olacoides* and *Pt. uncinatum*) is 2.7, the tracheids varying from 1600 to 2056 mu and the vessels from 608 to 844 mu in length. In *Olax* the ratio varies from 3.0 to 3.7 in the *Triandrae* (*Olax andromensis* and *O. mannii*), with tracheids varying from 1038 to 1576 mu and vessels from 280 to 556 mu in length and from 4.3 to 4.8 in the *Pentandrae* (*Olax subscorpoidea* and *O. pentandra*), with tracheids varying from 1526 to 1832 mu and vessels from 348 to 410 mu in length. In *Olax linderi* the rays are very wide and high, resembling those shown for *Worcesterianthus* (fig. 41); the $\frac{T}{V}$ ratio for *O. linderi* is 1.66, with tracheids about 1952 mu and vessels about 1176 mu in length; oil cells are found in the wood of *O. linderi*, similar to those found in *Agonandra*, *Champereia* and *Opilia celtidifolia* of the *Opiliaceae*. This species of *Olax* seems to be aberrant in the genus, but the study of more species of the genus *Olax* may close the apparent gap between this and the other species. Otherwise, it should be placed elsewhere. In *Liriosma spruceana* the ratio is about 3.8, the tracheids are about 1754 mu and the vessels about 504 mu in length.

Tribe. 6. *Aptandreae: Harmandia*, *Aptandra*, *Ongokea*. These genera are unilacunar. *Harmandia* is 1-1 at the node, whereas *Aptandra* and *Ongokea* are 5-1. *Harmandia* also possesses some primitive characters in the wood, at least of the twigs as this was the only wood available, as scalariform intervascular pittings on the walls of the vessels and diffuse pore distribution of the vessels in transverse section. *Aptandra* has porous intervascular pittings (fig. 77) and *Ongokea* has transverse pittings (fig. 76). In *Aptandra (zenkeri)* (fig. 27) the vessels form short (2-4 cells) pore-chains which may be vertical, horizontal or tangential to the radial axis of a transverse section. The wood parenchyma is diffuse-aggregate with long (20--40 cells) continuous series of cells between the tracheids extending along the radius of the transverse section (fig. 27). In *Ongokea (klaineana)* the vessels are in long tangential chains (3-15 cells) (fig. 28). The wood parenchyma is in diffuse-aggregates in small patches (fig. 28). The rays are Het. II in *Aptandra* (fig. 52) and Hom. I in *Ongokea* (fig. 53). The $\frac{T}{V}$ ratio for *Aptandra* (based

on three species, *A. liriosmoides, A. spruceana* and *A. zenkeri)* is 3.6, with tracheids measuring from 1528 to 1966 mu and vessels from 500 to 784 mu. In *Ongokea (klaineana)* the ratio is 4.3, the tracheids measuring about 1954 mu and the vessels about 452 mu.

**Subfamily *Schoepfioideae***

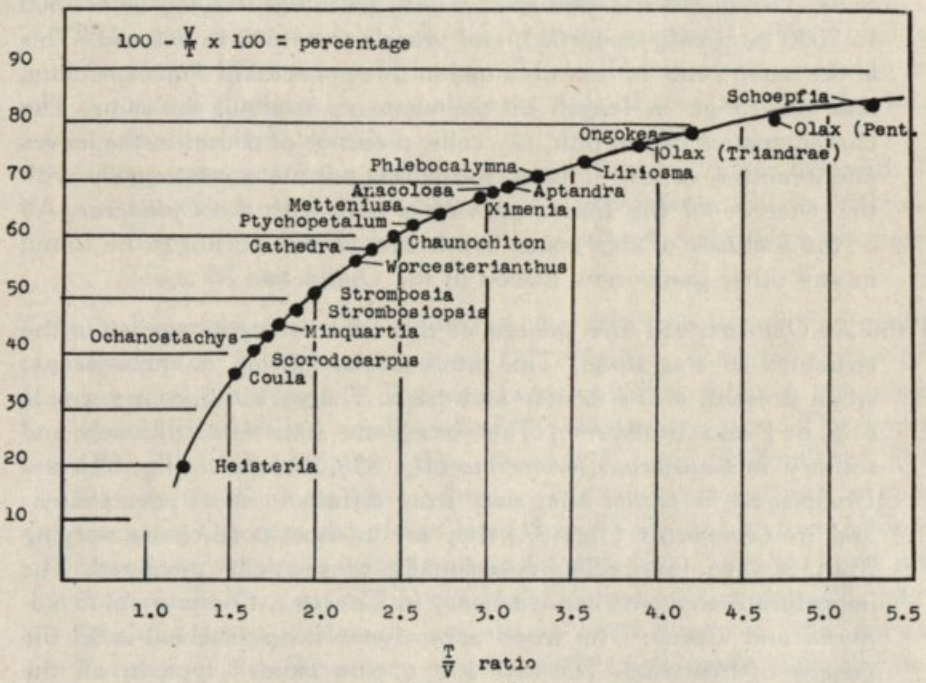
Tribe 7. *Schoepfieae: Schoepfia.* This is the most specialized genus in the family according to the wood anatomy, as well as to the floral anatomy. It is unilacunar (3-1). The intervascular pittings are transverse (figs. 78-79). The pore distribution is tangential with very short groups of vessels, often giving the appearance of being diffuse (figs. 29-30). The wood parenchyma is paratracheal (figs. 29-30). The rays are of the Hom. II type (figs. 54-55), the short vessels being storied in horizontal rows. The $\frac{T}{V}$ ratio varies from 4.8 to 5.3 in the two species of *Schoepfia* studied *(Sch. jasminodora* and *Sch. schreberi)*, the tracheids varying from 572 to 644 mu and the vessels from 118 to 122 mu in length.

The percentage of shortening of the tracheids to form vessels in the *Olacaceae* can be expressed by the following equation: $100 - \frac{T}{V} \times 100$. On the graph below are plotted the $\frac{T}{V}$ ratios against the percentage shortening for these genera. The more primitive genera in the family have scalariform vessels and their ratios vary from 1.20 to 2.00, with corresponding low percentages from 20 % to 56 % shortening in the vessels. The intermediate genera in the family have porous vessels and their ratios vary from 2.00 to 4.8, with percentages varying from 49.9 % to 73.0 %. The most specialized genera have transverse markings on the vessel walls, varying ratios from 2.8 to 3.1 with Het. II rays, or with varying ratios from 3.8 to 5.3, i. e. up to 81 % shortening, with Hom. I and II rays.

The two values used in plotting this graph are actually reciprocals and of themselves are of little value. But when the genera are placed in their proper places on the curve, they are distributed in a very significant way. If the grouping of the genera according to SLEUMER is compared to the grouping of the genera on this graph, several similarities will be noted, but so will several differences. For example, note where *Chaunochiton* is in relation to *Heisteria*, as well as where it is in relation to *Anacolosa* and *Cathedra*; note that the two sections of *Olax* studied, the *Triandrae* and *Pentandrae*, fall into two different places on

the curve; note that *Phlebocalymna*, with a ratio of 3.35, or 71 % shortening, would fall in the range of the subfamily *Olacoideae*; and note that *Metteniusa*, with a ratio of 2.7, would fall in the region of the tribe *Olaceae* of the *Olacoideae*.

RECORD (1938, pp. 11-37) states that some of the genera of the *Olacaceae* which have the pores in short to long radial multiples and




GRAPH 1. — Relationship of genera of the *Olacaceae:* ratio of length (in mu) of tracheids to vessels plotted against percentage shortening of vessels.

have the wood parenchyma abundantly developed and typically reticulate suggest similarities in the *Euphorbiaceae*. The latex tubes in the leaves and in the phloem, primary cortex and pith of *Heisteria* and all of the *Couleae* suggest such a relationship also.

## OPILIACEAE

Tribe 1. *Aveledoeae: Metteniusa (nucifera).* The wood anatomy of this genus indicates a relationship to the *Olaceae*, where it might more properly belong. The intervascular pitting of the vessels is scalariform-porous, as in *Curupira* of the *Olaceae*. The vessels are arranged

in short pore-chains varying from two to four cells, with a tendency to be tangentially arranged, similar to that found in *Olax* and *Curupira*. The wood parenchyma is diffuse-aggregate, similar to that found in all the *Olaceae*. The rays vary from Het. I to Het. III; *Ptychopetalum* has Het. I, *Olax* varies from Het. I to Het. II, *Curupira* is Het. III. The rays are quite high and are up to three cells wide. The $\frac{T}{V}$ ratio is about 2.7, with tracheids varying from 1800 to 2000 mu (twig material), and vessels from 630 to 900 mu. This is the same ratio as that obtained in three species of *Ptychopetalum*, and the range in length of the elements is about the same. The characteristics of the pith, ray cells, presence of druses in the leaves and features of the flowers and fruits indicate a relationship with the *Olaceae* of the *Olacaceae*, rather than with the *Opiliaceae*. All of the features of this genus mentioned above are not to be found in any other genus now placed in the *Opiliaceae*.

Tribe 2. *Opilieae*. All the genera of this tribe are quite similar in the structure of the wood. The intervascular pitting is quite scant; when present, it is alternate and small. The perforations are simple (fig. 88) and transverse. The vessels are distributed diffusely and solitary in *Cansjera, Champereia* (fig. 85), *Melientha* (fig. 89) and *Urobotrya;* in *Opilia* they vary from diffuse to short pore chains; and in *Lepionurus* (fig. 87) they are in short pore chains varying from two to four cells, occasionally tangentially arranged. The imperforate elements are tracheary in *Cansjera, Champereia, Lepionurus* and *Opilia*. The wood parenchyma is apotracheal in all the genera of this tribe. The rays are of the Hom. I type in all the genera (figs. 84, 86 and 90), up to five cells wide in *Champereia manillana*. Large cells containing cystolits of calcium carbonate are present in *Cansjera, Champereia, Lepionurus, Melientha, Opilia* and *Rhopalopilia*. The pits of the fibres are simple in *Champereia*, but are distinctly bordered in *Opilia*. In the other observed genera they are simple.

*Cansjera rheedi* — $\frac{T}{V}$ is 2.1 in twig material, T being 600 to 660 mu and V being 180 to 360 mu. Rays two cells wide, quite high.

*Urobotrya trinerva* — $\frac{T}{V}$ is 3.0 in twig material, T being 800 to 1000 mu and V being 270 to 360 mu. Rays 4 to 5 cells wide, high.

*Opilia amentacea* and *O. fragrans* — $\frac{T}{V}$ is 3.5 in twig material, T being 630 to 800 mu and V being 180 to 230 mu. Rays two to

three cells wide, very high. *Opilia celtidifolia* — $\frac{T}{V}$ is 5.8 in mature wood, T being 900 to 1200 mu and V being 90 to 270 mu. Rays 3 to 4 cells wide, not very high (10 cells) with oil canals or ducts similar to those in *Champereia*.

*Lepionurus latisquareus, L. sylvestris, L. oblongifolius* — $\frac{T}{V}$ is 4.8 in twig material, with T being 1200 to 1400 mu and V being about 270 mu. Rays 3 to 4 cells wide, rather high.

*Meliantha acuminata* — $\frac{T}{V}$ is 4.4 in twig material, with T being about 450 mu and V being 90 to 120 mu. Rays irregular in size and shape. A very aberrant type of stem structure for this family (figs. 89-90).

*Champereia manillana* and *Ch. lanceolata* — $\frac{T}{V}$ is 5.5 to 6.8, with T varying from 810 to 1400 mu, V varying from 180 to 350 mu. Rays up to five cells wide and quite high, with large oil ducts (figs. 84 and 92).

Tribe 3. *Agonandreae.* The woods of the five species of the genus *Agonandra* have been studied (*A. silvatica, obtusifolia, excelsa, racemosa, brasiliensis*). The intervascular pitting is rare, but when present is alternate, small and of the transverse type. The pores are exclusively solitary (figs. 83 and 91) in distribution. The imperforate elements are tracheary. The wood parenchyma is apotracheal. The rays are of the Hom. I type (fig. 82) and are seldom more than two cells wide (three cells wide in *A. silvatica*) and are moderately low (up to 10 cells high). Large cells containing cystoliths of calcium carbonate are absent in the rays of this genus. The pits of the fibres are simple, with small moderately distinct borders. The wood of *Gjellurupia* has not been studied.

## OCTOKNEMACEAE

The two genera of this family are so different in their wood anatomy that they should each be placed in separate tribes, if not in distinct subfamilies. NORMAND suggested that, while *Octoknema* has many wood characters in common with the *Olacaceae*, the structure of *Okoubaka* suggests affinity with the *Santalaceae*. The wood structure of *Octoknema* is unspecialized in all its characters, while *Okoubaka* is moderately highly specialized.

*Octoknema:* In this genus *O. borealis* was studied. The vessels are in pore chains and the perforation plates are scalariform. Wood parenchyma is absent. The rays are up to three cells wide and are

markedly heterogeneous, Het. I. The fibres have simple pits and are sometimes septate. The $\frac{T}{V}$ ratio is 1.6, with the tracheids about 2200 mu and the vessels varying from 1200 to 1600 mu in length. These features of the wood would place the genus between the *Heisterieae* and the *Couleae* on the curve. With more knowledge of the wood anatomy of other species of *Octoknema* and of other genera which might be brought into the *Olacaceae* or *Octoknemaceae* the true relationships here might be brought out.

*Okoubaka:* In this genus *O. aubrevillei* was studied. The vessels are solitary and the perforations are simple. The parenchyma is apotracheal as numerous scattered cells and short uniseriate lines, tending to be storied. The rays are up to 4 to 5 cells wide and homogeneous, Hom. II. The fibres have simple pits; fibre-tracheids occur about the vessels, with numerous bordered pits and thin walls. The $\frac{T}{V}$ ratio is 8.0, with the tracheids about 2000 mu and the vessels only 250 mu in length. This is a very specialized genus and belongs beyond *Schoepfia* on the curve.

### *SPECIALIZATIONS OF THE AXIS AND VASCULAR SYSTEM*

There are some specialities in the axis and the vascular system in the various genera and tribes of the *Olacales* worthy of mention. METCALFE and CHALK (1950) have mentioned some of them. The *cork* arising in the sub-epidermis is made up of thin-walled cells in most of the genera, but these may be intermixed with other cells which have thickened tangential walls in the *Couleae* (*Coula, Minquartia, Ochanostachys* and *Octoknema*) (note that the wood anatomy also places *Octoknema* near the *Couleae* and *Heisterieae*; there will be several similarities between these genera); it arises in the epidermis in some species of *Champereia* and *Opilia*. The *pericycle* contains a ring of sclerenchyma, which is complete and continuous in *Heisteria, Minquartia, Ochanostachys, Octoknema, Strombosia, Scorodocarpus, Agonandra, Cansjera, Champereia, Lepionurus* and *Opilia*, whereas it is in bands or isolated strands of fibres in *Liriosma, Olax, Ximenia* and *Schoepfia*. The *secondary phloem* is partly sclerenchymatous in *Liriosma*. There are *schizogenous secretory cavities* with resinous contents in the cortex of the *Couleae (Coula, Minquartia* and *Ochanostachys). Branched non-septate laticiferous tubes* are present in the primary cortex, phloem and pith of *Heisteria* and of all the *Couleae*.

The general morphology, structure and arrangement of the vascular

elements have already been presented above. In addition to these are some modifications in some of the tribes and genera. There is a common occurrence in the *Olacaceae* for there to be *perforations* between the vessels and the ray cells (*Liriosma*, fig. 75), found in *Liriosma, Ptychopetalum* and *Strombosia*; small perforations are also present between the ray cells and the parenchyma in *Chaunochiton, Cathedra rubricaulis, Ongokea* and *Schoepfia*. Even the pith cells are perforated in *Liriosma* (*spruceana*), in *Aptandra* and in most of genera of the *Opiliaceae*. In the *Opiliaceae* perforations to the ray and wood parenchyma are small and round, frequently striated.

*Tyloses* are found in the vessels of many genera of the *Olacaceae*. Note those in *Strombosia pustulata* (figs. 15, 80, 81). They are also known to be in *Minquartia, Ochanostachys, Scorodocarpus*, other species of *Strombosia, Strombosiopsis* and *Ximenia;* those in *Strombosiopsis tetrandra* are sometimes sclerosed. Sometimes the tyloses contain gum-like deposits.

The *parenchyma in the wood* varies considerably in its arrangement about the vessels and tracheids, this having been pointed out for each genus above while discussing the woods. *Chambered crystal-bearing cells* are common in the *Couleae* (*Coula, Endusa, Minquartia* and *Ochanostachys*), *Anacoloseae* (*Anacolosa* and *Chaunochiton*), *Olaceae* (*Olax, Ptychopetalum* and *Liriosma*) and *Aptandreae* (*Aptandra* and *Ongokea*). In a few species there are gum-like deposits in the parenchyma. Cystoliths similar to those in the leaves are present in the parenchyma of the axis, especially in the rays, in all of the genera of the *Opiliaceae*, except *Metteniusa* and *Agonandra*.

*Chambered cells* having abundant crystals are found in the *ray cells* of the *Couleae* (*Coula, Endusa, Minquartia* and *Ochanostachys*), *Anacoloseae* (*Anacolosa, Scorodocarpus, Strombosia* and *Strombosiopsis*), *Ximenieae* (*Ximenia*) and *Aptandreae* (*Ongokea*), *Octoknema* and *Okoubaka*. Some genera have gum-like deposits also in these ray cells. Note the various longitudinal sections showing the ray cells.

The *fibres* have distinct and numerous bordered pits in *Heisteria, Liriosma, Ongokea, Phlebocalymna, Ximenia, Agonandra* and *Opilia*, whereas the other genera have a rather few simple pits mainly restricted to the walls in contact with the ray or parenchyma cells, with funnel-shaped canals and slit-like inner and rounded outer apertures. The fibres have occasional septa in *Strombosia* and *Octoknema*. *Vascular tracheids* are present in *Olax*. *Fibre-tracheids* occur in *Okoubaka* about the vessels, with numerous bordered pits and thin walls.

In the wood of *Champereia* of the *Opiliaceae*, tribe *Opilieae*, there are oil ducts in the rays (figs. 84 and 92); there are oil cells in other parts of the wood of *Cansjera rheedii*, *Lepionurus latisquareus* and *Opilia celtidifolia*, as well as in *Agonandra (A. brasiliensis, A. racemosa* and *A. silvatica)* of the tribe *Agonandreae*. Also in the wood of *Olax linderi*, an aberrant species in that genus.

## V. PITH AND WOOD PARENCHYMA

In the young twigs of the *Olacaceae* several types of pith are present in the various subfamilies, tribes and genera. The phylogenetic significance and ontogenetic development of pith in the twigs remain matters for further investigation in the Angiosperms, at least in so far as determining what types are primitive or advanced.

The genera of the *Olacaceae* may be divided into two major groups depending upon the presence or absence of stone cells in the pith of the twigs. The presence of the stone cells in either patches or in bars across the pith further separates the genera. Finally, the presence or absence of a black amorphous gummy substance in the cells of the pith divided the genera into smaller groups. The genera of the *Olacaceae* then may be divided according to these characteristics in the following manner.

A. Stone cells present.

I. In bars varying to patches across the pith.

a. Black amorphous substance present in pith.

1. Trilacunar — Heisteria, Strombosiopsis.
2. Unilacunar (3-1) — Strombosia (fig. 7).
3. Pentalacunar — Lavalleopsis.

b. Black amorphous substance absent in pith.

1. Trilacunar — Erythropalum (in Erythropalaceae).

II. In patches only.

a. Black amorphous substance present in pith.

1. Trilacunar — Coula, Ximenia (fig. 6).
2. Unilacunar — Cathedra rubricaulis.
3. Pentalacunar — Scorodocarpus.

b. Black amorphous substance absent in pith.

1. Trilacunar — Minquartia, Ochanostachys, Curupira.
2. Unilacunar — Harmandia.

B. Stone cells absent.

I. Black amorphous substance present in pith.

a. Trilacunar — Ptychopetalum.
b. Unilacunar (3-1) — Olax.
c. Unilacunar (5-1) — Aptandra (fig. 5), Ongokea.

II. Black amorphous substance absent in pith.

a. Trilacunar — Worcesterianthus, Liriosma, Tetrastylidium.
b. Unilacunar (3-1) — Olax.
c. Unilacunar (1-1)—Chaunochiton, Anacolosa, Cathedra acuminata (fig. 8), Schoepfia.

The wood parenchyma in the genera of the *Olacaceae* may also be divided into two large groups, based upon the presence or absence of the black amorphous gummy substance in the cells. The presence of the substance can be detected in the rays quite easily (see figs. 31 to 55).

Those genera in which the black amorphous substance is present in the wood parenchyma are: *Heisteria, Coula, Ochanostachys, Endusa, Minquartia, Ximenia, Strombosia, Strombosiopsis, Anacolosa, Cathedra (rubricaulis), Chaunochiton, Curupira, Scorodocarpus* and *Lavalleopsis.* The following genera do not seem to possess this black substance: *Liriosma, Olax, Aptandra, Ongokea, Worcesterianthus* and *Schoepfia.*

It will be noted that some genera have this substance in the wood parenchyma, but lack it in the pith, as *Anacolosa, Chaunochiton, Cathedra (acuminata), Minquartia, Ochanostachys* and *Curupira.*

In the *Opiliaceae* stone cells or sclerids may also be present or absent in the pith. The black amorphous substance is present only in *Metteniusa,* in both the pith and the ray cells, as it is in some of the *Olacaceae.* Therefore, the genera of the *Opiliaceae* may be grouped in the following manner based upon these characters.

A. Stone cells present; black amorphous substance absent.

I. Stone cells scattered in small patches in the pith.

a. Champereia (lanceolata and manillana).

II. Stone cells in large clusters in the pith.

a. Melientha (acuminata).
b. Opilia (fragrans).

B. Stone cells absent.

I. Black amorphous substance present in pith and ray cells.

a. Metteniusa (nucifera).

II. Black amorphous substance absent.

a. Agonandra (excelsa, obtusifolia, racemosa, silvatica).
b. Cansjera (rheedi).
c. Lepionurus (latisquareus, oblongifolia, sylvestris).
d. Opilia (amentacea).
e. Urobotrya (trinerva).

From a study of the wood anatomy of the genera now being included in the *Opiliaceae, Metteniusa* seems aberrant in this family. In the *Olacaceae* it has a counterpart in the genus *Ptychopetalum* which also possesses the black amorphous substance in the pith, and it lacks the stone cells. Both have Het. I ray types, but the vessels are diffuse to short pore-chains as in *Curupira*, with a tendency to tangential pore distribution, as found in *Olax*. Thus, it links together several characteristics of the various genera of the tribe *Olaceae*. The large flowers and the enlarged fruit-calyx also could be included in this tribe. The presence of druse type crystals and absence of cystoliths in the leaves links the genus with the *Olacaceae* rather than with the *Opiliaceae*, which has characteristic cystoliths and no druses.

## VI. MORPHOLOGY OF THE POLLEN

The morphological characters of the pollen, primarily the exine-sculpture, the furrow-configuration and the pore-structure and secondarily the size and shape, can be used in taxonomic studies in identifying genera and species. In some families there is a common pattern, as the tetrad formation of the pollen-grains in the *Ericaceae*. In other cases the genera hold together among themselves, but vary from one another greatly within the family. In some genera the species vary sufficiently in sculpturing of the walls and in size that these characters may be used as confirmatory evidence in taxonomy. ERDTMAN has recently

(1952) used many of these characters in discussing « Pollen Morphology and Plant Taxonomy ».

The terminology used by ERDTMAN in identifying parts of the pollen grain is quite extensive. The usage of new terms will be kept to a minimum in this paper. Several methods for preparing the pollens for study are described by ERDTMAN. The author has mounted his pollen in lactic acid. There seems to be some difference between the measurements of some pollens given by ERDTMAN and those the author has obtained, whereas in others the measurements are identical. The mounts in lactic acid do not seem over extended and some have remained for as long as twelve years as mounted.

In the *Olacales* the species within a genus show greater similarities to each other than to species of any other genus, so that the pollen characters are of generic significance. However, there are a few species which seem to be misplaced, at least from the study of the samples used in this study, indicating perhaps that the study of the pollen may give a clue to a misplaced species within a genus. These species will be pointed out as they are presented.

The genera of the *Olacaceae* represent a number of types of pollen grains, varying greatly in size and structure in the various subfamilies and tribes of SLEUMER. The general morphology of the pollen is equally as diverse as the other morphological structures in this family have been. A preliminary survey of the *Santalaceae* especially suggests that these two families need to be reconsidered. BAILLON had fused the two, distributing the genera into various tribes. SWAMY (Amer. Jour. Bot. 36: 667, figs. 38-57. 1949) recently discussed and illustrated the pollens of some of the genera of the *Santalaceae*. They do not differ too greatly from those of some of the genera of the *Olacaceae*.

The arrangement of the genera in the *Olacaceae* and *Opiliaceae* shall be essentially the same as that presented by SLEUMER. The species in the genera of each tribe which have been studied by the author will be described and illustrated. The species studied by ERDTMAN will also be included, with a few notes from that author.

### *Olacaceae*: subfamily *Dysolacoideae*

Tribe 1: *Couleae.*

1. *Coula* Baill. *Coula edulis* from Cameroon has been studied (figs. 99-100). The pollen grains vary from 17.5 to 20.0 mu in diameter. They are tricolpate, with a small furrow in the exine over the round to

elliptic irregularly outlined pore. The exine is minutely punctate at a magnification of $\times$1200. There are indications of a punctate inner exine, or intine, at this magnification. The grains are triangular in polar view and flattened ellipsoidally in equatorial view; hence « oblate spheroidal (about 14-5$\times$16 mm) », ERDTMAN.

2. *Ochanostachys* Mast. In *O. amentacea* (figs. 102-104) from the East Indies the pollen grains vary from 17.0 to 18.0 mu in diameter. They are tricolpate, with a furrow in the exine over each elliptic irregularly outlined pore. The exine is deeply pitted at a magnification of $\times$1200. The intine is smooth over the pore. The grains are triangular in polar view and flattened ellipsoidally in equatorial view; hence « oblate (about 9.5$\times$13.5 mu) », ERDTMAN.

3. *Minquartia* Aubl. In *M. guianensis* (fig. 111) from Brazil the pollen grains vary from 23.0 to 25.0 mu in diameter. They are tricolpate, with short furrows about the pores. The exine is smooth at $\times$1200, with a few scattered pits. The grains are triangular in polar view and flattened ellipsoidally in equatorial view. The pollen of *Minquartia punctata* (*Endusa* Miers) does not differ essentially from that of *M. guianensis* (see figs. 109-110 and 111). The pollen of *M. parvifolia* is also quite similar to that of *M. guianensis*. ERDTMAN: « *M. guianensis*, suboblate (14.5$\times$16.5 mu) ».

Tribe 2. *Heisterieae*.

4. *Heisteria* Jacq. Several species of this genus of 47 species from Central and South America, and 3 species from Africa, have been studied. The pollen grains vary from 15.0 to 20.0 mu in diameter. They are tricolpate, with ellipsoidal pores, much as in the *Couleae*. The exine is smooth with very small pits scattered about. The grains are triangular in polar view and ellipsoidal in equatorial view. This type of pollen grain is found in the following species. The mean size follows the species. *H. macrophylla* Oerst., Mexico, 15.3 mu; *H. parvifolia* Sm., Africa, 17.5 mu; *H. parvicalyx* A. C. Smith, Brazil, 18.3 mu; *H. cyanocarpa* Engl., S. America, 16.3 mu; *H. spruceana* Engl., Brazil, Peru, about 17 mu; « *H. zimmereri*, Cameroon, suboblate (equatorial diameter about 15 mu) », ERDTMAN.

The pollen grains of *H. cauliflora* Sm. from Guiana (figs. 95-98) present an anomalous type of grain for this genus. The three pores are eccentrically situated on one side of the grain, almost anacolosoid. There are no furrows. The pores are round. The exine is irregularly and variously sculptured with a coarse reticulum, at a magnification of

×1200. The grains vary from 20.0 to 20.5 mu in diameter. In polar view the grains are rounded-triangular; in equatorial view, irregularly ovoid. These grains seem to be similar to those of *Chaunochiton*.

The genus *Aptandropsis* was described by DUCKE as being intermediate between *Heisteria* and *Aptandra*, with floral characters similar to those of *Heisteria*. Since pollen was not available for the species of this genus, this character can not be verified at this time.

5. *Chaunochiton* Benth. The pollen grain of three species of this genus have been studied by the author. In *Ch. breviflorum* Ducke (figs. 105-108) from South America the pollen grains vary in diameter from 35.0 to 37.5 mu. The three pores are ovoid in shape, with ovoid furrows which taper at each end. Between each of the pores, on each of the four faces of the bluntly tetrahedral pollen grains is a window. The thick exine between the pores and the windows is coarsely and irregularly reticulate. The pollens of *Ch. angustifolium* and *Ch. loranthoides* are equally as beautifully sculptured on their surfaces, the grains being a little smaller in diameter in these two species. ERDTMAN studied *Ch. kappleri* from Brazil, «oblate (about 25×34 mu)». The pollen grains of this genus are different from any of the others in this family, except those of *Heisteria cauliflora*, which appears not to fit there either. ERDTMAN remarks in this regard «*Chaunochiton* has pollen grains of a more or less unique type and should probably not be included in *Heisterieae* (cf. also FAGERLIND 1948)».

Tribe 3. *Anacoloseae*. ERDTMAN states that the «*Anacoloseae* is palynologically heterogeneous: the grains in *Anacolosa* and *Cathedra* are distinctly different from those of *Scorodocarpus*, *Strombosia* and *Strombosiopsis*.

6. *Cathedra* Miers. The pollen grains of four species (out of five) were studied. In *C. oblonga* the grains vary in size from 18.0 to 19.0 mu. They are triangular in polar view, with three pores on each surface, i. e. the upper and lower (anacolosoid); in equatorial view, broadly flattened ellipsoidally with four of the pores visible. The exine is smooth at magnifications up to ×1200. The grains of this species are similar to those of *Anacolosa*. The pollen of *C. rubricaulis* (fig. 137) are also similar to those of *Anacolosa;* «equatorial diameter, 18.5 mu», ERDTMAN. The slide of pollen of *C. acuminata* was thought to be contaminated, since the grains were so different from those of the other species. ERDTMAN also studied *C. crassifolia* (Brazil), «suboblate (13.5×18 mu)».

7. *Anacolosa* Blume. Of the 13 species of the genus the pollen of four have been studied. The structure of the pollen grains, designated as anacolosoid, is similar to that of *Cathedra oblonga*. They are triangular in polar view, with three pores on the upper and lower surfaces; in equatorial view, flattened ellipsoidally with at least four of the pores visible. The exine is smooth at magnifications up to × 1200. In *A. glochidiiformis* (figs. 126-129) the grains vary in size from 24 to 26 mu; in *A. luzoniensis*, from 29 to 32 mu (figs. 124-125). ERDTMAN: «*A. lutea* Fiji, in polar view rounded-triangular, oblate (14.5 × 23 mu), exine thinner at the angles than along the sides; sexine (outer exine) as thick as nexine (inner exine) or slightly thinner; reticulate». Also ERDTMAN: «*A. griffithii* (Tenasserim and Andamans), pores of each face closer to poles than in *A. lutea*».

8. *Strombosia* Blume. Five of the 15 species have been studied. The grains are tricolpate, with the oblong to obovoid pores apically situated. The outer exine is variously pitted, from very fine to quite distinct, at a magnification of × 1200. The thin outer exine forms the outer furrow about each pore, the furrows meeting at their apices, thus dividing the outer surface up into three main regions between the long furrows. Then the thicker inner exine, which may also be finely pitted, forms the usual type of short tapering furrow about each pore. The grains are bluntly triangular in polar view and rounded, ovoid in equatorial view. *Strombosia rotundifolia* King, Malacca, 18.5 mu (figs. 118--120); *Str. javanica* Blume, India, 19 5 to 21 mu; *Str. pustulata* Oliv., Africa, 20.0 to 21.5 mu (figs. 116-117); *Str. minor* Engl., Cameroon, 20.0 mu (fig. 123).

In *Strombosia (Lavallea) philippinensis* (Baill.) Rolfe (figs. 121--122) the outer intine forms an additional furrow inside the one formed by the inner exine. The inner intine covers the pore. The outer intine is not pitted. The pollen grains vary from 24 to 25 mu in size.

9. *Lavalleopsis* Van Tiegh. The pollen grains of *L. densivenia* (figs. 114-115) average about 20 mu in diameter. They are tricolpate, with a smooth exine at magnifications up to × 1200. No additional furrows are present, except the irregular outline of the elliptical pore. In polar view the grains are triangular; in equatorial view they are ellipsoidal. In *Strombosia* this species becomes *Str. grandifolia* Hook. f. ERDTMAN states: «*L. densivenia* (Cameroon): strombosioid, oblate spheroidal (17.5 × 19.5 mu)». Then for *Strombosia grandifolia* (Cameroon), the only species studied by ERDTMAN for this genus, he states, «3-colpate, flattened (equatorial diameter about 17.5 mu), tenui-exinous».

Since these two names are synonymous, no species of *Strombosia* were studied by ERDTMAN, and his statements for *Strombosia* refer to *Lavalleopsis*.

10. *Strombosiopsis* Engl. In *Str. tetrandra* Engl., the pollen grains are tricolpate, with oblong to ovoid pores apically situated. The outer exine is variously pitted (figs. 112-113). The furrows about the pores meet at their apices, much as they do in *Strombosia*. The grains are bluntly triangular in polar view and broad ovoid in equatorial view. The grains average about 20 mu in diameter (ERDTMAN: equatorial diameter about 13 mu).

11. *Scorodocarpus* Becc. In *Sc. borneensis* (Baill.) Becc. from the East Indies the pollen grains (figs. 130-131) are triangular in polar view and broadly rounded ellipsoidal in equatorial view. They are tricolpate, with short tapering furrows. The exine is punctate, the punctations being larger and closer together away from the pores and furrows. The grains vary from 38 to 41 mu in size. ERDTMAN: suboblate (19.5×25 mu).

The pollens of the genera *Tetrastylidium, Worcesterianthus* and *Brachynema* (which might belong in the *Ebenaceae*) have not been studied.

Tribe 4. *Ximenieae*.

12. *Ximenia* Linn. Five of the ten species have been studied. The pollen grains are triangular in polar view and rounded ellipsoidally in equatorial view. They are tricolpate with a short, narrow, tapering furrow. The pores are elliptical. The exine possesses small granular patches over the entire surface, or in some species (as *X. caffra*) only in the middle region between the pores. *Ximenia americana* L., World tropics, 18 to 19 mu (figs. 132-133), ERDTMAN: Eritrea and Florida, equatorial diameter about 15 mu); *X. coriacea* Engl., South America, 16.3 mu; *X. caffra* Sonder, Africa, 21.5 to 23 mu (figs. 134-136); *X. parviflora* Benth., Mexico, 22 to 23 mu; *X. pubescens* Standl., Mexico, 20 mu.

### *Olacaceae:* subfamily *Olacoideae*

Tribe 5. *Olaceae*. ERDTMAN refers to the pollen grains of this tribe as being proteaceoid.

13. *Ptychopetalum* Benth. Four of the species in this genus were studied. In *Pt. uncinatum* Anselmino from Brazil the pollen grains (figs. 138-139) vary from 34 to 36 mu in size. The grains are rounded-trian-

gular in polar view and broadly ellipsoidal in equatorial view. They are tricolpate, with uniform conspicuous pitting over the entire surface. The exine is broken in such a way as to form three pores, hence no definite furrows are present. Occasional oil droplets are present over the surface of the grain. The pollen of *Pt. anceps* is very similar to that of *Pt. uncinatum*. ERDTMAN: «*Pt. uncinatum*, tricolpate, equatorial diameter about 27 mu. Sexine as thick as nexine or slightly thinner, reticulate; grains very proteaceoid.» For *Pt. olacoides* (Brazil) ERDTMAN states: «tri-aperturate (apertures circular or slightly lolongate (longitudinally elongated), suboblate (21.5×26 mu)». In *Pt. petiolatum* (Cameroon). ERDTMAN states: «anacolosoid, 6 (-8)-forate, oblate (16×22.5 mu)», This seems to be an aberrant species in the genus.

14. *Curupira* Black. The pollen grains of *C. tefeensis* (fig. 143) are tricolpate, with rounded pores and very slight furrows about the pores. The exine is faintly, at a magnification of ×1200, pitted in small patches. The grains are bluntly triangular in polar view, as shown in the drawing. They vary from 24 to 26 mu in diameter. In general, they are similar to the pollens of *Ptychopetalum* and *Olax*.

15. *Olax* Linn. Eighteen species of the 45 known in this genus have been studied. In general the pollen grains of this genus are tricolpate, with round pores and no distinct furrows, designated as olacoid. The exine possesses fine patchy granulations over the surface, at a magnification of ×1200. At lower magnifications the grains appear to be smooth. In polar view the grains are rounded to sharply triangular in shape; in equatorial view they vary from broadly to narrowly ellipsoidal, hence oblate to peroblate.

The genus *Olax* was divided into four sections by ENGLER, based upon the number of stamens and staminodes. On the basis of this and other floral characters, the species may be arranged in the following manner.

A. *Pentandrae* Engl. 5-6 stamens and 3 staminodes. West Africa. Two of the eleven species have been studied. In *O. dissitiflora* Oliv. (figs. 172-173) the grains vary from 34 to 36 mu in size; in *O. subscorpioidea* Oliv., from 18 to 19 mu (figs. 184-187).

B. *Hemiandrae* Engl. Represented by a single species from Madagascar, *O. madagascariensis* Pet.-Thou. (*Pseudaleia* Pet.-Thou.), the pollen of which has not been studied.

C. *Triandrae* Engl. There are several subsections of this section.

a. 3 stamens and 5 staminodes with racemose flower clusters. *O. scandens* Roxb., East Indies, 17 to 18 mu; *O. acuminata*

Wall. India. 18 to 19 mu (figs. 176-178); *O. zeylanica* L. Ceylon. 29 to 30.0 mu (figs. 168-171); *O. imbricata* Roxb. East Indies. 24 to 25.5 mu (figs. 182-183).

b. 3 stamens and 5 staminodes with single flowers.
*O. nana* Wall. Western Himalaya. 19 to 20 mu (figs. 179--181); *O. phyllanthi* R. Br. Australia. 27 to 28.5 mu; *O. benthamiana* Miq. Australia. 44 to 45.5 mu (figs. 159-161), ERDTMAN: peroblate, sexine thicker than nexine, 20×43 mu; *O. stricta* R. Br. Australia. 45 to 46 mu (figs. 153-156), ERDTMAN: occasionally tetraporate (aptandroid), oblate (24×43 mu); sexine as thick as nexine or slightly thinner; *O. retusa* F. Muell. Australia. 44 mu (figs. 157-158), ERDTMAN: peroblate, 17×40 mu.

c. 5 free, nearly undivided staminodes. West Africa.
*O. macrocalyx* Engl. 22 to 23 mu, (ERDTMAN, oblate, 16×23 mu); *O. viridis* Oliv. 25 to 26.5 mu (figs. 164-165); *O. mannii* Oliv. 24 mu.

d. 5 cleft staminodes. South Africa and Madagascar, Congo.
*O. andronensis* Baker. 27.5 mu (figs. 162-163).

Other pollen grains of species of *Olax* which have been studied, but which have not been placed in the above groupings are: *Olax kerstingii* Engl. (probably belongs in *O. subscorpioidea*), 19.5 to 21 mu (figs. 188-190); *O. obtusa* Blume, 29.5 to 31 mu (figs. 166-167, 174--175); and *O. linderi*, 14.5 to 15.5 mu. (This is an aberrant species in wood anatomy also).

D. *Estaminodiales* Engl. (*Pseudoleioides* Pet.-Thou.). Three species of *Olax* belong here, but the pollen of none of them have been studied. One is known from Madagascar and two from West Africa.

16. *Liriosma* Poepp. et Engl. Six of the 15 known species have been studied. All are rounded triangular in polar view. They are tricolpate, with a rounded «furrow» about the pore. The exine possesses scattered granular patches over the otherwise smooth surface (at ×1200). The grains are broadly ellipsoidal in equatorial view. All species are South American in distribution. *L. spruceana* Engl. 29 to 31 mu; *L. gracilis* A. C. Smith, Peru. 27 to 28 mu (ERDTMAN: equatorial diameter 26 mu); *L. macrophylla* Benth. 32 to 33 mu; *L. adhaerens* Spruce, Peru, 32 to 33.5 mu (figs. 140-143), (ERDTMAN: peroblate-oblate, about 13×26 mu); *L. pallida* Miers (like *L. adhaerens*); *L. acuta* Miers, Brazil (ERDTMAN: oblate, 16×28 mu, olacoid).

Tribe 6. *Aptandreae.*

17. *Aptandra* Miers. In *A. spruceana* Miers from the Amazon region the pollen (figs. 144-147) are pentcolpate, tetracolpate and more rarely tricolpate, with rounded pores delimited by the irregular edges of the exine, there being no furrows in addition to the pores; this type of pollen being designated as aptandroid. The exine, at a magnification of ×1200, shows very small granular patches made up of a few granules. In equatorial view the grains are flattened ellipsoidally. The grains average 14.7 mu in size. ERDTMAN writes about this species: « *A. spruceana*, Peru, tri- to tetracolpate, equatorial diameter about 14 mu. *A. liriosmoides*, Brazil, tetra- to pentacolpate, oblate, about 9×14 mu, with more or less deeply concave sides. » *A. spruceana* along with two other species represents the subgenus *Euaptandra* Engl., all of which live in the Amazon region. There is one other species from West Africa, *A. zenkeri* Engl., the pollen grains of which have not been studied. This species was once in *Harmandia (H. congoensis)*, but now represents the subgenus *Aptandrina* Engl. in *Aptandra.*

18. *Ongokea* Pierre. In *O. gore* (Hua) Engl. the pollen grains (figs. 148-152) are tetracolpate or less often tricolpate, with rounded pores. The exine is more definitely pitted at a magnification of ×1200 than in *Aptandra.* A very short tapering furrow is formed by the exine, and the outer intine (or inner exine) breaks irregularly into an ovate or rounded furrow about the pore. The grains vary from 12.5 to 13.5 mu in size. ERDTMAN: *O. kamerunensis*, aptandroid, subisopolar, tetracolpate, oblate, longest equatorial diameter 13.5 mu; side deeply concave. Both of the species of this genus are from the Cameroon region in West Africa.

19. *Harmandia* Pierre. One of the two species in this genus has been studied by ERDTMAN. In *H. mekongensis*, the grains are more or less aptandroid, tri-, but usually, tetracolpate, oblate with the longest equatorial diameter about 28 mu.

***Olacaceae:* subfamily *Schoepfioideae***

Tribe 7. *Schoepfieae.*

20. *Schoepfia* Schreb. The pollen of 14 of the 35 known species have been studied. They are tricolpate, with furrows which meet on one side at a large window, but do not extend beyond the pore on the other side. Concerning this condition, ERDTMAN explains it thus for *Sch. arborescens:* « probably tetrahedral, with four more or less circular apertures

at the apices and six rugoid interapertural streaks». The exine is finely pitted uniformly. The inner exine or intine is often exposed in the furrows and around the pores.

Three subgenera are recognized in this genus, and the species for which pollen grains have been studied are given below.

A. *Codonium* (Vahl) Engl. Tropical America.
*Sch. arborescens* from Florida, studied by ERDTMAN, main axis measures 18.5 mu, the characters for the grains are given above; *Sch. californica* Brandegee. Mexico-California. 29 to 30 mu; *Sch. angulata* Planch. Mexico. 24.5 to 25.5 mu (figs. 195--196); *Sch. pringlei* Robins. Mexico. 28 to 29.5 mu; *Sch. schreberi* Gmel. Peru. 27 to 28.5 mu; *Sch. chrysophylloides* Planch. West Indies. 28 to 31 mu (ERDTMAM: Florida. aperatures similar to *Sch. arborescens*, main axis about 20 mu); *Sch. obovata* Wright. Cuba. 22 to 24 mu; ERDTMAN *Sch. obovata* (Haiti) and *Sch. haitiensis* (Haiti) are 4-aperaturate, main axis about 18 mu; *Sch. flexuosa* Roem. et Schult. Peru. (fig. 191); *Sch. parvifolia* Planch. Mexico.

B. *Euschoepfia* Engl. Tropical Asia. *Sch. fragans* Wall. 48 to 51 mu (fig. 197). ERDTMAN: Grains of this species of two sizes, small (main axes about 22.5 mu, similar to those of *Sch. arborescens* and *Sch. chrysophylloides*) and medium (main axes about 33 mu, often more or less irregular, triangular, or square and provided with 5-6 three-slit, tenuimarginate aperatures).

C. *Schoepfiopsis* (Miers) Engl. South Asia. *Sch. jasminodora* Sieb. et Zucc. China, Japan. 32 to 33 mu; *Sch. chinensis* Gard. et Champ. China. 27 to 28 mu.

ERDTMAN verifies the statement made earlier by the author that some of the pollens of the *Olacaceae* resemble those found in the *Santalaceae*. He cites the *Schoepfioideae* as having such similar pollen grains, and compares *Sch. fragrans* (representative of the subgenus *Euschoepfia*) which has two types of grains, indicating possible heterostyly, with *Arjona* of the *Santalaceae*.

***Opiliaceae*: Tribe 1. *Aveledoeae***

1. *Metteniusa* Karsten. In *M. nucifera* the pollen is tricolpate with large rectangular pores, across which pass elongated furrows (figs. 215--219). The surface of the exine is deeply and rather evenly pitted. The

grains are sub-triangular in polar view and broadly elliptical in equatorial view. The pollen of this genus is quite different from that of any other genus in this family or *Olacaceae*. *M. nucifera*. South America. 50 to 54 mu in diameter.

***Opiliaceae*: Tribe 2. *Opilieae***

2. *Lepionurus* Blume. The pollens of two species of this genus have been studied. They are tricolpate in polar view and ovoid to elliptically rounded in equatorial view with the pore and its furrow plainly in view (figs. 199 and 202). The entire surface of the grain shows a reticulate pattern. The pores are elliptical, showing through the elongated furrow, which extend beyond the pore, but do not quite meet the other furrows on either surface. *L. silvestris* Blume. 17.5 mu (figs. 198-199); *L. munifolia*. 17.5 mu (figs. 200-202).

3. *Cansjera* Juss. *C. rheedii* Gmel., from French Indo-China, tricolpate, suboblate (21×24 mu), sexine probably as thick as the nexine, ERDTMAN.

4. *Champereia* Griff. In *Ch. manillana* (Blume) Merr., the pollen grains are tricolpate, with rounded pores, with broadly elliptical furrows which taper abruptly either side of the pore. The surface of the grain is coarsely pitted (figs. 208-210). *Ch. manillana* (Blume) Merr. Asiatic tropics. 14 mu; *Ch. cummingiana* (Baill.) Merr. Philippine Isl. 15.5 mu (= *Ch. manillana*).

5. *Opilia* Roxb. The pollen of four species of this genus have been studied. They are tricolpate, with irregularly margined pores. The furrows are elliptical, tapering abruptly either way from the pore, (figs. 205 and 207). The grains vary from round to nearly triangular in polar view, and broadly elliptical in equatorial view. The surface in *O. fragrans* is moderately reticulate over the surface, similar to some species of *Lepionurus*. In *O. amentacea* Roxb. the grains are nearly smooth at a magnification of ×1200 (figs. 206-207). *O. fragrans* Elmer. Palawan. 15.5 mu (figs. 203-205); *O. amentacea* Roxb. Celebes. 15 to 18 mu (ERDTMAN: angulaperturate, suboblate, 11×13 mu); *O. celtidifolia* (Guill. et Perr.) Endl. Kenya. 18 mu (ERDTMAN: oblate, spheroidal, 13×14 mu); *O. tomentella* (Oliv.) Engl. Portugese East Africa. (ERDTMAN: angulaperturate, suboblate, 13×16 mu, sexine slightly thinner than nexine, reticulate pattern).

6. *Urobotrya* Stapf. The species of this genus have been separated from *Opilia*. ERDTMAN studied one species. In *U. afzelii* (Engl.) from the Cameroons, the grains are suboblate, about 11.5×14 mu. The sexine

is as thick as the nexine, or slightly thinner, with a minute pattern on the surface.

7. *Rhopalopilia* Pierre. Two species of this genus have been studied. In *Rh. soyauxii* from the Congo the pollen grains are tricolpate, with irregularly margined pores, similar to those in *Opilia*. The furrows are elliptical, tapering gradually either from the pore. The grains are nearly round in polar view and are broadly elliptical in equatorial view. The surface is nearly smooth at high magnifications. About 18 mu in diameter, in polar view. ERDTMAN studied *Rh. umbellulata* (Baill.) Engl., Kenya: usually suboblate, about 13×16.5 mu.

The pollen of *Melientha* Pierre, Tropical East Indies, has not been studied.

***Opiliaceae*: Tribe 3. *Agonandreae***

8. *Agonandra* Miers. Seven species of this genus have been studied. They are tricolpate, with irregularly margined pores (figs. 211 and 213) similar to those found in *Opilia*. The broad elliptical furrows extend from nearly to the poles to about half way to the poles, and taper abruptly at the ends. The grains are nearly rounded in polar view, and broadly elliptical in equatorial view. The surface has patches of granular material in the exine which are somewhat raised (fig. 214). *A. brasiliensis* Miers. Tropical South America. 18.5 mu (figs. 211-212); *A. excelsa* Griseb. Argentina. 22.5 mu (figs. 213-214); *A. racemosa* (DC.) Standl. Mexico. 20.0 mu (ERDTMAN: Mexico, suboblate-subprolate, diameter about 20 mu, tenui-exinous, coarse exine pattern); *A. granadensis* Rusby. Colombia. 17.5 mu; *A. benthamiana*. 20.0 mu; *A. obtusifolia* Standl. Mexico. 18.5 mu; *A. silvatica* Ducke. Brazil. 19.5 mu.

The pollen of the genus *Gjellerupia* Lauterbach from New Guinea has not been studied.

OCTOKNEMACEAE

1. *Octoknema* Pierre. The pollen grains are tricolpate, with irregularly margined pores, without furrows. The entire surface is pitted similar to that of *Champereia manillana* (figs. 218-220). The grains are sub-triangular in polar view and very broadly elliptical in equatorial view. *O. borealis* Hutchinson et Dalziel, from Liberia. 12.5 mu in diameter; *O. affinis* Pierre from Gabun. ERDTMAN: suboblate, 15×22.5 mu, sexine as thick as nexine, non-equatorial parts of pores sunk below the general surface of the grain; apertures with granulate membranes; *O. klaineana* Pierre from Gabun, 12.5×22.5 mu.

The genus *Okoubaka* Pellegrin et Normand from the Ivory Coast has not been studied.

## ERYTHROPALACEAE

Because of the inclusion of the genus *Erythropalum* in the *Olacaceae* at one time or another, its structural features will be outlined below. It is interesting to note in passing that two species have been described as fossils in this genus, *E. europaeum* Reid and Chandler and *E. striatum* Reid and Chandler, both from the London Clays of England.

The genus *Erythropalum* was originally described by Blume (Bijdr. 921. 1826) and placed for a long time in the vicinity of the *Olacaceae*, where it was treated on various occasions by Engler (Nat. Pfl.-fam.) from 1872 to 1900. In 1910 Gagnepain (Bull. Soc. Bot. Fr., p. 373) placed it in a family unto itself. In 1931 Lemée (Dict. Desc. et Syn. Genera Pl. Phanerogam., 3: 14) treated it in this family. And finally in 1942 Sleumer again described it as a monotypic family (Nat. Pfl.-fam. 20 B). The family is currently placed in the vicinity of the *Olacaceae*.

*Erythropalum:* Climbing shrubs with alternate leaves, having petioles simple, without stipules, and three main veins. Inflorescences axillary in loosely spreading corymbs, the flowers very small; calyx cup-shaped with 5 segments more or less imbricate to the receptacle, persistent and accrescent; petals 5, free, valvate; stamens 5, opposite the petals and united with each other at the base, the filaments short, the anthers introrse, dehiscing longitudinally by 2 slits; disc superior, indented on the edge; ovary inferior, with one compartment, anatropous; style short, the stigma more or less obscurely trilobed; fruit a drupe, fleshy, bearing at the summit the rest of the perianth and the disc, the stone crustaceous, albumen abundant, the embryo upright or straight, the radicle growing up over it. There are four species in the genus, found in tropical Asia east to the Philippine Islands.

Even though the plants have twining stems there are several primitive features in the vascular structure. The nodes are trilacunar. The rays are Het. I, though slightly modified. The pore distribution is more advanced in being tangential in the transverse sections. The walls of the vessels have porous perforations. The imperforate elements are libriform fibres. Therefore some of the characters of the wood anatomy are relatively primitive, while others are quite advanced. The wood and stem structure of *E. scandens* was studied (figs. 93-94).

In the leaves there are parallelogram crystals along the veins, and

rhombics and druses in the mesophyll, in *E. scandens* and *E. vagum*, similar to those found in the leaves of many genera of the *Olacaceae*.

The pollen grains of *E. scandens* (figs. 221-224) are tricolpate with rounded, slightly irregularly margined pores. The furrows extend briefly beyond the pores. The exine has patches of granular material similar to that found in species of *Agonandra* (figs. 212 and 213), *Strombosia* (fig. 121), *Ximenia* (fig. 132 and 134), *Curupira* (fig. 143), *Liriosma adhaerens* (fig. 140-141) and some species of *Olax*, especially the Australian species fig. 153). However, the patches are not raised as they are in *Agonandra*. The grains are bluntly triangular in polar view and broadly elliptical in equatorial view. *E. scandens* pollen measures about 27.5 mu in diameter. Concerning this species ERDTMAN states, based on specimens from China: « tricolpate, subprolate. 21.5×17 mu. Exine stratification obscure. Pores covered with fairly substantial membranes. Pollen grains in *Erythropalum* differ from those in *Anacolosa* and closely related genera *(Olacaceae).*» Even though the pollens do differ from those of *Anacolosa*, they do show some semblance to those of other *Anacoloseae*, as *Strombosia*, as well as to genera in the tribes *Ximenieae* and *Olaceae* of the *Olacaceae* and to *Agonandra* of the *Opiliaceae*, as mentioned above.

In the wood anatomy *Erythropalum* shares the following features with other genera of the *Olacaceae*: Het. I ray type with *Heisteria*, *Ptychopetalum* and *Olax* (of the *Olaceae*) and *Strombosia* (of the *Anacoloseae*); trilacunar nodes with *Ptychopetalum*, *Liriosma* and *Curupira* of the *Olaceae*, *Ximenia* and the *Couleae* and *Heisterieae;* porous vessel perforations with all the *Olaceae*, except *Curupira*, as well as with the *Anacoloseae* (*Anacolosa*, *Cathedra* and *Chaunochiton*, but not with the other genera of this tribe) and *Aptandreae* (*Aptandra* only); the tangential arrangement of the pores in transverse sections with *Olax*, *Curupira*, *Aptandra*, *Ongokea* and *Schoepfia;* stone cells in the pith with *Heisteria*, many *Anacoloseae (Strombosia*, *Strombosiopsis*, *Lavalleopsis*, *Scorodocarpus* and *Catedra)* and *Ximenia;* absence of the black gummy substance in the pith with some of the *Couleae (Minquartia* and *Ochanostachys)*, some of the *Anacoloseae (Chaunochiton*, *Anacolosa*, *Cathedra*, *Worcesterianthus* and *Tetrastylidium)*, some of the *Olaceae (Olax*, *Liriosma* and *Curupira)*, with *Harmandia* of the *Aptandreae* and with *Schoepfia* of the *Schoepfieae*.

In conclusion there seems to be considerable evidence to the effect that *Erythropalum* belongs in the *Olacaceae*-complex, but whether it should be separated away from the rest of the family still remains to

be determined, since it differs even less than *Schoepfia* from the other genera now considered in the *Olacaceae*. Also when other genera which are now only putative relatives of the *Olacaceae* are definitely placed in that family, some of the apparent gaps may be filled and this genus may find its niche in the *Olacaceae* once again.

* * *

Recently (Dec. 1954), CAVACO described a new genus, *Phanerodiscus*, in the *Olacaceae (Anacoloseae)*, from Madagascar. The new genus, placed between *Anacolosa* and *Cathedra*, possesses the following characteristics: the absence of stipules on the leaves, the ovary superior, the ovules with one integument, the stamens as many as the petals and opposite the petals, the presence of a disc, axillary placentation with pendant ovules, a single ovule in each locule. The flowers are axillary and monoecious. The floral parts are 6-merous: 6 sepals fused in a campanulate calyx; 6 petals free, valvate; 6 stamens opposite the petals, anthers extrorse; disc hypogynous with 6 glands alternating with the petals; ovary superior, free, 2-loculate, a single ovule in each locule. The fruit and seed are unknown.

Except that the plant is a small to medium-sized tree (8-12 m tall), no mention is made of the wood or nodal anatomy; and other than the general structure of the flower, no mention is made of the structure of the pollen.

CAVACO discusses the affinities of the new genus, *Phanerodiscus (perrieri)*, with *Brachynema*, *Strombosiopsis*, *Tetrastylidium*, *Scorodocarpus*, *Cathedra*, *Anacolosa*, *Strombosia* and *Worcesterianthus* of the *Olacaceae*. *Phanerodiscus* approaches *Worcesterianthus* in possessing a 2-loculate ovary with a single pendant ovule in each locule. However, *Worcesterianthus* is dioecious. It compares with *Anacolosa* and *Cathedra* in having the floral parts 6-merous, the ovary superior and the disc situated above the ovary (united in *Anacolosa* and free in *Cathedra*); and with *Strombosia* which has a short tubular calyx with distinct sepals. There are three floral characteristics which are stable for this new genus: the calyx is divided into six sepals, the stamens are opposite the petals and have extrorse anthers, and the ovary is completely 2-loculate with one ovule in each locule.

Until the wood anatomy, the nodal anatomy and the pollen structure have been studied, this genus should be placed in the *Anacoloseae* of the *Olacaceae* between *Anacolosa* and *Cathedra*.

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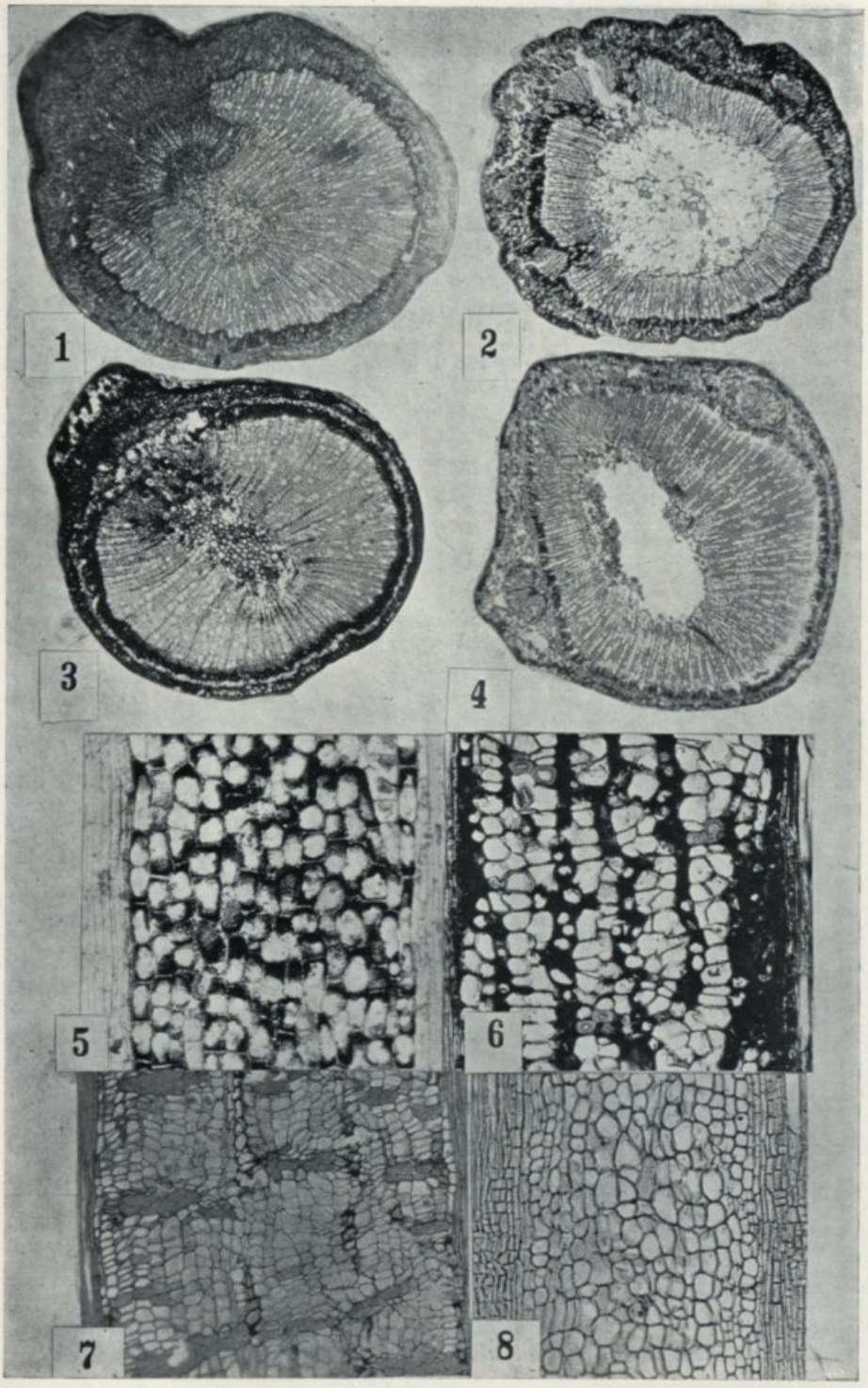
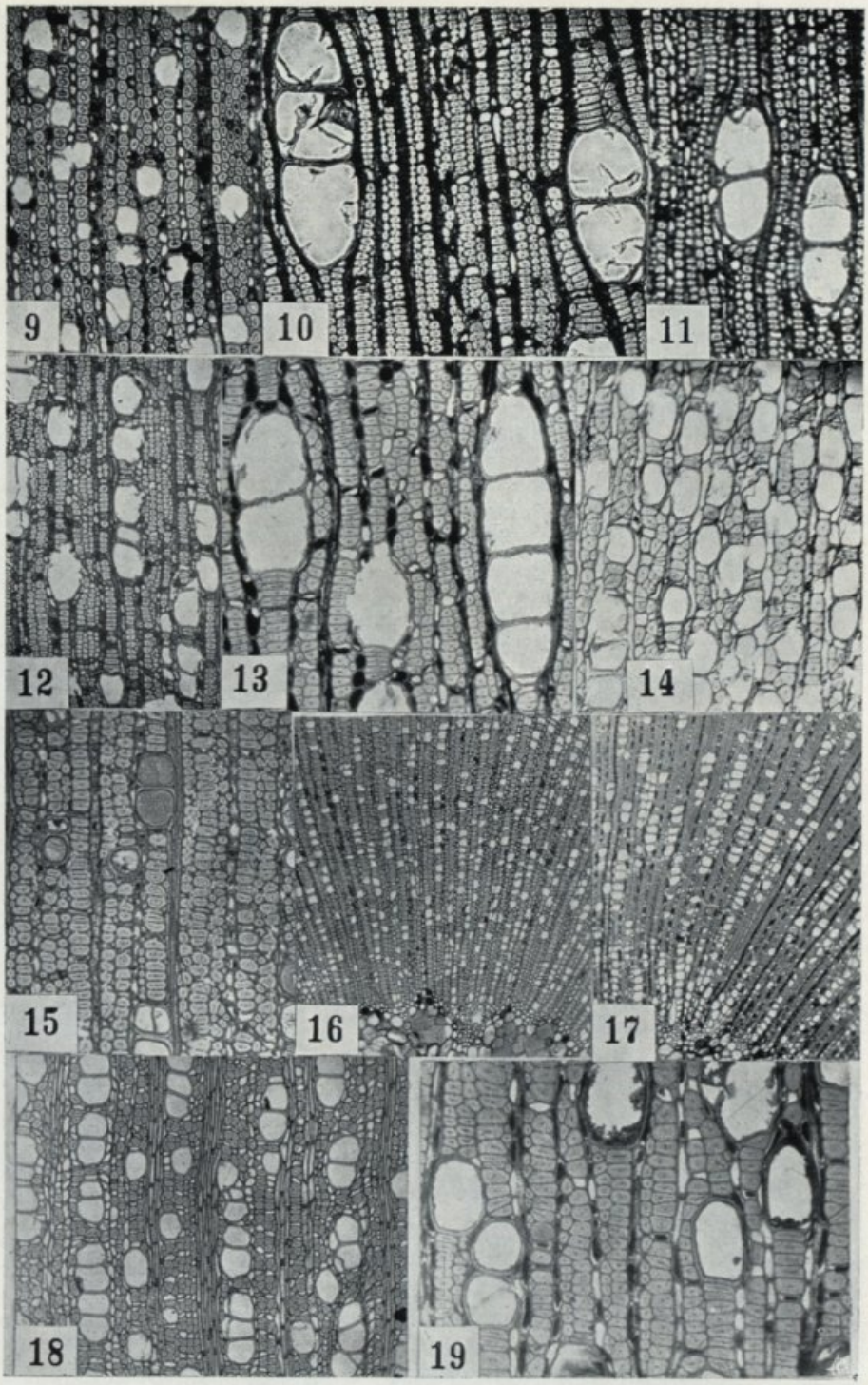
## PLATE I

Fig. 1-4. Transverse sections of twigs at the nodal level. Fig. 1. *Anacolosa lutea;* fig. 2. *Scorodocarpus borneensis;* fig. 3. *Aptandra spruceana;* fig. 4. *Strombosiopsis tetrandra.* Fig. 5-8. Longitudinal sections through the pith of twigs. Fig. 5. *Aptandra liriosmoides;* fig. 6. *Ximenia elliptica;* fig. 7. *Strombosia zeylanica;* fig. 8. *Cathedra acuminata.*

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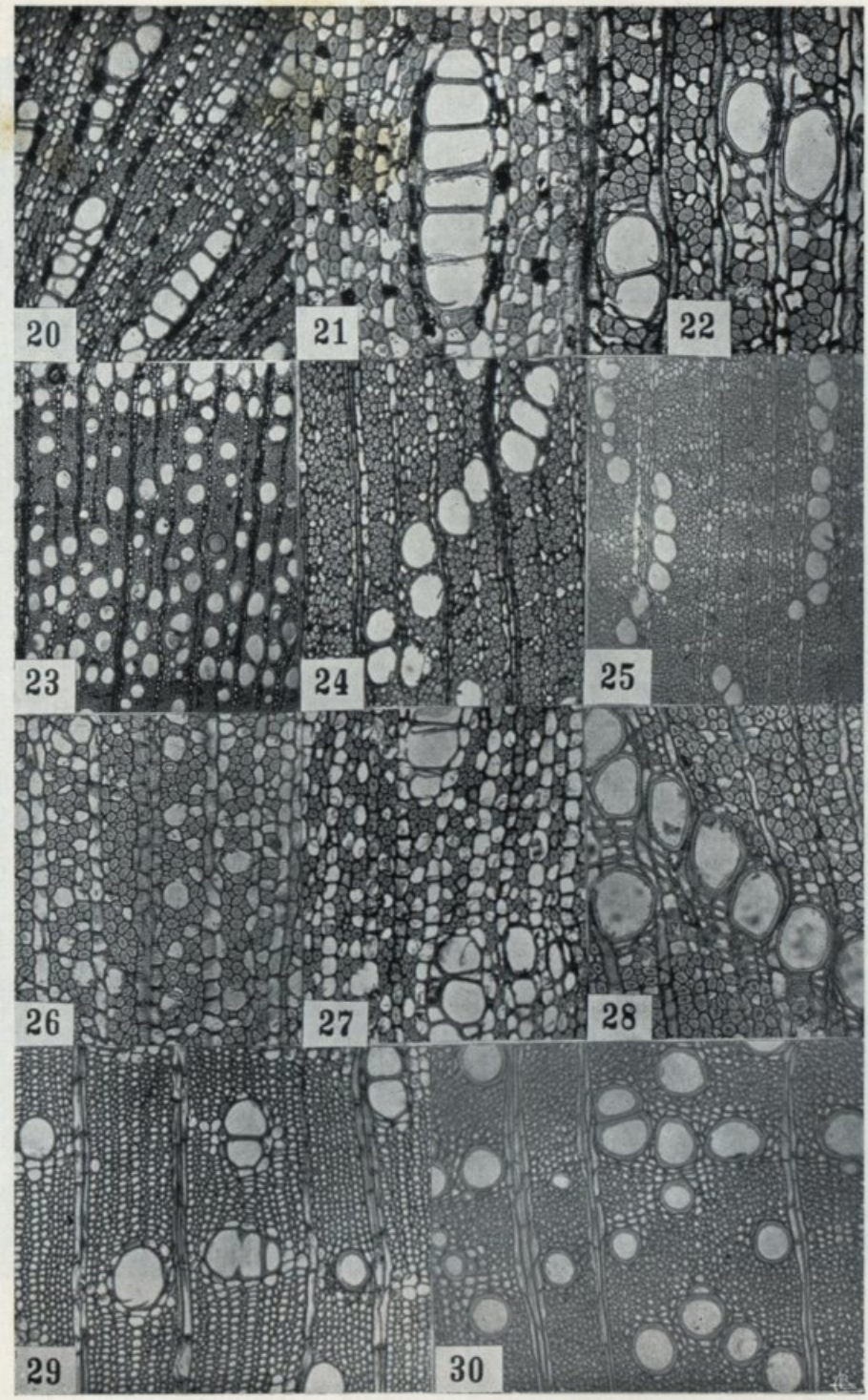
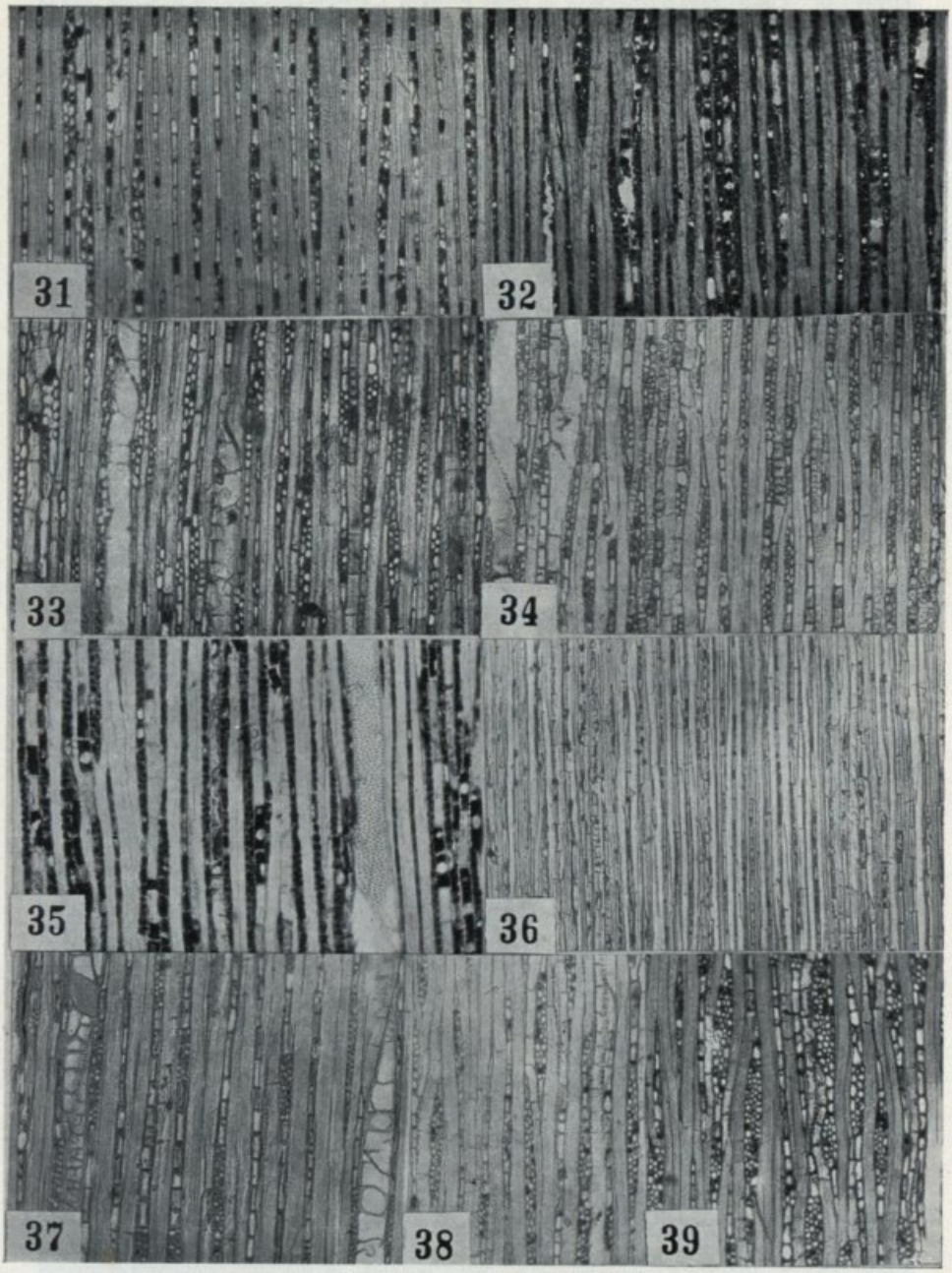
## PLATE II

Fig. 9-19. Transverse sections of mature secondary xylem. Fig. 9. *Heisteria cyanocarpa;* fig. 10. *Coula edulis;* fig. 11. *Minquartia guianensis;* fig. 12. *Endusa punctata;* fig. 13. *Ochanostachys amentacea;* fig. 14. *Strombosia javanica;* fig. 15. *Strombosia pustulata;* fig. 16. *Strombosia zeylanica;* fig. 17. *Strombosiopsis tetrandra;* fig. 18. *Worcesterianthus magallanensis;* fig. 19. *Scorodocarpus borneensis.*

## Plate III

Fig. 20-30. Transverse sections of mature secondary xylem. Fig. 20. *Cathedra rubricaulis;* fig. 21. *Anacolosa arborea;* fig. 22. *Chaunochiton breviflorum;* fig. 23. *Ximenia americana;* fig. 24. *Olax pentandra;* fig. 25. *Olax subscorpioidea;* fig. 26. *Liriosma spruceana,* fig. 27. *Aptandra zenkeri;* fig. 28. *Ongokea klaineana;* fig. 29. *Schoepfia jasminodora;* fig. 30. *Schoepfia schreberi.*

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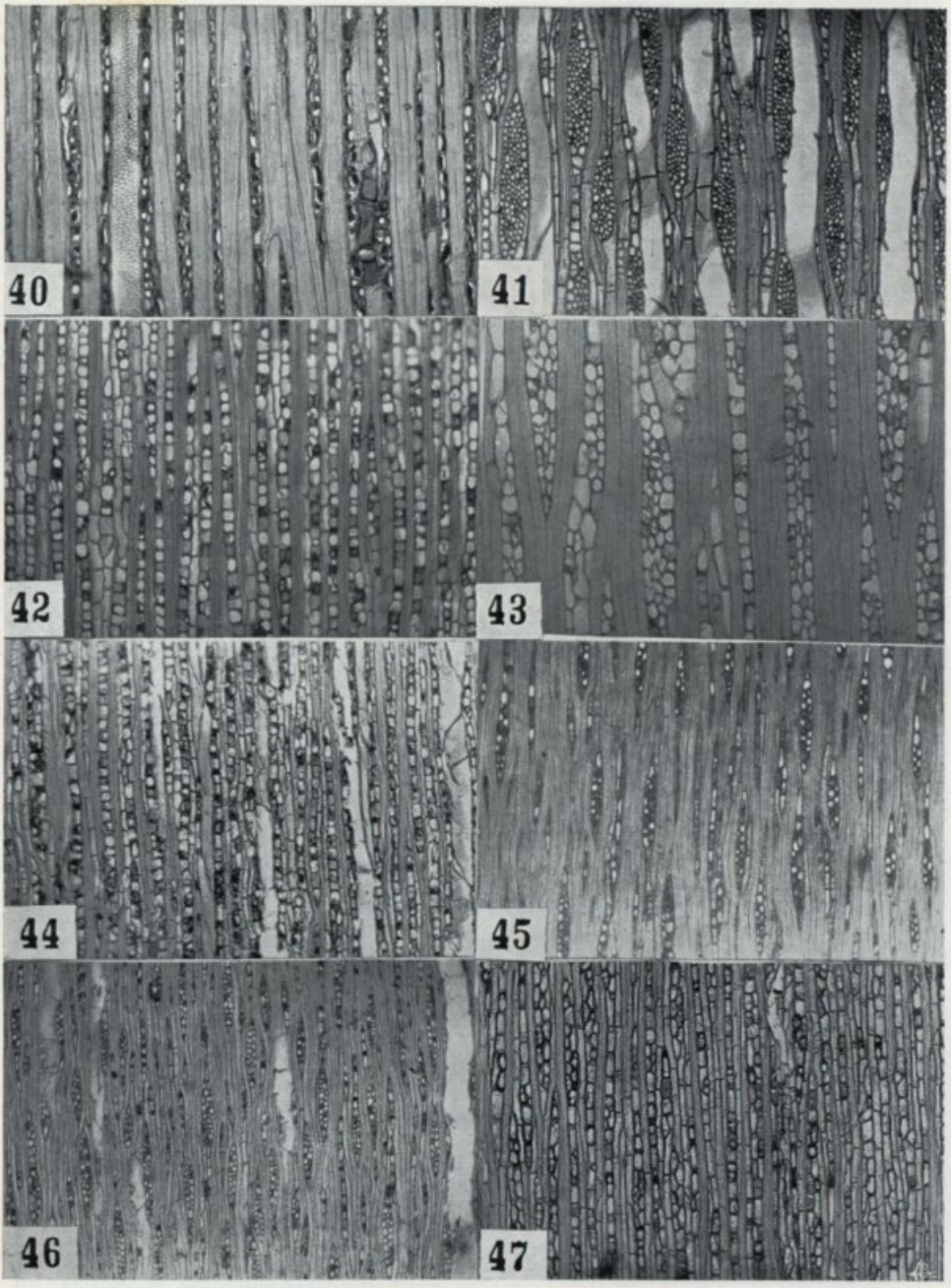
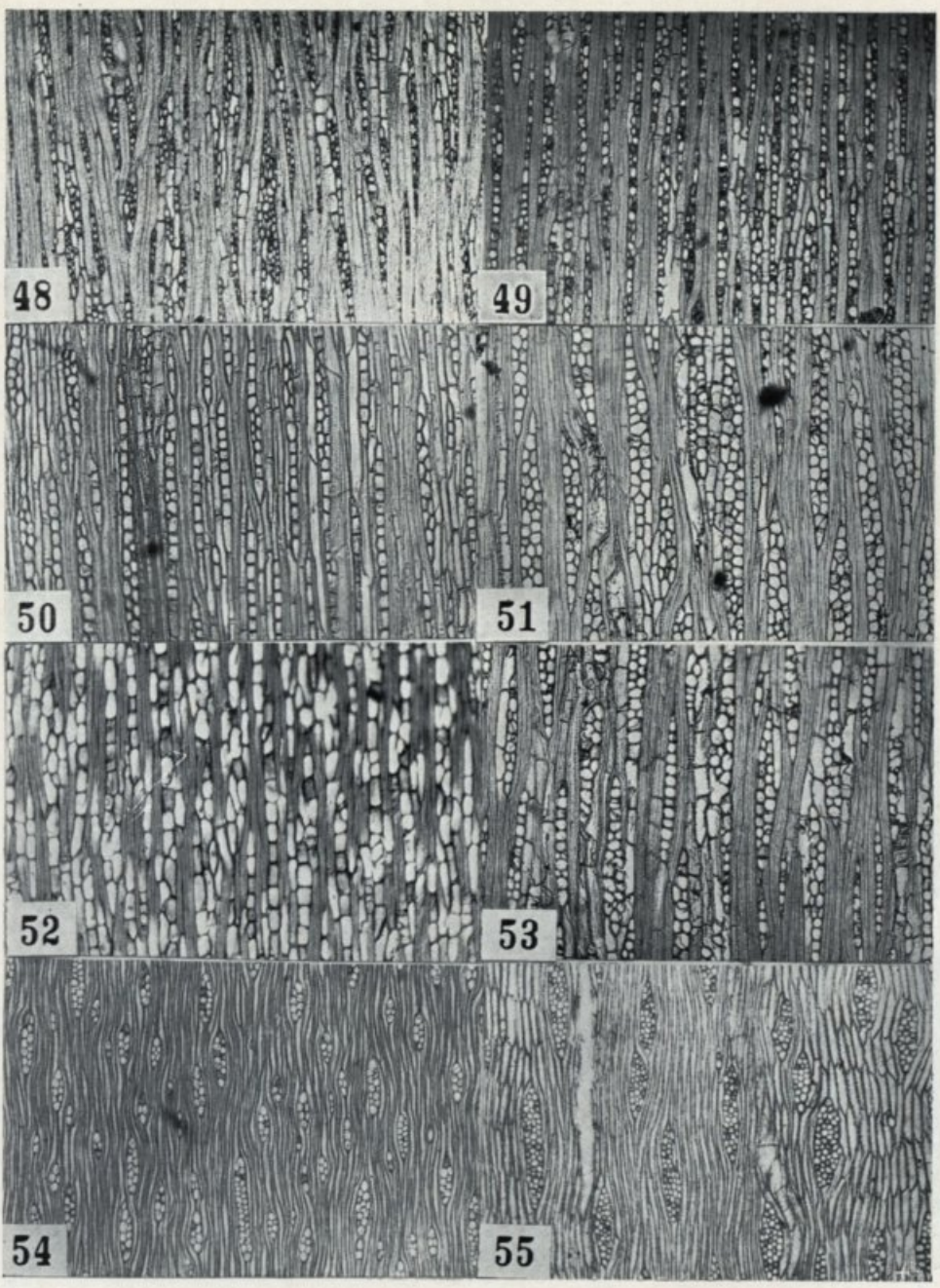
## PLATE IV

Fig. 31-39. Longitudinal sections of mature secondary xylem showing ray structure. Fig. 31. *Heisteria cyanocarpa;* fig. 32. *Coula edulis;* fig. 33. *Minquartia guainensis;* fig. 34. *Endusa punctata;* fig. 35. *Ochanostachys amentacea;* fig. 36. *Lavalleopsis densivenia;* fig. 37. *Strombosia pustulata;* fig. 38. *Strombosia membranacea;* fig. 39. *Strombosia philippinensis.*

## Plate V

Fig. 40-47. Longitudinal sections of mature secondary xylem showing ray structure. Fig. 40. *Scorodocarpus borneensis;* fig. 41. *Worcesterianthus magallanensis;* fig. 42. *Anacolosa arborea;* fig. 43. *Chaunochiton breviflorum;* fig. 44. *Cathedra rubricaulis;* fig. 45. *Ximenia americana;* fig. 46. *Ximenia elliptica;* fig. 47. *Ptychopetalum anceps.*

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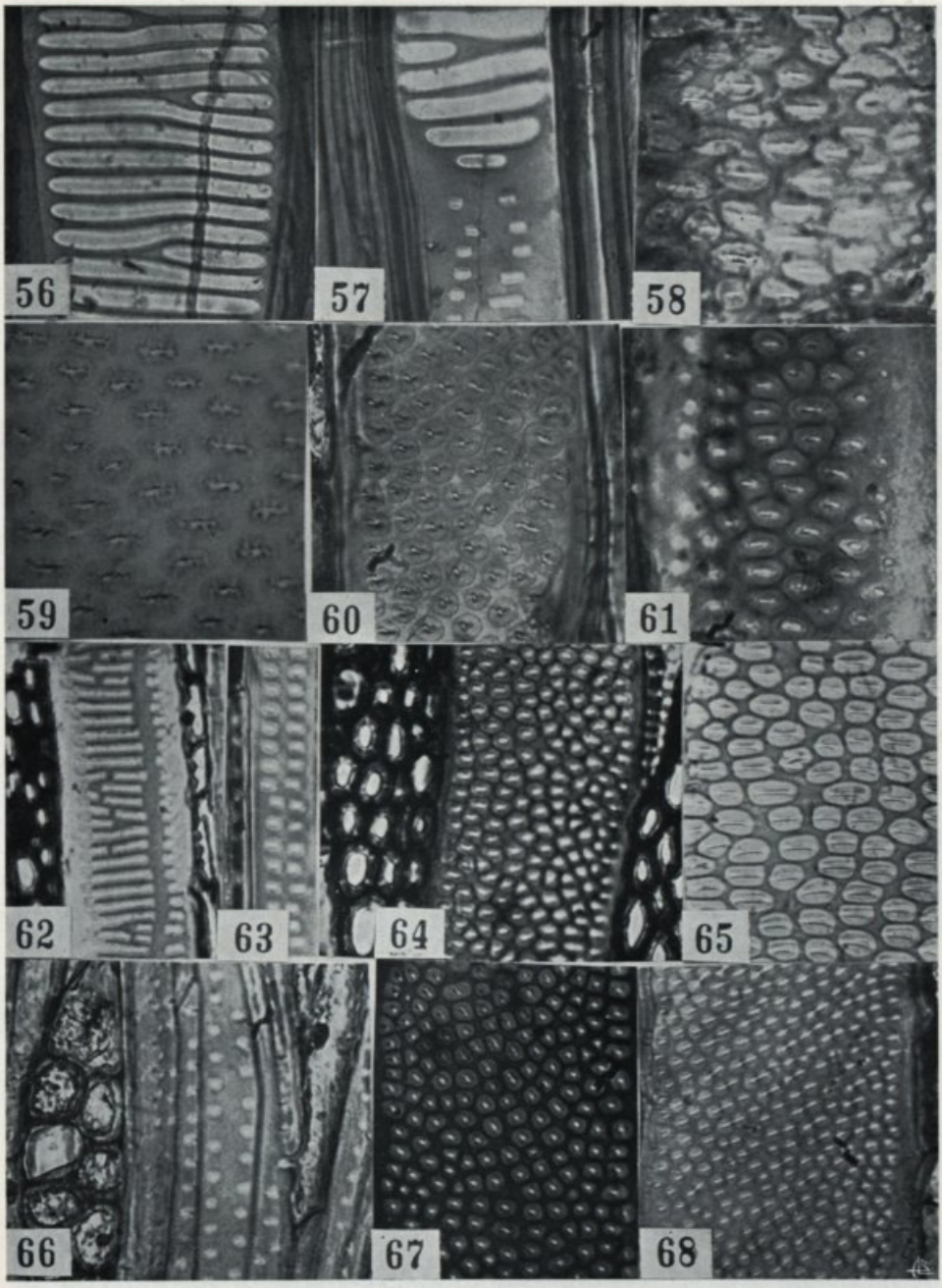
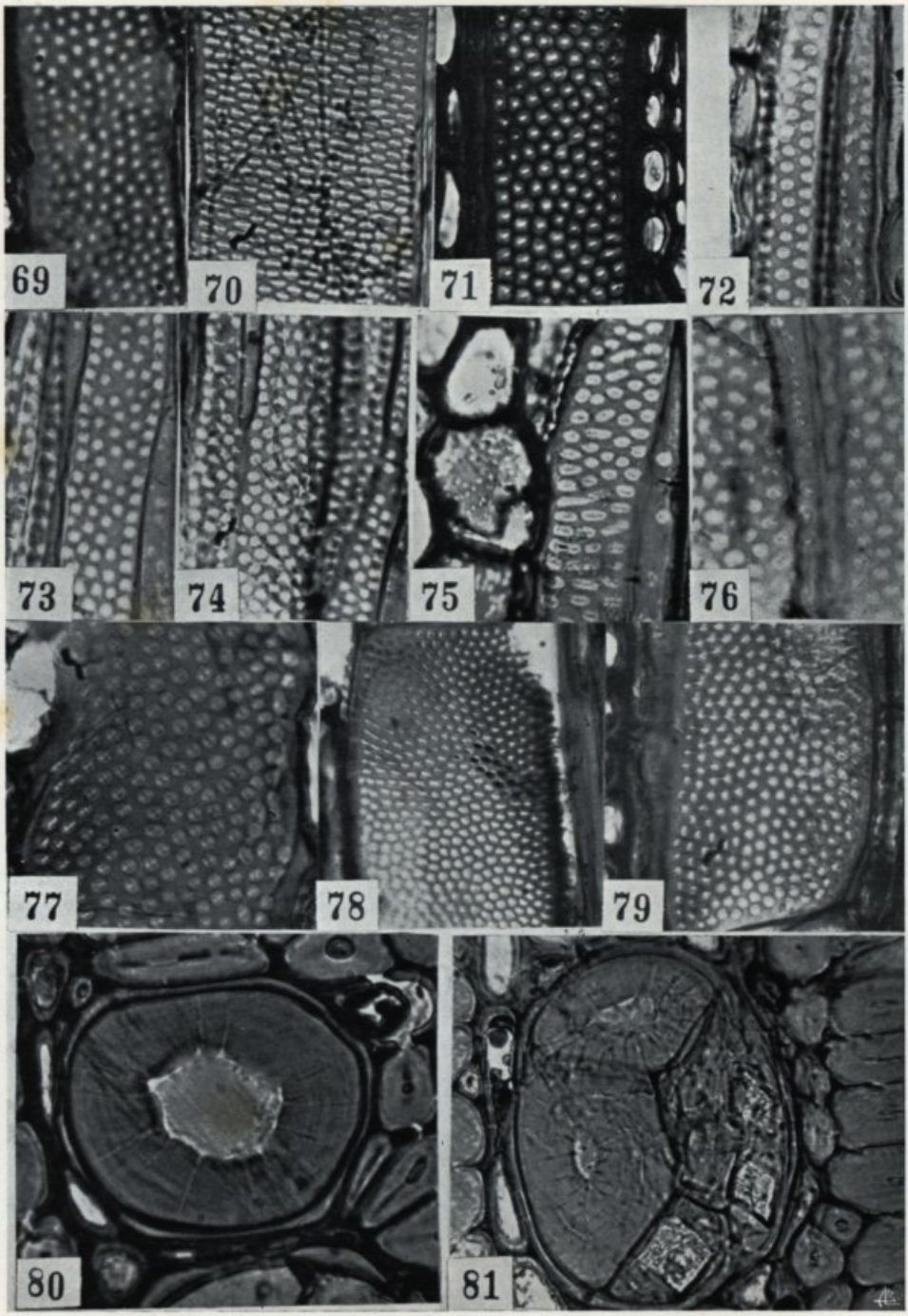
## Plate VI

Fig. 48-55. Longitudinal sections of mature secondary xylem showing ray structure. Fig. 48. *Ptychopetalum olacoides;* fig. 49. *Ptychopetalum uncinatum;* fig. 50. *Olax mannii;* fig. 51. *Liriosma spruceana;* fig. 52. *Aptandra zenkeri;* fig. 53. *Ongokea klaineana;* fig. 54. *Schoepfia schreberi;* fig. 55. *Schoepfia jasminodora.*

## Plate VII

Fig. 56-68. Intervascular pitting of vessels. Fig. 56. *Heisteria cyanocarpa;* fig. 57. *Heisteria cauliflora;* fig. 58. *Coula edulis;* fig. 59. *Ochanostachys amentacea;* fig. 60. *Endusa punctata;* fig. 61. *Minquartia guianensis;* fig. 62. *Strombosia membranacea;* fig. 63. *Lavalleopsis densivenia;* fig 64. *Worcesterianthus magallanensis;* fig. 65. *Scorodocarpus borneensis;* fig. 66. *Ximenia americana;* fig. 67. *Chaunochiton breviflorum;* fig. 68. *Anacolosa arborea.*

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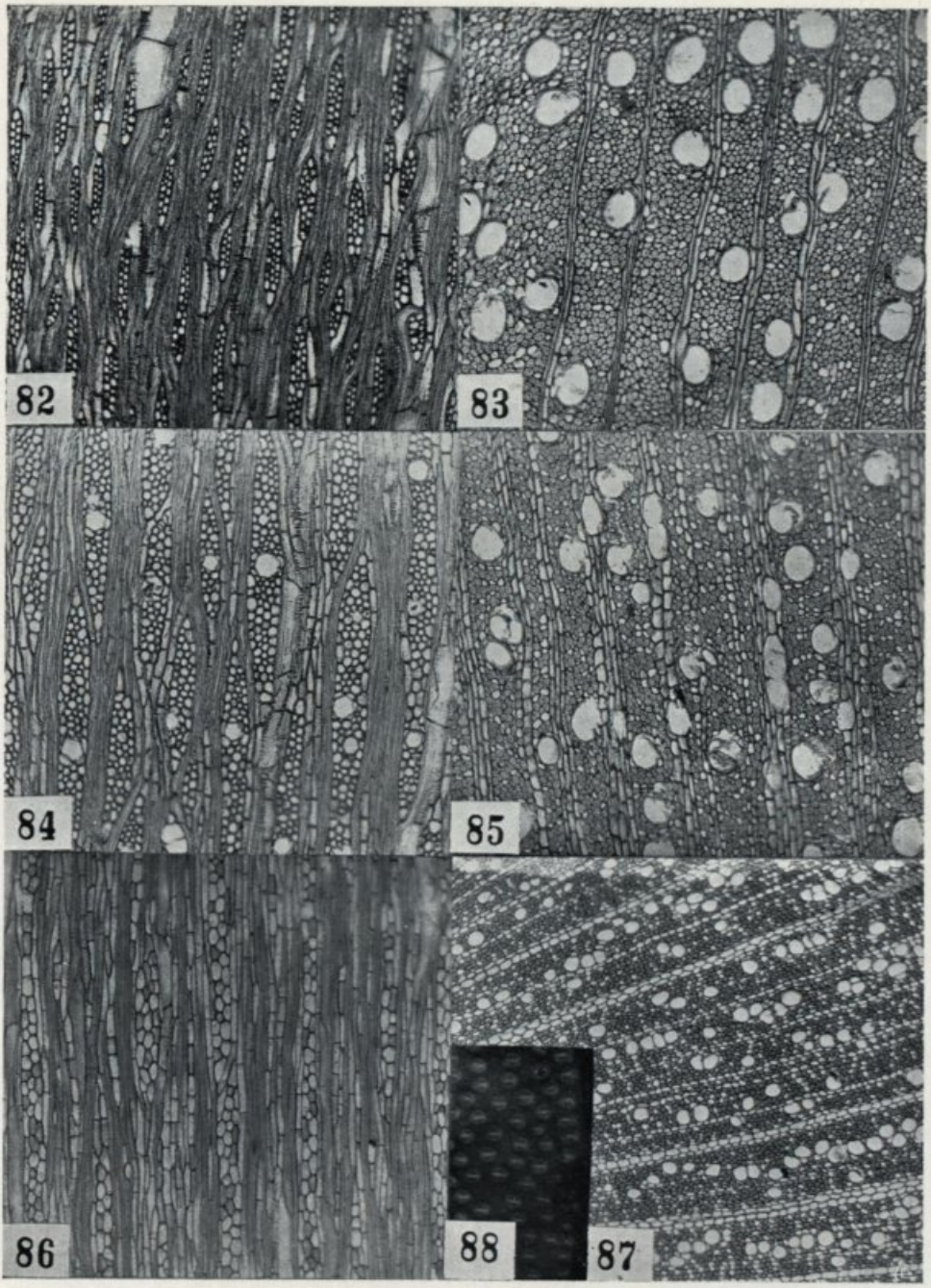
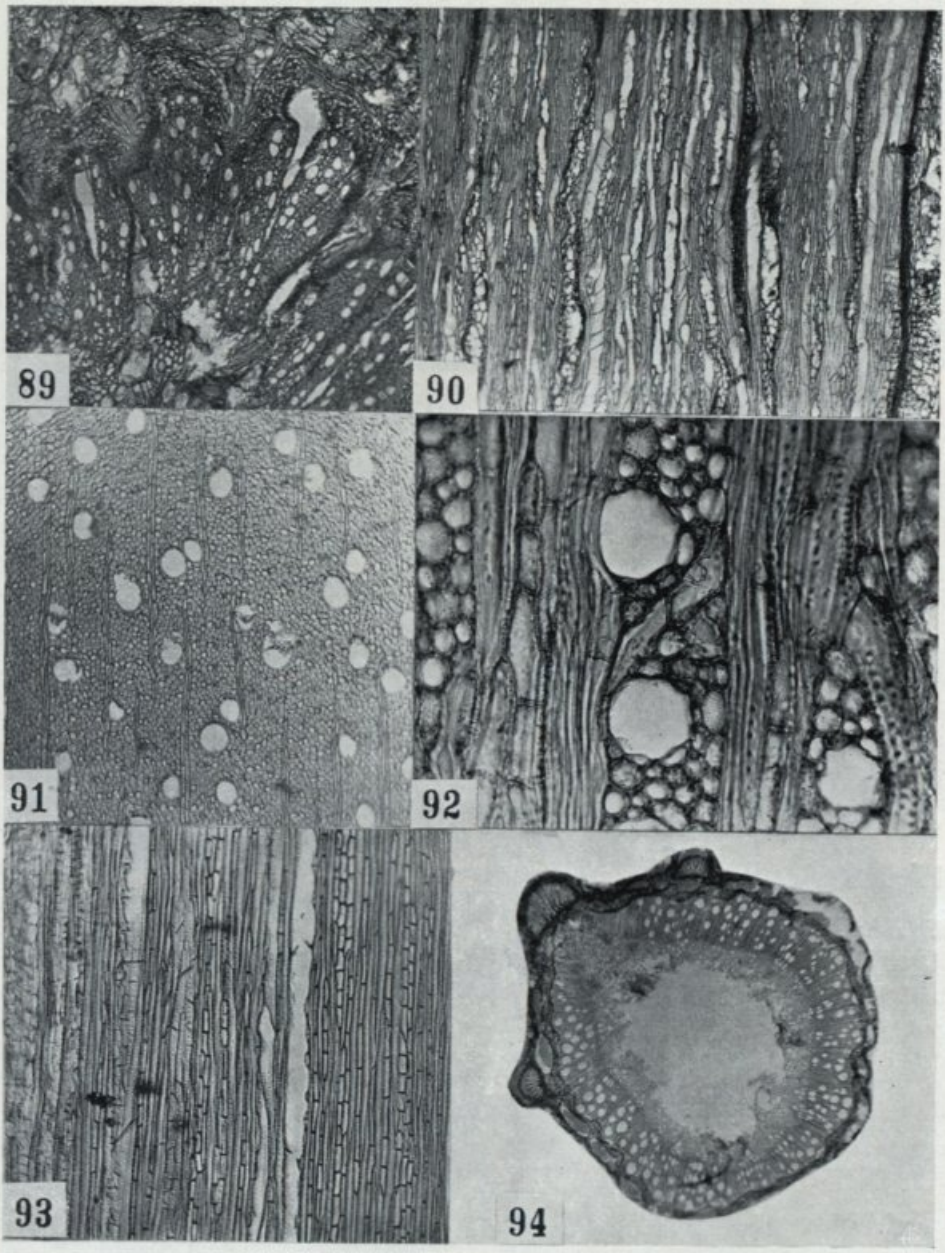
## Plate VIII

Fig. 69-79. Intervascular pitting of vessels. Fig. 69. *Cathedra rubricaulis;* fig. 70. *Ptychopetalum anceps;* fig. 71. *Ptychopetalum olacoides;* fig. 72. *Olax mannii;* fig. 73. *Olax subscorpioidea;* fig. 74. *Olax pentandra;* fig. 75. *Liriosma spruceana;* fig. 76. *Ongokea klaineana;* fig. 77. *Aptandra spruceana;* fig. 78. *Schoepfia schreberi;* fig. 79. *Schoepfia jasminodora;* figs. 80-81. Tyloses seen in transverse sections of vessels of *Strombosia pustulata.*

## Plate IX

*Agonandra brasiliensis*, fig. 82, longitudinal section of mature secondary xylem; fig. 83, transverse section of mature secondary xylem; *Champereia manillana*, fig. 84, l. s. of xylem; fig. 85, t. s. of xylem; *Lepionurus latisquareus*, fig. 86, l. s. of xylem; fig. 87, t. s. of xylem; fig. 88, pitting of vessel wall.

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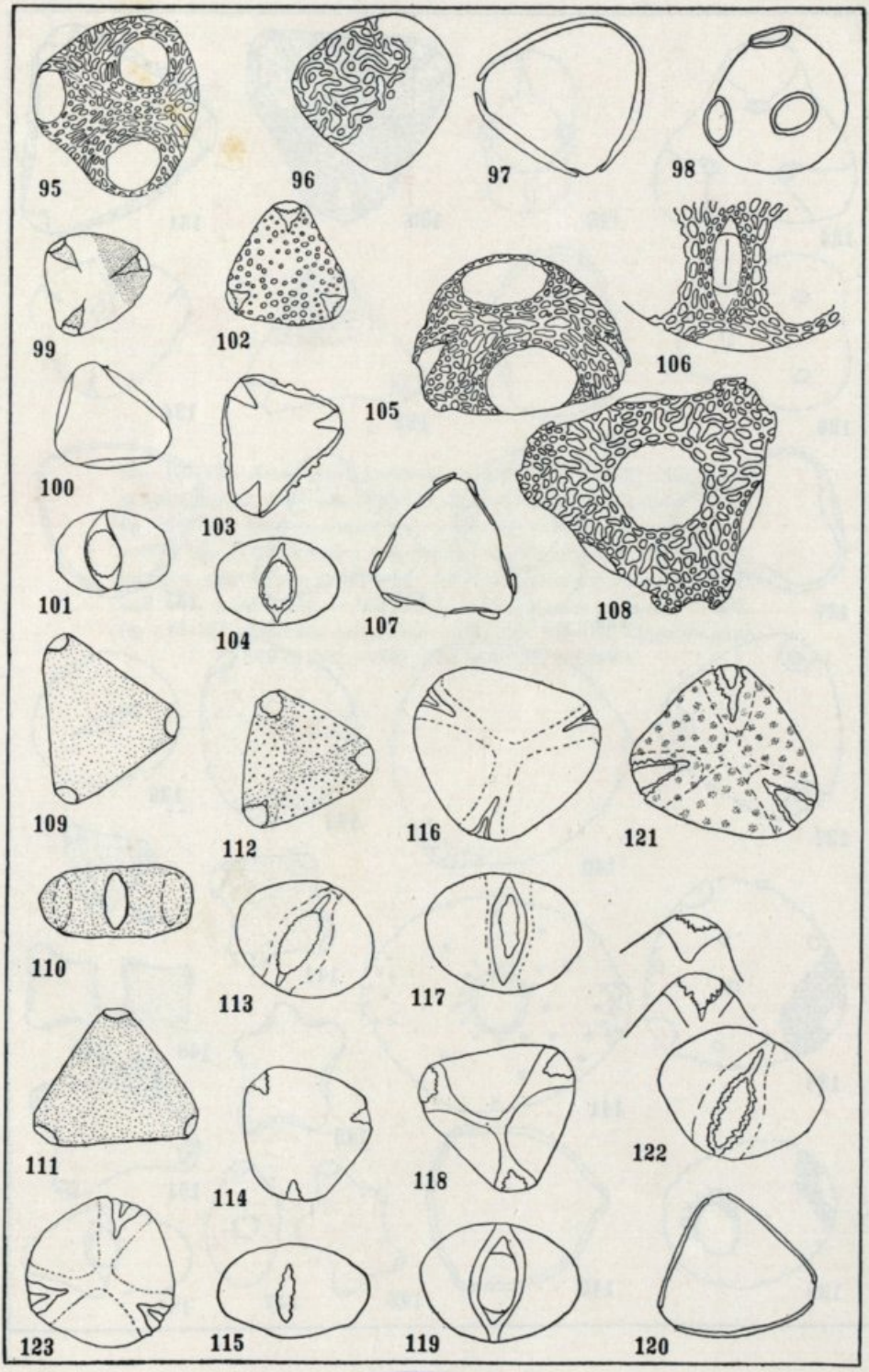
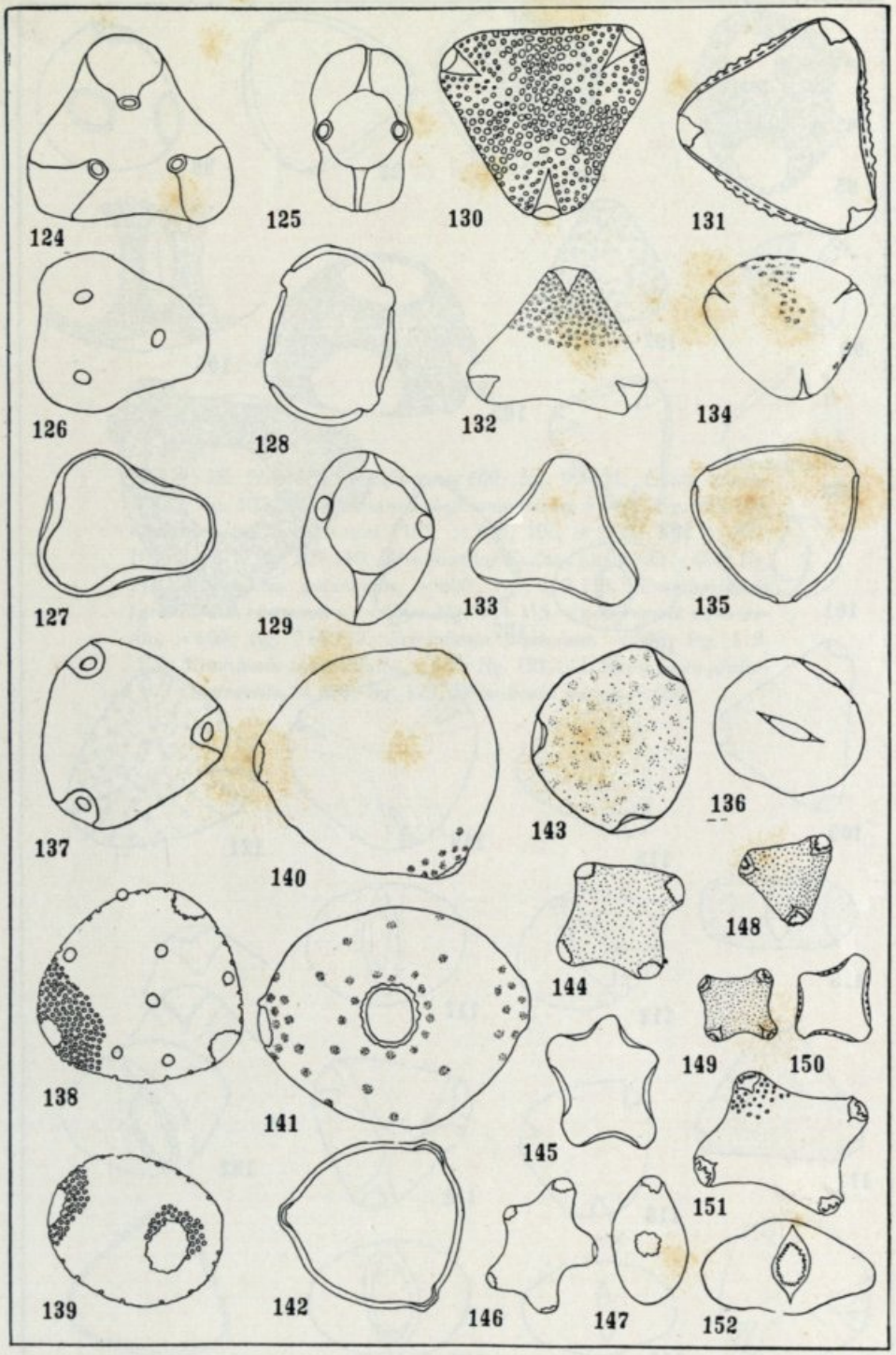
## Plate X

*Melientha acuminata*, fig. 89, transverse section of young stem; fig. 90, longitudinal section of xylem in young stem; *Agonandra racemosa*, fig. 91, transverse section of mature secondary xylem; *Champereia manillana*, fig. 92, longitudinal section of mature secondary xylem, magnified to show the rays; *Erythropalum scandens*, fig. 93, longitudinal section of xylem; fig. 94, transverse section of twig at the node.

## Plate XI

Fig. 95-98. *Heisteria cauliflora*, × 600; fig. 99-101. *Coula edulis*, × 600; fig. 102-104. *Ochanostachys amentacea*, × 450; fig. 105-108. *Chaunochiton breviflorum* (105, × 400; 106, × 1,000; 107, × 300; 108, × 600); fig. 109-110. *(Minquartia) Endusa punctata*, × 600; fig. 111. *Minquartia guianensis*, × 600; fig. 112-113. *Strombosiopsis (grandifolia) tetrandra*, × 600; fig. 114-115. *Lavalleopsis densivenia*, × 600; fig. 116-117. *Strombosia pustulata*, × 600; fig. 118-120. *Strombosia rotundifolia*, × 600; fig. 121-122. *Strombosia philippinensis*, × 600; fig. 123. *Strombosia minor*, × 600.

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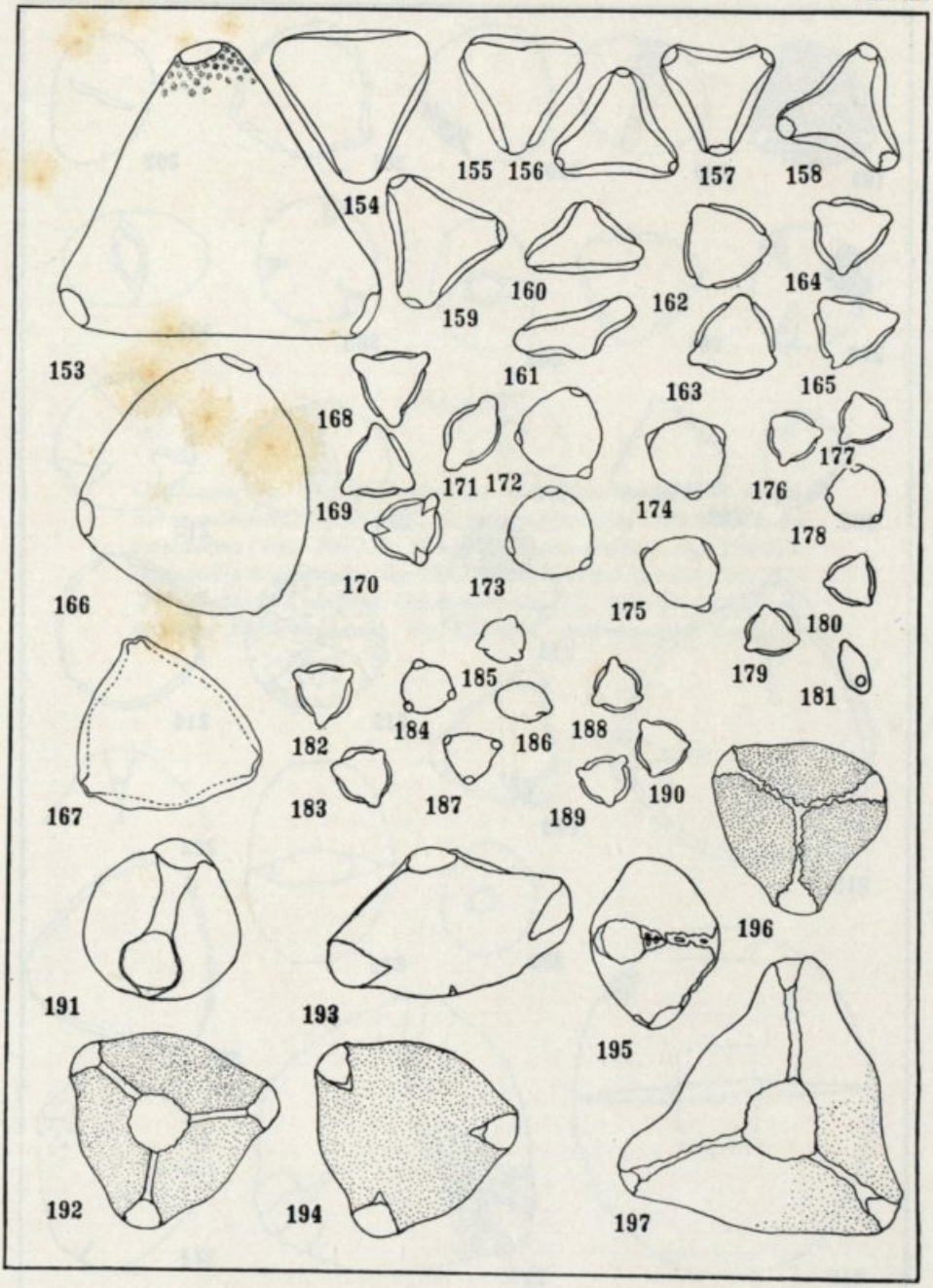
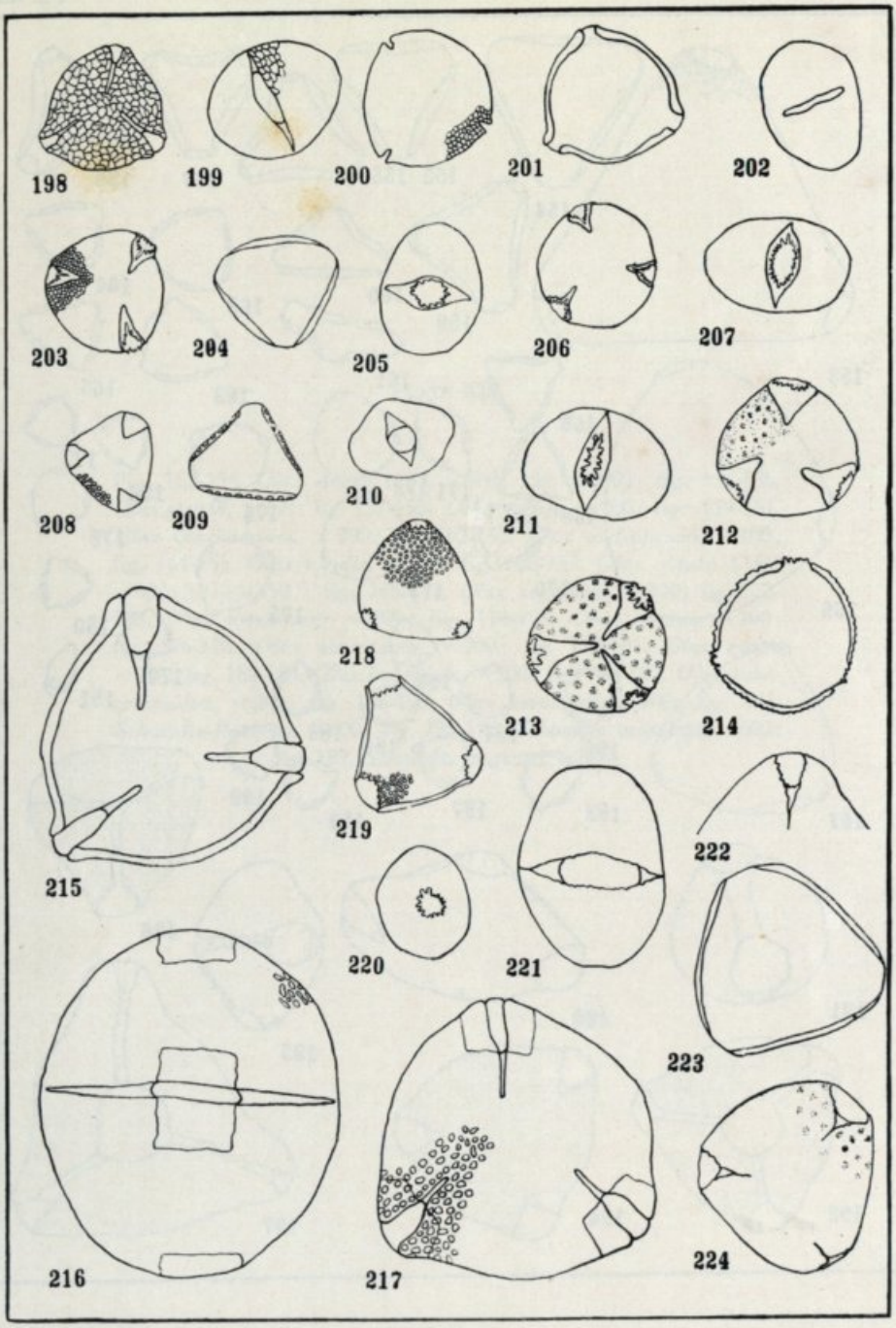
## Plate XII

Fig. 124-125. *Anacolosa luzoniensis*, ×600; fig. 126-129. *Anacolosa glochidiformis*, ×600; fig. 130-131. *Scorodocarpus borneensis*, ×450; fig. 132-133. *Ximenia americana*, ×600; fig. 134-136. *Ximenia caffra*, ×600; fig. 137. *Cathedra rubricaulis*, ×600; fig. 138-139. *Ptychopetalum uncinatum*, ×600; fig. 140-142. *Liriosma adhaerens* (140 and 141, ×600; 142, ×450); fig. 143. *Curupira tefeensis*, ×600; fig. 144-147. *Aptandra spruceana*, ×600; fig. 148-152. *Ongokea gore* (148 to 150, ×600; 151 and 152, ×1,000).

## Plate XIII

Fig. 153-154. *Olax stricta* (153, ×600; 154, ×300); fig. 155-156. *Olax stricta*, ×200; fig. 157-158. *Olax retusa*, ×200; fig. 159-161. *Olax benthamiana*, ×200; fig. 162-163. *Olax andronensis*, ×200; fig. 164-165. *Olax viridis*, ×200; fig. 166-167. *Olax obtusa* (166, ×600; 167, ×450); fig. 168-171. *Olax zeylanica*, ×200; fig. 172-173, *Olax dissitiflora*, ×200; fig. 174-175. *Olax obtusa*, ×200; fig. 176-178. *Olax acuminata*, ×200; fig. 179-181. *Olax nana*, ×200; fig. 182-183. *Olax imbricata*, ×200; fig. 184-187. *Olax subscorpioidea*, ×200; fig. 188-190. *Olax kerstingii*, ×200; fig. 191. *Schoepfia flexuosa*, ×600; fig. 195-196. *Schoepfia angulata*, ×600; fig. 197. *Schoepfia fragrans*, ×600.

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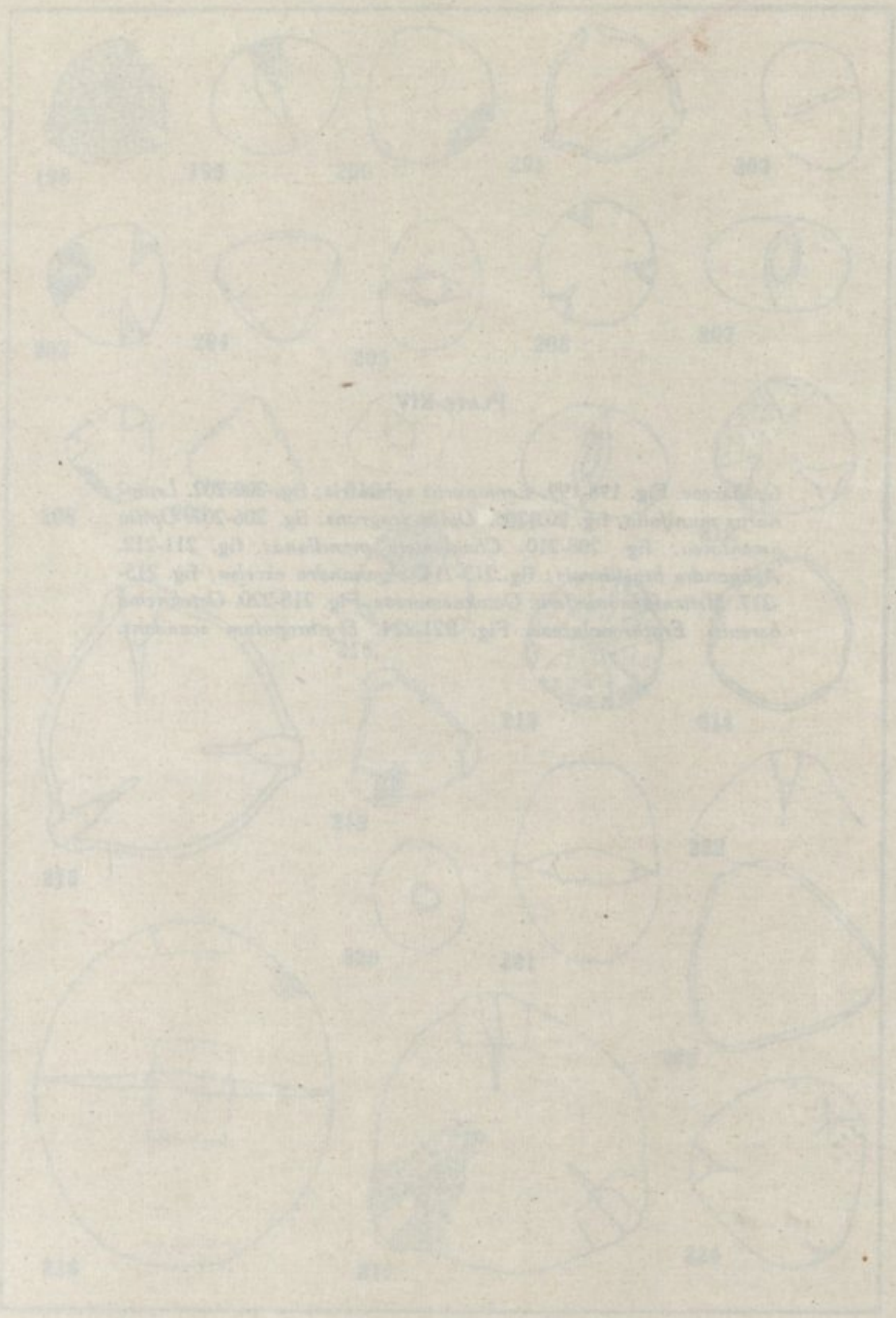
## Plate XIV

*Opiliaceae.* Fig. 198-199. *Lepionurus sylvestris;* fig. 200-202. *Lepionurus munifolia;* fig. 203-205. *Opilia fragrans;* fig. 206-207. *Opilia amentacea;* fig. 208-210. *Champereia manillana;* fig. 211-212. *Agonandra brasiliensis;* fig. 213-214. *Agonandra excelsa;* fig. 215--217. *Metteniusa nucifera. Octoknemaceae.* Fig. 218-220. *Octoknema borealis. Erythropalaceae.* Fig. 221-224. *Erythropalum scandens.*



# ÍNDICE