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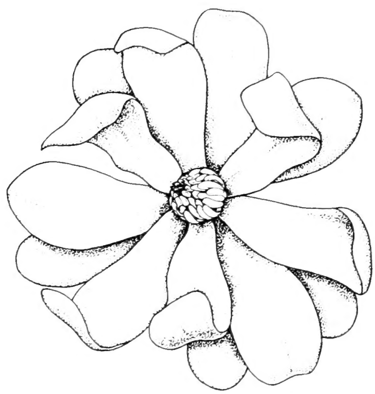

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THE GARDENS' BULLETIN SINGAPORE

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INSTRUCTIONS TO AUTHORS

Manuscripts: The Editorial Committee of the Gardens' Bulletin will be glad to receive and consider for publication original research findings and reviews of progress in the fields of botany, horticulture, and allied subjects. Contributions must be original and the material must not have been submitted or, if accepted, be submitted for publication elsewhere.

Two copies of the manuscript should be submitted, typed or typeprinted, and if typed, then the top copy must be one of the two. Type or print on one side only, with double-line spacings and a margin of at least 4 cm. Do not type all the letters of any word in capitals. Underline only in pencil: with a straight line for italic type face and wavy line line for bold type face. Authors should see the layout of other papers recently published in this journal to ensure that papers submitted conform as closely as possible to the accepted pattern. Numerical data should only be included if it is essential to the argument and this can be presented either in the form of tables or diagrams.

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Abbreviations: Standard chemical symbols may be used in the text (e.g. IAA, IBA, ATP), but the full term should be given on the first mention. Dates should be cited as: 3 May 1976. Units of measurement should be spelled out except when preceded by a numeral where they should be abbreviated in standard form: g, mg, ml, etc. and not followed by stops.

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Singh, H. (1967). Sclereids in *Fagraea. Gard. Bull. Sing.* 22, 193–212.

Abbreviations of titles of journals should be those of the World List of Scientific Periodicals (4th Edition) or the Selected Abbreviated Titles of Biological Journals (London: Institute of Biology).

References to books and monographs should be cited according to the following form:

Ridley, H.N. (1930). *The Dispersal of Plants Throughout the World*, L. Reeve; Ashford, Kent; 242–255.

For literature citations in taxonomic papers the following style is required:

Medinilla alternifolia Bl., Mus. Bot. Lugd.-Bat. I:2 (1849) 19.
Sterculia acuminatissima Merr., Philip. J. Sci. 21 (1922) 524.

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The Angiosperm Flora of Singapore Project

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EFFECTIVE PUBLICATION DATE: 15 MAR 1993

The Angiosperm Flora of Singapore Project is long-term and was initiated on 1st November, 1988. A piecemeal, family by family approach is to be adopted. The approximately 200 families containing an estimated 2,400 native and naturalized species are to be studied by either experts willing to contribute to the project or the researchers of the project. Family treatments will be published in the Gardens' Bulletin, Singapore as and when ready. It is hoped that the project will be completed within ten years from the publication of the first family treatment. Ultimately, when all family treatments are completed, a monograph compiling all the updated family treatments will be published.

The main objective of this National University of Singapore funded project is to produce an Angiosperm Flora of the Republic of Singapore. So far, only annotated species lists have been written (Ridley, 1900, 1901; Sinclair, 1953, 1956; Keng, 1973, 1974*a*, 1974*b*, 1976, 1978, 1980, 1982, 1983, 1985, 1986, 1987, 1990). During World War II, staff members of the Singapore Botanic Gardens Herbarium compiled the Flora of Syonan but this consisted only of a species list and is extant only in typescript (Keng, 1990). Recently, Keng (1990) published the Concise Flora of Singapore but this included only about 1,200 species, about 44 per cent of the estimated total flora, and excluded the monocotyledons. A checklist of all vascular plants recorded to occur in Singapore has recently been compiled (Turner, Chua and Tan, 1990).

The target audience for this Flora are scientists and informed laymen who require precise information for the identification of angiosperm specimens from Singapore. Thus, this flora will be of a traditional format using concise and precise language.

Collections of plants from all accessible parts of the main island and islands of the Republic of Singapore are being carried out. All plants extant and previously found in Singapore will be catalogued, described and distinguished by keys. Illustration of representative taxa by line drawings and photographs will also be included. Expert systems for the identification of the taxa are planned. A database is currently being developed.

The advisors of this project are Drs Hsuan Keng and Tan Wee Kiat (Executive Director, National Parks Board). The researchers include Drs Hugh Tan Tiang Wah (editor), Ian Mark Turner and Mr Chua Keng Soon.

Authors for family treatments are welcome and advised to contact the editor to discuss choice of families and to obtain the format for the Flora. Please address correspondence to:

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References

Keng, H. (1973). Annoted list of seed plants of Singapore (I). *Gard. Bull. Sing.* 26, 233-237.

_____. (1974*a*). Annotated list of seed plants of Singapore (II). *Gard. Bull. Sing.* 27, 67-83.

_____. (1974*b*). Annotated list of seed plants of Singapore (III). *Gard. Bull. Sing.* 27, 247-266.

_____. (1976). Annotated list of seed plants of Singapore (IV). *Gard. Bull. Sing.* 28, 237-258.

_____. (1978). Annotated list of seed plants of Singapore (V). *Gard. Bull. Sing.* 31, 84-113.

_____. (1980). Annotated list of seed plants of Singapore (VI). *Gard. Bull. Sing.* 33, 329-367.

_____. (1982). Annotated list of seed plants of Singapore (VII). *Gard. Bull. Sing.* 35, 83-103.

_____. (1983). Annotated list of seed plants of Singapore (VIII). *Gard. Bull. Sing.* 36, 103-124.

_____. (1985). Annotated list of seed plants of Singapore (IX). *Gard. Bull. Sing.* 38, 149-174.

_____. (1986). Annotated list of seed plants of Singapore (X). *Gard. Bull. Sing.* 39, 67-95.

_____. (1987). Annotated list of seed plants of Singapore (XI). *Gard. Bull. Sing.* 40, 113-132.

_____. (1990). *The concise Flora of Singapore: gymnosperms and dicotyledons.* Singapore Univ. Press; Singapore.

Ridley, H.N. (1900). The Flora of Singapore. *J. Straits Branch Roy. As. Soc.* 33, 27-196.

_____. (1901). Supplementary notes on the Flora of Singapore. *J. Straits Branch Roy. As. Soc.* 35, 84-90.

Sinclair, J. (1953). Additions to the Flora of Singapore and new localities in Singapore for some plants thought to be extinct. *Gard. Bull. Sing.* 14, 30-39.

_____. (1956). Additions to the Flora of Singapore and new localities in Singapore for some plants thought to be extinct — Part II. *Gard. Bull. Sing.* 15, 22-30.

Turner, I.M., Tan, H.T.W. and Chua, K.S. (1990). A checklist of the native and naturalized vascular plants of the Republic of Singapore. *J. Sing. Nat. Acad. Science* 18 & 19, 58-88.

The Angiosperm Flora of Singapore 1. Introduction

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The Republic of Singapore is an independent state of 2.7 million people at the southern tip of the Malay Peninsula, 137 km north of the equator (Fig. 1). It consists of the island of Singapore and more than 50 smaller islands. The main island is 42 km by 23 km at its widest points and has an area of 574 km^2, of which more than 30 km^2 has been added by recent land reclamation (Anon, 1990). It is separated from Malaysia by shallow straits, 0.6 km wide at the narrowest point. The largest of the other islands are Pulau Tekong Besar (1,793 ha), Pulau Ubin (1,019 ha) and Sentosa (309 ha). The total land area, including all the islands, is 626 km^2.

The topography of Singapore is predominantly low, with an average elevation of only 15.1 m (Thomas, 1991). The landscape of the main island can be roughly divided into three parts. In the centre of the island is a hilly region of granite and other igneous rocks, rising to a maximum of 162 m at Bukit Timah Hill. The western, southwestern and southern region, including most of the southern islands, consists of a variety of sharply folded sedimentary rocks with northwest-trending ridges and valleys. The eastern region is relatively flat and covered in semi-consolidated deposits of sand and gravel. Low-lying coastal plains and the lower parts of river valleys are filled with recent alluvium.

Singapore's "rivers" are large streams with broad estuaries, which result from flooding of valleys incised during periods of low sea-levels in the Pleistocene. Around the coastline, cliffs and other rocky shores are of limited extent, except on some of the southern islands. Until recently, most shores consisted of mud and sand in varying proportions. Muddy shores with mangroves predominated, except along the southeast coast, which was lined with sandy beaches. Today, however, much of the coastline is entirely artificial as a result of extensive land reclamation and coastal development.

Palaeogeography

Singapore is part of the Southeast Asian extension of the great Eurasia plate and is largely unaffected by the tectonic and volcanic activity around the plate margins to the west, south and east. The regional pattern of land and sea, however, has changed dramatically many times during the last million years or so, largely as a result of changes in sea-level. During glacial periods, sea-levels were up to 200 m lower than at present, exposing most of the Sunda shelf and joining the Malay Peninsula, Sumatra, Java and Borneo into one land mass ("Sundaland"), with Singapore somewhat west of centre (Morley and Flenley, 1987). At the opposite extreme, reported Holocene sea-levels up to 5 m higher than present (Geyr and Kudrass, 1979; Pirazzoli, 1991), would have substantially reduced Singapore's land area. Glacial periods occupied much more

Fig. 1 Map of Singapore showing major roads and reservoirs. Inset map shows the geographical position of Singapore.

of the Pleistocene than interglacials, so the present geography of the region must be seen as the exception rather than the rule. Singapore is cut off from the Malay Peninsula by water less than 10 m deep at the shallowest crossing, which implies a final separation about 7,000 years ago (Pirazzoli, 1991). The sea is deeper in the Singapore Straits to the south, so Singapore would have been cut off from Riau before it was separated from the Peninsula.

The repeated alternation of glacial and interglacial periods was also reflected in the region's climate. A decrease in total rainfall and increase in rainfall seasonality during the glacial periods has been suggested for that part of the Sunda Shelf which includes Singapore (Morley and Flenley, 1987; Heaney, 1991). A pollen assemblage from middle Pleistocene Subang, 300 km northwest of Singapore, is striking for the dominance of pine and grass pollen and absence of typical rain forest taxa, suggesting a very different climate. In Singapore itself, the Pleistocene Old Alluvium, which blankets much of the eastern part of the island, seems to have been deposited under far more seasonal climatic conditions during a period of glacial low sea-levels (Gupta *et al.*, 1987). The question of glacial temperatures is more controversal. Oxygen isotope and foraminiferal data suggest a lowering of sea surface temperatures by at most 2 °C at the last glacial maximum, in the vicinity of the Sunda shelf (CLIMAP, 1981). However, this is very difficult to reconcile with evidence for much greater temperature changes at higher altitudes in the region (Walker and Flenley, 1979). Sea-level temperatures 5 °C or more below present have been suggested for near-equatorial Amazonia (Bush *et al.*, 1990) and this possibility must be considered for equatorial Asia (Liu, K.B., pers. comm.). In any case, it is clear that as little as 10–15,000 years ago and for most of the Pleistocene, Singapore would have been occupied by a vegetation and flora very different from today's and probably lacking a modern analogue elsewhere in the region.

On a longer time-scale, the phytogeography of the region has been affected by its complex tectonic history. The Malay Archipelago, as it exists today, was created by a mid-Miocene collision between Australia-New Guinea and Southeast Asia, in the vicinity of Sulawesi (Audley-Charles, 1987). There has never been a dry land connection between Australia and Southeast Asia, even at extreme Pleistocene low sea-levels, but the many islands between Sunda and Sahul (Australia-New Guinea) must have greatly facilitated floristic exchange.

Until recently, paleogeographic reconstructions of the region before convergence showed a huge gap between Southeast Asia and Australia, making earlier biotic interchange between the regions unlikely (e.g. Audley-Charles, 1981). It now appears that, not only was this gap much narrower than once believed, but the whole of Southeast Asia is made up of a series of continental fragments rifted from northeastern Gondwanaland. The dating of these events is still contentious. Even if rifting of the major fragments occurred in the Jurassic (Audley-Charles, 1987), it is unlikely that the rifted fragments carried an Angiosperm flora at the beginning of their journey north, although they may well have acted as "stepping stones" between Australia and Asia later on. If, as much of the evidence suggests, the major fragments were already welded to Eurasia by the early Mesozoic (Metcalfe, 1990), they cannot have carried angiosperms. At Gunong Belumut, 75 km north of Singapore, there is a Later Permian fossil flora of undoubted Cathaysian (i.e. tropical Eurasian) affinities, with no Gondwanic elements (Hutchison, 1989). However, other blocks that make up modern Sundaland had Gondwanic floras at this time, showing they had not yet separated from that continent. Moreover, smaller fragments apparently continued to be added to the margins of Southeast Asia during the Jurassic and Cretaceous. It thus appears that the sea between Australia and Eurasia has never been empty, although speculation on the details of the regional palaeogeography are premature at this stage.

India, which did not rift from Gondwanaland until the early Cretaceous, and then moved very rapidly north, provides another possible route for one-way transport of Gondwanic angiosperms to Eurasia. India's collision with Tibet occurred in the Eocene.

Human Impact

Early man arrived in southeast Asia a million or so years ago, followed by modern *Homo sapiens* at least 50,000 years ago. It seems likely that human population densities in the equatorial lowlands were low before the introduction of agriculture within the last 4,000–6,000 years but it would be a mistake to underestimate the possible impact of pre-agricultural man on the biota of the region. The arrival of *Homo erectus*, an adaptable and intelligent hunter, is likely to have affected populations of large, ground-dwelling herbivores and this impact would have extended into the forest canopy when, later, throwing spears or similar weapons were added to man's arsenal. The extinction of large herbivores would have influenced forest structure both directly, through reduced grazing, browsing and trampling, and indirectly through the loss of their role in seed dispersal. Man's use of fire – of uncertain antiquity – must have been most significant during the dryer, glacial episodes, but droughts occur even during the wet interglacials and extra sources of ignition increase the risk of fire.

The process of homogenisation of the economic and weed floras of the Old World tropics must have started early. The Malay Archipelago has been linked by a maritime trading network from prehistoric times and has had trade links with China, India and the Middle East for at least 1,500 years (Dunn, 1975). With the arrival of Europeans in the early fifteenth century and the establishment of trans-Pacific trading routes, neotropical crops and weeds also made their appearance. Maize, tobacco, chilli, peppers, papaya, pineapple and sweet potato all became established in the region before the end of the fifteenth century (Reid, 1988). In recent times, Singapore, as a port city with a large botanic gardens, may have been the point of entry to the region for many exotic plants.

Although human populations must have lived in Singapore for thousands of years, the first definite historical accounts of a settlement on the island date from the fourteenth century, when Temasek (later called Singapura) appears in Javanese, Chinese and Vietnamese records. Temasek/Singapura was probably not the great trading city described in the Malay Annals but there is archaeological evidence for a substantial settlement at the mouth of the Singapore River in the fourteenth century (Miksic, 1985). Tome Pires, who lived in Malacca from 1512–1515, says that Chinese vessels came for the "infinite quantities of the black wood that grows in Singapore" (Cortesao, 1944). Temasek went into gradual decline during the fifteenth century and the last vestiges of the settlement were burned by the Portuguese in 1613. For the next 300 years, the island disappeared from history but there is no reason to believe it was ever uninhabited.

When the British arrived in 1819, the population of Singapore island consisted of about 1,000 people. Most of these were boat dwellers: the Orang Kallang, who lived in the swamps at the mouth of the Kallang River; the Orang Seletar, who lived in mangrove areas along the north side of the island; and the Orang Gelam, in the Singapore River (Logan, 1847; Thomson, 1848). These people apparently grew no crops but may have had a significant ecological impact through their hunting and collecting activity. The remainder of the population consisted of Malays and Chinese living in a small settlement at the mouth of the Singapore River or growing gambier in the surrounding hills.

The foundation of the British colony led to a rapid and sustained rise in population. From the beginning, Singapore was primarily a trading centre, but the cultivation of cash crops also expanded and spread into the interior of the island. Many crops were grown during the nineteenth century but, except on the sandy soils of the southeast coast, where coconuts were the major crop, most of the initial clearance of primary forest seems to have been for the cultivation of gambier (*Uncaria gambir* (Hunt.) Roxb.). Gambier was grown for export to China, and later Britain, where it was used for tanning leather and as a dye. It grows best on soil newly-cleared of forest and each plantation required a roughly equal area of forest to provide firewood for boiling the gambier leaves (Jackson, 1965). The Chinese gambier growers rarely had any legal title to the ground and simply moved on when the soil was exhausted and the fuelwood supply insufficient. Abandoned plantations were invaded by the grass *Imperata cylindrica* (L.) P. Beauv. or by secondary scrub.

Gambier continued to be a major crop in Singapore until 1890, after which the area declined rapidly. By this time, little of the original forest cover remained and most surviving forest fragments had been heavily exploited for timber and firewood (Corlett, 1991*a, b*). After the departure of the gambier growers, the cultivation of other crops, particularly pineapples, increased. However, it was an entirely new crop, rubber (*Hevea brasiliensis* (A. Juss.) M.A.), which had the major impact in the first half of this century. After the first commercial plantings in the 1900s, the area expanded rapidly, reaching a maximum in 1935, when nearly 40 per cent of Singapore's total land area was under rubber plantations. After this, the area under cultivation declined sharply, except for a temporary increase in the production of food crops during the Japanese occupation (1942–45). The post-war era saw a decline in all crops except vegetables as agricultural land was increasingly lost to urbanisation and industrialisation. Today, less than 100 hectares are used for intensive vegetable cultivation while more than half the main island is urban in character.

Although heavily exploited for firewood, most of Singapore's extensive mangrove forest area survived into the twentieth century. All but a few small areas have subsequently succumbed to conversion to brackish water ponds for agriculture, systematic reclamation for building and, more recently, the barraging of all major non-urban estuaries to create freshwater reservoirs (Corlett, 1987).

Conservation

In the early decades of the colony, exploitation and clearance of the forest apparently proceeded unchecked. In 1848, however, concern about possible effects on Singapore's climate led the Governor to prohibit the further destruction of forest on the summits of hills. This prohibition seems to have been effective for Bukit Timah, at least (Corlett, 1988*b*). By 1882, when Nathaniel Cantley was commissioned to survey the forest resources of the Straits Settlements (Singapore, Malacca, Province Wellesley and Penang), concern for the climatic effects of deforestation had largely been replaced by worries about the timber supply. Cantley, reporting that only 7 per cent of the original forest remained, proposed the creation of forest reserves (Cantley, 1884). His recommendations were accepted and, eventually, about 10 per cent of the island was protected in this way (Fig. 2). Unfortunately, most of the reserve area consisted of grassland, scrub or degraded mangrove, with little good forest. In addition to the forest reserves, an area around Singapore's first reservoir (now called MacRitchie

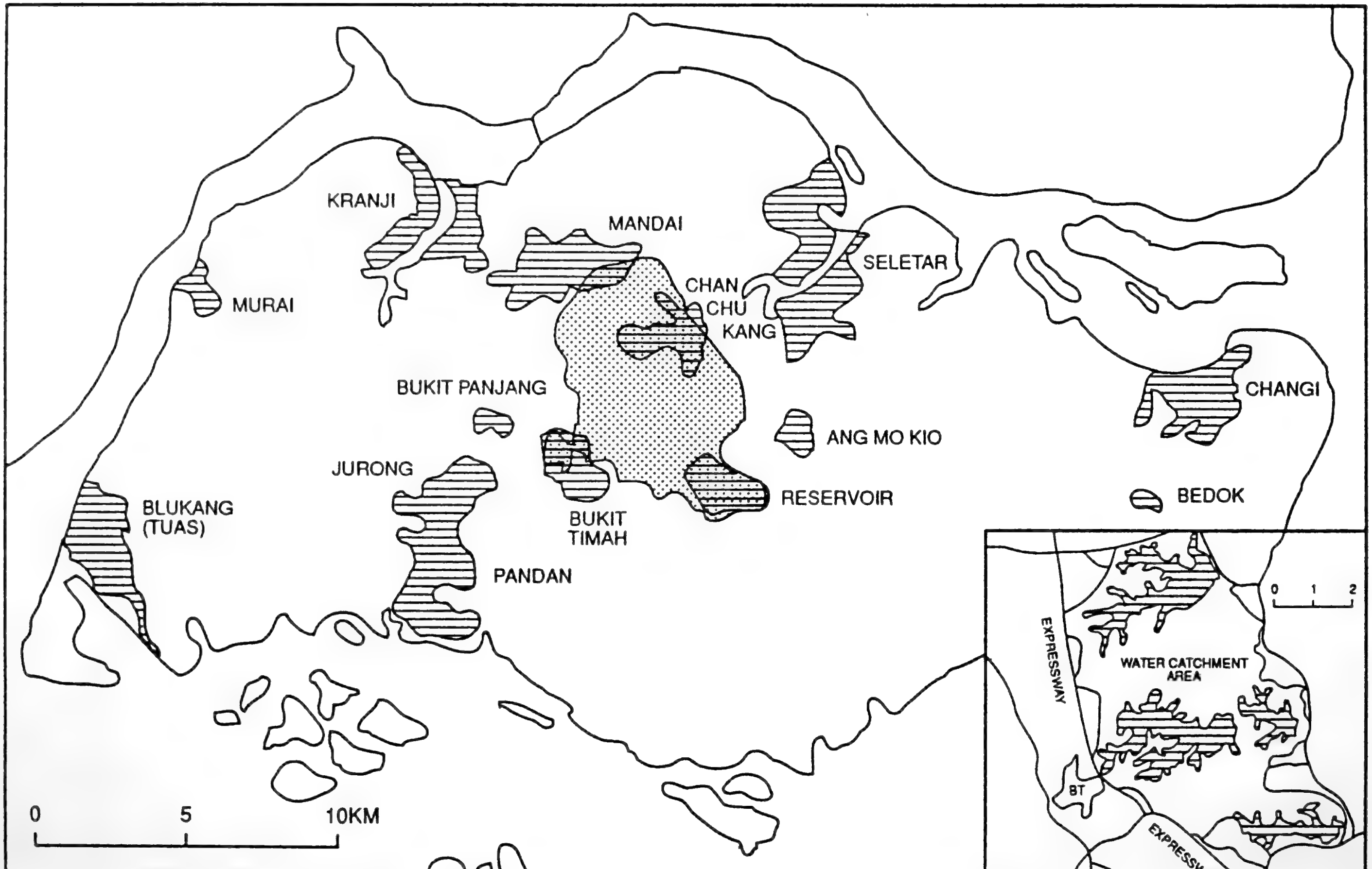

Fig. 2 Map of Singapore showing Forest Reserves in 1897 (hatched) and Nature Reserves in 1991 (dotted). Inset map of the central part of the island showing the water catchment area and Bukit Timah Nature Reserve (BT).

Reservoir), partly covered in degraded primary forest, was protected during the 1890s as a catchment.

Most of the reserves were eventually worked for timber, handed over to squatters or otherwise developed. An area of primary forest survived at Changi until 1927, when it was cleared for construction of a military base. The decline in the forest reserves coincided with an increase in the protected catchment area as new reservoirs were constructed in the centre of the island. The expanded catchment area incorporated several fragments of disturbed primary forest, including what remained of Chan Chu Kang Forest Reserve and part of the Mandai Reserve, although this latter area was later cleared for the extension of Seletar Reservoir in 1940–41.

The Forest Reserves were finally abolished in 1936 but Bukit Timah and parts of the mangrove reserves at Pandan and Kranji were placed under the control of the Botanic Gardens. In 1951, these three areas, with the entire catchment area and 4 hectares of cliff face at Labrador, became Nature Reserves. The mangrove reserves were subsequently lost to development. Today the Nature Reserve system consists of 2,795 hectares in the centre of the island, of which 81 hectares is in Bukit Timah Nature Reserve and the rest in the Public Utilities Board Catchment Area (Fig. 2). A small area of mangrove at Sungei Buloh is protected as a bird sanctuary.

Climate

Singapore is only 137 km north of the equator and has an equatorial climate. The range of mean monthly temperatures is only 25.5–27.3 °C and of mean monthly rainfall 160–300 mm. In Southeast Asia, similar climates are confined to the southern part of the Malay Peninsula, parts of Sumatra, much of Borneo and part of western Java. Elsewhere, only the island of New Guinea and parts of the central and western Amazon region have extensive areas of such climates. The botanical consequences of this extreme aseasonality are most obvious in urban areas, where the tree-lined streets are green all the year round but rarely show the massed flowering displays of other tropical cities. As discussed below, however, both seasonal and non-seasonal variations in the climate are of great significance for the native flora.

Despite its small size, Singapore also shows a surprising amount of spatial variation in rainfall. Mean annual rainfall exceeds 2,300 mm in the central part of the island and falls below 2,000 mm along much of the south coast (Chia and Foong, 1991). This spatial variation may have had a significant effect on plant distributions before the nineteenth century but its influence is now obscured by the effects of recent human impact.

A thorough review of Singapore's climate with additional references can be found in Chia & Foong (1991). Here I will only discuss features of direct botanical relevance.

Seasonality

Despite its apparent constancy, Singapore's climate is perceived by people, birds (Hails, 1987), and plants as seasonal. The time difference between the longest and shortest days of the year is only 9 minutes so photoperiod effects are unlikely, if not impossible. The long term means of air temperature, rainfall, relative humidity and solar radiation are clearly seasonal, although within a narrow range (Fig. 3). This limited seasonality is a consequence of the changes in the prevailing wind direction. The northeast monsoon prevails from November to March and the southwest (or, more accurately in Singapore, south) monsoon from May to October. During the inter-monsoon periods of April/May and October/November wind directions are variable.

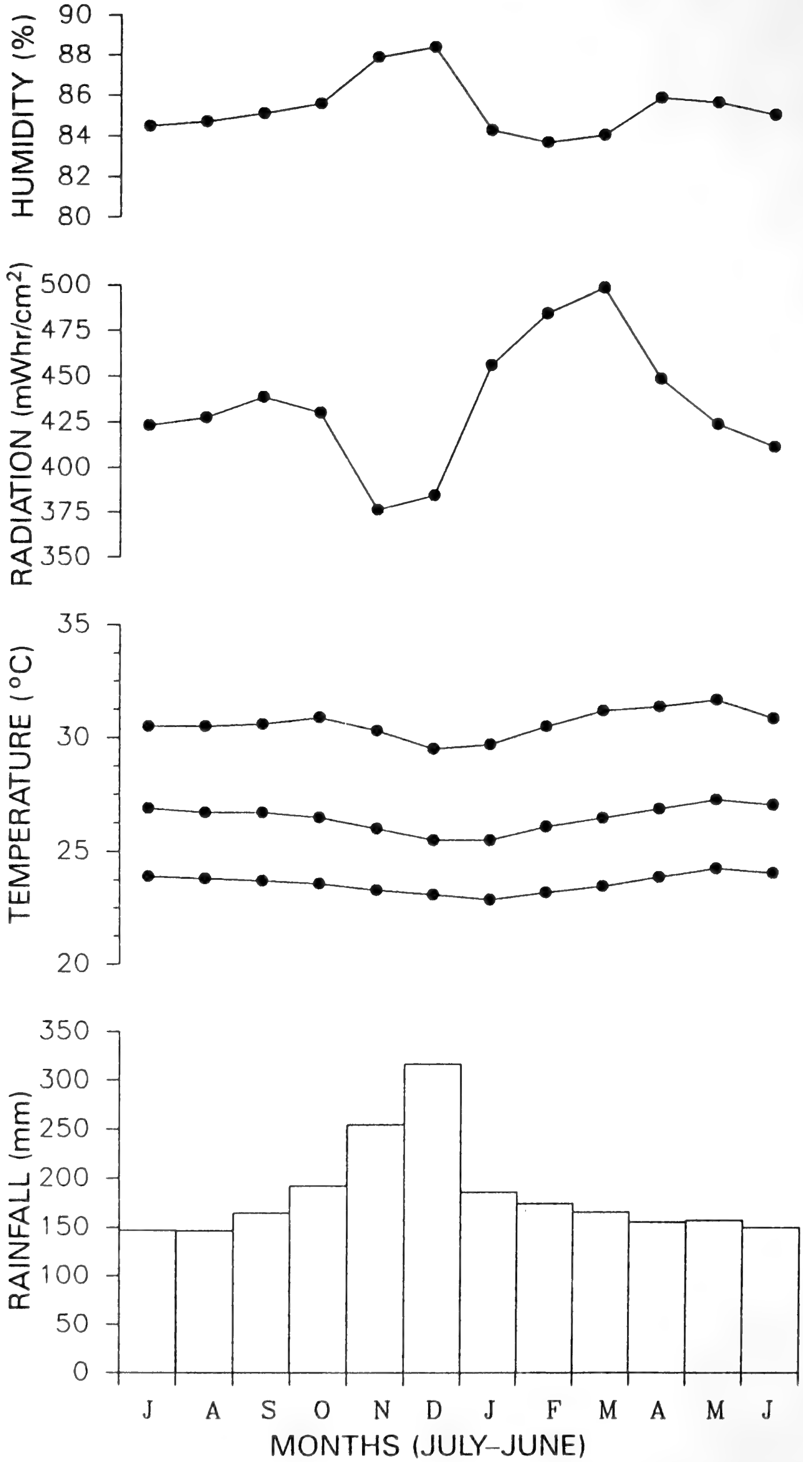

Fig. 3 Annual variation in the long-term means for humidity, solar radiation, temperature and rainfall for Paya Lebar, Singapore. Note that the time scale is from July to June so that the major annual climatic change appears in the centre of the graph.

November and December are generally cooler, wetter and cloudier than other months. The solar radiation maximum is in February/March, which is also the period most prone to long dry spells. The month with the lowest mean rainfall, however, varies in different parts of the island. The hottest months are May and June. The most striking climatic change in most years is between the cloudy, wet period at the beginning of the northeast monsoon in November/December and the relatively drier and sunny period towards the end, in February/March (Fig. 3). The strength of this contrast is obscured in long-term averages because the precise timing varies from year to year but, in most years, it is the most significant interruption to the uniformity of the climate.

A single annual community-level flowering peak — around April — has been reported from several lowland forest sites in the Malay Peninsula (Ng, 1988), presumably triggered by this change. Corner (1988) suggests that there is often a second, weaker, flowering peak later in the year, triggered by a second, less predictable, dry period. There is no quantitative evidence for this but two annual peaks of leaf flushing have been described at some sites. Clear annual (e.g. *Campnosperma auriculatum* (Bl.) Hook. f.) or biannual (e.g. *Fagraea fragrans* Roxb.) flowering periodicities are fairly common in the Singapore flora.

The absence of regular seasonal climatic extremes must make non-seasonal extremes more easy for plants to detect. It is not surprising, therefore, that irregular climatic events that do not follow an annual cycle are of at least equal botanical significance in Singapore. Some of these climatic cues occur with a frequency greater than annual. The sudden drop in temperature caused by daytime thunderstorms is known to provide the trigger for already-formed flower buds to complete their development in certain orchid species (e.g. *Dendrobium crumenatum* Sw.) and the angsana tree (*Pterocarpus indicus* Willd.). Several other species which flower synchronously several times per year (e.g. *Rhodamnia cinerea* Jack, *Timonius wallichianus* (Korth.) Valeton) presumably have a climatic trigger for floral initiation.

Other climatic extremes occur with less than annual frequency. Many forest species show supra-annual reproductive cycles which may have climatic triggers. At irregular intervals of 2–10 years, the reproductive activity of many species coincides in a massive burst of flowering followed by an equally striking fruiting peak. The cue for this dramatic mass-flowering is certainly climatic but the precise event responsible is still uncertain. Dry weather (Foxworthy, 1932; Medway, 1972), increased daily sunshine hours (Ng, 1977), and a drop in minimum temperature (Ashton *et al.*, 1988) have all been suggested. All three suggested triggers tend to occur together near the beginning of the year and may be associated with the El Niño-Southern Oscillation Event (Ashton *et al.*, 1988). A mass-flowering event in Singapore in 1987 (Corlett, 1990) followed an exceptionally dry and sunny February, but there was no significant drop in minimum temperature. The consequences of this supra-annual pattern of forest phenology for the common, basically frugivorous, monkey, *Macaca fascicularis*, are described by Lucas & Corlett (1991).

Climatic extremes may act as constraints as well as triggers but this effect is not obvious in Singapore. The extreme minimum (19 °C, in January 1934) and maximum (35.8 °C, in April 1979) temperatures recorded on the island differ little from the annual extremes. Hailstorms are rare and the longest recorded dry spell was 32 consecutive days in February and March, 1970. Singapore is well outside the typhoon belt but during the south monsoon short-lived squalls, known locally as 'Sumatras', can cause damage to isolated trees.

Microclimates

Few plants experience the "raw" climate recorded at standard meteorological stations. For the majority, climatic means and extremes are modified by the presence of other plants and non-living structures. The contrast between the microclimate near the forest floor and that above the canopy or in a large clearing is well-documented (Whitmore, 1990). Most of Singapore's native flora must have been adapted to spending all or part of its life cycle in the cool, damp shade of the forest understorey. The only exceptions would have been canopy epiphytes, gap specialists and coastal species. Most of Singapore is now one huge, permanent clearing so the dominance of exotics and coastal species among both the planted and spontaneous flora is not surprising. Outside the forest, there is also a marked rural-urban contrast in microclimate (Singapore Meteorological Service, 1986), attributed to heat stored in urban structures, but the botanical significance of this is unknown.

Geology and Soils

Geology

The geology of Singapore has recently been reviewed by Thomas (1991) and a geological map of the island is available (PWD, 1975). Only a brief summary is given here.

The centre of the main island is underlain by the Bukit Timah Granite. This consists of acid igneous rocks, ranging from granodiorite to true granite, dated to the early-middle Triassic (230–205 Myrs B.P.). Other granites of similar or more recent age outcrop at Changi Point, Pulau Sekuda and Pulau Ubin. The Gombak Norite outcrops in a restricted area on the west of the Bukit Timah Granite, around Bukit Panjang and Bukit Gombak. It consists of basic igneous rocks ranging from norite to gabbro and is older than the Bukit Timah Granite. Most of the southern, south-western, and western part of the main island, and most of the southern islands, are underlain by a variety of sharply-folded sedimentary rocks termed the Jurong Formation. These include conglomerates, sandstones, siltstones and mudstones. They are younger than the Bukit Timah Granite: probably of upper Triassic to early or middle Jurassic age (230–180 myrs B.P.).

Much of eastern Singapore and a part of the northwest is covered in semi-consolidated alluvial sands and gravels, with some silt and clay. This deposit, called the Old Alluvium, is predominantly granitic in provenance and seems to have been deposited in a braided river environment during the more seasonal climate of one or more of the Pleistocene cold stages (Gupta *et al.*, 1987). Holocene deposits of various types cover low-lying coastal areas and fill the lower parts of river valleys. These include beach sands and gravels deposited during the Holocene sea-level maximum (ca. 5,000 B.P.) and a variety of other marine, estuarine and alluvial gravels, sands, muds and peats.

Soils

The soils of Singapore were classified into 24 series and mapped by Ives (1977) and have recently been reviewed by Rahman (1991). Unfortunately, soil classifications produced by soil scientists, principally for agricultural purposes, often seem to have little predictive value for ecology, particularly in the tropics. This is probably because many ecologically important features of a soil are destroyed by cultivation. A soil can be cleared of its vegetation cover, suffer severe compaction, have its organic matter oxidised, its nutrients leached, and its surface layers eroded, without changing its position in the classification. Moreover, Singapore's continuous high temperature and rainfall, and the resulting intense weathering and leaching, have resulted in soils with similar properties on a range of different parent materials. Extreme parent materials, such as limestone and ultrabasic rocks, do not occur in Singapore.

Most soils in Singapore can be described as sandy clay loams and have a bimodal particle-size distribution. All are acidic, with a low cation exchange capacity and low to very low concentrations of available nutrients. All except those under the small areas of primary forest have undergone at least one agricultural cycle and much of Singapore is covered in soils which, whatever their taxonomic position, are characterised by extreme soil degradation as a result of nineteenth and early twentieth century agricultural practices. Over large areas the original soil has been removed, buried or drastically altered by construction activity. A variety of different fill materials have been used for the extensive reclamation of land from the sea, including clayey subsoil from inland construction projects and marine sand dredged from the sea bed. Sand fill resembles natural coastal deposits but clayey fill, after compaction to ensure stability, results in a soil that is completely structureless, poorly aerated and drained, and very low in fertility.

Six of the ten soil orders in the United States Department of Agriculture (USDA) Soil Taxonomy have been recognised in Singapore (Rahman, 1991). The largest area is covered in Ultisols. These are found on granite, on the fine- and mixed-grained sedimentary rocks of the Jurong Formation, and on the Old Alluvium. Soil development is greatest on well-drained, level ground over granite and least on the Old Alluvium, where some of the less-developed soils may be better classified as Inceptisols or Entisols (Rahman 1991). Inceptisols are also found on some of the coarse-grained, resistant rocks of the Jurong Formation. Soils over granodiorite and the more basic igneous rocks typically develop into Oxisols. The soils on recent alluvium are mostly Entisols, although of widely varying properties. Other soil types of relatively minor extent occur near the coast, including highly organic Histosols formed under freshwater swamp forest, Spodosols (podzols) on old beach deposits, and the distinctive Sulfaquents under mangrove.

Biogeography

This account of the biogeography of Singapore's flora is based on the species list of Turner *et al.* (1990), with distributional data from regional floras, principally the Flora Malesiana, Tree Flora of Malaya, Flora of Thailand, Flore du Laos, du Cambodge et du Vietnam, and the Flora of Australia, supplemented, where possible, by data from more recent monographs. This data has a number of obvious limitations, apart from its incomplete taxonomic coverage. Most serious is the undercollection of much of the region around Singapore, particularly Riau, Sumatra and Kalimantan. There is also the problem of non-coincidence of biogeographical and political boundaries. In the region under consideration here, the clearest examples are the Malaysia-Thailand border, which is somewhat south of the northern limits of much of the Malesian flora, and the island of Palawan, which is biogeographically Bornean but politically part of the Philippines. Thus "Thailand" or "the Philippines", unqualified, in a description of a species distribution, are not very helpful to the biogeographer.

Takhtajan (1986) places Singapore in the Malesian Subregion of the Malesian Region of the Paleotropical Kingdom. The Malesian Subregion is further divided into five provinces, with Singapore in the Malay Province. However, the suggested differences between the Malay Province and the adjacent Sumatran and Kalimantan Provinces are minor. Indeed, at the species level, the most striking feature of Singapore's flora is its broad distribution. The question of possible Singapore endemics is probably best left until **after** this Flora is completed, but they are undoubtedly very few, if any. Even among the inland rain forest flora – the plants most likely to have restricted distributions – only 15 per cent of the 730 species for which I could obtain reasonable data are apparently confined to the Malay peninsula (including peninsular Thailand and, in a few cases, peninsular Burma or the Riau Archipelago). A further 50 per cent of forest species occur more widely in the everwet "core" of Sundaland (Sumatra, Borneo and West Java). The remaining third of the species are even more widespread, extending northwards into continental Asia (21 per cent), or eastwards through Malesia towards Australia (14 per cent). The wide distribution of most Singapore forest species is no doubt the result of the unexceptional nature of the physical environment and Singapore's position near the centre of the Sunda shelf. It does suggest, however, that whatever the effects of full-glacial aridity on the vegetation of the region, continuous rain forest was re-established on Sundaland *before* rising sea-levels created major barriers to dispersal.

It is important to point out that the Singapore populations of widespread species are still of conservation value because of the likelihood of ecotypic variation at the margins of the range. Moreover, deforestation to the north and south of Singapore is rapidly restricting the range of species that were widespread ten or twenty years ago.

As might be expected, the coastal flora is much more widely distributed. *Caesalpinia bonduc* Roxb. and *Thespesia populnea* (L.) Correa are effectively pantropical while a number of species range from East Africa to the western Pacific (e.g. *Bruguiera gymnorrhiza* (L.) Lamk., *Excoecaria agallocha* L.). These extremely wide ranges presumably reflect both the tendency to seawater dispersal in the coastal flora and the relative uniformity of the coastal environment.

The flora of man-made open sites is essentially pantropical, consisting of species of Asian origin which have now spread around the world, and exotics from Africa and the Neotropics that have become naturalised in Singapore. As is true throughout the region, the recognizably exotic component of Singapore's flora contains many more species of Neotropical origin (at least 84 species) than from Africa (14 species) (Corlett, 1988). This may reflect similarities in climate and, perhaps, agricultural systems, as well as the large number of crop and ornamental plants deliberately introduced from tropical America. Another interesting feature of Singapore's weed flora is the rarity or absence of several pantropical exotics, abundantly-naturalised in the more seasonal climates of the region (e.g. *Crassocephalum crepidiodes* (Benth.) S. Moore, represented only by a single old record) and the absence of weeds of temperate origin (Corlett, 1992*b*). The composition of the weed flora demonstrates clearly that, far from being a "greenhouse climate" in which anything can grow, Singapore's year-round high temperatures and rainfall exclude unadapted species as effectively as extreme cold or drought.

The biogeography of Singapore's flora at the genus and family levels is that of the Sunda Shelf flora as a whole. The dual origin of the regional flora from both Gondwanic and Laurasian sources has long been recognised. However, the complex geological origin of the Malay Archipelago, outlined above, probably provided a multiplicity of times and routes for interchange, making the recognition of distinct "elements" in the flora difficult. For example, the family Dipterocarpaceae shows an overwhelming concentration of living species in West Malesia (Sundaland plus the Philippines) and probably entered the region from the Asian mainland, but the global distribution of living and fossil members suggests a possible ultimate origin on Gondwanaland (Ashton, 1982). Plants of originally Gondwanic families have probably entered the region from both the south-east (after the Miocene collision between Laurasia and Gondwanaland or, earlier, via island "stepping-stones") and from the north-west (after being "rafted" northwards from Gondwanaland on India). Some taxa (e.g. the palms, of disputed ultimate geographic origin, and the Loranthaceae) have apparently entered the region from both ends (Dransfield, 1987; Barlow, 1990).

Vegetation

Primeval Vegetation

I have been unable to find any useful description of Singapore's vegetation before the late nineteenth century. Early maps and written accounts make insufficient distinction between vegetation types or only refer to small areas. It is a reasonable assumption, however, that, except for sandy beaches and steep cliffs, and the immediate vicinity of the major settlement, closed canopy forest covered the whole island in 1819. To what extent this forest had been exploited, disturbed or cleared in the past is impossible now to determine. From topography, soil patterns and late nineteenth century maps, I estimate that mangrove forest would have occupied about 13 per cent of the main island, freshwater swamp forests of various types 5 per cent, and lowland evergreen rain forest the remaining 82 per cent (Corlett, 1991*a*). The floristic composition of the rain forest must have varied considerably with soil type and topography but extensive botanical collection did not start until the 1880s, when more than 90 per cent of the forest had gone, so we have little information on this variation. The distinctive floras of the 10 ha forest remnant at Changi, cleared in 1927, and the 4 ha Gardens' Jungle, now badly degraded, suggest that much of Singapore's primeval flora may have been lost before it was collected. Even in the 1890s, Ridley could collect rain forest taxa at many sites where forest no longer exists. Known extinctions are mostly coastal, reflecting the complete destruction of the coastal forest, with the exception of some small areas of mangrove.

Primary Forest Today

Today, primary rain forest, disturbed to varying extents, is confined to the 71 ha Bukit Timah Nature Reserve (which is about two-thirds primary forest) and scattered patches of various sizes, totalling about 50 ha, in the adjacent water catchment area. Most of these primary forest remnants are in the areas of overlap between the Forest Reserves established in the late nineteenth century and the current Nature Reserve system (Fig. 2). The Bukit Timah forest has apparently never been legally exploited, at least since its first protection in the 1840s (Corlett, 1988*b*). Extensive illegal cutting of timber and firewood has, however, undoubtedly occurred at times of reduced protection. At least 840 angiosperm species (excluding non-forest weeds) have been recorded from Bukit Timah in the past century (Corlett, 1990, 1991*b*). Five families — Rubiaceae, Euphorbiaceae, Orchidaceae, Moraceae and Annonaceae — account for almost a third of the angiosperm flora. In terms of numbers of species, the Euphorbiaceae, Rubiaceae, Myrtaceae, Annonaceae and Lauraceae are the most important tree families, but the Dipterocarpaceae provides the greatest number of large tree individuals (Wong, 1987). The Rubiaceae and Palmae are the biggest climber families, ferns dominate the herb layer, and ferns and orchids account for most of the epiphytes (Corlett, 1990).

The largest primary forest remnants in the catchment area are around MacRitchie Reservoir and the Nee Soon (Yishun) firing ranges. Both areas have been protected since the late nineteenth century (as a catchment area and Chan Chu Kang forest reserve, respectively (Fig. 2)) but, before that, were probably exploited heavily. Continuity of forest cover — and thus justification for considering them "primary" — is shown by the extremely rich flora, including numerous species absent from the adjacent secondary forests. The Nee Soon area also includes about 15 ha of disturbed freshwater swamp forest, the last remnant of the much larger area studied by Corner (1978). The floristics of these other primary forest remnants have not been investigated as thoroughly as Bukit Timah, but the floras seem to be to some extent complementary.

Secondary Forest and Scrub

The rest of the central catchment area (Fig. 2) is covered in secondary forest of various ages (Corlett, 1991*c*). This area was cleared of its original forest cover by the mid nineteenth century, cultivated until exhaustion and then abandoned to lalang. Protection as part of an expanded water catchment, mostly in the period 1899–1906, did not lead to an immediate regeneration of forest because of frequent grass fires, but most of the area seems to have been under woody cover by the nineteen-thirties. Some parts have been cut or burned more recently. The oldest areas of forest (?50–80 years old) are 15–20 m tall with 35–65 species >2 cm d.b.h. in 0.1 ha plots. This tall secondary forest is dominated by members of the families Guttiferae (*Calophyllum* spp., *Garcinia* spp.), Lauraceae (*Lindera lucida* (Bl.) Boerl., *Litsea* spp.), Myrtaceae (*Eugenia* spp., *Rhodamnia cinerea* Jack), and Elaeocarpaceae (*Elaeocarpus* spp.). It is clearly distinguished from the included primary forest remnants by its lower stature and species diversity, even canopy, poorly-developed understorey, and the complete absence of Dipterocarpaceae and other species with large, wind-dispersed seeds.

For historical reasons, tall secondary forest is confined to the central catchment area, but areas of younger secondary forest and scrub, probably all less than 40 years old, are scattered around the main island and on several offshore islands (Corlett, 1991*c*). This pioneer community is remarkably uniform, floristically, despite the wide range of rock types on which it occurs. Large areas contain less than 20 vascular plant species in total. The explanation for this relative floristic poverty must be severe soil degradation — chemical, physical or both. The dominant species is usually *Adinandra dumosa* Jack, particularly after the formation of a closed canopy has eliminated the smaller species. Transitions between the low (6–12 m), *Adinandra*-dominated forest and the tall secondary forest described above can be found in some parts of the central catchment area. Whether or not the outlying areas, if protected, will ever undergo this transition, in the absence of nearby seed sources, is an interesting question!

Except for small areas at the back of beaches, all herbaceous vegetation in Singapore is secondary and results from recent or continued disturbance. Fire prevention and control have virtually eliminated the vast areas of lalang (*Imperata*) grassland which dominated the Singapore landscape in the late nineteenth and early twentieth century. Spontaneous herbaceous vegetation is now most extensive on wasteland awaiting development and on land newly reclaimed from the sea. Except on the poorest soils (such as land reclaimed with sand fill), this wasteland vegetation is dominated by naturalised exotic species, particularly African grasses and tropical American legumes (Corlett, 1988*a*). Exotics also dominate the weed flora of parks, gardens and other managed vegetation.

The surviving fragments of Singapore's once extensive mangrove forests all show the effects of past exploitation and disturbance (Corlett, 1987). There are few old trees and the inland margins of most patches have been destroyed by reclamation.

Moreover, land reclamation, barraging of estuaries, and developments inland have drastically changed the patterns of sediment deposition and erosion along Singapore's coastline, so even protected mangrove areas are unstable. The rich epiphytic flora recorded earlier this century has almost entirely disappeared but most of the woody flora survives.

Managed Vegetation

For most visitors to Singapore, the lasting botanical impression is not the untamed exuberance of tropical nature but the orderly rows of matching trees and neat expanses of close-mown grass. This impression has been achieved at considerable expense in money and labour, and only after many years of careful planning and experimentation (Corlett, 1992*c*). Although the final image is very Singaporean, the flora of the managed vegetation is pantropical. A continued programme of plant introductions and field trials has resulted in an exceptionally diverse park and roadside flora, with the plantings often dateable from a knowledge of past changes in the favoured tree species. The few native species that are widely planted are all coastal in origin: examples include the Pong Pong (*Cerbera odollam* Gaertn.), the Sea Apple (*Eugenia grandis* Wight), the Yellow Flame (*Peltophorum pterocarpum* (DC.) Heyne), the Sea Almond (*Terminalia catappa* L.), and the near-native Angsana (*Pterocarpus indicus* Willd.). Many early introductions were from tropical America, such as the Rain Tree (*Samanea saman* Merr.) and the Broad-leaved Mahogany (*Swietenia macrophylla* King). More recently, African Mahoganies (*Khaya* spp.) have been very widely planted, but no major tropical area is unrepresented.

Much of the diversity in the planted shrub flora is at the infraspecific level, with Bougainvillea (*Bougainvillea X buttiana* Holttum & Standley), Hibiscus (*Hibiscus rosa-sinensis* L.) and others represented by numerous cultivars. Managed grasslands, in contrast, are largely planted with one species, *Axonopus compressus* (Swartz) Beauv., propagated vegetatively and now probably the commonest plant in Singapore. Fine lawns, particularly in private gardens, are usually planted with species of *Zoysia*, while several cultivars of Bermuda Grass (*Cynodon dactylon* (L.) Pers. and hybrids) are used on golf courses.

Conclusions

Despite its small size, relatively uniform topography and recent history of massive human impact, Singapore still supports a vascular plant flora of incredible diversity. The majority of this diversity, however, is dependent on the protection of a few, small areas: most importantly, the primary forest remnants at Bukit Timah, MacRitchie and Nee Soon. Even the oldest secondary forest in the central catchment area is depauperate in comparison and its conservation significance lies more in its role as a buffer for the primary forest remnants, its importance as a habitat for vertebrates, and its potential for future floristic enrichment, by natural processes or with human intervention. Along the coast, the few remaining patches of mangrove forest, although of low floristic diversity, support an extremely rich and interesting fauna. Outside the forest, the flora, both spontaneous and planted, consists largely of pantropical species which, although often of considerable biological interest and aesthetic value, have no particular conservation importance.

The Flora of Singapore project is of major significance for plant conservation in Singapore. The availability of a modern Flora will greatly facilitate the detailed studies of species and habitats on which long-term conservation management of the flora will ultimately depend. Singapore, with its stable Government, strong economy, high education standards and well-deserved reputation for long-range planning, can and should set an example for the rest of the tropical world.

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References

Anon (1990). *Singapore: facts and pictures 1990.* Ministry of Communications and Information, Singapore.

Ashton, P.S. (1982). Dipterocarpaceae. *Flora Malesiana, Ser. I.* 9, 237–552.

Ashton, P.S., Givnish, T.J. and Appanah, S. (1988). Staggered flowering in the Dipterocarpaceae: new insights into floral induction and the evolution of mass fruiting in the aseasonal tropics. *Amer. Nat.* 132, 44–66.

Audley-Charles, M.G. (1981). Geological history of the region of Wallace's Line. In: Whitmore, T.C. ed. *Wallace's Line and Plate Tectonics*, Clarendon Press; Oxford; 24–35.

____. (1987). Dispersal of Gondwanaland: relevance to the evolution of the angiosperms. In: Whitmore, T.C. ed. *Biogeographical Evolution of the Malay Archipelago*, Clarendon Press; Oxford; 5–25.

Barlow, B.A. (1990). Biogeographic relationships of Australia and Malesia: Loranthaceae as a model. In: Baas, P., Kalkman, K. and Geesink, R. eds. *The Plant Diversity of Malesia*, Kluwer; Netherlands; 273–292.

Bush, M.B., Colinvaux, P.A., Wiemann, M.C., Piperno, D.R. and Liu, K.B. (1990). Late Pleistocene temperature depression and vegetation change in Ecuadorian Amazonia. *Quaternary Res.* 34, 330–345.

Cantley, N. (1884). *Report on the forests of the Straits Settlements.* Singapore Printing Office, Singapore.

Chia, L.S. and Foong, F.F. (1991). Climate and weather. In: Chia, L.S., Rahman, A. and Tay, D.B.H., eds. *The Biophysical Environment of Singapore*, Singapore University Press; Singapore; 13–49.

CLIMAP (1981). *Seasonal reconstruction of the Earth's surface at the last glacial maximum.* Geological Society of America, New York.

Corlett, R.T. (1987). Singapore. *Mangroves of Asia and the Pacific*, UNDP/UNESCO; 211–218.

. (1988*a*). The naturalized flora of Singapore. *J. Biogeogr.* 15, 657–663.

. (1988*b*). Bukit Timah: the history and significance of a small rain-forest reserve. *Environ. Conserv.* 15, 37–44.

. (1990). Flora and reproductive phenology of the rain forest at Bukit Timah, Singapore. *J. Trop. Ecol.* 6, 55–63.

______. (1991*a*). Vegetation: In: Chia, L.S., Rahman, A. and Tay, D.B.H., eds. *The Biophysical Environment of Singapore,* Singapore University Press; Singapore; 134–154.

______. (1991*b*). Singapore. In: Collins, N.M., Sayer, J.A. and Whitmore, T.C., eds. *The Conservation Atlas of Tropical Forests: Asia and the Pacific,* Macmillan; London; 211-215.

______. (1991*c*). Plant succession on degraded land in Singapore. *J. Trop. For. Sci.* 4 (2), 151-161.

______. (1992*a*). The ecological transformation of Singapore: 1819–1990. *J. Biogeogr.* 19, 411–420.

______. (1992*b*). The naturalized flora of Hong Kong: a comparison with Singapore. *J. Biogeogr.* 19, 421–430.

______. (1992*c*). The changing urban vegetation. In: Gupta, A. and Pitts, J., eds. *Physical Adjustments in a Changing Landscape: the Singapore Story,* Singapore University Press; Singapore; 190–214.

Corner, E.J.H. (1978). The freshwater swamp forest of South Johore and Singapore. *Gard. Bull. Sing. Suppl.* 1, 1–266.

______. (1988). *Wayside Trees of Malaya.* Malayan Nature Society, Kuala Lumpur.

Cortesao, A. (1944). *The Suma Oriental of Tome Pires: an account of the East, from the Red Sea to Japan, written in Malacca and in India in 1512–1515.* Hakluyt Society, London.

Dransfield, J. (1987). Bicentric distribution in Malesia as exemplified by palms. In: Whitmore, T.C. ed. *Biogeographical Evolution of the Malay Archipelago,* Clarendon Press; Oxford; 60–71.

Dunn, F.L. (1975). *Rain-forest collectors and traders: a study of resource utilization in modern and ancient Malaya.* Malayan Branch, Royal Asiatic Society, Kuala Lumpur.

Foxworthy, F.W. (1932). *Dipterocarpaceae of the Malay Peninsula,* Malayan Forest Records 10, Forest Department, Kuala Lumpur.

Geyr, M.A. and Kudrass, H.R. (1979). Sea-level changes during the late Pleistocene and Holocene in the Straits of Malacca. *Nature* 278, 441–443.

Gupta, A., Pitts, J., Rahman, A. and Wong, P.P. (1987). The Old Alluvium of Singapore and the extinct drainage system of the South China Sea. *Earth Surface Processes and Landforms* 12, 259–275.

Hails, C. (1987). *Birds of Singapore,* Times Editions, Singapore.

Hutchison, C.S. (1989). *Geological evolution of South-east Asia* Clarendon Press; Oxford.

Heaney, L.R. (1991). A synopsis of climatic and vegetational change in Southeast Asia. *Climatic Change* 19, 53–61.

Ives, D.W. (1977). *Soils of the Republic of Singapore,* New Zealand Soil Survey Report 36, New Zealand Soil Bureau; New Zealand.

Jackson, J.C. (1965). Chinese agricultural pioneering in Singapore and Johore, 1800–1917. *J. Malay. Branch Roy. As. Soc.* 38, 77–105.

Logan, J.R. (1847). The Orang Biduanda Kallang of the River Pulai in Johore. *J. Indian Archipelago and East Asia* 1, 299–302.

Lucas, P.W. and Corlett, R.T. (1991). The relationship between the diet of *Macaca fascicularis* and forest phenology. *Folia Primatologica* 57, 210–215.

Medway, Lord. (1972). Phenology of a tropical rainforest in Malaya. *Biol. J. Linn. Soc.* 4, 117–146.

Metcalfe, I. (1990). Allochthonous terrane processes in Southeast Asia. *Phil. Trans. R. Soc. Lond.* A 331, 625–640.

Miksic, J.N. (1985). *Archaeological research on the "Forbidden Hill" of Singapore: excavations at Fort Canning, 1984.* National Museum, Singapore.

Morley, R.J. and Flenley, J.R. (1987). Late Cainozoic vegetational and environmental changes in the Malay Archipelago. In: Whitmore, T.C. ed. *Biogeographical Evolution of the Malay Archipelago,* Clarendon Press; Oxford; 50–59.

Ng, F.S.P. (1977). Gregarious flowering of dipterocarps in Kepong 1976. *Malay. For.* 40, 126–137.

______. (1988). Forest Tree Biology. In: Earl of Cranbrook ed. *Malaysia.* Pergamon Press; Oxford; 102–125.

Oxley, T. (1847). Gutta Percha. *J. Indian Archipelago and East Asia* 1, 22–29.

Pirazzoli, P.A. (1991). *World atlas of Holocene sea-level changes,* Elsevier; Amsterdam; 114–115.

Public Works Department (1975). *Geology of the Republic of Singapore,* Public Works Department; Singapore.

Rahman, A. (1991). Soils. In: Chia, L.S., Rahman, A. And Tay, D.B.H., eds. *The Biophysical Environment of Singapore,* Singapore University Press; Singapore; 89–133.

Reid, A. (1988). *Southeast Asia in the age of commerce, 1450–1680.* Yale University Press, USA.

Ridley, H.N. (1900). The Flora of Singapore. *J. Roy. As. Soc. Str. Br.* 33, 27–196.

Singapore Meteorological Service (1986). A study of the urban climate of Singapore. In: Chia, L.S., Lee, H.C., Rahman, A., Tong, P.L. and Woo, W.K., eds. *Proceedings, The Biophysical Environment of Singapore and its Neighbouring Countries,* Geography Teachers' Association; Singapore; 50–76.

Takhtajan, A. (1986). *Floristic Regions of the World,* University of California Press, California.

Thomas, G.S.P. (1991). Geology and Geomorphology. In: Chia, L.S., Rahman, A. and Tay, D.B.H., eds. *The Biophysical Geography of Singapore,* Singapore University Press; Singapore; 50–88.

Thomson, J.T. (1848). Remarks on the Seletar and Sabimba tribes. *J. Indian Archipelago and East Asia* 1, 341–351.

______. (1850). General report on the residency of Singapore drawn up principally with a view to illustrating its agricultural statistics. *J. Indian Archipelago and East Asia* 4, 41–77, 102–106, 134–143, 206–219.

Turner, I.M., Chua, K.S. and Tan, H.T.W. (1990). A checklist of the native and naturalized vascular plants of the Republic of Singapore. *J. Sing. Nat. Acad. Sci.* 18, 100–130.

Walker, D. and Flenley, J.R. (1979). Late Quaternary vegetational history of the Enga District of upland Papua New Guinea. *Phil. Trans. Roy Soc. B.* 286, 265–344.

Wang, G. (1958). The Nanhai trade. *J. Malay. Branch Roy. As. Soc.* 31, 1–135.

Whitmore, T.C. (1990). *An Introduction to Tropical Rain Forests*, Clarendon Press; Oxford; 99–102.

Wong, Y.K. (1987). Ecology of trees at Bukit Timah Nature Reserve. *Gard. Bull. Sing.* 40, 45–76.

Five New Species of *Didymocarpus* (Gesneriaceae) from Peninsular Malaysia

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Abstract

Five new species of *Didymocarpus* are described from Peninsular Malaysia. Two, *D. anthonyi* Kiew and *D. leiophyllus* Kiew, are from the east coast and belong to sect. Boeopsis; *D. leucanthus* Kiew is from the foothills of Selangor; *D. stoloniferus* Kiew from Gunung Ulu Kali, Pahang; and *D. salicinoides* Kiew, from Trengganu and southern Kelantan, is raised to specific rank having previously been described as *D. salicinus* var. *major* Ridley. The sections Boeopsis and Salicini are defined and keys to their species provided. *Didymocarpus lithophilus* Kiew is validated.

Introduction

In common with several other large families of herbaceous plants, such as the Begoniaceae and Orchidaceae, the Gesneriaceae exhibits a high level of endemism (more than 90 per cent) in Peninsular Malaysia. Of the 85 odd species of *Didymocarpus* presently described, only *D. crinitus* Jack, *D. platypus* C.B.Cl. and *D. reptans* Jack (and possibly *D. fasciatus* Ridley) occur outside Peninsular Malaysia and southern Thailand. Within the peninsula, the majority of species is not widespread and 70 per cent are known from a single locality (Kiew, 1991).

Recent exploration of areas that are still botanically little known, such as the east coast, has led to the discovery of several new species. Two described here belong to sect. Boeopsis, a section which has a south-easterly distribution. However, even relatively well-known areas, such as Gunung Ulu Kali, may harbour undescribed species.

The last complete account of Malayan *Didymocarpus* is that in Ridley's flora (1923). There he recognised six sections based largely on characters of habit, inflorescence and floral morphology. These sections have remained broadly useful although several contain anomalous species. Sect. Elati (sect. Eudidymocarpus of Ridley) has been redefined by Weber & Burtt (1983). Section Didymanthus contains a hotchpotch of species including the anomalous *D. parviflorus* and *D. leucanthus* (see below), *D. falcatus* and *D. flavobrunneus*, which belong to another alliance (Burtt, 1990) and a group of species with large bracts (to be excluded from sect. Didymanthus and placed in a new section based on *D. venustus*). Section Reptantes and sect. Heteroboea remain as Ridley circumscribed them. Section Pectinati has been redefined to exclude *D. densifolius* (Kiew, 1987), which is now placed in sect. Salicini (see below). Section Boeopsis is here redefined. In addition, the genus *Codonoboea* is now reduced to sectional level in *Didymocarpus* (Kiew, 1990). There remain several species that do not fit comfortably into any of these sections, such as *D. caelestis* (Ridley) Kiew, *D. cordatus* Jack, *D. geitleri* Weber, *D. leucocodon* (Ridley) Kiew, *D. longipes* C.B.Cl., *D. primulinus*

Ridley, and *D. violascens* Ridley. Until details of floral morphology of the majority of species are better known, not only for the peninsular species but also for species throughout the geographic range of the genus, a fundamental revision of the sections will not be possible.

Descriptions of New Species

1. **Didymocarpus anthonyi** Kiew *sp. nov.*

Differt a *Didymocarpo heterophyllo* Ridley statura majore, foliis longioribus, lamina in petiolum decrescente et floribus majoribus.

Typus: Trengganu, Ulu Besut R. Kiew *RK 2700* (holo UPM; iso K, SING).

Erect, unbranched plant, stem woody to 37 cm by 6 mm thick, flowering at 9 cm tall. Indumentum of stem apex and petioles deep brown, densely matted with long uniseriate hairs. Leaves in a tuft at top of stem, upper internodes crowded, lower internodes to 5 mm apart. Lamina oblanceolate, (12.5–) 16 (–19) by 4–4.3 cm, narrowed to apex, base narrowly cuneate, sometimes unequal, glabrous above and beneath, in life deep green above and light green beneath, drying thinly leathery. Margin in the upper half of the leaf finely and distantly serrate with a tuft of hairs in the notch, in lower half ± entire, marginal strip hairy beneath. Secondary veins 11–16 pairs, midrib and secondary veins plane but conspicuous above, prominent beneath and sparsely hairy, arching close to margin, tertiary veins obscure above, prominent beneath. Petiole 1–2 cm long in youngest leaves elongating to 1.7–2.5 cm in older leaves, grooved above, geniculate abaxially.

Inflorescence 4-flowered cyme, several per axil. Peduncle 6–8.5 (–11 cm), erect with flowers held above leaves, brownish-purple, pedicel 10–17 mm. Bract pair ligulate, 6 by 1.5 mm long. Indumentum of peduncle, pedicel, bracts and calyx sparse with appressed, long, multicellular eglandular hairs with fewer short glandular hairs. Flowers nodding. Calyx divided almost to base, lobes narrowly acute, 2–3 by 1 mm. Corolla broadly campanulate, tube 5–6 by 7–8 mm, white, minutely pubescent outside, lobes broadly oblong, apex rounded, upper two 4–6 by 6 mm, pale to deep purple, reflexed, lower three 5 by 5–6 mm, white suffused purple, projecting 6–10 mm beyond upper. Stamens with thick fleshy filament, *c.* 2.5 mm long, joined to base of corolla tube, anthers white, broadly sagittate, 3 by 2 mm, connivent at apex. Ovary ellipsoid, 3 by 1.5 mm, purplish red, style whitish-green, 5 mm long and projecting beyond corolla tube, ovary and style minutely pubescent, stigma minute, rounded, *c.* 0.3 mm across, white, glistening, apex papillose. Disc none. Capsule narrowly ellipsoid, slightly curved, 3 cm long, *c.* 1.5 mm thick, ± glabrous.

Distribution: Endemic to Peninsular Malaysia — Trengganu, Ulu Besut.

Habitat: Hill slope, common on earth banks.

Specimens examined: Trengganu — Ulu Besut: Kg. Keruak 1 September 1986 S. Anthony *SA 675* (SING, UPM); Kg. La 7 May 1988 R. Kiew *RK 2700* (K, SING, UPM).

Notes: By virtue of its broadly campanulate, purple corolla and large, shortly stalked anthers, this species belongs to sect. Boeopsis. However, it is the most robust species in this section with stems that attain 37 cm in height. In its leaves, which are glabrous above, and in its simple cymes, it resembles *D. heterophyllus* Ridley, from which it is readily distinguished not only by its greater height, but also by its larger leaves, which are strongly narrowed to the base (in *D. heterophyllus* the leaf base is rounded), and in its larger flowers (Table 1).

Table 1
Diagnostic differences between *Didymocarpus anthonyi, D. heterophyllus* and *D. leiophyllus*

Character	*D. anthonyi*	*D. heterophyllus*	*D. leiophyllus*
Stem height (cm)	9–37	0–7	2–19
Lamina length (cm)	12.5–19	5–13.5	7–11
Lamina width (cm)	4–4.3	2–4	2.5–4
Lamina base	narrowed	rounded	narrowed
Leaf margin	distantly serrate	crenulate	± entire
Petiole length (cm)	1–2.5	0.5–3	1–2
No. flowers/inflorescence	4	3–4	1
Calyx length (mm)	2–3	1–2	4
Corolla length (mm)	9–12	3–4	11

This species is named for S. Anthonysamy, herbarium assistant in the Department of Biology, Universiti Pertanian Malaysia, who is an excellent field botanist and who made the first collection of this species.

Among species of *Didymocarpus* the indumentum of the ovary and style is variable both with regard to trichome type and their density. The difference between a finely pubescent indumentum of long-stalked trichomes and a pustulate indumentum consisting of short-stalked glandular ones is clearly discernible with the naked eye.

The range of stylar indumentum is illustrated in Plate 1. All species examined possess short-stalked glandular hairs, either with a single-celled rounded head (*D. corneri* Pl. le; *D. geitleri* Pl. 1g; *D. yongii* Pl. 1d) or with a 2-celled head (*D. leucanthus* Pl. 1a; *D. leucocodon* Pl. 1b) or with a 4-celled head (*D. anthonyi* Pl. 1c). Except for *D. yongii* (Pl. 1d), they possess in addition short, 2 or 3-celled eglandular hairs on a raised base. Those of *D. anthonyi* are exceptionally short. *D. leucanthus, D. quinquevulnerus* (Pl. 1h) and *D. platypus* possess a third type, long-stalked glandular hairs.

The density of stylar trichomes varies from extremely sparse (the style of *D. anthonyi* is almost glabrous), moderately sparse (*D. leucanthus, D. quinquevulnerus* and *D. platypus*) to, in most cases, dense (*D. corneri, D. geitleri, D. leucanthus, D. leucocodon,* and *D. yongii*).

Even with this small sample, trichome type is not apparently related to taxonomic affinity. Within sect. Boeopsis stylar trichome type differs among species: *D. anthonyi* has long eglandular and glandular hairs (the latter with a 4-celled head); *D. yongii* has only glandular hairs and these have a single-celled head. In addition, long-stalked glandular hairs are found in species in sect. Didymanthus (*D. leucanthus*) and in sect. Heteroboea (*D. quinquevulnerus*) and short, glandular trichomes with a rounded head are found in sect. Codonoboea (*D. corneri*) and sect. Boeopsis (*D. yongii*).

In species where the style projects beyond the corolla tube (*D. anthonyi, D. corneri* and *D. geitleri*), the predominant trichome type is short-stalked glandular trichomes and, in contrast, eglandular hairs are extremely sparse. It is tempting to suggest that these glandular hairs function to secrete substances that attract the pollinator either by scent (none of these species has a scent perceptible to the human nose) or by sight. The indumentum is glistening in all species and in some species contrasts in colour

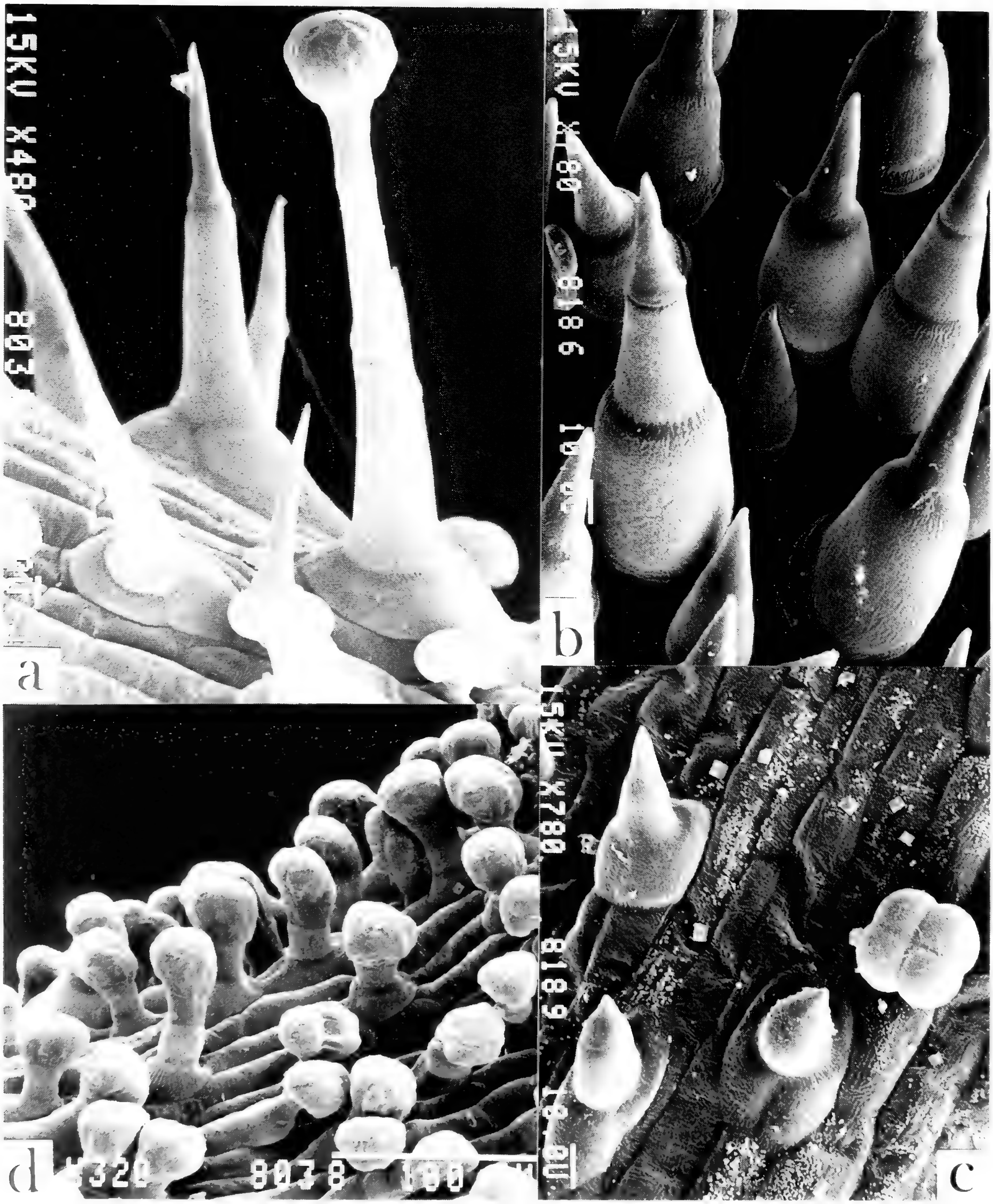

Plate 1. Stylar trichomes in *Didymocarpus*.
a. *D. leucanthus*; **b.** *D. leucocodon*; **c.** *D. anthonyi*; **d.** *D. yongii*.

with the white corolla. It is pale fawn in *D. corneri* and magenta-purple in *D. geitleri*. Weber (1989) recorded the indumentum of the latter species as orange. In contrast, the white style of *D. anthonyi* is almost glabrous.

Long-stalked glandular hairs are found in those species which have a long corolla tube which includes the style, namely *D. leucanthus* and *D. quinquevulnerus*. It is possible, therefore, that trichome type is related to pollinator guild rather than to taxonomic affinity.

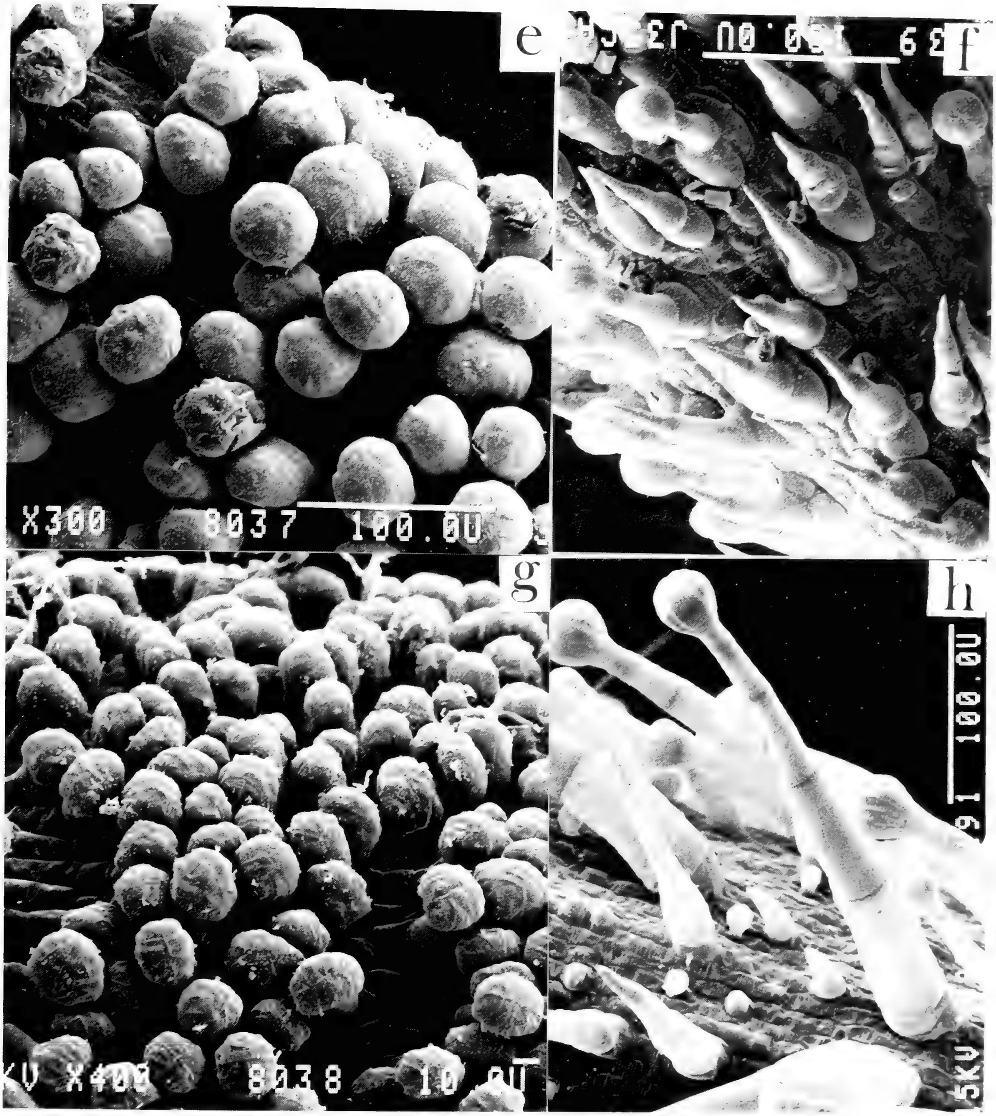

Plate 1. Stylar trichomes in *Didymocarpus* (cont.).
e. *D. corneri* (below stigma); **f.** *D. corneri* (above ovary); **g.** *D. geitleri*; **h.** *D. quinquevulnerus*.

In general, the indumentum of the ovary is more dense than that of the style (with the exception of *D. leucocodon* (Pl. 2b) where it is more dense on the style). In some cases trichome type is the same on the style and ovary, although the hairs may be longer (e.g. *D. leucanthus* Pl. 2a, *D. anthonyi* Pl. 2c) or shorter (e.g. *D. leucocodon*) on the ovary. In other species, (*D. geitleri* Pl. 2f, *D. corneri* Pl. 2e and *D. yongii* Pl. 2d) trichome type on the style and ovary is different because short-stalked glandular trichomes with a rounded head are absent from the ovary. In *D. yongii*, in addition to eglandular hairs, there are long-stalked glandular hairs on the ovary. These latter species have a transitional zone in the lower part of the style where all types of trichome are present. This is seen in *D. corneri* (Pl. 1f) where three trichomes types are present. The transitional zone in *D. geitleri* is illustrated by Weber (1989).

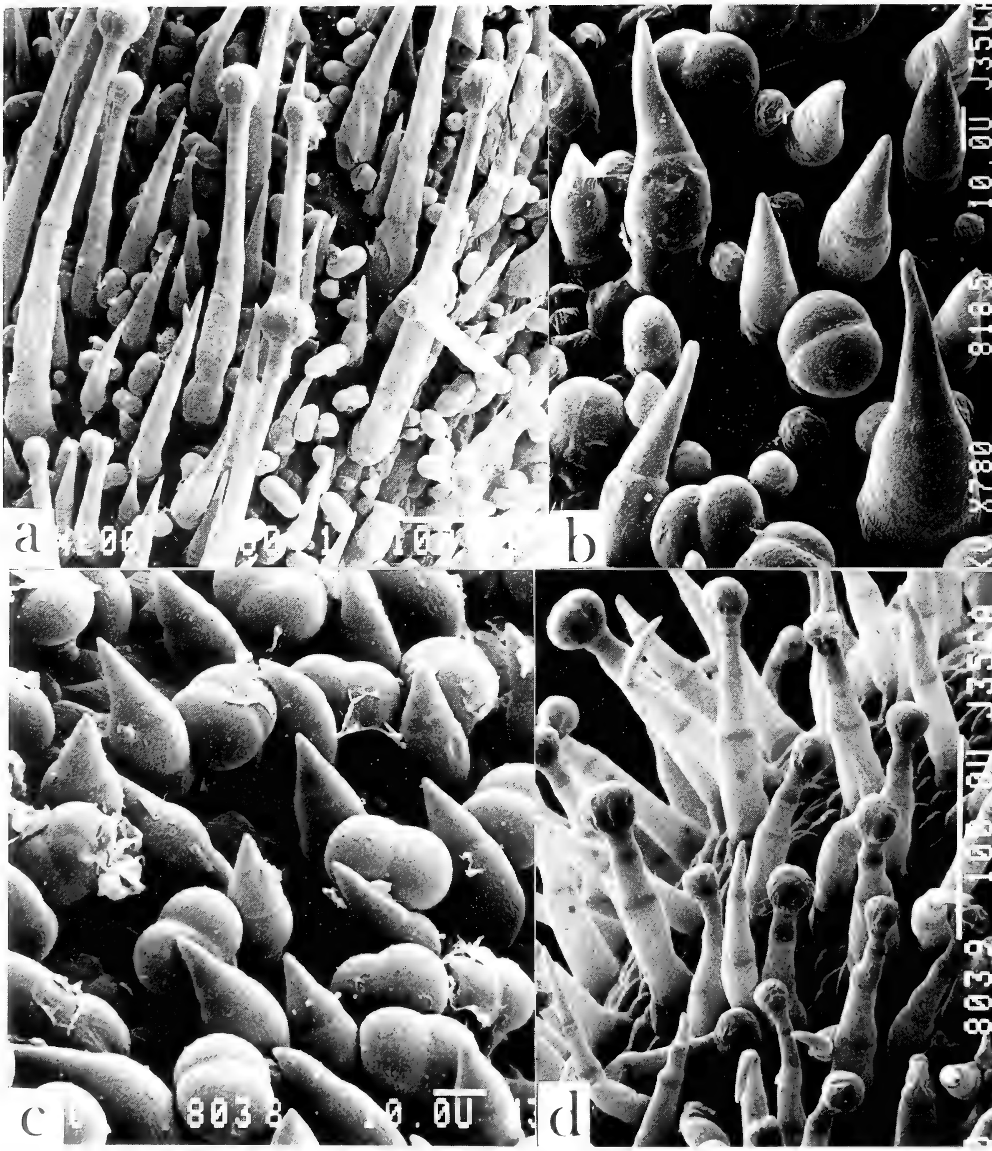

Plate 2. Trichomes of the ovary of *Didymocarpus*.
a. *D. leucanthus*; **b.** *D. leucocodon*; **c.** *D. anthonyi*; **d.** *D. yongii*.

In all species examined (except for *D. quinquevulnerus*, Pl. 2h), there is a preponderance of short eglandular hairs, which suggests they may play a protective role in the immature ovary.

2. **Didymocarpus leiophyllus** Kiew *sp. nov.* Plate 3

Differt a *Didymocarpo heterophyllo* Ridley inflorescentia uniflora, foliis fere integerrimis et floribus majoribus.

Typus : Trengganu, Ulu Setui R. Kiew *RK 2265* (holo UPM; iso SING).

Erect, unbranched plant, stem woody to 19 cm and 3–4 mm thick, flowering at

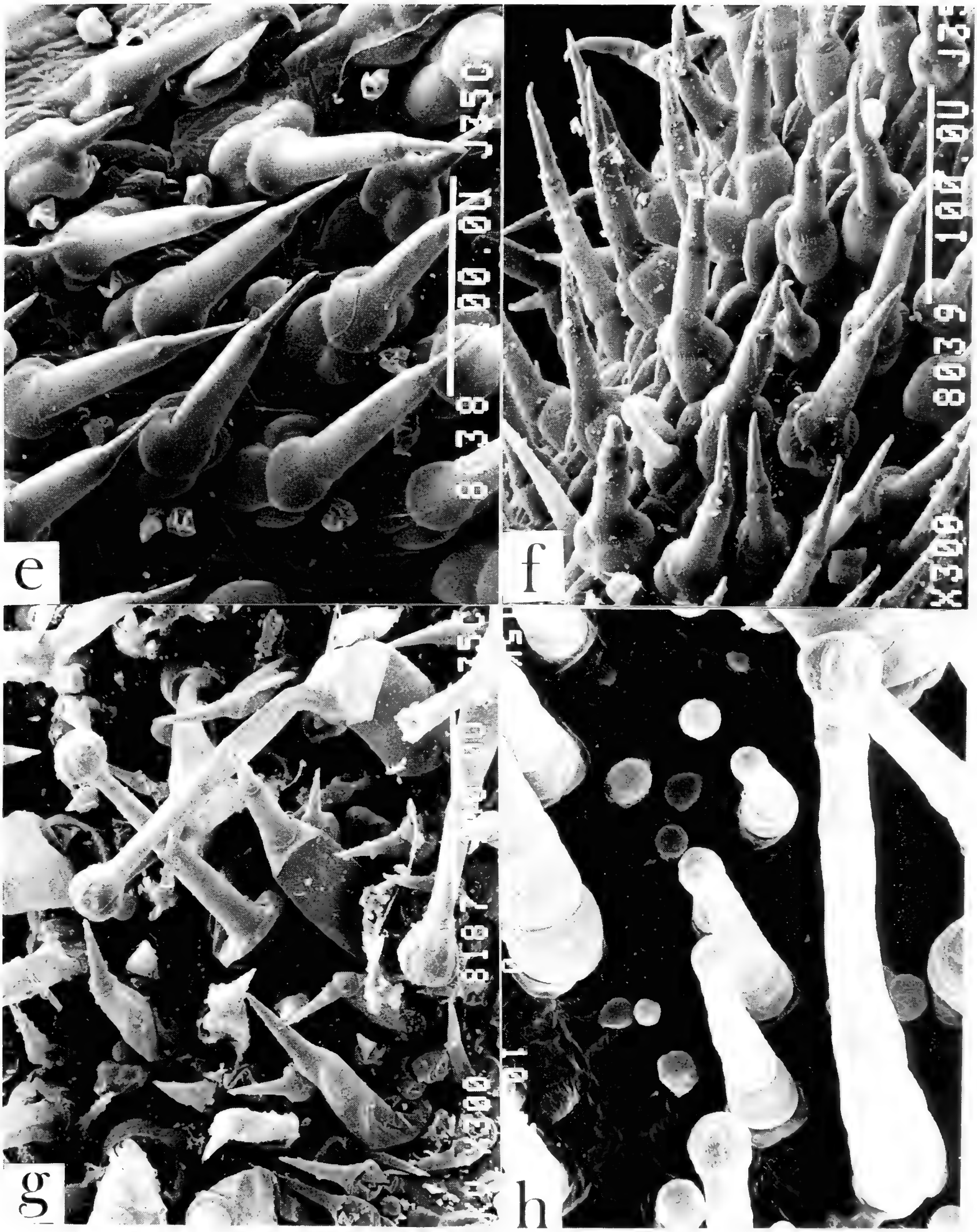

Plate 2. Trichomes of the ovary of *Didymocarpus* (cont.).
e. *D. corneri*; **f.** *D. geitleri*; **g.** *D. platypus*; **h.** *D. quinquevulnerus*.

2 cm tall. Leaves forming a tuft at the top of the stem, lower leaves to 2.5 cm apart, spirally arranged. Lamina oblanceolate, 7–11 by 2.5–4 cm, apex acute or sometimes shortly acuminate, narrowed to base, unequal, glabrous above and beneath, in life dark green above, paler beneath, fleshy drying thinly leathery. Margin ± entire, sometimes shallowly dentate towards apex, marginal strip hairy beneath. Midrib prominent above and beneath, secondary veins 8–14 pairs, plane above, prominent beneath, arching close to margin, tertiary veins ± obscure beneath. Petiole 1 (–2) cm. Indumentum

of stem apex, petiole, and lower surface of midrib and secondary veins of appressed uniseriate hairs.

Inflorescence 1-flowered. Peduncle and pedicel slender, purple-red, minutely pubescent, erect, 3.5–6 cm long with flowers held above leaves. Bract pair ligulate, 1.5–2 mm long. Calyx divided almost to base, lobes narrowly acute, 4 by 1 mm, purple-red, pubescent. Corolla broadly campanulate, tube 6 by 5 mm, white or bluish purple, minutely pubescent outside, lobes broadly oblong, apex slightly rounded, 5 by 4–5 mm, pale lilac, upper lobes reflexed. Stamens with filaments 1.5–2 mm long, broadening to the base and joined to base of corolla tube, anthers broadly sagittate, 2 by 1 mm, connivent. Ovary narrowly ovoid, 5 by 1.3 mm, style 5 mm long, yellowish, minutely hairy and projecting beyond the corolla tube, stigma slightly discoid ± 1 mm across. Disc encircling base of ovary, *c.* 0.5 mm tall, deeply lobed. Capsule narrowly ovoid, slightly curved, 1.5–3.3 cm, purple, minutely hairy.

Distribution: Endemic to Peninsular Malaysia – Trengganu, Ulu Setui.

Habitat: Locally common in lowland forest on slopes above river banks or on steep earth banks.

Specimens examined: Trengganu – Ulu Sg. Setui 28 April 1986 R. Kiew *RK 2265* (UPM, SING), 29 April 1986 *RK 2272* (UPM), 30 August 1986 S. Anthony *SA 662* (UPM), 31 August 1986 *SA 670* (UPM), 5 November 1986 *SA 718* (UPM).

Plate 3. *Didymocarpus leiophyllus.*

Notes: *D. leiophyllus* (Pl. 3) is a distinctive species in its smooth leaf surface (the veins are not impressed above) and in its almost entire leaves. It belongs to sect. Boeopsis. In its flower it most resembles *D. anthonyi* in size (both have a larger flower than *D. heterophyllus*) and in colour (they both have a white or very pale purple corolla tube and lobes which are a deeper purple compared with *D. heterophyllus* where the corolla tube and lobes are uniformly mid-purple). Leaves of both *D. leiophyllus* and *D. anthonyi* are rather fleshy and have a pronounced pubescent marginal strip. *D. leiophyllus* differs from both *D. anthonyi* and *D. heterophyllus* in its single-flowered inflorescence (Table 1). Some populations of *D. puncticulatus* also have single-flowered inflorescences but *D. leiophyllus* would not be confused with it as *D. puncticulatus* has hairy leaves which are punctate above and which frequently have a paler band down the centre.

3. **Didymocarpus leucanthus** Kiew *sp. nov.*

***Didymocarpo parvifloro* Ridley affinis sed foliis margine crenaturis praeditis supra pubescentibus et floribus albis differt.**

Typus: Selangor, Ulu Ampang R. Kiew *RK 2767* (holo, UPM, iso SING).

Stem prostrate with erect branching woody shoots to 1 m tall and 3 mm thick, deep purple in life. Leaves opposite, equal-sized, distant up to 7 cm apart. Lamina lanceolate, 12–13.5 by 5–5.5 cm, apex acute or sometimes acuminate, base cuneate, in dried state chartaceous, margin minutely crenate. In life dark green above and pale beneath. Lateral veins *c.* 9 pairs and ascending towards margin, sometimes with a minor vein parallel to lateral veins but petering out midway to margin, lateral veins and midrib plane above, prominent beneath, tertiary veins obscure above and below. Indumentum of short uniseriate hairs with *c.* 4 cells, on stem and petiole dense and appressed, lamina silky above and roughly pubescent beneath, with both long and short hairs. Lamina minutely pustulate beneath. Petiole terete, 1.5 to 3 cm long, deep purple in life.

Inflorescence axillary, 1-flowered, produced in a series so that axils bear buds, flowers and fruits at the same time. Peduncle and pedicel slender, 6–8 mm long, lengthening to 12 mm in fruit. Indumentum of peduncle, pedicel, bracts and calyx dense consisting of minute glandular hairs. Bracts ligulate 2 mm long. Calyx divided to base, lobes ligulate, 2 by 1 mm. Corolla narrowly tubular, white with a yellow spot at base of tube, tube 9 by 4–5 mm, minutely pubescent outside, lobes 5, oblong, apex broadly rounded, upper lobes 3 by 2.5 mm, reflexed, minutely glandular hairs on inner surface, lower lobes 3 by 4 mm, projecting 5 mm beyond upper lobes. Stamens 2, filaments slender 4 m long, anthers ellipsoid, 1.5 by 0.5 mm, connivent. Ovary narrowly cylindric 4 mm long, style enclosed within tube 3 mm long, densely pubescent, stigma rounded, 1 mm across, papillose. Disc 1 mm tall, subtending lower half of base of ovary. Capsule 3.5–4 cm long and 1 mm wide, densely pubescent.

Distribution: Endemic to Peninsular Malaysia — Selangor, Ulu Ampang.

Habitat: In lowland forest at *c.* 100 m, locally common and forming clumps on earth banks.

Specimens examined: Selangor, Ulu Ampang at Ampang Impounding Reservoir: 20 May 1984 R. Kiew *RK 1307* (UPM); 16 August 1988 *RK 2767* (UPM, SING).

Notes: *Didymocarpus leucanthus* most resembles *D. parviflorus* Ridley in its habit (it is decumbent producing erect, branching stems), in its long-petioled leaves and in its small, tubular corollas. It differs from *D. parviflorus*, which is a smaller, more or less prostrate plant and which has smaller leaves (25–50 by 6–13 mm) with entire margins, yellow flowers and shorter fruits (*c.* 1 cm long).

Ridley (1905, 1923) included *D. parviflorus* in sect. Didymanthus, presumably as it has distant pairs of leaves. However, both *D. parviflorus* and *D. leucanthus* differ from other members of this section by their smaller, tubular flowers, which are not produced on long-peduncled cymes. These two species should therefore be excluded from sect. Didymanthus as it is presently circumscribed. However, until the Malayan species are better known, it is premature to erect a new section for them. For example, the little-known *D. flavescens* Ridley is similar to these two species in its small tubular, yellowish-white flowers on single-flowered inflorescences, but it is conspicuously different in its long peduncles, which are 2.5–7 cm long.

Among Malayan species of *Didymocarpus, D. leucanthus* (Pl. 4a) is unusual in possessing a nectary that does not completely surround the base of the ovary. The most common type of nectary in the genus is cylindrical and relatively large. In sect. Heteroboea, nectaries range from 0.7 mm tall (*D. platypus*, Pl. 4e) to 0.9 mm (*D. quinquevulnerus*, Pl. 4f) to 1.5 mm tall in *D. polyanthoides*. This type of nectary is also seen in most other sections, e.g. in sect. Didymanthus (*D. parvifolius*), in sect. Codonoboea (*D. corneri*, Pl. 4d) and in sect. Boeopsis (*D. yongii*, Pl. 4c). That of *D. yongii* is unusual in being distinctly lobed.

Nectary morphology is not always a reliable indicator of taxonomic affinity, although all species in the *D. falcatus–D. flavobrunneus–D. pyroliflorus* alliance have unilateral nectaries (Weber, 1989). *D. leucanthus* also has a unilateral nectary but is not at all related to this alliance. Some closely related species have different nectary types, such as *D. parvifolius* and *D. leucanthus* (*D. parvifolius* has a cylindrical nectary *c.* 0.5 mm tall and *D. leucanthus* has a unilateral one) and *D. anthonyi* and *D. leiophyllus* (the former species does not have a nectary and in the latter the nectary is cylindrical and lobed).

Flowers of a few *Didymocarpus* species do not have a nectary (e.g. *D. anthonyi* and *D. codonion*) or have a very small one (*D. geitleri*, Weber, 1989; *D. leucocodon*, Pl. 4b). Weber has described the features of pollen flowers in *D. geitleri* and pointed out that the evolution from nectar to pollen as a floral reward has occurred in several genera of the Gesneriaceae. In the pollen flower, not only is the nectary reduced in size but the anthers are large and conspicuous in the gaping mouth of the corolla, which has a short tube. In *Didymocarpus* this type of flower often has a style which projects beyond the mouth of the corolla. This flower type is seen in sect. Boeopsis, in sect. Salicini and in sect. Codonoboea (*D. corneri*). However, in sect. Boeopsis nectary size ranges from large (*D. yongii*) to absent (*D. anthonyi* and *D. codonion*). In *D. yongii* the style is not exserted as it is in *D. anthonyi*. Some species, such as *D. leiophyllus*, while having an exserted style, also have a nectary.

That pollen flowers have evolved several times in the Gesneriaceae and probably also within a large genus such as *Didymocarpus* means that the position of *D. geitleri* should be reconsidered, especially as its leaf morphology and indumentum is more typical of sect. Heteroboea than sect. Boeopsis, with which Weber (1989) suggested it was allied.

There is still a great deal to be learnt about pollination in *Didymocarpus*. Although many *Didymocarpus* species produce striking flowers often in abundance (a single plant of *D. quinquevulnerus* Ridley can have up to 40 flowers open at any one time, although 20–30 are more usual), it is an extremely rare event to see an insect visitor. I have only observed pollination in one species, *D. robinsonii* Ridley, where on Gunung Tahan its flowers were visited by bumblebees. It is probable that various types of bees visit the large, trumpet-shaped flowers that have conspicuous nectar guides. For those

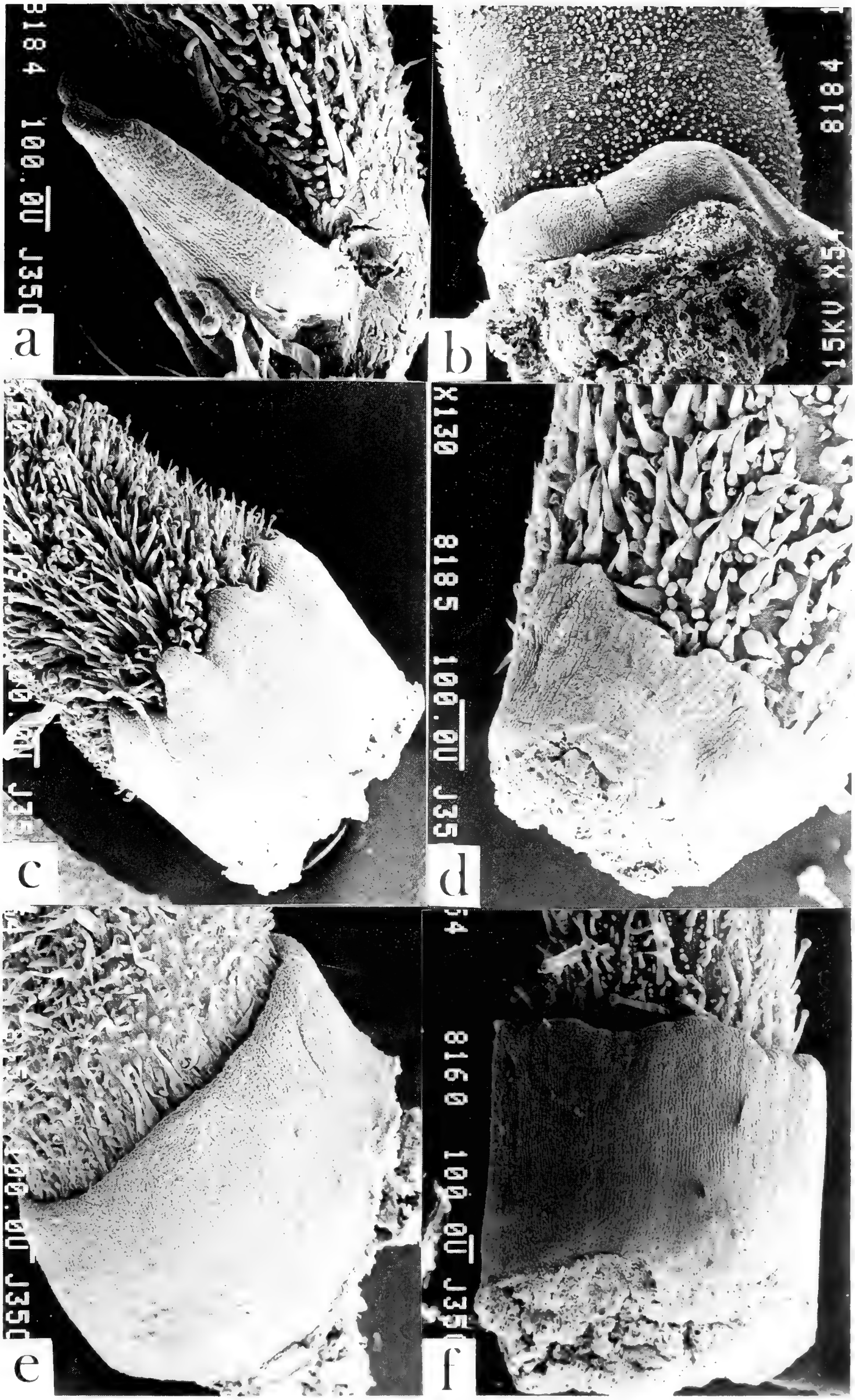

Plate 4. Nectary morphology in *Didymocarpus*.
a. *D. leucanthus*; **b.** *D. leucocodon*; **c.** *D. yongii*; **d.** *D. corneri*; **e.** *D. platypus*; **f.** *D. quinquevulnerus*.

species with narrow-tubed flowers, such as *D. leucanthus*, or small purple flowers of sect. Boeopsis and sect. Salicini, which do not have conspicuous nectar guides, or small white flowers with exserted styles found in *D. corneri, D. geitleri* and *D. pyroliflorus* the pollinator remains unknown. Nor is it known whether flowers of *D. leucocodon*, which are large, pure white and bell-like and have a relatively small nectary, are pollen or nectar flowers.

In all species of *Didymocarpus* that I have observed in the field, the stigma in the receptive phase is white and glistening, presumably due to secretions by the papillose cells (Pl. 5b). (Papillose cells in *D. leucocodon*, Pl. 5c, may be undeveloped as the stigma shown is from an immature gynaecium from a flower bud.)

In general, flowers with tubular corollas and enclosed anthers and style have larger, more or less discoid, peltate stigmas, e.g. *D. leucanthus* (Pl. 5a), *D. parviflorus* and *D. quinquevulnerus* (Pl. 5h), compared with those flowers with a projecting style, where the stigma is globose or minute and rounded (*D. anthonyi*, Pl. 5d; *D. corneri*, Pl. 5f; *D. geitleri*, Pl. 5g). The stigma of *D. geitleri* is unique among *Didymocarpus* species is possessing a conspicuously naked zone between the stigma and the pustular trichome layer on the style.

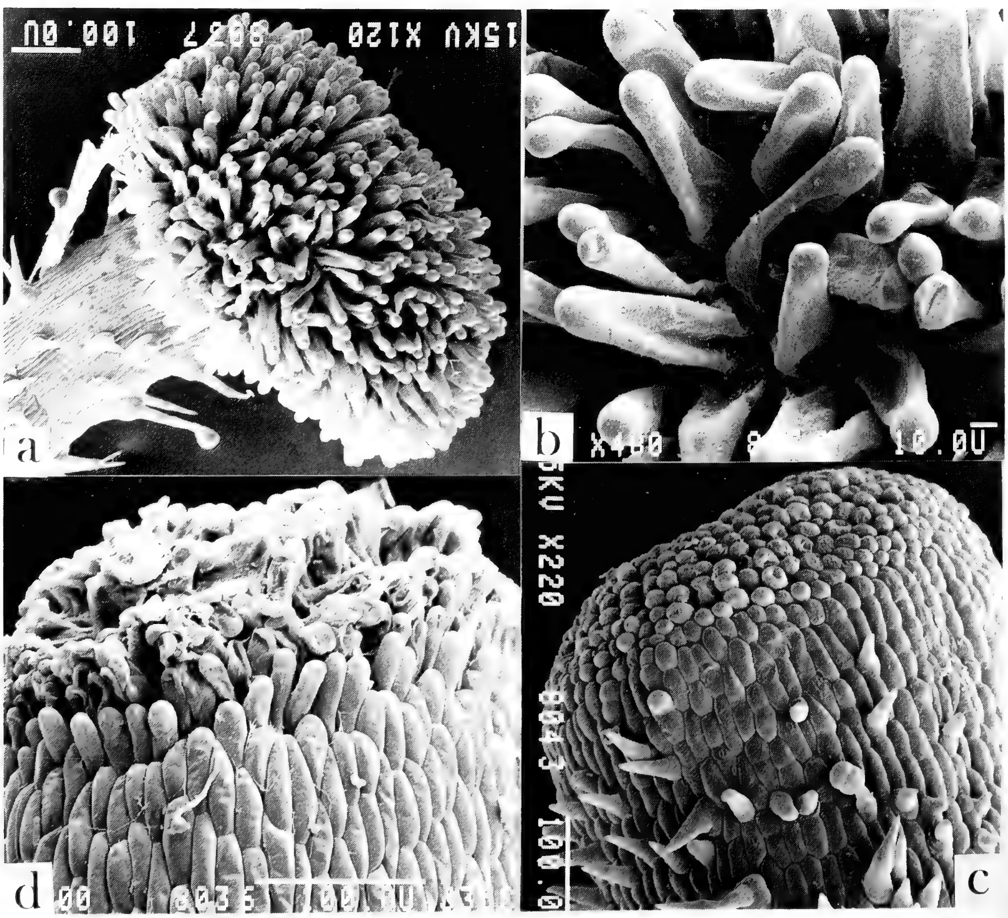

Plate 5. Stigma morphology in *Didymocarpus*.
a. *D. leucanthus*; **b.** papillose surface of *D. leucanthus*; **c.** *D. leucocodon*; **d.** *D. anthonyi*.

4. **Didymocarpus salicinoides** Kiew *stat. et nom. nov.*

Synonym: *Paraboea salicinia* (Ridley) Ridley var. *major* Ridley. Flora Malay Peninsula 5 (1925) 325.

Typus: Kelantan, Kuala Aring, *Yapp 193* (lecto K, isolecto CGE).

Distribution: Endemic to Peninsular Malaysia – south Kelantan, Trengganu.

Habitat: Lowland forest growing on earth banks.

Specimens examined: Kelantan – Kuala Aring 12 September 1899 *Yapp 193* (K, CGE); Trengganu – Kemaman, Ulu Bendong 30 October 1935 *Corner SFN 30027* (K), Bk.

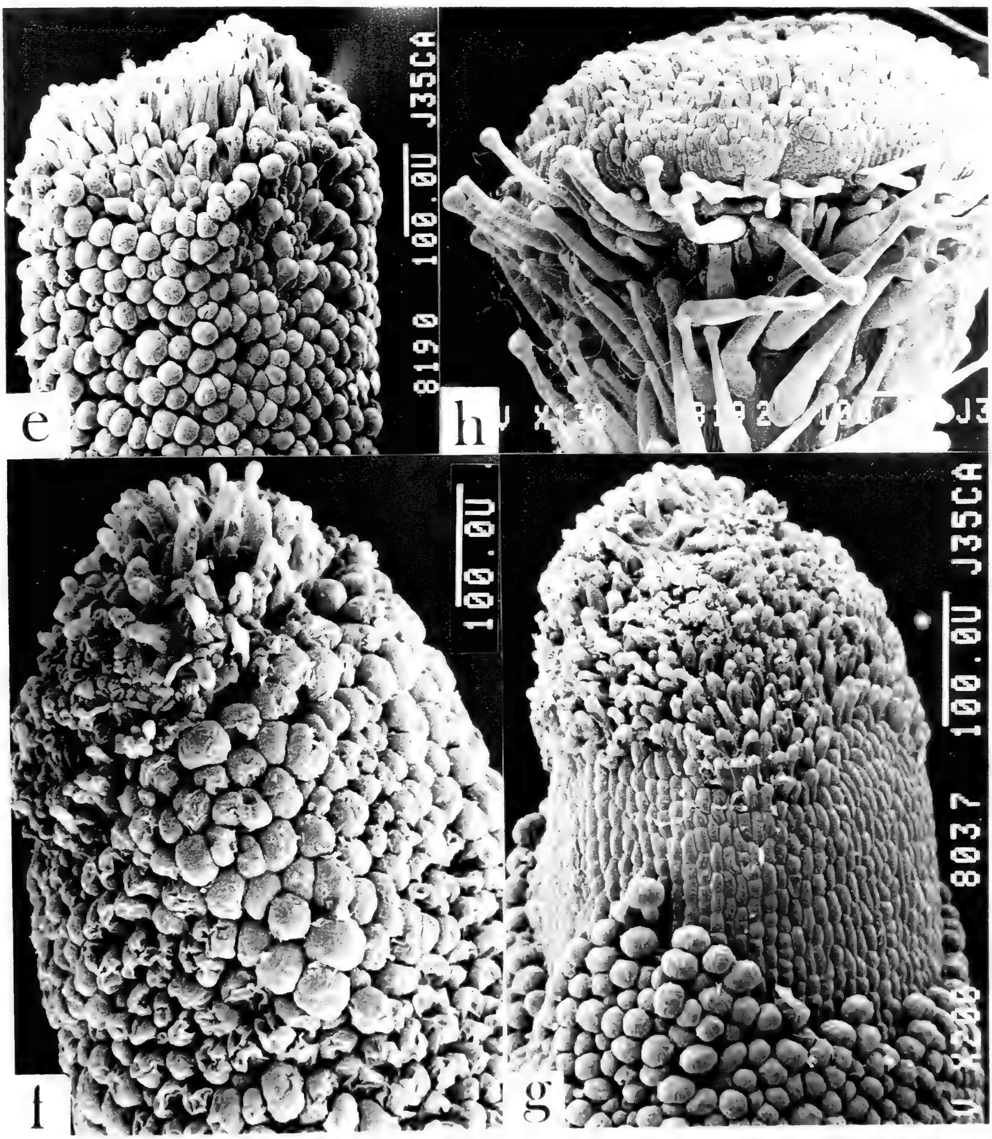

Plate 5. Stigma morphology in *Didymocarpus* (cont.).
e. *D. yongii*; **f.** *D. corneri*; **g.** *D. geitleri*; **h.** *D. quinquevulnerus*.

Kajang 2 November 1935 *Corner SFN 30198* (K), Bk. Bauk 27 August 1986 *S. Anthony SA 596* (UPM), Sg. Nipa 5 May 1988 *R. Kiew RK 2654* (K, L, SING, UPM).

Notes: This species shares several common characters with *D. salicinus* Ridley. Both are plants with a wiry stem with a tuft of narrowly lanceolate leaves at the top; the leaves are flat (i.e. the veins are not impressed above), glabrous and shiny above, thinly leathery and the margin is finely serrate; the flowers are small; and the fruits are short (12–20 mm long) and narrow. In addition, both produce young leaves which are white or pale pink at the base. The species epithet is chosen to reflect the close relationship between the two species.

Ridley (1925) distinguished his var. *major* from the typical variety by its broader leaves and panicled cymes. Table 2 lists additional differences between them.

Table 2
Diagnostic differences between *Didymocarpus salicinus* and *D. salicinoides*

Character	*D. salicinoides*	*D. salicinus*
Stem	unbranched	branched (small plants unbranched)
Leaf width (mm)	20–33	10–22
Leaf apex	acute	acuminate
Petiole length (mm)	(8–) 20 (–27)	(7–) 11 (–14)
Petiole & midrib with transverse ribs	+	–
Corolla length (mm)	3 (–4)	(2–) 3
Corolla colour	white with purple upper lobes	pale violet-pink
Inflorescence length (cm)	(4–) 5 (–8)	3 (–4)
Inflorescence type	twice branched cyme	simple cyme
No. flowers/inflorescence	7 (–10)	2–4

In addition, the habitat of these two taxa differs. Plants of *D. salicinus* are rheophytes, while those of *D. salicinoides* grow on earth banks in lowland forest not necessarily close to streams. While differences in leaf width may be attributed to the different conditions under which they live (and indeed plants of *D. salicinus* that grow above the flood level do have broader leaves, Kiew 1989), even when this is taken into account there is still a difference (Table 2).

It may be a coincidence that another species pair (*D. heterophyllus-D. floribundus*) shows this same difference in the riverine taxon having simple cymes and the forest undergrowth species panicled cymes and that these two species pairs grow together. Thus the plants with simple cymes, *D. salicinus* and *D. heterophyllus* grow along the Sg. Tahan, and *D. salicinoides* and *D. floribundus* grow together in the Kemaman area.

Didymocarpus salicinus and *D. salicinoides* belong to sect. Salicini.

5. **Didymocarpus stoloniferus** Kiew *sp. nov.*

Inter congeneribus Peninsulae Malaysiae habitu, foliis et fructibus ad *D. puncticulatum* accedens, sed stolonibus, pedunculis brevibus et corollis majoribus et tubaeformibus differt.

Typus: R. Kiew *RK 1638* (holo UPM, iso SING).

A rosette plant producing thin stolons 30 cm or longer with plantlets at intervals. Leaves in opposite pairs forming a compact rosette of *c.* 8 leaves. Lamina broadly elliptic 3–6 by 1.5–2.5 cm, apex acute (rarely acuminate), base rounded sometimes unequal, in life fleshy, drying membraneous, margin serrate. Indumentum on upper surface of lamina dense with 4-celled unbranched hairs with conspicuously raised hair base, dense on lower surface of lamina, midrib, veins and petiole. Midrib and secondary veins depressed above and prominent beneath, secondary veins 6–9 pairs, tertiary veins obscure above and below. Petiole slender, 6–40 mm long.

Inflorescence 1-flowered. Peduncle and pedicel 12–16 mm long. Indumentum of pedicel and calyx with glandular hairs with a multicellular stalk. Bracts linear 1.5–2 mm long. Calyx divided to base, lobes ligulate, 2–3 by 1 mm. Corolla trumpet-shaped, tube 17 mm long by 1.5 mm wide at base dilating to 9 mm across at mouth, glabrous, whitish tinged purplish-pink, throat white with 2 lemon-yellow nectar guides, lobes pale purple-pink, equal-sized, broadly oblong, apex rounded, 4 by 4–5 mm. Stamens 2, filaments slender 4 mm long, anthers ellipsoid, 2 by 1 mm, connivent. Ovary ovoid, 2.5 by 1 mm, style slender 19 mm long, ovary and style densely pubescent, stigma discoid *c.* 0.5 mm across, not projecting beyond the corolla tube. Disc cylindrical, *c.* 0.5 mm tall. Capsule 8–10 by 2.5 mm, spreading pubescent (*Burtt & Stone B 11690*).

Distribution: Endemic to Peninsular Malaysia – Pahang, Gunung Ulu Kali.

Habitat: Growing in moss on large granite rocks or rockfaces in upper montane forest at *c.* 1,600 m a.s.l.

Specimens examined: Pahang, G. Ulu Kali – 12 October 1978 *B.L. Burtt & B.C. Stone B 11690* (E); 25 March 1985 *Ruth Kiew RK 1638* (UPM, SING).

Notes: This species has been found at just two sites: one population was growing on the drier side of large rocks in forest (*B 11690*), the other on a sheer rock face some 15 m high, which forms one side of a damp, dark gully (*RK 1638*). Although the latter population has been visited at all times of year over a period of more than ten years, it has only been found in flower on two occasions (March 1985 and October 1989), when many plants were in flower. It is interesting that the other collection was also made in October (1978) when "the plants were flowering freely" (Burtt, pers. comm.).

The assignment of this species to one of the presently circumscribed sections is problematic. On the one hand its small rosette habit and short fruits ally it with sect. Boeopsis but it has neither the long peduncles nor the short campanulate corolla of this section; on the other hand its trumpet-shaped flower with distinct yellow nectar guides resembles species in sect. Heteroboea but it is not a robust plant with a woody stem and large leaves. Although it superficially resembles *D. puncticulatus* in sect. Boeopsis in its one-flowered inflorescence, its short fruit and small crenate leaves, which are hairy above; it differs from this species as *D. puncticulatus* does not have stolons, its leaves are punctate above and have a broad pale green band down the midrib, its inflorescence has a long peduncle and its flowers are shortly campanulate. In possessing stolons *D. stoloniferus* is unique among Malayan *Didymocarpus*.

Didymocarpus lithophilus Kiew Validated

Mr B.L. Burtt has pointed out to me that the application of *Didymocarpus kompsoboea* C.B.Cl. to a Malayan taxon being simply a misidentification, the new name *D. lithophilus* (Kiew, 1989) therefore requires a latin diagnosis to be valid, which is here supplied,

Didymocarpus lithophilus Kiew *spec. nov.*

Gardens' Bull. Singapore 42 (1989): 54.

Synonym: *D. kompsoboea* auct.; Ridley Trans. Linn. Soc. 2nd Ser. 3 (1893) 328; Fl. Mal. Pen. 2 (1923): 518 – non C.B.Cl. in DC Mon. Phan. 5 (1883) 92.

Typus: Ridley 2152 Kuala Tahan, Pahang (holo K; iso SING).

Didymocarpo platypodi **affinis sed venatione (in** ***D. lithophilo*** **areolis oblongis; in** ***D. platypode*** **areolis polygonalibus) et fructibus brevioribus differt. Differt a** ***Didymocarpo rugoso*** **foliis tenuibus non bullatis et pedunculis duplo longioribus.**

Section Boeopsis

Section Boeopsis includes species that are smallish rosette plants with broadly campanulate flowers. The earliest Malayan species in this group, *D. heterophyllus*, was described by Ridley in 1893. In 1896, he grouped it with *D. puncticulatus* Ridley in sect. Kompsoboea. The latter includes species with a rosette habit but their flowers are larger and trumpet-shaped compared with the smaller campanulate ones of either *D. heterophyllus* or *D. puncticulatus*. (Sect. Kompsoboea is not represented in Peninsular Malaysia.) In 1905 Ridley described a new section, Acaules, which he defined as comprising plants that are 'Stemless or nearly so. Leaves crowded' and in which he included *D. violaceus* Ridley, *D. lacunosus* Hook. f., *D. pumilus* Ridley as well as *D. heterophyllus, D. perditus* Ridley and *D. puncticulatus*. (Acaules is not available as a sectional name in *Didymocarpus*, as its lectotype, *D. lacunosus* has been transferred to *Chirita*.)

In 1907 Ridley described a new section, Boeopsis, to accommodate *D. perditus, D. puncticulatus, D. heterophyllus* and *D. battamensis* Ridley, the latter a species from Pulau Batam, an island south of Singapore. He described the species in this section as being small plants with short corolla tubes and two short stamens with thick sigmoid filaments and subglobose or elliptic anthers.

In his 1923 account of the genus, Ridley defined sect. Boeopsis as comprising plants with 'leaves crowded in a tuft at the top of a woody root stock, peduncles slender, flowers usually small' and in this he included *D. longipes* C.B.Cl., *D. primulinus* Ridley, *D. soldanella* Ridley, *D. pumilus* and *D. grandiflorus* Ridley, as well as those included in his 1907 account. *D. grandiflorus* (now renamed *D. ridleyanus* Burtt), on account of its distant pairs of leaves and large tubular flowers, obviously does not belong to this section and is now placed in sect. Didymanthus (Kiew, 1989). *D. longipes* and *D. primulinus* are both anomalous within this section in possessing yellow flowers with narrow corolla tubes. All other species in sect. Boeopsis have purple, campanulate corollas.

D. longipes is quite unlike any other Malayan species in its leaves and its condensed cymes borne on long peduncles. Its narrow tubular flowers recall those of *D. flavobrunneus* Ridley and *D. falcatus* Kiew. In 1896 Ridley had noted that 'it is difficult to find any species really nearly allied to this' and he did not place it in sect. Kompsoboea. In his 1905 account he included *D. longipes* in sect. Didymanthus (i.e. not in sect. Acaules with *D. heterophyllus* and *D. puncticulatus*). Burtt (1954) selected *D. longipes* as the lectotype of sect. Boeopsis based on Ridley's flora account of 1923 as he did not realize that this section had already been published in 1907 where it did not include *D. longipes* (Burtt, pers. comm.)

It is proposed here that sect. Boeopsis be redefined in its original 1907 sense and that *D. longipes, D. primulinus* and *D. ridleyanus* be excluded from the section. Burtt (1971) returned most species that Ridley had included in *Paraboea* sect. Campanulati to *Didymocarpus* sect. Salicini. However, sect. Salicini is best kept in Ridley's original sense for narrow-leaved species (see below). Only two of the remaining *Paraboea* species conform to the circumscription of sect. Boeopsis, viz. *D. floribundus* (Henderson) Burtt and *D. rubiginosus* (Ridley) Burtt, both of which have a rosette habit and purple, campanulate flowers. Apart from the two new species described above, another three recently described species, *D. codonion* Kiew, *D.* n.sp (proposed to be named *D. oreophilus* Kiew) and *D. yongii* Kiew all belong to this section. *D. perditus* Ridley is a synonym of *D. puncticulatus* (Kiew, 1987). Therefore at present, this section includes eleven species. *D. heterophyllus* is here chosen as the lectotype of the section as it is typical in its small rosette habit, its purple campanulate flowers and its short capsule.

Section Boeopsis Ridley J. Str. Br. Roy. Asiatic Soc. 49 (1907) 22; Ridley Fl. Mal. Pen. 2 (1923) 508.

Lectotype: *D. heterophyllus* Ridley Trans. Linn. Soc. 2nd Ser. 3 (1893) 329.

Small to medium-sized herbs, stemless or not, with a rosette of usually oblanceolate leaves, flowers held above the leaf rosette in a lax cyme of 3–18 (rarely 1–2) flowers, corollas short and broadly campanulate, purple (sometimes pink) without yellow nectar guides, stamens with short, thick filaments, anthers large, broadly oblong and prominently positioned in the mouth of corolla tube, style either contained within corolla tube or projecting well beyond it, ovary short, capsule short (up to 2.5 cm long).

Key to Malayan Species of Section Boeopsis

1. Peduncle more than 13 cm long 2
    2. Leaf velvety above, veins and lamina concolorous .... *D. rubiginosus*
    2. Leaf ± glabrous above, veins outlined in white .... *D. yongii*
1. Peduncle less than 10 cm long 3
    3. Inflorescence with one or sometimes 2 flowers 4
        4. Leaf glabrous above, margin ± entire .... *D. leiophyllus*
        4. Leaf hairy above, margin crenate 5
            5. Leaf sparsely hairy and minutely punctate above, fruit to 15 mm long .... *D. puncticulatus*
            5. Leaf densely velvety and not punctate above, fruit to 25 mm long .... *D. n. sp.*
    3. Inflorescence cymose with 3 or more flowers 6
        6. Inflorescence with 8 or more flowers 7
            7. Leaf petiole 2.5–7 cm, calyx 1–1.5 mm, corolla to 4 mm long .... *D. codonion*
            7. Leaf petiole 0.5–2 cm, calyx 3–5 mm, corolla to 7–9 mm long .... *D. floribundus*
        6. Inflorescences with 3–4 flowers 8
            8. Leaf silky grey above .... *D. pumilus*
            8. Leaf glabrous above 9
                9. Leaf 12–19 cm long, base narrowed .... *D. anthonyi*
                9. Leaf 5–13.5 cm long, base rounded 10
                    10. Leaf oblanceolate, apex acute, fruit *c.* 25 mm long .... *D. heterophyllus*
                    10. Leaf obovate, apex rounded, fruit *c.* 15 mm long .... *D. soldanella*

The geographic range of species in sect. Boeopsis is centred on the east and south of Peninsular Malaysia (Fig. 1). The majority are confined to the lowlands with the exception of *D. puncticulatus*, which has an altitudinal range from near sea level

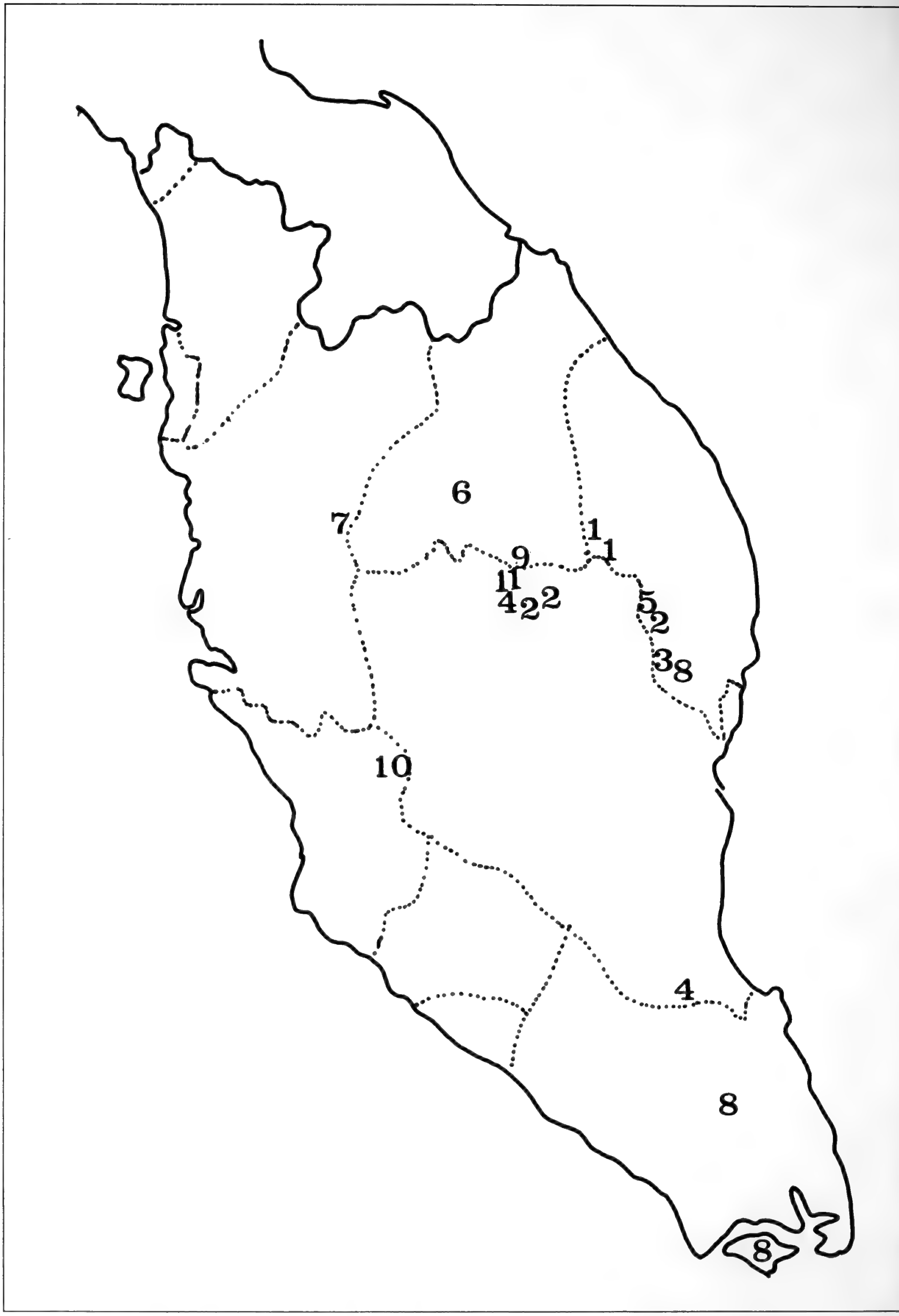

Fig. 1. Distribution of *Didymocarpus* species belonging to Section Boeopsis.
1. *D. anthonyi*; 2. *D. codonion*; 3. *D. floribundus*; 4. *D. heterophyllus*; 5. *D. leiophyllus*; 6. *Didymocarpus* sp. nov.; 7. *D. soldanella*; 8. *D. puncticulatus*; 9. *D. rubiginosus*; 10. *D. pumilus* and 11. *D. yongii*.

to 1,000 m. The few that are confined to the mountains include *D. rubiginosus* on Gunung Tahan (1,300–2,000 m), and *D.* n. sp. on G. Setong (1,000 m), *D. pumilus* on Fraser's Hill (1,000 m) and *D. soldanella* on G. Kerbau, the latter three are from the Main Range but notably not collected from the western side. Apart from *D. soldanella* (unfortunately poorly known from a single scrap of a fruiting specimen), the other montane species all have leaves that are densely hairy on the upper surface, as does *D. puncticulatus.* The grey, silky indumentum of *D. pumilus* recalls the appearance of species of *Loxocarpus* and indeed it is this section that includes the *Didymocarpus* species with the shortest fruits (Kiew, 1987). However, all species of *Loxocarpus* have much smaller flowers and the cymes are more compressed.

Section Salicini

Ridley (1896) described species in section Salicini as being 'small, short flowered species with narrow willow leaves crowded at the top of a short woody stem'. He included in this section *D. pectinatus, D. salicinus* and *D. densiflorus,* (the last an undescribed species based on a specimen collected by H.J. Kelsall from G. Janing, Johore). In 1905 he added *D. serratifolius.*

Ridley did not include this section in his 1923 account in which he transferred *D. salicinus* to *Paraboea* sect. Campanulati. The species that remained in *Didymocarpus, D. densifolius, D. pectinatus* and *D. serratifolius,* he placed in a new section Pectinati. (Section Pectinati is a distinct group of species with deeply serrate or pectinate leaf margins and small white tubular flowers. For this reason *D. densifolius* was excluded from this section, Kiew 1987).

In returning species from *Paraboea* Sect. Campanulati to *Didymocarpus* sect. Salicini, Burtt (1971) only excluded *D. cordatus* and *D. tahanicus* from sect. Salicini. However, apart from *D. caeruleus, D. filicifolius* and *D. salicinus,* the other species do not conform to Ridley's concept of the section comprising species with willow-shaped leaves. Kiew (1987) has suggested that sect. Salicini be used in its original restricted sense. It presently includes the following species: *D. densifolius* Ridley (syn. *Paraboea caerulea* Ridley and *D. azureus* Burtt, Kiew 1987), *D. salicinoides, D. salicinus* Ridley (syn. *D. filicifolius* Ridley, Kiew, 1989) and *D. tiumanicus* (Ridley) Burtt. (Although *D. holttumii* (Henderson) Burtt has narrowly lanceolate leaves, 8–11 by 1.5–2 cm, it does not belong to this section as its leaves are arranged in distant pairs. In addition, its flower buds are reported as yellow. Flower colour in sect. Salicini ranges from pink to purple to bluish-purple.)

Key to Species in Section Salicini

1. Leaf hairy above .... *D. tiumanicus*
1. Leaf glabrous above 2
    2. Leaves 10–19 cm long, decurrent, leaf margin entire, flowers 12–17 mm long .... *D. densifolius*
    2. Leaves 5–7 cm long, petiolate, leaf margin minutely serrate, flowers 2–6 mm long 3
        3. Cymes simple, petiole not transversely ribbed .... *D. salicinus*
        3. Cymes panicled, petiole and midrib transversely ribbed .... *D. salicinoides*

As mentioned above, *D. salicinoides* and *D. salicinus* are closely similar. They differ from *D. densifolius* and *D. tiumanicus* in their smaller flowers and slender peduncles. (*D. tiumanicus* has corollas *c.* 12 mm long). This raises the suspicion that this section may include rheophytes, and that the tufted habit and willow-shaped leaves reflect ecological adaptation rather than relatedness of the species. The purple campanulate corolla with a wide mouth and conspicuous white anthers is also seen in sect. Boeopsis. However, until the range of floral structure in *Didymocarpus* is more fully understood, it is premature to split this section further.

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References

Burtt, B.L. (1954). Studies in the Gesneriaceae for the Old World. Sections proposed by Ridley. *Notes Roy. Bot. Gard. Edinb.* 21: 203–225.

______. (1971). Studies in the Gesneriaceae of the Old World. *Didymocarpus* sect. Salicini. *Notes Roy. Bot. Gard. Edinb.* 31: 43–44.

______. (1990). Gesneriaceae of the Old World. II. A new *Didymocarpus* from Sumatra. *Edin. J. Bot.* 47: 235–237.

Kiew, R. (1987). The herbaceous flora of Ulu Endau, Johore-Pahang, Malaysia, including taxonomic notes and descriptions of new species. *Mal. Nat. J.* 41: 201–234.

______. (1989). *Didymocarpus* (Gesneriaceae) on Gunung Tahan, Malaysia. *Gard. Bull. Sing.* 42: 47–64.

______. (1990). Reassessment of the generic status of *Codonoboea* (Gesneriaceae) and its species. *Blumea* 35: 167–176.

______. (1991). Herbaceous Plants. In R. Kiew (ed.). *The State of Nature Conservation in Malaysia.* Malayan Nature Society, Kuala Lumpur, pp. 71–77.

Ridley, H.N. (1893). On the flora of the eastern coast of the Malay Peninsula. *Trans. Linn. Soc.* 2nd Ser. 3: 329.

______. (1896). Cyrtandraceae Malayenses — *Didymocarpus* sect. Salicini and sect. Kompsoboea. *J. Linn Soc. Bot.* 32: 514.

______. (1905). The Gesneriaceae of the Malay Peninsula. *J. Roy. As. Soc. Str. Br.* 43: 27–57.

______. (1907). New or rare Malayan Plants. Section Boeopsis. *J. Roy. As. Soc. Str. Br.* 49: 22.

______. (1923). *Didymocarpus. Fl. Mal. Pen.* 2: 506–523.

______. (1925). *Didymocarpus. Fl. Mal. Pen.* 5: 325.

Weber, A. (1989). *Didymocarpus geitleri*, a remarkable new species of Gesneriaceae with deceptive pollen flowers. *Pl. Syst. Evol.* 165: 95–100.

Weber, A. & Burtt, B.L. (1983). *Didymocarpus corchorifolius* and its allies (Gesneriaceae). *Blumea* 28: 291–309.

Notes on the Development of the Fruit-bodies of Four Malayan Species of *Amanita* (Basidiomycetes)

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Abstract

The development of the fruit-bodies was observed under natural conditions in the forest. Those of *A. elata*, *A. princeps* and *A. virginea* took 12–14 days to reach maturity when they persisted for merely 1–3 days. Expanded fruit-bodies soon became fly-blown and this hastened their decay. *A. elata* and *A. princeps* fructify early in the fungus season, as do most Malayan species, but *A. virginea* appears towards the end of the season. The presence of these species is revealed only for a few days twice each year.

Introduction

These observations were made in 1929–1931. The species used to fructify in roughly the same places every year in the Singapore Botanic Gardens Jungle and at Bukit Timah Forest Reserve, as if they were mycorrhizal, though I could not associate them with particular trees. However, this fact enabled me to disturb the humus gently in the likely spots and discover the young primordia. When to look for them was a few days after heavy rain had soaked the ground after the drier months of January–February and July–August (Corner, 1935). These species were described by Corner and Bas (1962).

Amanita elata (Mass.) Corner et Bas

From 22 March and 22 September 1930 I watched the successful development of 6 fruit-bodies in the Singapore Botanic Gardens Jungle. They reached, eventually, overall heights of 70–95 mm with pilei 25–80 mm wide. Several other fruit-bodies which I began to measure rotted off before the stem emerged from the volva. Measurements were made at about 8 a.m. daily. On day 1, the unopened volva was 8–10 mm high, 4–5 mm wide. By day 3, it had grown to 16–25 mm high, 9–13 mm wide. At 8 a.m. on day 4, the volva had ruptured, evidently during the night, and the stem had begun to project the pileus; the overall height was 26–63 mm but the convex pileus was merely 14–20 mm wide; the volva had ruptured into flat pieces on the unopended and pale umber pileus. On day 5, four fruit-bodies A–D were fully expanded, 70–78 mm high with plane pilei 30–60 mm wide. Two fruit-bodies, E and F, were *c.* 80 mm high with half-open pilei 30–46 mm wide. On day 6, fruit-bodies A–D were the same but E and F had fully expanded, 80–95 mm high with plane pilei 36 and 80 mm wide respectively. On day 7, A–D were dead. On day 8, E and F had collapsed by 4 p.m.

Full expansion from the volva had taken 48–72 hours and seemed to occur mainly during the night. The plane pileus persisted sporing for some 50–60 hours. From the incidence of heavy rain at that time, I judged that the mycelium had taken *c.* 10 days to develop the primordia to their state on day 1. The full life of the fruit-body, therefore, would be 14–15 days with a sporing period of *c.* 2 days or 50–60 hours.

The largest fruit-bodies that I recorded for this species had stems 13 cm long and pilei 9 cm wide. Such fruit-bodies might require an extra day for development and enjoy another day of sporing.

Amanita sp. aff. **A. fritillaria** (Berk.) Sacc.

On 15 March 1931 I marked two young fruit-bodies of this species in the Singapore Botanic Gardens Jungle. They were expanding with overall height 30 mm and pilei 11 mm wide. They expanded fully overnight and next morning were 73 mm high with plane pilei 38 mm wide. They lasted, evidently sporing, in this state for *c.* 36 hours before collapsing.

Amanita princeps Corner et Bas

In March and September 1930, I watched the development of 18 specimens of this lofty species. It grew in the deep shade of Fern Valley in Bukit Timah Forest Reserve. My observations were made at 3–4 p.m. The youngest specimens found were enclosed in the volva 15–21 mm wide. In 2 days the volva had enlarged to 32–48 mm wide. The next day, which was day 4 in the sequence, the volva had ruptured, evidently at night, and the stem had reached its full height 15-25 cm but the pilei were only one quarter to half open with the intact veil still covering the gills. On day 5, the pileus was fully expanded, plane or concave, 10–19 cm wide. The fruit-bodies then persisted for some 36–48 hours before becoming rotten. Many flies and small beetles had crawled over the expanding pilei to lay their eggs, and larvae together with the heavy rain hastened the demise of the fruit-bodies. Early development up to the rupture of the volva probably took some 12 days. In my experience this conspicuous fungus could be seen merely on 3–4 days, twice a year in March and September.

Amanita virginea Mass.

This fungus is unlike other species of the genus in the Malay Peninsula because it fruits towards the end of the fungus season after 2–3 months of rainy weather. The fruit-bodies are not to be found in the usual run of fungus about March and September but in May or November–December. In 1929 I watched the development of 10 fruit-bodies which came up in the Singapore Botanic Gardens Jungle in the second half of November and in the first half of December. Four of these failed to grow beyond an early stage when the primordia were merely a few days old. The others conformed to the sequence shown in Table 1.

The primordia took 8–10 days to develop from 10–15 mm high to the fully expanded state. The sporing period from the rupture of the veil to the collapse of the fruit-body varied from 30–70 hours. The expanded fruit-bodies were soon swarmed over by little flies, and how long they would last clearly depended on the extent to which they were fly-blown.

In 3 fruit-bodies the veil began to rupture about noon but was not fully broken and detached until 4 hours later. In one case the veil ruptured during the night. The veil split irregularly and fell to the ground in fairly large pieces.

It seemed likely that the primordia 10–15 mm high were not more than 3–4 days old. All the primordia and the freshly expanded fruit-bodies had very firm, turgid and compact texture. On section, a pale amber fluid issued from the cut surface, especially of the pileus and stem-apex.

Table 1
Fruit-body development of *Amanita virginea*

Day 8 a.m.	Height overall mm	Pileus width mm	
1	10–15	9–10	pileus a small hump
2	20	14	
3	25	18	
4	38	23	
5	45	30–35	
6	60	40–45	
7	75–85	50–55	
8	90–100	75–85	veil rupture
9	105–140	135–145	
10	110–150	150–190	fully grown

References

Corner, E.J.H. (1935). The seasonal fruiting of Agarics in Malaya. *Gard. Bull. Str. Settl.*, IX: 79–88.

_____ and Bas, C. (1962). The genus *Amanita* in Singapore and Malaya. *Persoonia* 2: 241–304.

Notes on the Rare Fern, *Pteris holttumii* C. Chr.

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Abstract

Pteris holttumii C. Chr. was found in the vicinity of the lowland dipterocarp forest of Dent Peninsula, of Lahad Datu. It is the second record for Malaysia, and the only known record from the lowlands for the species.

Introduction

There is no comprehensive study on the Sabah ferns reported to date. The only detailed reference available is the work of Christensen and Holttum (1934) on the Mount Kinabalu ferns. The more recent treatments on the subject are rather general or restricted to specific taxa only (Price, 1987; Bidin & R. Jaman, 1989; Bidin, R. Jaman & K.M. Salleh, 1988). The richness of ferns in Sabah as exemplified by Mount Kinabalu, which habours about 500 species, will only be known once thorough studies have been conducted on the Crocker and Trus Madi Ranges as well as the lowlands.

In one of the many collecting trips to Sabah in search of ferns, the authors came across a handsome fern of the genus *Pteris* in the lowlands of the Tabin Wildlife Reserve of Dent Peninsula (near Lahad Datu, East Sabah, alt. 50 m). The fern, *Pteris holttumii* C. Chr. was found on a steep river bank near a waterfall. Extensive search in the area failed to find the species in other localities. Specimens collected are deposited at the Universiti Kebangsaan Malaysia Herbarium (UKMB) and a live plant brought back is grown in the Fernery of the same University (Fig. 1).

The find constitutes the second record for the species in Sabah. In describing the species in 1934, Christensen wrote: "This splendid new species, which I dedicate to its collector, is the finest novelty discovered in recent years. . . . " The species collected by R.E. Holttum near Dallas Mt. Kinabalu (alt. ± 850 m) in 1931 was never recorded again in Sabah until the Tabin specimen surfaced. As for the region, the only finding for the species was by Hovenkamp & De Joncheere in Palu, Sulawesi at 500 m (Hovenkamp & De Joncheere, 1988).

Observations

External Features of *P. holttumii*

The gross morphological characters of the species resembles *Acrostichum aureum* in terms of size and divisions of frond. These characters prompted Christensen and Holttum to suggest that *Acrostichum* is derived from the Pterideae.

Rhizomes creep horizontally, slightly beneath ground, bearing solitary fronds at short intervals; thickly covered (especially at stipe base) by long wiry roots. Stipes are

Fig. 1. *Pteris holttumii* growing at the Universiti Kebangsaan Fernery.

grooved on the inner side, scattered, pale to yellowish, hard conicle prickles present. Fronds are simply pinnate; pinnae uniform, basal pinnae not branched on the basiscopic sides near the base, basiscopic side of the base fused to the rachis, each pinna about 40 cm long. Rachises and upperside of costae are grooved, lower costae prominent. Veins are reticulate, forming up to 10 series of aerioles. Sori are marginal, elongated, without inner indusium (Fig. 2 A–E).

Endomorphic Characteristics of the Stipe

In transectional view, the stipe is subsulcate in outline enclosing a single vascular bundle which runs throughout the stipe. The bundle is a modified U-shaped strand with a wide base.

Ogura (1972) stressed the importance of the shape of the xylem strand in segregating families and genera of ferns, including relationships among taxa. In *Pteris holttumii* the xylem strand follows the outline of the bundle with both ends curved inside but without hooks, which in Ogura's classification is termed as the non-hippocampus type (Fig. 2B).

Summary

Pteris holttumii was first collected in Sabah in 1931 and described in 1934. Extensive botanical surveys by later workers in other parts of Borneo (Iwatsuki *et al.* 1980; Iwatsuki & Kato, 1980*a*, & *b*, 1981 & 1983*a* & *b*) did not include the fern in their lists. With the present finding and that of Hovenkamp and De Joncheere in Sulawesi, it is established here that *P. holttumii* is found in the lowlands as well as at high elevations.

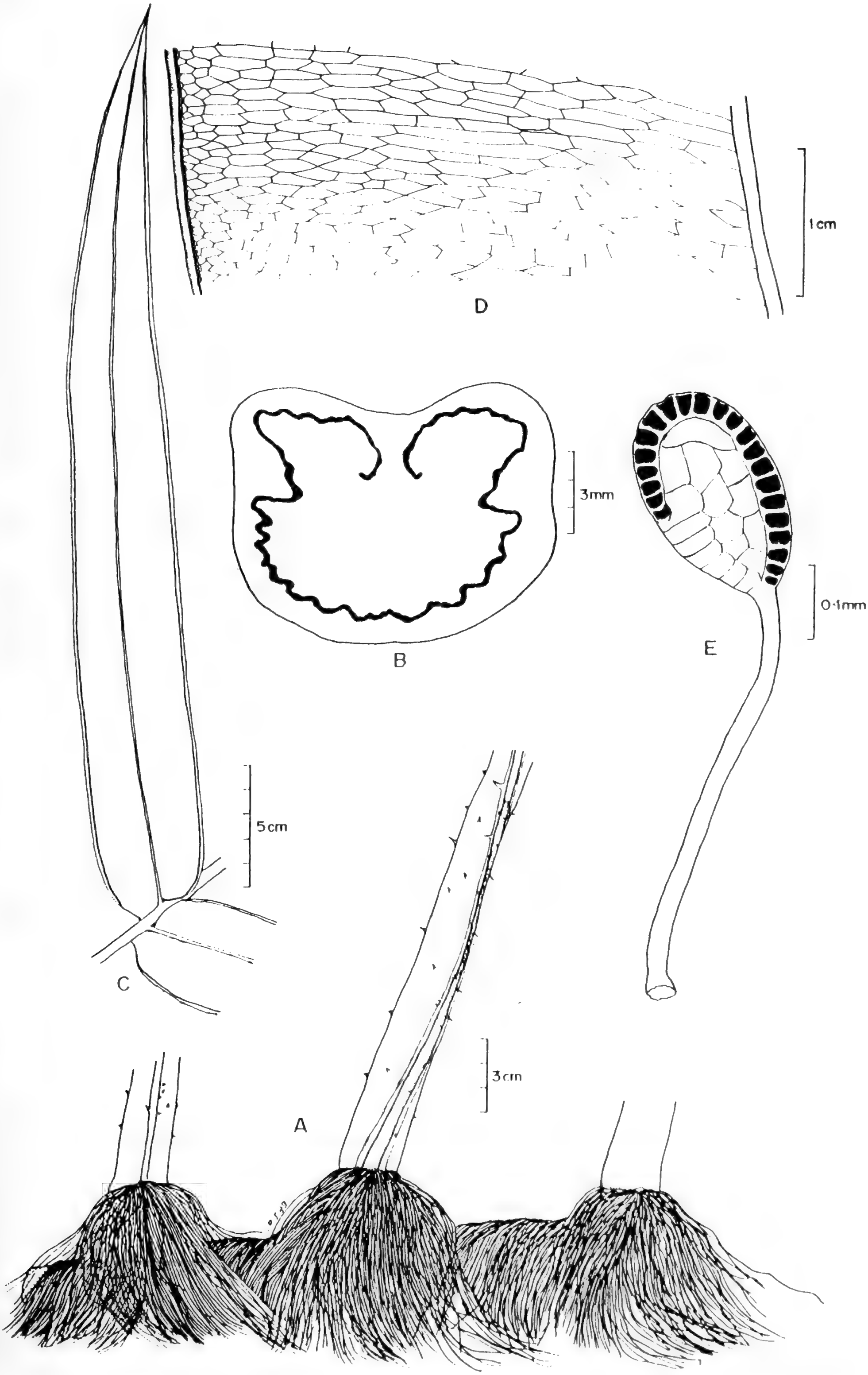

Fig. 2. *Pteris holttumii.* **A.** Part of rhizome, showing roots and stipe bases. **B.** Xylem configuration, middle of stipe. **C.** Part of frond, showing pinnae bases and sori outline. **D.** Vennation of pinna. **E.** Sporangium.

The species differs from the rest of the genus in having hard conicle prickles throughout the stipe as well as in the basal pinnae not being branched on the basiscopic sides near the base. It is the only species in *Pteris* with reticulate venation. It is hoped that with the availability of a live specimen in our collection, the cytology of the species would be determined in due time in order to give some indications on the phylogenetic relationship within the genus.

Acknowledgements

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References

Bidin, A., Jaman, R. and Salleh, K.M. (1988). A new species of *Adiantum* from Trus Madi Range, Sabah. *Gard. Bull. Sing.* 41(2): 45–48.

Bidin, A. and Jaman, R. (1989). *The Pteriodophytes of Tabin Wildlife Reserve*. Sabah Museum Journal. Special Issue. (In press).

Christensen, C. and Holttum, R.E. (1934). The ferns of Mount Kinabalu, *Gard. Bull. Str. Settl.* 7(3): 191–316.

Hovenkamp, P. and De Joncheere, G.J. (1988). Additions to the fern flora of Sulawesi. *Blumea* 33: 395–409.

Iwatsuki, K., Mogea, J.P., Murata, G. and Kartawinata, K. (1980). A botanical survey in Kalimantan during 1978–1979. *Acta Phytotax. Geobot.* 31(1–3): 1–23.

Iwatsuki, K. and Kato, M. (1980*a*). Enumeration of Kalimantan Pteridophytes collected during 1978–1979(1). *Acta Phytotax. Geobot.* 31(1–3): 24–43.

______. (1980*b*). Enumeration of Kalimantan Pteridophytes collected during 1978–1979(2). *Acta Phytotax. Geobot.* 31(4–6): 164–181.

______. (1981). Enumeration of Kalimantan Pteridophytes collected during 1978–1979(3): *Acta Phytotax. Geobot.* 32(1–4): 121–132.

______. (1983*a*). Additions to the enumeration of East Kalimantan Pteridophytes 1. *Acta Phytotax. Geobot.* 34(1–3): 55–65.

______. (1983*b*). Additions to the enumeration of East Kalimantan Pteridophytes 2. *Acta Phytotax. Geobot.* 34(4–6): 130–141.

Ogura, Y. (1972). *Comparative Anatomy of Vegetative Organs of the Pteridophytes.* 2nd ed. Gebruder Borntraeger. Berlin, Stuttgart.

Price, M.G. (1987). Sabah ferns collected by John Beaman. *Contr. Univ. Mich. Herb.* 16: 189–200.

A Botanical Survey of Pulau Ubin

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Abstract

An intense botanical survey of Pulau Ubin, a 1019.2 ha island within the Republic of Singapore, found at least 332 native and naturalized vascular plant species. These are listed in the paper together with 40 species found to have escaped from cultivation. Previous botanical records for Pulau Ubin are also collated. The contemporary flora is dominated by early successional and ruderal species in addition to mangrove and beach forest elements. The low diversity and relatively high frequency of aliens (71 out of 332 spp.; 21 per cent of the flora) reflects the high degree of human disturbance on the island.

Introduction

Pulau Ubin is an island within the Republic of Singapore. It was chosen as a site for an intensive botanical survey because as one of the least urbanised and under botanized areas of the city state it was believed likely to possess an interesting flora. Additionally, development of Pulau Ubin is currently a topic of public interest in Singapore. Basic biological information such as a plant species list is prerequisite to the development of nature conservation programmes. This survey will therefore be of value to those involved in future decisions concerning changes in land use on Pulau Ubin.

Site

Pulau Ubin (N 1° 25′, E 103° 57′) is a granite island of 1019.2 ha (Ng, 1988) lying off the north-east coast of Singapore Island (Fig. 1). The main land uses at present are granite quarrying, agriculture, horticulture, aquaculture and recreational activities, largely of an athletic nature. Pulau Ketam and P. Sekudu, islets to the south of Ubin, were also included in the survey.

Methods

Most of the specimens were gathered by a team of 19 collectors during the period 17–22 June 1990. Some collections have been made subsequently on occasional visits to the island up to May 1991. The collections have been identified, largely by matching to named specimens in the Herbarium, Singapore Botanic Gardens (SING). The Pulau Ubin specimens have been deposited in the Herbarium, Department of Botany, National University of Singapore (SINU).

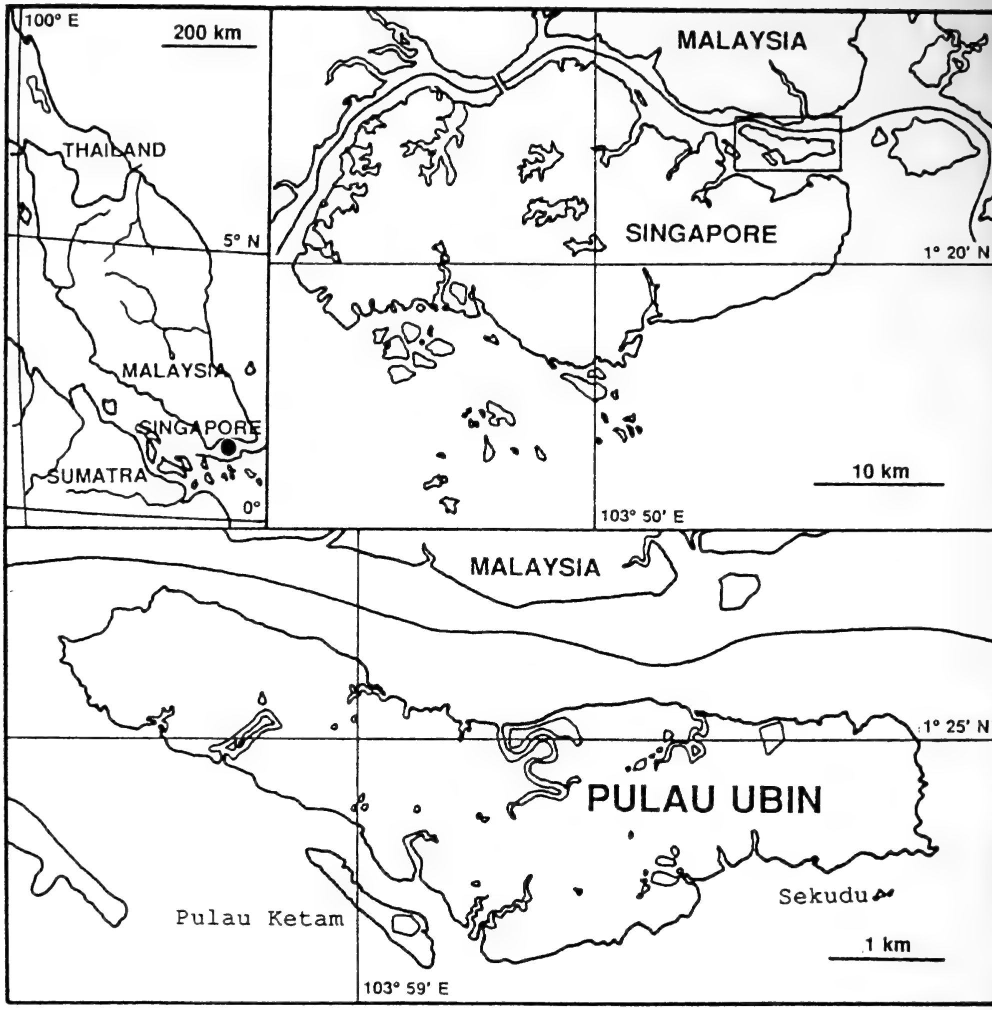

Fig. 1. Map showing locality of study site.

Results and Discussion

The names of the species collected are given in Table 1, the few sterile collections that could not be identified have been omitted. A total of 332 native and naturalized species were collected plus 40 species of cultivated plants that had escaped or were relics of cultivation in now abandoned areas. The distinction between alien and escaped species is somewhat arbitrary and is based largely on Turner, Chua and Tan (1990). The Ubin flora included 24 pteridophytes and one gymnosperm; the rest (including all the escapes) being angiosperms.

The Ubin flora represents about one eighth of the total flora recorded for Singapore. The species list is made up largely by common weed, secondary forest and mangrove species. Primary forest species are nearly completely lacking; a *Knema* species sapling being the only real rain forest tree found. The orchids *Spathoglottis plicata* and *Thrixspermum amplexicaule* were the most notable collections, though the former may possibly be a relic of cultivation. Eight species, *Adiantum latifolium, Hemigraphis primulaefolia, Pennisetum polystachyon, Scurrula parasitica, Sesamum radiatum,* *Talinum paniculatum, Thysanolaena latifolia* and *Typha angustifolia,* were not previously recorded for Singapore. All but *Scurrula parasitica* can be called weeds, being able to colonise disturbed sites readily.

Pulau Ubin was presumably covered in lowland rain forest and mature mangrove forest until at least the middle of the Nineteenth Century. A list of previous botanical records from the island (Table 2) does include some species one would associate more strongly with primary vegetation such as *Chisocheton macrophyllus, Cyathostemma viridiflorum, Dipterocarpus* c.f. *sublamellatus, Forrestia gracilis, Lithocarpus elegans, Phoebe grandis* and several celastraceous climbers, but the general impression is that even by the 1880s and 1890s when Ridley and Hullett were collecting on Pulau Ubin much of the vegetation must have been secondary. One has to conclude that all of the terrestrial vegetation has been cleared at some time, much of this by the turn of the century. The state of the mangrove is little better. There are earlier records for 156 species from Pulau Ubin, of which 111 were not re-collected in the survey. This clearly reflects the rapid changes that have occurred on the island.

Two late Nineteenth Century collections of Ridley from Pulau Ubin have been described as isosyntypes. Neither of these species, *Chisocheton macrophyllus* and *Ardisia singaporensis,* were re-collected and are thus very probably extinct in one of their type localities. Hullett's collection of *Claoxylon longifolium* from Ubin (Hullett s.n., March 1885) was described as a syntype of *Claoxylon longifolium* var. *brachystachys* by J.D. Hooker (Hooker 1887, p. 411) but this variety is now generally not recognized and the name reduced to synonymy with the type variety (e.g. Airy Shaw, 1972, Whitmore, 1973). Luerssen (1882) described *Phegopteris subdecurrens* from a fern collection made on Ubin (Kehding 2960) but this taxon is now generally synonymized to *Tectaria semipinnata* (Roxb.) Morton (e.g. Holttum, 1981).

The broad floristic changes brought about by human activities can be examined by comparing the relative abundances of the commonest angiosperm families in the current flora of Ubin and that recorded for Singapore as a whole (Table 3). The Orchidaceae are the commonest family in the flora of Singapore. Only five of the 194 species were found in the current survey on Pulau Ubin. The Leguminosae and the Euphorbiaceae are among the top three families with most species on contemporary Ubin. Both of these families have many weedy, alien species that have added to their diversity.

The flora of Pulau Ubin is clearly depauperate. Bukit Timah Nature Reserve has 854 species recorded (Corlett, 1990), nearly three times the number in one-fifteenth the area. Human interference on Pulau Ubin has lead to a semi-natural vegetation dominated by relatively few early successional species with a fairly high representation, 21 per cent of the flora, of alien species. It would be difficult to make a case for the conservation of the present day vegetation of Pulau Ubin on solely botanical grounds from an international perspective. However, from a Singapore standpoint, the patches of mangroves and the larger areas of belukar are of value in a country with so little natural vegetation remaining. Any plans for their destruction merit in-depth consideration of all the possible alternatives before being allowed to proceed.

Acknowledgements

The National University of Singapore Botany Honours Class (1990–1991) did most of the collecting on Pulau Ubin. We are most grateful for their efforts and enthusiasm. Our thanks also go to Soong Beng Ching, Shawn Lum and David Burslem for their assistance. We are grateful to the Director of the Singapore Botanic Gardens for allowing us access to the Herbarium. The survey was supported by the National University of Singapore.

Table 1
List of species collected on Pulau Ubin since June 1990. Representative collection given in square brackets. Marginal note: a = alien species naturalized in Singapore, e = escape from cultivation.

PTERIDOPHYTES

Acrostichum aureum L. [M.F. Choong 22]
Acrostichum speciosum Willd. [H.H. Neo 11]
a *Adiantum latifolium* Lamk. [M.Y. Kok 32]
Asplenium nidus L. [A. Ho & J. Lee 11]
Blechnum orientale L. [K.S. Tan 47]
Ceratopteris thalictroides (L.) Brongn. [K.S. Chua & H.T.W. Tan 427]
Davallia denticulata (Burm.) Mett. [A. Ho & J. Lee 13]
Dicranopteris linearis (Burm. f.) Underw. [A. Ho & J. Lee 1]
Drynaria quercifolia (L.) J. Sm. [A. Ho & E.M. Sim 21]
Lindsaea ensifolia Sw. [A. Ho & E.M. Sim 8]
Lycopodium cernuum L. [A. Ho & J. Lee 7]
Lygodium circinnatum (Burm. f.) Sw. [H.H. Neo 103]
Lygodium microphyllum Cav.) R. Br. [A. Ho & J. Lee 5]
Nephrolepis biserrata (Sw.) Schott [A. Ho & J. Lee 3]
Phymatosorus scolopendria (Burm.) Pichi Serm. [I.M. Turner 42]
a *Pityrogramma calomelanos* (L.) Link [M. Chan & Roslina 31]
Platycerium coronarium (Koenig) Desv. [T.S. Teo 59]
Pteridium caudatum (L.) Maxon ssp. *yarrabense* (Domin) Parris [K.S. Tan 56]
Pteris vittata L. [H.H. Neo 203]
Pyrrosia longifolia (Burm.) Morton [Latifah 6]
Pyrrosia piloselloides (L.) Price [A. Ho & J. Lee 12]
Schizaea digitata (L.) Sw. [H.H. Neo 206]
Stenochlaena palustris (Burm.) Bedd. [E.M. Sim & L.P. Ng 32]
Taenitis blechnoides (Willd.) Sw. [H.H. Neo 5]

SPERMATOPHYTES

Acanthaceae

Acanthus ebracteatus Vahl [E.M. Sim & L.P. Ng 18]
Acanthus volubilis Wall. [H.H. Neo 117]
a *Andrographis paniculata* (Burm. f.) Nees [J. Lee 104]
Asystasia nemorum Nees [E.M. Sim & L.P. Ng 14]
a *Hemigraphis primulaefolia* (Nees) Vill. [E.M. Sim & L.P. Ng 39]
a *Thunbergia fragrans* Roxb. [M. Chan & Roslina 32]
a *Thunbergia grandiflora* Roxb. [T.S. Teo 124]

Agavaceae

e *Sansevieria trifasciata* Prain [L.P. Ng 21]

Aizoaceae

Sesuvium portulacastrum L. [L.P. Law 4]

Table 1 *(Continued)*

	Amaranthaceae
a	*Celosia argentea* L. [K.S. Tan 37]
	Cyathula prostrata (L.) Bl. [K.S. Chua 101]
e	*Gomphrena globosa* L. [J. Sim 31]
	Anacardiaceae
a	*Anacardium occidentale* L. [K.S. Chua & H.T.W. Tan 440]
	Bouea macrophylla Griff. [M.F. Choong 58]
	Buchanania arborescens (Bl.) Bl. [T.S. Teo 25]
	Campnosperma auriculatum (Bl.) Hook. f. [I.M. Turner 20]
e	*Mangifera indica* L. [J. Sim 33]
	Annonaceae
	Desmos dasymaschala (Bl.) Safford [M.F. Choong 38]
	Apocynaceae
e	*Allamanda cathartica* L. [J. Sim 40]
	Alstonia angustiloba Miq. [H.H. Neo 205]
a	*Catharanthus roseus* (L.) G. Don [A. Ho & E.M. Sim 7]
	Cerbera odollam Gaertn. [I.M. Turner 111]
	Araceae
a	*Alocasia macrorrhizos* (L.) G. Don [M.F. Choong 42]
a	*Colocasia esculenta* (L.) Schott [H.H. Neo 10]
e	*Dieffenbachia seguine* (Jacq.) Schott [T.S. Teo 70]
	Araliaceae
	Arthrophyllum diversifolium Bl. [L.P. Law 10]
e	*Polyscias fruticosa* (L.) Harms [T.S. Teo 60]
	Schefflera elliptica (Bl.) Harms [H.H. Neo 111]
	Asclepiadaceae
	Dischidia major (Vahl) Merr. [M.Y. Kok 36]
	Dischidia nummularia R. Br. [J. Lee 1]
	Hoya parasitica (Roxb.) Wall. ex. Wight [Latifah 117]
	Avicenniaceae
	Avicennia alba Bl. [J. Sim 23]
	Avicennia officinalis Bl. [T.S. Teo 16]
	Avicennia rumphiana Hall. f. [T.S. Teo 20]
	Bignoniaceae
a	*Spathodea campanulata* Beauv. [M.Y. Kok 27]
	Bombacaceae
e	*Durio zibethinus* J. Murray [K.S. Tan 17]
	Boraginaceae
a	*Cordia cylindristachya* R. & S. [E.M. Sim & L.P. Ng 43]
	Heliotropium indicum L. [Roslina 45]

	Bromeliaceae
e	*Ananas comosus* (L.) Merr. cv. Mauritius [J. Sim 27]
	Cannaceae
e	*Canna indica* L. [M. Chan 30]
	Capparaceae
a	*Cleome rutidosperma* DC. [Roslina 37]
	Caricaceae
e	*Carica papaya* L. [J. Sim 21]
	Casuarinaceae
	Casuarina equisetifolia J. R. & G. Forst. [J. Sim 7]
	Combretaceae
	Lumnitzera littorea (Jack) Voigt [M.Y. Kok 38]
	Lumnitzera racemosa Willd. [J. Sim 26]
	Terminalia catappa L. [J. Sim 1]
	Commelinaceae
	Commelina diffusa Burm. f. [L.P. Law 18]
	Compositae
a	*Ageratum conyzoides* L. [L.P. Ng & L.P. Law 2]
a	*Bidens pilosa* L. [K.S. Chua 100]
	Blumea balsamifera (L.) DC. [K.S. Chua & H.T.W. Tan 443]
	Eclipta prostrata (L.) L. [M.F. Choong 43]
	Elephantopus scaber L. [A. Ho & E.M. Sim 14]
	Emilia sonchifolia (L.) DC. ex Wight [A. Ho & E.M. Sim 15]
	Erigeron sumatrensis Retz. [M.Y. Kok 25]
	Gynura procumbens (Lour.) Merr. [L.P. Ng 8]
	Mikania cordata (Burm. f.) B.L. Robinson [M.Y. Kok 21]
	Pluchea indica (L.) Less. [Roslina 19]
a	*Sparganophora sparganophorus* (L.) C. Jeffrey [K.S. Chua & H.T.W. Tan 428]
	Spilanthes iabadicensis A.H. Moore [K.S. Chua & H.T.W. Tan 100]
a	*Synedrella nodiflora* (L.) Gaertn. [J. Lee 3]
	Tridax procumbens L. [M. Chan 33]
	Vernonia cinerea (L.) Less. [M.Y. Kok 33]
	Wedelia biflora (L.) DC. [M.Y. Kok 11]
a	*Wedelia trilobata* (L.) Hitch. [E.M. Sim & L.P. Ng 42]
	Youngia japonica (L.) DC. [T.S. Teo 125]
	Connaraceae
e	*Cnestis palala* (Lour.) Merr. [T.S. Teo 57]
	Convolvulaceae
	Erycibe tomentosa Bl. [T.S. Teo 54]
	Ipomoea aquatica Forsk. [A. Ho & E.M. Sim 34]
e	*Ipomoea batatus* (L.) Lamk. [L.P. Law & L.P. Ng 20]
a	*Ipomoea cairica* (L.) Sweet [J. Sim 41]
	Merremia tridentata (L.) Hallier f. [M. Chan 53]

Table 1 *(Continued)*

Cucurbitaceae

e *Cucumis sativa* L. [M.F. Choong 50]

Cyperaceae

Bulbostylis barbata (Rottb.) Clarke [Roslina 21]

a *Cyperus aromaticus* (Ridl.) Mattf. & Kuk [Roslina 6]
Cyperus compactus Retz. [Latifah & H.H. Neo 2]
Cyperus compressus L. [Roslina 1]
Cyperus cyperinus (Retz.) Valck. Sur. [Latifah 2]
Cyperus halpan L. [M. Chan 13]
Cyperus javanicus Houtt. [A. Ho & E.M. Sim 66]
Cyperus kyllingia Endl. [Latifah 18]
Cyperus pilosus Vahl [Latifah & H.H. Neo 3]
Cyperus trialatus (Boeck.) Kern [Latifah 1]

Fimbristylis cymosa R. Br. [Latifah 12]
Fimbristylis dichotoma (L.) Vahl [Roslina 4]
Fimbristylis griffithii Boeck. [M. Chan 10]
Fimbristylis polytrichoides (Retz.) R. Br. [Latifah 11]
Fimbristylis schoenoides (Retz.) Vahl [H.H. Neo 204]

Hypolytrum nemorum (Vahl) Spreng. [H.H. Neo & Latifah 1]

Scleria corymbosa Roxb. [M. Chan & Roslina 27]
Scleria levis Retz. [Latifah 10]

Thoracostachyum bancanum (Miq.) Kurz [Latifah 13]

Dilleniaceae

Dillenia suffruticosa (Griff.) Mart. [E.M. Sim & L.P. Ng 8]

Tetracera indica (Christm. & Panz.) Merr. [E.M. Sim & L.P. Ng 27]

Dioscoreaceae

Dioscorea glabra Roxb. [T.S. Teo 29]
Dioscorea laurifolia Wall. ex Hook. f. [K.S. Chua & H.T.W. Tan 437]

Elaeocarpaceae

Elaeocarpus ferrugineus (Jack) Steud. [I.M. Turner 38]
Elaeocarpus pedunculatus Wall. ex Mast. [J. Sim 5]

a *Muntingia calabura* L. [T.S. Teo 43]

Eriocaulaceae

Eriocaulon longifolium Nees [M. Chan 12]

Erythroxylaceae

Erythroxylum cuneatum (Miq.) Kurz [K.S. Tan 30]

Euphorbiaceae

Antidesma velutinosum Bl. [L.P. Law 8]

e *Baccaurea motleyana* (M.A.) M.A. [A. Ho & E.M. Sim 13]

Breynia coronata Hook. f. [T.S. Teo 10]

Bridelia stipularis (L.) Bl. [M. Chan & Roslina 29]

Claoxylon indicum (Reinw. ex Bl.) Endl. ex Hassk. [M.F. Choong 19]

e *Codiaeum variegatum* (L.) Bl. [T.S. Teo 64]

	Croton hirtus L'Héritier [K.S. Tan 28]
a	*Euphorbia hirta* L. [M.F. Choong 40]
	Excoecaria agallocha L. [K.S. Tan 3]
	Glochidion superbum Baill. [I.M. Turner 113]
a	*Hevea brasiliensis* (Willd. ex A. Juss.) M.A. [M.Y. Kok 7]
	Macaranga conifera M.A. [M.Y. Kok 54]
	Macaranga gigantea (Rchb. f. & Zoll.) M.A. [L.P. Law & L.P. Ng 25]
	Macaranga griffithiana M.A. [I.M. Turner 116]
	Macaranga heynei I.M. Johnston [K.S. Tan 19]
	Macaranga hypoleuca (Rchb. f. & Zoll.) M.A. [M.Y. Kok 26]
	Macaranga triloba (Bl.) M.A. [L.P. Law & L.P. Ng 7]
	Mallotus paniculatus (Lamk.) M.A. [M. Chan & Roslina 25]
a	*Manihot esculenta* Crantz [M.Y. Kok 28]
a	*Manihot glaziovii* M.A. [H.H. Neo 104]
e	*Phyllanthus acidus* (L.) Skeels [T.S. Teo 50]
a	*Phyllanthus amarus* Schum. & Thonn. [A. Ho & E.M. Sim 35]
a	*Phyllanthus debilis* Klein ex Willd. [E.M. Sim & L.P. Ng 7]
a	*Phyllanthus urinaria* L. [E.M. Sim & L.P. Ng 35]
a	*Ricinus communis* L. [K.S. Tan 48]
	Sapium discolor (Champ. ex Benth.) M.A. [T.S. Teo 9]
	Suregada multiflora (Juss.) Baill. [I.M. Turner 30]
	Flagellariaceae
	Flagellaria indica L. [M. Chan 11]
	Gnetaceae
	Gnetum macrostachyum Hook. [J. Sim 13]
	Goodeniaceae
	Scaevola sericea Vahl [M.Y. Kok 39]
	Gramineae
a	*Axonopus compressus* (Swartz) Beauv. [M. Chan 15]
e	*Bambusa glaucescens* (Willd.) Sieb. [T.S. Teo 28]
	Centotheca lappacea (L.) Desv. [Latifah 3]
a	*Chloris barbata* Swartz [A. Ho & E.M. Sim 27]
	Chrysopogon aciculatus (Retz.) Trin. [Latifah 15]
a	*Coix lacryma-jobi* L. [T.S. Teo 39]
	Cynodon dactylon (L.) Pers. [K.S. Chua & H.T.W. Tan 447]
	Cyrtococcum accrescens (Trin.) Stapf [Latifah & H.H. Neo 5]
	Dactyloctenium aegyptium (L.) P. Beauv. [Roslina 17]
	Digitaria ciliaris (Retz.) Koel. [K.S. Chua & H.T.W. Tan 446]
	Echinochloa colona (L.) Link [M. Chan & Roslina 34]
	Eleusine indica (L.) Gaertn. [M. Chan 18]
	Eragrostis pilosa (L.) P. Beauv. [Latifah 9]
	Imperata cylindrica (L.) P. Beauv. [M. Chan 8]

Table 1 *(Continued)*

	Ischaemum indicum (Houtt.) Merr. [Roslina 3]
	Ischaemum muticum L. [M. Chan 1]
	Mnesithea glandulosa (Trin.) Koning & Sosef [T.S. Teo 121]
a	*Panicum maximum* Jacq. [L.P. Law 23]
a	*Paspalum conjugatum* Berg. [Latifah 6]
	Paspalum orbiculare Forst. f. [Latifah 7]
a	*Pennisetum polystachyon* (L.) Schult. [Roslina 16]
	Pogonatherum paniceum (Lamk.) Hack. [K.S. Chua & H.T.W Tan 445]
a	*Rhynchelytrum repens* (Willd.) C.E. Hubb. [Roslina 7]
	Saccharum arundinaceum Retz. [L.P. Law 17]
	Sporobolus indicus (L.) R. Br. [M. Chan 12]
a	*Thysanolaena latifolia* (Roxb. ex Hornem.) Honda [A. Ho & E.M. Sim 19]
	Zoysia matrella (L.) Merr. [M. Chan 14]
	Guttifera
	Calophyllum inophyllum L. [M.Y. Kok 51]
	Calophyllum pulcherrimum Wall. ex Choisy [H.H. Neo 207]
e	*Garcinia mangostana* L. [K.S. Tan 15]
	Garcinia nigrolineata Planch. ex T. Anders. [E.M. Sim & L.P. Ng 51]
	Hypoxidaceae
	Curculigo orchioides Gaertn. [K.S. Tan 27]
	Ixonanthaceae
	Ixonanthes reticulata Jack [M.F. Choong 17]
	Labiatae
a	*Hyptis brevipes* Poit. [A. Ho & E.M. Sim 20]
a	*Hyptis capitata* Jacq. [K.S. Chua 99]
a	*Hyptis suaveolens* (L.) Poit. [A. Ho & E.M. Sim 45]
	Leucas zeylanica (L.) R. Br. [E.M. Sim & L.P. Ng 36]
	Ocimum basilicum L. [A. Ho & E.M. Sim 33]
	Lauraceae
	Cassytha filiformis L. [L.P. Law 21]
	Cinnamomum iners Reinw. ex Bl. [K.S. Tan 49]
	Neolitsea zeylanica Merr. [M.Y. Kok 29]
	Leeaceae
	Leea indica (Burm. f.) Merr. [M.Y. Kok 31]
	Leguminosae
a	*Abrus precatorius* L. [J. Lee 4]
a	*Acacia auriculiformis* A. Cunn. ex Benth. [J. Sim 15]
e	*Acacia mangium* Willd. [I.M. Turner 44]
	Alysicarpus vaginalis (L.) DC. [E.M. Sim & L.P. Ng 48]
e	*Andira inermis* (W. Wright) H.B.K. ex DC. [I.M. Turner 115]
	Archidendron clypearia (Jack) I. Nielsen [M.F. Choong 16]

	Caesalpinia crista L. [K.S. Chua & H.T.W. Tan 426]
	Calopogonium mucunoides Desv. [L.P. Ng 10]
	Canavalia cathartica Thou. [A. Ho & J. Lee 15]
a	*Cassia alata* L. [L.P. Law 19]
a	*Cassia lechenaultiana* DC. [K.S. Chua 80]
a	*Cassia mimosoides* L. [L.P. Ng & L.P. Law 19]
	Centrosema pubescens Benth. [A. Ho & E.M. Sim 44]
a	*Clitoria laurifolia* Poir. [J. Sim 18]
	Crotalaria mucronata Desv. [K.S. Tan 8]
	Dalbergia candenatensis (Dennst.) Prain [T.S. Teo 17]
e	*Derris elliptica* (Roxb.) Benth. [M.Y. Kok 3]
	Derris trifoliata Lour. [A. Ho & J. Lee 14]
	Desmodium heterocarpon (L.) DC. [L.P. Ng & L.P. Law 14]
	Desmodium heterophyllum (Willd.) DC. [M. Chan & Roslina 31]
	Desmodium umbellatum (L.) DC. [M.F. Choong 11]
	Entada spiralis Ridl. [K.S. Tan 12]
	Intsia bijuga (Colebr.) O. Ktze. [K.S Chua & H.T.W. Tan 441]
a	*Mimosa invisa* Mart. ex Colla [T.S. Teo 42]
a	*Mimosa pigra* L. [M.F. Choong 28]
a	*Mimosa pudica* L. [M. Chan & Roslina 30]
a	*Neptunia plena* (L.) Benth. [T.S. Teo 71]
	Peltophorum pterocarpum (DC.) Backer ex Heyne [K.S. Tan 25]
e	*Pterocarpus indicus* Willd. [A. Ho & E.M. Sim 40]
	Lemnaceae
	Lemna perpusilla Torrey [K.S. Chua & H.T.W. Tan 449]
	Liliaceae
e	*Cordyline fruticosa* (L.) A. Chev. [L.P. Law 15]
	Dianella ensifolia (L.) DC. [M. Chan 19]
e	*Gloriosa superba* L. [J. Lee 102]
	Linaceae
	Indorouchera griffithiana (Planch.) Hallier f. [H.H. Neo 208]
	Loganiaceae
	Fagraea acuminatissima Merr. [I.M. Turner 105]
	Fagraea fragrans Roxb. [M.Y. Kok 12]
	Loranthaceae
	Dendrophthoe pentandra (L.) Miq. [A. Ho & J. Lee 10]
	Macrosolen cochinchinensis (Lour.) Tiegh. [H.H. Neo 114]
	Scurrula parasitica L. [P.T. Chew & A.S. Chew 46]
	Magnoliaceae
e	*Michelia champaca* L. [J. Lee 5]
	Malpighiaceae
	Tristellateia australasiae A. Rich. [E.M. Sim & L.P. Ng 20]

Table 1 *(Continued)*

	Malvaceae
e	*Hibiscus rosa-sinensis* L. [L.P. Ng 14]
	Hibiscus tiliaceus L. [E.M. Sim & L.P. Ng 4]
	Sida rhombifolia L. [E.M. Sim & L.P. Ng 41]
	Thespesia populnea (L.) Soland. ex Correa [J. Lee 8]
	Urena lobata L. [E.M. Sim & L.P. Ng 34]
	Melastomataceae
a	*Clidemia hirta* D. Don [E.M. Sim & L.P. Ng 6]
	Dissochaeta gracilis (Jack) Bl. [K.S. Chua 104]
	Melastoma malabathricum L. [E.M. Sim & L.P. Ng 2]
	Memecylon edule Roxb. [K.S. Tan 20]
	Meliaceae
	Xylocarpus granatum Koen. [M.F. Choong 4]
	Menispermaceae
	Fibraurea tinctoria Lour. [L.P. Ng & L.P. Law 4]
	Limacia scandens Lour. [M.F. Choong 20]
	Moraceae
e	*Artocarpus integer* (Thunb.) Merr. [J. Lee 6]
e	*Artocarpus heterophyllus* Lamk. [A. Ho & E.M. Sim 26]
	Ficus aurata Miq. [K.S. Tan 63]
	Ficus fistulosa Reinw. ex Bl. [M.F. Choong 49]
	Ficus grossularioides Burm. f. [M.F. Choong 6]
	Ficus heteropleura Bl. [M.Y. Kok 19]
	Ficus microcarpa L. f. [T.S. Teo 34]
	Ficus variegata Bl. [K.S. Tan 36]
	Ficus virens Ait. var. *glabella* (Bl.) Corner [M.F. Choong 36]
	Streblus elongatus (Miq.) Corner [M.Y. Kok 47]
	Musaceae
e	*Musa acuminata* Colla cultivar [J. Sim 32]
	Myricaceae
	Myrica esculenta Buch.-Ham. [L.P. Law & L.P. Ng 8]
	Myristicaceae
	Knema sp. [K.S. Tan 51]
	Myrsinaceae
	Ardisia crenata Sims [T.S. Teo 72]
	Ardisia elliptica Thunb. [T.S. Teo 14]
	Embelia ribes Burm. [M.Y. Kok 16]
	Myrtaceae
e	*Eugenia jambos* L. [K.S. Tan 54]
	Eugenia longiflora (Presl) F.-Vill. [M.Y. Kok 14]
	Eugenia palembanica (Miq.) Merr. [K.S. Tan 18]
	Eugenia spicata Lamk. [T.S. Teo 1]

e *Psidium guajava* L. [M.Y. Kok 30]
Rhodamnia cinerea Jack [J. Sim 19]
Rhodomyrtus tomentosa (Ait.) Hassk. [Roslina 15]
Tristaniopsis whitiana (Griff.) Wilson & Waterhouse [M.Y. Kok 40]

Nepenthaceae

Nepenthes gracilis Korth. [E.M. Sim & L.P. Ng 54]

Olacaceae

Ximenia americana L. [K.S. Tan 1]

Onagraceae

Ludwigia hyssopifolia (G. Don) Exell [M. Chan & Roslina 30]

Opiliaceae

Champereia manillana (Bl.) Merr. [E.M. Sim & L.P. Ng 13]

Orchidaceae

Bromheadia finlaysoniana (Lindl.) Rchb. f. [M. Chan 61]
Dendrobium crumenatum Sw. [A. Ho & J. Lee 9]
Spathoglottis plicata Bl. [A. Ho & E.M. Sim 42]
Thrixspermum amplexicaule (Bl.) Rchb. f. [T.S. Teo 32]
Vanilla griffithii Rchb. f. [T.S. Teo 26]

Oxalidaceae

a *Oxalis barrelieri* L. [E.M. Sim & L.P. Ng 9]
a *Oxalis corniculata* L. [J. Lee 2]

Palmae

e *Arenga pinnata* (Wurmb) Merr. [H.H. Neo 112]
Caryota mitis Lour. [K.S. Tan 10]
a *Cocos nucifera* L. [K.S. Tan 5]
Licuala spinosa Wurmb [J. Sim 12]
Nypa fruticans Wurmb [J. Sim 29]
Oncosperma tigillarium (Jack) Ridl. [I.M. Turner 37]

Pandanaceae

e *Pandanus amaryllifolius* Roxb. [K.S. Tan 46]
Pandanus odoratissimus L. f. [J. Sim 2]
Pandanus yvanii Solms. [L.P. Law & L.P. Ng 3]

Passifloraceae

a *Passiflora foetida* L. [K.S. Tan 13]
a *Passiflora laurifolia* L. [E.M. Sim & L.P. Ng 44]
a *Passiflora suberosa* L. [A. Ho & J. Lee 45]

Pedaliaceae

a *Sesamum radiatum* Schum. [K.S. Chua & H.T.W. Tan 82]

Piperaceae

a *Peperomia pellucida* (L.) H.B.K. [M.F. Choong 39]

e *Piper betle* L. [I.M. Turner 53]
Piper sarmentosum Roxb. ex Hunter [M. Chan & Roslina 29]

Plantaginaceae

a *Plantago major* L. [M.F. Choong 52]

Portulacaceae

a *Talinum paniculatum* (Jacq.) Gaertn. [M.F. Choong 57]

Rhamnaceae

Colubrina asiatica L. ex Brongn. [T.S. Teo 38]

Rhizophoraceae

Bruguiera cylindrica (L.) Bl. [T.S. Teo 19]
Bruguiera gymnorrhiza (L.) Lamk. [T.S. Teo 23]

Ceriops tagal (Perr.) C.B. Robinson [M.F. Choong 29]

Gynotroches axillaris Bl. [A. Ho & E.M. Sim 56]

Rhizophora apiculata Bl. [M.F. Choong 31]
Rhizophora mucronata Poir. [M.F. Choong 47]

Rubiaceae

a *Borreria alata* (Aubl.) DC. [M.F. Choong 15]
Borreria articularis (L. f.) F.N. Will. [E.M. Sim & L.P. Ng 29]
Borreria laevicaulis (Miq.) Ridl. [A. Ho & E.M. Sim 9]
Borreria setidens (Miq.) Bold. [K.S. Chua & H.T.W. Tan 434]

a *Diodia ocymifolia* (Willd. ex R. & S.) Bremek. [A. Ho & E.M. Sim 17]

Guettarda speciosa L. [J. Sim 9]

Hedyotis corymbosa (L.) Lamk. [L.P. Law & L.P. Ng 61]

Ixora congesta Roxb. [T.S. Teo 24]

a *Morinda citrifolia* L. [A. Ho & E.M. Sim 3]
Morinda umbellata L. [E.M. Sim & L.P. Ng 47]

Oxyceros longiflora (Lamk.) Yamazaki [E.M. Sim & L.P. Ng 31]

Scyphiphora hydrophyllacea Gaertn. f. [T.S. Teo 15]

Tarenna costata (Miq.) Merr. [T.S. Teo 4]
Tarenna fragrans (Nees) K. & V. [T.S. Teo 3]

Timonius wallichinus (Korth.) Valeton [J. Sim 2]

Rutaceae

Euodia roxburghiana (Cham.) Benth. ex Hook. f. [K.S. Chua & H.T.W. Tan 108]

e *Murraya koenigii* (L.) Spreng. [M. Chan 27]

Santalaceae

Dendrotrophe varians (Bl.) Miq. [I.M. Turner 102]

Sapindaceae

Allophyllus cobbe (L.) Raeusch. [M.Y. Kok 22]

Guioa pleuropteris (Bl.) Radlk. [A. Ho & E.M. Sim 57]

Mischocarpus sundaicus Bl. [I.M. Turner 36]

e *Nephelium lappaceum* L. [M.Y. Kok 45]

	Sapotaceae
	Planchonella obovata (R. Br.) Pierre [T.S. Teo 12]
	Scrophulariaceae
a	*Limnophila sessiliflora* Bl. [K.S. Chua & H.T.W. Tan 431]
	Lindernia antipoda (L.) Alston [E.M. Sim & L.P. Ng 30]
	Lindernia crustacea (L.) F.v.M. [K.S. Chua & H.T.W. Tan 432]
	Lindernia sessiliflora (Benth.) Wettst. [K.S. Chua & H.T.W. Tan 433]
a	*Scoparia dulcis* L. [A. Ho & E.M. Sim 18]
	Simaroubaceae
	Brucea javanica (L.) Merr. [T.S. Teo 45]
	Smilacaceae
	Smilax megacarpa DC. [K.S. Chua & H.T.W. Tan 425]
	Solanaceae
	Physalis minima L. [K.S. Chua 71]
e	*Solanum melongena* L. [K.S. Chua 72]
a	*Solanum torvum* Sw. [M.Y. Kok 17]
	Sonneratiaceae
	Sonneratia alba J.J. Smith [K.S. Chua & H.T.W. Tan 442]
	Sonneratia ovata Backer [J. Lee 7]
	Sterculiaceae
	Commersonia bartramia (L.) Merr. [M.Y. Kok 52]
	Heritiera littoralis Dryand. ex W. Ait. [I.M. Turner 45]
	Pterospermum diversifolium Bl. [T.S. Teo 40]
	Symplocaceae
	Symplocos fasciculata Zoll. [E.M. Sim & L.P. Ng 52]
	Theaceae
	Adinandra dumosa Jack [E.M. Sim & L.P. Ng 26]
	Eurya acuminata DC. [M.Y. Kok 56]
	Thymelaeaceae
	Linostoma pauciflorum Griff. [Latifah & H.H. Neo 4]
	Tiliaceae
	Triumfetta rhomboidea Jacq. [M.F. Choong 55]
	Turneraceae
a	*Turnera ulmifolia* L. [Roslina 12]
	Typhaceae
a	*Typha angustifolia* L. [I.M. Turner 117]
	Ulmaceae
	Trema cannabina Lour. [K.S. Tan 34]
	Trema tomentosa (Roxb.) Hara [A. Ho & E.M. Sim 40]

Table 1 *(Continued)*

	Umbelliferae
	Centella asiatica (L.) Urb. [Roslina 28]
	Urticaceae
	Laportea interrupta (L.) Chew [H.H. Neo 105]
	Verbenaceae
	Clerodendrum inerme (L.) Gaertn. [E.M. Tim & L.P. Ng 49]
	Clerodendrum laevifolium Bl. [E.M. Sim & L.P. Ng 44]
e	*Clerodendrum paniculatum* L. [T.S. Teo 61]
e	*Clerodendrum philippinum* Schauer [A. Ho & E.M. Sim 22]
	Clerodendrum villosum Bl. [K.S. Chua 69]
	Gmelina asiatica L. [J. Lee 103]
a	*Lantana camara* L. [T.S. Teo 31]
	Premna corymbosa (Burm. f.) Rottl. & Willd. [K.S. Tan 35]
	Stachytarpheta indica (L.) Vahl [K.S. Chua 95]
	Vitex pinnata L. [J. Sim 14]
	Vitex trifolia L. [K.S. Tan 52]
	Vitaceae
	Ampelocissus elegans (Kurz) Gegnep. [M.Y. Kok 7]
	Cissus hastata (Miq.) Planch. [A. Ho & E.M. Sim 6]
	Zingiberaceae
e	*Languas galanga* (L.) Stuntz. [L.P. Law 9]

Table 2
Species previously recorded from Pulau Ubin;
representative collections are indicated in square brackets.

Species	Reference
PTERIDOPHYTES	
Adiantum flabellulatum L.	Ridley 1900
Asplenium macrophyllum Sw.	Ridley 1900
Cheilanthes tenuifolia (Burm.) Sw.	Ridley 1900
Drynaria sparsisora (Desv.) Moore	Johnson 1977
Humata heterophylla (Sm.) Desv.	Johnson 1977
Lindsaea divergens Hk. & Grev.	Johnson 1977
Phymatosorus scolopendria (Burm.) Pic. Ser.	Johnson 1977
Pityrogramma calomelanos (L.) Link	Johnson 1977
Pteris ensiformis L. [Ridley 3040]	–
Pyrrosia lanceolata (L.) Farwell [Ridley 9510]	Ridley 1900
Tectaria semipinnata (Roxb.) Morton [Ridley 6027]	Johnson 1977

Table 2 *(Continued)*

Species	Reference
SPERMATOPHYTES	
Agavaceae	
Dracaena elliptica Thunb.	Ridley 1900
Dracaena porteri Bak.	Ridley 1900
Amaranthaceae	
Amaranthus lividus L. [Ridley 4690]	Keng 1990
Cyathula prostrata (L.) Bl.	Ridley 1900
Amaryllidaceae	
Crinum asiaticum L.	Ridley 1900
Annonaceae	
Cyathostemma viridiflorum Griff. [Ridley s.n. Feb 1894]	Keng 1990
Apocynaceae	
Urceola lucida (DC.) Hook. f. [Ridley s.n. 1894]	Ridley 1900
Urnularia flavescens (Hook. f.) Stapf	Ridley 1900
Willughbeia coriacea Wall. [Ridley 9501]	Ridley 1900
Willughbeia grandiflora Dyer ex Hook. f. [Ridley s.n. 1893]	Markgraf 1972
Araceae	
Aglaonema simplex Bl. [Ridley s.n. 1890]	Ridley 1900
Araliaceae	
Schefflera cephalotes (C.B. Clarke) Harms.	Ridley 1900
Schefflera lanceolata Ridl.	Ridley 1900
Asclepiadaceae	
Calotropis procera (Ait.) Ait. f. — esc. cult.	Ridley 1900
Avicenniaceae	
Avicennia officinalis Bl.	Ridley 1900
Bignoniaceae	
Dolichandrone spathacea (L. f.) K. Schum.	Ridley 1900
Celastraceae	
Reissantia indica (Willd.) Hallé	Ridley 1900
Salacia chinensis L.	Ridley 1900
Salacia grandiflora Kurz [Ridley 4784]	Ridley 1900
Commelinaceae	
Aclisia secundiflora (Bl.) Bakh. f. [Ridley 4759]	Ridley 1900
Forrestia gracilis Ridl. [Ridley 4810]	Ridley 1900
Compositae	
Adenostemma lavenia (L.) O. Kuntze [Hullett 78]	Ridley 1900
Blumea riparia (Bl.) DC. [Ridley s.n. 1894]	—

Table 2 *(Continued)*

Species	Reference
Eleuthanthera ruderalis (Sw.) Sch.-Bip. [Furtado 18629]	Ridley 1900
Erigeron sumatrensis Retz. [Furtado 18342]	Ridley 1923
Synedrella nodiflora (L.) Gaertn. [Furtado 18624]	–
Tridax procumbens L. [Furtado 18347]	–
Wedelia biflora (L.) DC. [Hullett 387]	Keng 1990
Connaraceae	
Connarus planchonius Schellenb.	Ridley 1900
Cyperaceae	
Fimbristylis ferruginea (L.) Vahl	Ridley 1900
Scleria oblata S.T. Blake [Furtado 18630]	Blake 1961
Dipterocarpaceae	
Dipterocarpus c.f. *sublamellatus* Foxw. [Ridley s.n. 1890]	–
Euphorbiaceae	
Acalypha indica L.	Keng 1990
Antidesma velutinosum Bl. [Hullett 629]	Ridley 1900
Claoxylon longifolium Endl. ex Hassk. [Hullett s.n. 1885]	Ridley 1900
Galearia fulva (Tul.) Miq.	Ridley 1900
Glochidion microbotrys Hook. f.	Ridley 1900
Macaranga triloba (Bl.) M.A.	Ridley 1900
Suregada multiflora (Juss.) Baill.	Ridley 1900
Fagaceae	
Lithocarpus elegans (Bl.) Hatus. ex Soepadmo	Ridley 1900
Lithocarpus wallichianus (Lindl. ex Hance) Rehd. [Ridley 7479]	Soepadmo 1970
Flagellariaceae	
Flagellaria indica L.	Ridley 1900
Goodeniaceae	
Scaevola sericea Vahl	Ridley 1900
Gramineae	
Chloris barbata Sw. [Furtado 18348]	–
Digitaria ciliaris (Retz.) Koel. [Furtado 18637]	–
Digitaria violascens Link [Ridley s.n. 1894]	–
Eragrostis tenella (L.) P. Beauv. ex R. & S. [Ridley s.n. 1892]	–
Ischaemum muticum L. [Furtado 18625]	–
Leptaspis urceolata (Roxb.) R. Br. [Ridley 369]	–
Mnesithea glandulosa (Trin.) Koning & Sosef [Ridley s.n. 1892]	Ridley 1900
Guttiferae	
Calophyllum inophyllum L.	Ridley 1900
Garcinia eugeniaefolia Wall. ex T. Anders. [Ridley 9488]	Ridley 1900
Garcinia hombroniana Pierre [Ridley 4791]	Ridley 1900
Garcinia nervosa Miq.	Ridley 1900

Table 2 *(Continued)*

Species	Reference
Labiatae	
Hyptis suaveolens (L.) Poit. [Furtado 18344]	–
Ocimum tenuiflorum L. [Furtado 18622]	–
Lauraceae	
Actinodaphne macrophylla (Bl.) Nees [Ridley 9489]	Keng 1990
Litsea umbellata (Lour.) Merr. [Ridley s.n. 2 Mar 1893]	Ridley 1900
Neolitsea zeylanica Merr.	Ridley 1900
Phoebe grandis Merr.	Keng 1990
Leguminosae	
Albizia retusa Benth. [Ridley 4752]	Ridley 1900
Alysicarpus vaginalis (L.) DC.	Ridley 1900
Canavalia cathartica Thou. [Hullett 463]	Ridley 1922
Crotalaria mucronata Desv. [Furtado 18634]	–
Dalbergia candenatensis (Dennst.) Prain [Ridley 4678]	Keng 1990
Dalbergia junghuhnii Benth.	Keng 1990
Derris heptaphylla (L.) Merr. [Hullett 6194]	Ridley 1900
Derris trifoliata Lour. [Furtado 18346]	Ridley 1900
Pithecellobium ellipticum (Bl.) Hassk.	Ridley 1900
Pongamia pinnata (L.) Pierre [Ridley s.n. 1891]	Ridley 1900
Loganiaceae	
Fagraea auriculata Jack	Ridley 1900
Fagraea racemosa Jack ex Wall.	Ridley 1900
Malpighiaceae	
Tristellateia australasiae A. Rich.	Ridley 1900
Malvaceae	
Abutilon indicum (L.) Sweet	Ridley 1900
Hibiscus surattensis L. [Furtado 18623]	Ridley 1900
Thespesia populnea (L.) Sol. ex Correa [Ridley 4624]	Ridley 1900
Melastomataceae	
Diplectria viminalis (Jack) O. Ktze.	Keng 1990
Pogonanthera pulverulenta Bl. [Hullett 391]	Keng 1990
Meliaceae	
Chisocheton erythrocarpus Hiern	Ridley 1900
Chisocheton macrophyllus King [Ridley 4767, isosyntype]	Ridley 1900
Dysoxylum cauliflorum Hiern [Hullett 392]	Ridley 1900
Sandoricum koetjape (Burm. f.) Merr.	Ridley 1900
Menispermaceae	
Cyclea laxiflora Miers	Ridley 1900
Moraceae	
Artocarpus dadah Miq. [Ridley 4721]	Ridley 1900
Ficus fistulosa Reinw. ex Bl.	Ridley 1900

Table 2 *(Continued)*

Species	Reference
Ficus kerkhovenii Val.	Keng 1990
Ficus laevis Bl.	Ridley 1900
Ficus obscura Bl. var. *borneensis* (Miq.) Corner	Ridley 1900
Ficus pellucido-punctata Griff.	Ridley 1900
Myristicaceae	
Knema glaucescens Jack	Ridley 1900
Knema globularia (Lamk.) Warb. [Ridley 4817]	Keng 1990
Myrsinaceae	
Aegiceras corniculatum (L.) Blanco	Ridley 1900
Ardisia singaporensis Ridl. [Ridley 2816, isosyntype]	Ridley 1900
Ardisia villosa Roxb. [Ridley 2809]	Ridley 1900
Myrtaceae	
Eugenia leucoxylon (Korth.) Miq. [Ridley 9486]	Keng 1990
Tristaniopsis whitiana (Griff.) Wilson & Waterhouse [Ridley 4970]	Ridley 1900
Oleaceae	
Olea brachiata (Lour.) Merr.	Ridley 1900
Ochnaceae	
Gomphia serrata (Gaertn.) Kanis	Ridley 1900
Orchidaceae	
Bulbophyllum medusae (Lindl.) Rchb. f.	Ridley 1900
Corymborkis veratrifolia (Reinw.) Bl. [Ridley 2037]	Ridley 1900
Cymbidium finlaysonianum Lindl. [Goodenough s.n. 1894]	–
Grammatophyllum speciosum Bl.	Ridley 1900
Renanthera elongata Lindl.	Ridley 1900
Spathoglottis plicata Bl. [Furtado 18621]	–
Thrixspermum calceolus (Lindl.) Rchb. f. [Goodenough s.n. 23/5/1896]	Ridley 1900
Vanilla griffithii Rchb. f.	Ridley 1900
Palmae	
Caryota mitis Lour. [Goodenough 3148]	–
Licuala spinosa Wurmb [Ridley 3166]	Ridley 1900
Nenga pumila (Mart.) Wendl. [Goodenough s.n. 1890]	–
Orania sylvicola (Griff.) H.E. Moore [Ridley 3146]	Ridley 1900
Pandanaceae	
Pandanus odoratissimus L. f.	Ridley 1900
Pandanus parvus Ridley	Ridley 1900
Passifloraceae	
Passiflora foetida L. [Furtado 18626]	–
Piperaceae	
Piper caninum Bl.	Ridley 1900
Rhamnaceae	
Ventilago malaccensis Ridl.	Keng 1990

Table 2 *(Continued)*

Species	Reference
Rhizophoraceae	
Bruguiera cylindria (L.) Bl. [Ridley 366]	Ridley 1900
Rubiaceae	
Borreria articularis (L. f.) F.N. Will. [Furtado 18339]	–
Borreria laevicaulis (Miq.) Ridl. [Furtado 18343]	Keng 1990
Gaertnera viminea Hook. f. ex Clarke [Ridley 9500]	Ridley 1900
Ixora congesta Roxb.	Ridley 1900
Lasianthus cyanocarpus Jack [Ridley 9499]	Ridley 1900
Morinda umbellata L.	Ridley 1900
Ophiorrhiza singaporensis Ridl.	Ridley 1923
Oxyceros longiflora (Lamk.) Yamazaki [Ridley 9487]	–
Psychotria griffithii Hook. f.	Ridley 1900
Psychotria malayana Jack	Ridley 1900
Psychotria rostrata Bl.	Keng 1990
Uncaria glabrata (Bl.) DC.	Ridley 1900
Urophyllum streptopodium Wall. ex Hook. f. [Hullett 393]	Ridley 1900
Rutaceae	
Clausena excavata Burm. f.	Ridley 1900
Sapindaceae	
Cardiospermum halicacabum L.	Ridley 1900
Lepisanthes rubiginosa (Roxb.) Leenh. [Hullett 386]	Ridley 1900
Mischocarpus sundaicus Bl. [Ridley 9495]	–
Solanaceae	
Datura candida (Pers.) Pasq. – esc. cult.	Ridley 1900
Physalis minima L. [Ridley 367]	Keng 1990
Solanum torvum Sw. [Furtado 18628]	–
Sterculiaceae	
Pterospermum diversifolium Bl. [Ridley 387]	Ridley 1900
Sterculia coccinea Jack	Ridley 1900
Turneraceae	
Turnera ulmifolia L. [Furtado 18633]	–
Urticaceae	
Poikilospermum cordifolium (Borg.-Petr.) Merr.	Ridley 1900
Poikilospermum suaveolens (Bl.) Merr.	Ridley 1900
Verbenaceae	
Clerodendrum inerme (L.) Gaertn.	Keng 1990
Stachytarpheta indica (L.) Vahl [Furtado 18627]	–
Vitex trifolia L.	Keng 1990
Zingiberaceae	
Hornstedtia leonurus (Koenig) Retz. [Ridley 9494]	Holttum 1950

Table 3
The five angiosperm families with the most species for the flora of Singapore (after Turner *et al.* 1990) and the contemporary flora of Pulau Ubin. Total number of species with number of alien species in brackets.

Singapore		**Pulau Ubin**	
Orchidaceae	194 (0)	Gramineae	26 (8)
Rubiaceae	147 (7)	Leguminosae	25 (10)
Euphorbiaceae	127 (13)	Euphorbiaceae	24 (8)
Gramineae	119 (18)	Cyperaceae	19 (1)
Cyperaceae	95 (3)	Compositae	18 (5)

References

Airy Shaw, H.K. (1972). The Euphorbiaceae of Siam. *Kew Bull.* 26, 191–363.

Blake, S.T. (1961). Two new species of *Scleria*. *Blumea* 11, 219–223.

Corlett, R.T. (1990). Flora and reproductive phenology of the rain forest at Bukit Timah, Singapore. *J. Trop. Ecol.* 6, 55–65.

Holttum, R.E. (1950). The Zingiberaceae of the Malay Peninsula. *Gard. Bull. Sing.* 13, 1–249.

_____. (1981). The fern genus *Tectaria* Cav. in Malaya. *Gard. Bull. Sing.* 13, 132–147.

Johnson, A. (1977). *A student's guide to the ferns of Singapore Island*, Second Edition, Singapore University Press, Singapore.

Keng, H. (1990). *The concise flora of Singapore: gymnosperms and dicotyledons*, Singapore University Press, Singapore.

Luerssen, C. (1882). Pteridologische Notizen. *Botanisches Centralblatt* 11, 26–31.

Markgraf, F. (1972). Florae Malesianae Praecursores LIII. Apocynaceae II. 6. *Urnularia*, 7. *Willughbeia*, 8. *Kopsia*. *Blumea* 20, 407–425.

Ng, P.S. (1988). *Singapore facts and pictures 1988*. Information Division, Ministry of Commuications & Information, Singapore.

Ridley, H.N. (1900). The flora of Singapore. *J. Straits' Branch Roy. As. Soc.* 33, 27–196.

_____. (1922). *The flora of the Malay Peninsula*, Volume I, L. Reeve & Co., London.

_____. (1923). *The flora of the Malay Peninsula*, Volume II, L. Reeve & Co., London.

Soepadmo, E. (1970). Florae Malesianae Praecursores XLIX Malesian species of *Lithocarpus* Bl. (Fagaceae). *Reinwardtia* 8, 197–308.

Turner, I.M., Chua, K.S. and Tan, H.T.W. (1990). A checklist of the native and naturalized vascular plant species of the Republic of Singapore. *J. Sing. Nat. Acad. Sc.* 18 & 19, 58–88.

Whitmore, T.C. (1973). Euphorbiaceae. *Tree Flora of Malaya*, Volume 2, 34–136.

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Diatoms from Marine Environments of Peninsular Malaysia and Singapore

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Abstract

A total of 230 taxa of diatoms belonging to 58 genera were recorded from 12 locations in Peninsular Malaysia and 14 locations in Singapore. The most common genera are *Navicula* and *Nitzschia.*

Introduction

For a long time now the only detailed studies on the marine diatoms of the South-east Asian region have been those by Mann (1925) and Allen & Cupp (1935) on the Philippines Islands and the Java Sea, respectively. More recent studies include those by Takano (1960) who collected from the Arafura and eastern Timor Seas; Wood (1963) who listed many species from the Indonesian waters; Podzorski & Hákansson (1987) on the freshwater and marine diatoms of Palawan, Philippines; and Wah & Wee (1988) on the diatoms of mangrove environments of Singapore and southern Peninsular Malaysia. This paper gives an account on the diatoms of marine environments of Peninsular Malaysia and Singapore.

Materials and Methods

Materials collected for diatoms were from seaweeds obtained from the littoral and sublittoral zones of coastal areas. In addition, sand, molluscs, stones, debris and sediments were also collected. A total of 12 locations in Peninsular Malaysia and 14 locations in Singapore were visited during 1986–87 (Fig. 1). Samples of planktonic diatoms came from the Zoological Raffles Collection of the National University of Singapore. These were collected from the vicinity of Sisters Island in 1968–69. Permanent slides were prepared after the method of Gerloff & Natour (1982), details of which are described in an earlier publication (Wah & Wee, 1988). All taxa were identified from the prepared slides using the classical criteria of size, shape and ornamentation. Relative abundance of the taxa refers to the abundance of the diatoms in the slides referred to. Details of slide numbers giving collection locations and substrata are tabulated in Table I. Slides were deposited in the Cryptogamic Herbarium of the Botany Department, National University of Singapore.

Results

A total of 230 taxa of diatoms belonging to 58 genera were recorded from 12 locations in Peninsular Malaysia and 14 locations in Singapore. Only five genera were

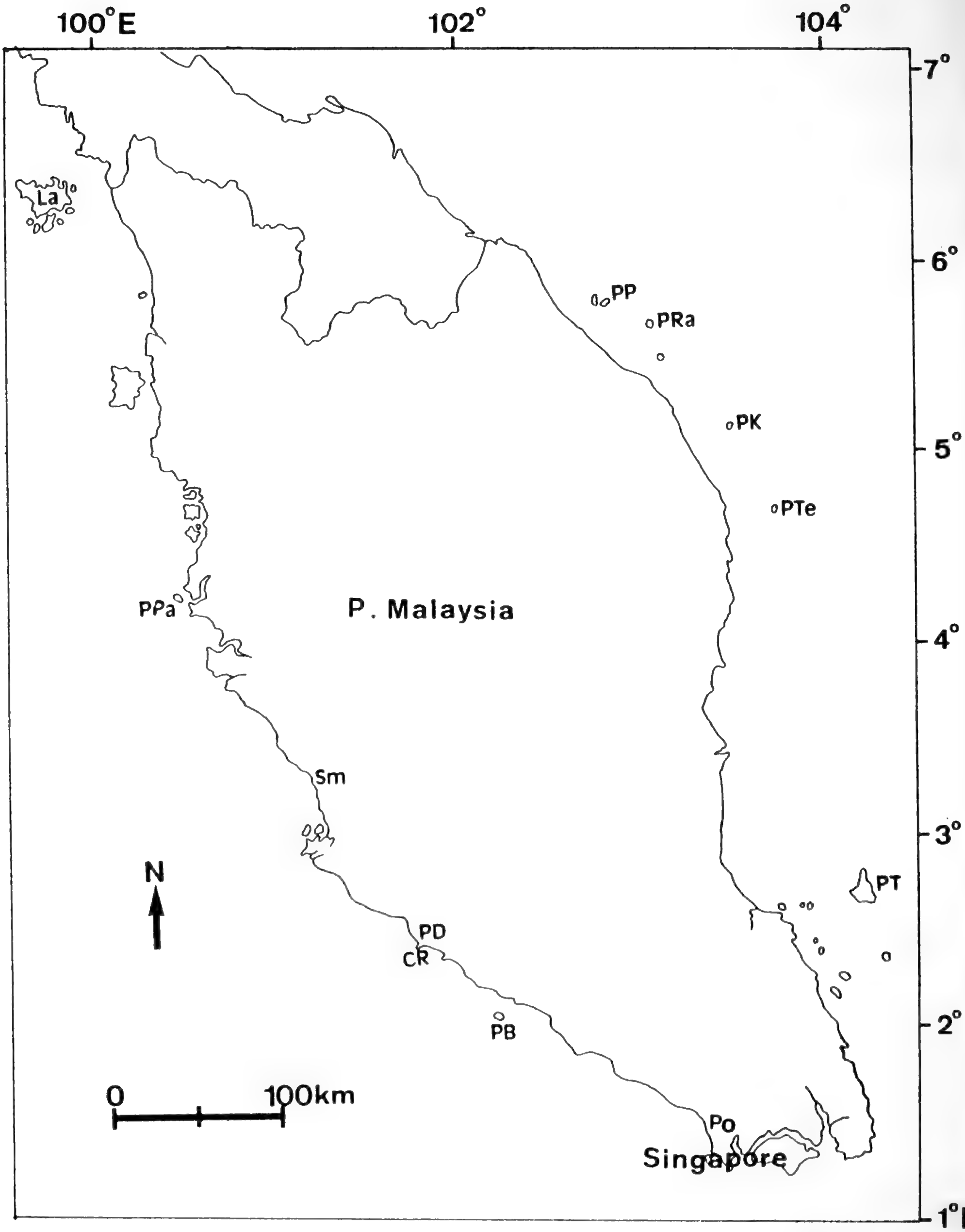


Fig. 1a. Map of Peninsular Malaysia showing collecting sites (CR: Cape Rachado; La: Pulau Langkawi; Po: Pontian; PB: Pulau Besar; PD: Port Dickson; PK: Pulau Kapas; PP: Pulau Perhentian; PPa: Pulau Pangkor; PRa: Pulau Redang; PT: Pulau Tioman; PTe: Pulau Tenggul; Sm: Sementa).

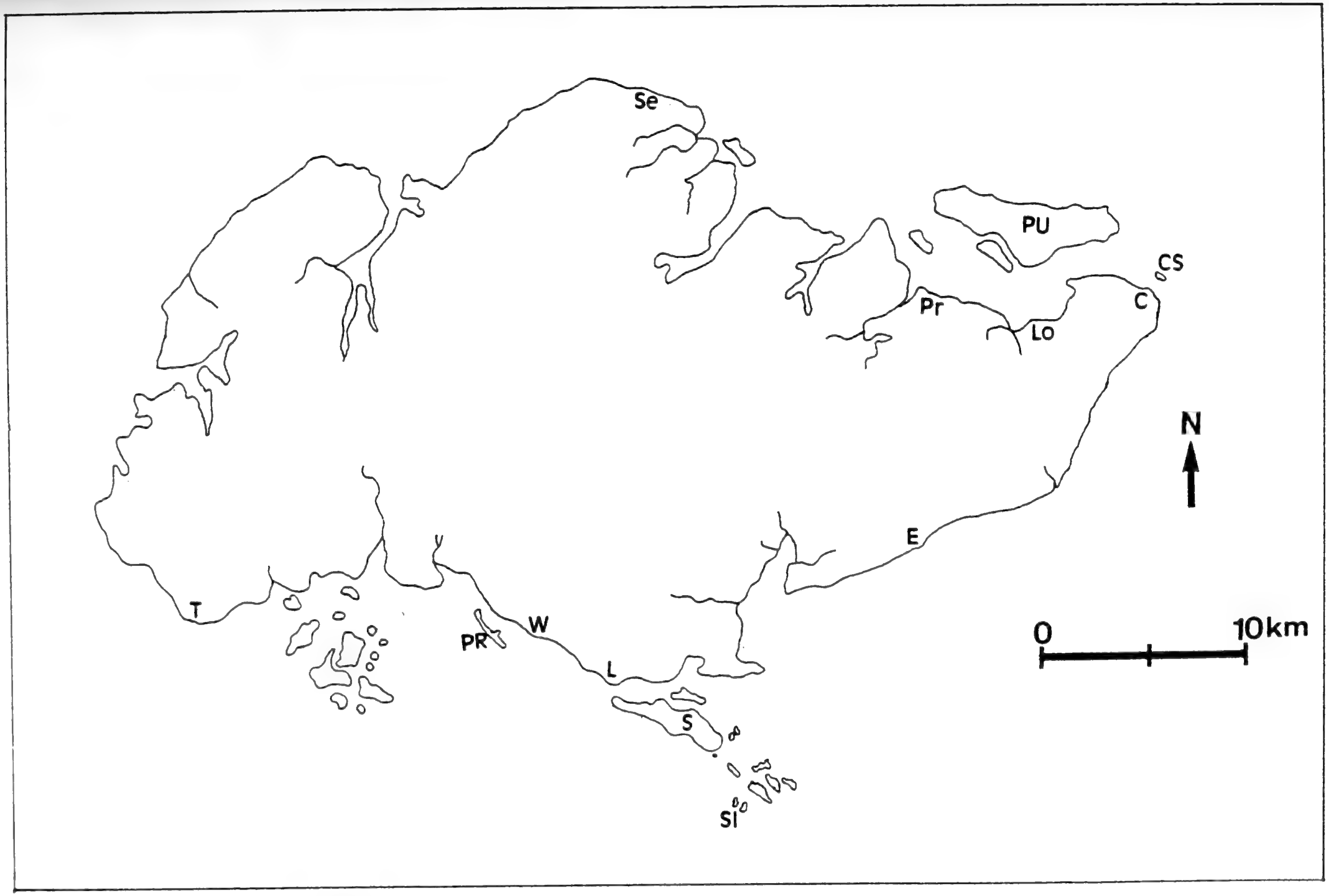


Fig. 1b. Map of Singapore showing collecting sites (C: Changi; CS: Changi seafarm; E: East Coast Park; L: Labrador Park; Lo: Loyang; Pr: Pasir Ris; PR: Pulau Retan Laut; PU: Pulau Ubin; S: Sentosa; Se: Sembawang; SI: Sisters Island; T: Tuas; W: West Coast Park).

Table 1
List of slides giving collection locations and materials collected.

No.	Locations	Materials
1, 2, 3, 4	East Coast Park	seaweeds
12	Changi	seaweeds
17	Kranji	mollusc
19	Loyang	stones
31	Pulau Ubin	roots and algae
33	Pulau Ubin	mud
37, 38	Pulau Ubin	sand
40	Pulau Ubin	reddish sand
43	Pulau Ubin	rock
47, 48	East Coast Park	seaweeds
49	Changi	seaweeds
75	Labrador Park	red algae
79, 80	Labrador Park	sediment
81	Labrador Park	seaweeds
91	Port Dickson	sediment and sand
93	Port Dickson	seaweeds
95	Pasir Ris	sand
100	Pasir Ris	seaweeds
116	Pulau Retan Laut	seaweeds
119, 120	Pulau Tioman	molluscs
122	Pulau Tioman	debris
124	Pulau Tioman	seaweeds
125	Pulau Tioman	water
129, 130	Pulau Tioman	sand
132	Pulau Tioman	black sediment
135, 138	Pulau Tioman	pole
141	Changi	seafarm debris
175	Sembawang	foam
183	Sembawang	seaweeds
257	West Coast Park	seaweeds
259	West Coast Park	sand
273	Sentosa	sand
278	Sentosa	submerged grasses
297	Pontian	sandy mud
315	Around Sisters Island	surface pumping, 16.4.68
317	Around Sisters Island	bottom pumping, 16.4.68
319	Around Sisters Island	surface towing, 21.5.68
321	Around Sisters Island	surface pumping, 14.1.69
323	Around Sisters Island	bottom pumping, 14.1.69
333	Pulau Kapas	seaweeds
335	Pulau Redang	seaweeds
337	Pulau Pangkor	seaweeds
339	Sementa	red algae
341	Pulau Langkawi	water sample
343	Pulau Besar	seaweeds
345	Pulau Tenggul	coral
347	Cape Rachado	seaweeds
350	Pulau Perhentian	seaweeds
351	Tuas	sand
353	Tuas	seaweeds
355	Tuas	filamentous algae
357, 359	Tuas	debris, stone

represented by ten or more taxa, and these were *Amphora* (14), *Diploneis* (21), *Navicula* (29), *Nitzschia* (20) and *Pleurosigma* (11). The most common genera were *Navicula* and *Nitzschia*, the former represented by 27 species and the latter by 19 species.

Systematics

For the sake of convenience, the list of taxa presented here is arranged alphabetically by genus with species and their varieties listed alphabetically within each genus. Figures are given for all taxa.

Achnanthes Bory 1822

A. brevipes var. *intermedia* (Kütz.) Cl. Figs. 2–3

References: Cleve 1894–95, 27(3), p. 193; Hustedt 1959, 7(2), p. 425, figs. 877d, e.
Description: Length 25–42 μm, breadth 9–10 μm, 8–10 striae in 10 μm. United into short filament.
Distribution: Very common. Found on slides 1, 135, 257, 339, 347, 353.
Comments: A cosmopolitan species.

A. hauckiana Grun. Figs. 4–5

References: Cleve 1894–95, 27(3), p. 190; Patrick & Reimer 1966, p. 267, pl. 17, figs. 25–32.
Description: Length 16–25 μm, breadth 8–10 μm, 7–10 striae in 10 μm.
Distribution: Common. Found on slides 125, 353.
Comments: A cosmopolitan species. Freshwater to brackish.

A. lewisiana Patr. Figs. 6–7

References: Patrick & Reimer 1966, p. 266, pl. 17, figs 19, 20.
Description: Length 14 μm, breadth 6 μm, 15 striae in 10 μm.
Distribution: Common. Found on slides 273, 343, 353, 355.
Comments: Freshwater species.

A. longipes Ag. Figs. 8–9

References: Cleve 1894–95, 27(3), p. 195; Hendey 1964, p. 174, pl. 28, figs. 1–6; pl. 42, fig. 2.
Description: Length 62–69 μm, breadth 11–14 μm, 6–7 costae and 9–10 striae in 10 μm. Solitary or joined into filament; attached by mucous stipe.
Distribution: Very common. Found on slides 12, 116.
Comments: A cosmopolitan species.

Actinocyclus Ehrenb. 1838

A. ehrenbergii var. *sparsa* (Greg.) Hust. Fig. 10

References: Hendey 1964, p. 84; Foged 1984, p. 15, pl. 19, fig. 3.
Description: Diameter 37–66 μm, 5–6 areolae and 9–11 marginal striae in 10 μm.
Distribution: Common. Found on slides 48, 119, 124, 138.
Comments: A cosmopolitan species.

A. octonarius Ehrenb Fig. 11

References: Hendey 1964, p. 83, pl. 24, fig. 3; Priddle & Fryxell 1985, p. 108.
Description: Diameter 60 μm, 7 areolae and 16 marginal striae in 10 μm.

Distribution: Not common. Found on slides 95, 339.
Comments: A cosmopolitan species.

A. platensis Müll. Melchers. Fig. 12

References: Hendey 1958, p. 43, pl. 5, figs. 1, 2.
Description: Diameter 56–77 μm, 20 marginal striae in 10 μm.
Distribution: Common. Found on slide 3.

Actinoptychus Ehrenb. 1839

A. senarius (Ehrenb.) Ehrenb. Fig. 13

References: Hendey 1964, p. 95, pl. 23, figs 1 and 2; Priddle & Fryxell 1985, p. 110, fig. A.
Description: Diameter 39 μm.
Distribution: Not common. Found on slides 4, 79, 116, 323, 343.
Comments: A cosmopolitan species.

Amphora Ehrenb. 1840

A. acutiuscula Kütz. Figs. 14–15

References: Prowse 1962, p. 55, pl. 17, figs. e–f, n, q, v–w; pl. 18, fig. b; Patrick & Reimer 1975, p. 77, pl. 14, figs. 9, 10.
Description: Length 35–55 μm, breadth 6–13 μm, 11–12 dorsal, 18–20 ventral striae in 10 μm.
Distribution: Common. Found on slides 12, 17, 43, 297.
Comments: A freshwater species.

A. angusta var. *eulensteinii* Grun. Fig. 16

References: Cleve 1894–95, 27(3), p. 135.
Description: Length 81 μm, breadth 15 μm, 11 dorsal and 14 ventral striae in 10 μm.
Distribution: Not common. Found on slides 100, 357.
Comments: A cosmopolitan species.

A. angusta var. *oblongella* Grun. Fig. 17

References: Cleve 1894–95, 27(3), p. 135.
Description: Length 52–57 μm, breadth 8–10 μm, 12–15 striae in 10 μm.
Distribution: Rare. Found on slides 183, 353.

A. angusta var. *ventricosa* (Greg.) Cl. Fig. 18

References: Cleve 1894–95, 27(3), p. 135; Navarro 1982, p. 31, pl. 20, figs. 1–2.
Description: Length 49–58 μm, breadth 10–13 μm, 14–15 striae in 10 μm.
Distribution: Common. Found on slides 335, 355.

A. coffeiformis (Ag.) Kütz. Fig. 19

References: Prowse 1962, p. 56, pl. 17, figs. h, o.
Description: Length 30–33 μm, breadth 6–7 μm, 18–20 striae in 10 μm.
Distribution: Not common. Found on slides 1, 257, 335. Freshwater to brackish.
Comments: A cosmopolitan species.

A. crassa Greg. Fig. 20

References: Hendey 1964, p. 262. Foged 1975, p. 10, pl. 36, fig. 10.
Description: Length 132 μm, breadth 18 μm, 5 dorsal, 6 ventra costae in 10 μm.
Distribution: Rare. Found on slide 93.
Comments: A cosmopolitan species.

A. decipiens Cl. Fig. 21

References: Cleve 1894–95, 27(3), p. 108, pl. V, figs. 16–18.
Description: Length 41 μm, breadth 17 μm, 12 striae in 10 μm.
Distribution: Rare. Found on slide 12.

A. graeffi var. *minor* Perag. Fig. 22

References: Hendey 1964, p. 263, pl, 37, fig. 8.
Description: Length 38 μm, breadth 9 μm, 11–12 striae in 10 μm.
Distribution: Rare. Found on slides 2, 12.

A. holsatica Hust. Figs. 23–26

References: Caljon 1983, p. 119, pl. 21, figs. 2–8.
Description: Length 18–42 μm, breadth at girdle view 8–14 μm and at valve view 5 μm, 12–20 striae in 10 μm.
Distribution: Very common. Found on slides 1, 12, 122, 257, 259, 273, 335, 337, 339, 341, 343, 347, 350, 353.
Comments: A cosmopolitan species. Freshwater to brackish.

A. ostrearia Bréb Fig. 27

References: Cleve 1894–95, 27(3), p. 129.
Description: Length 58 μm, breadth 15 in valve view, 38 μm in girdle view, 11–12 striae in 10 μm.
Distribution: Rare. Found on slide 38.
Comments: A cosmopolitan species. Freshwater to marine.

A. proteus Greg. Fig. 28

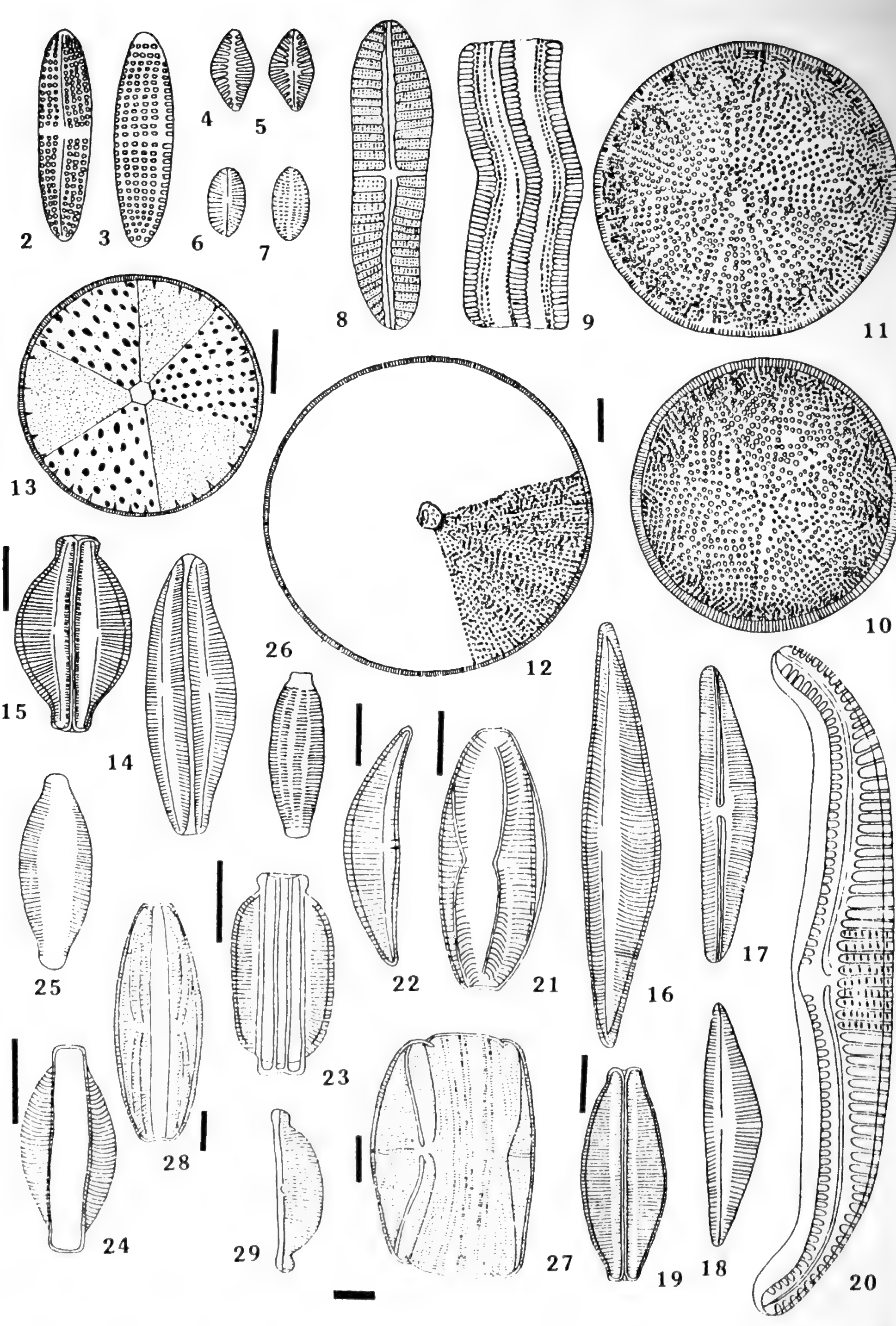
References: Prowse 1962, p. 58, pl. 17, fig. u; pl. 18, fig. a; Cleve 1894–95, 27(3), p. 103.
Description: Length 56 μm, breadth 8 in valve view, 20 μm in girdle view, 9–12 striae in 10 μm.
Distribution: Rare. Found on slide 3.
Comments: A cosmopolitan species.

A. turgida Greg. Fig. 29

References: Cleve 1894–95, 27(3), p. 123; Hendey 1964, p. 264.
Description: Length 32 μm, breadth 9–10 μm, 15 striae in 10 μm.
Distribution: Rare. Found on slides 273, 333, 341, 351.
Comments: A cosmopolitan species. Marine to brackish.

A. valida Perag. Fig. 30

References: Cleve 1894–95, 27(3), p. 102.
Description: Length 82 μm, breadth 16–18 μm in valve, 50 μm in girdle view, 7 striae in 10 μm.
Distribution: Rare. Found on slide 124.



Figs. 2–29 (horizontal common scale bar and those of Figs. 12, 13, 15, 19, 21–24, 27 and 28 = 10 μm)

Figs. 2–3. *Achnanthes brevipes* var. *intermedia*, raphe valve and rapheless valve. Figs. 4–5. *A. hauckiana*, raphe valve and rapheless valve. Figs. 6–7 *A. lewisiana*, raphe valve and rapheless valve. Figs. 8–9. *A. longipes*, raphe valve and girdle view. Fig. 10. *Actinocyclus ehrenbergii* var. *sparsa*. Fig. 11. *A. octonarius*. Fig. 12. *A. platensis*. Fig. 13 *Actinoptychus senarius*. Figs. 14–15. *Amphora acutiuscula*. Fig. 16. *A. angusta* var. *eulensteinii*. Fig. 17. *A. angusta* var. *oblongella*. Fig. 18. *A. angusta* var. *ventricosa*. Fig. 19. *A. coffeiformis*. Fig. 20. *A. crassa*. Fig. 21. *A. decipiens*. Fig. 22. *A. graeffi* var. *minor*. Figs. 23–26. *A. holsatica*. Fig. 27 *A. ostrearia*. Fig. 28. *A. proteus*. Fig. 29. *A. turgida*.

A. wisei (Salah) Simonsen. Fig. 31

References: Foged 1975, p. 12, pl. 26, fig. 11.
Description: Length 14 μm, breadth 5 μm, 16 striae in 10 μm.
Distribution: Rare. Found on slide 273.
Comments: A cosmopolitan (?) species.

Asterionella Hassall 1855

A. japonica Cl. & Möll. Fig. 32

References: Cupp 1943, p. 188, fig. 138; Hendey 1964, p. 158, pl. 21, fig. 1.
Description: Length 92–104 μm, inflated length 22–24 μm, inflated breadth 11-12 μm.
Distribution: Not common. Found on slide 321.

Bacillaria Gmelin 1788

B. paradoxa var. *tumidula* Grun. Fig. 33

References: Navarro 1982, p. 51.
Description: Length 106–149 μm, breadth 10-13 μm, 15–20 striae, 7–9 keel puncta in 10 μm.
Distribution: Common. Found on slide 2.
Comments: A cosmopolitan species. Freshwater to marine.

Bacteriastrum Schadbolt 1853

B. delicatulum Cl. Fig. 34

References: Gran & Angst 1931, p. 463, fig. 46a–b; Hendey 1964, p. 139, pl. 6, fig. 2.
Description: Diameter 16 μm, 9 bristles. United to form chains.
Distribution: Not common. Found on slide 317.
Comments: Common in temperate waters.

B. elongatum Cl. Fig. 35

References: Cupp 1943, p. 99, fig. 57; Hendey 1964, p. 139, pl. 6, fig. 3.
Description: Diameter 14 μm, 9 bristles.
Distribution: Not common. Found on slide 339.
Comments: Common in tropical seas.

B. hyalinum Lauder. Fig. 36

References: Cupp 1943, p. 96, fig. 56(A); Hendey 1964, p. 139, pl. 6, fig. 1.
Description: Diameter 24–39 μm, 14–27 bristles. United to form chains.
Distribution: Common. Found on slide 317.

Biddulphia Gray 1821

B. biddulphiana (Smith) Boyer (*B. pulchella* Gray.). Figs. 40–42

References: Hendey 1964, p. 101, pl. 25, fig. 1.
Description: Length 76–101 μm, breadth 69–82 μm in pervalvar axis; length 77–90 μm, breadth 38–58 μm in top view. Colonial, united with their processes to form short chains.
Distribution: Common. Found on slides 12, 355.
Comments: A cosmopolitan species.

B. mobiliensis (Bailey) Grun. Fig. 37

References: Gran & Angst 1931, p. 490, fig. 74; Cupp 1943, p. 153, fig. 110; Hendey 1964, p. 104, pl. 22, fig. 3.
Description: Length 69 μm in apical axis, breadth 44 μm, 11 striae in 10 μm. Solitary or in chains.
Distribution: Rare. Found on slide 323.

B. petitiana (Leud.-Fortm.) Mann. Figs. 38–39

References: Mann 1925, p. 43, pl. 10, figs. 4, 5.
Description: Length 70 μm in pervalvar axis; length 66 μm, breadth 38 μm in top view.
Distribution: Rare. Found on slide 75.

B. recticulata Roper. Fig. 43

References: Boyer 1926–27, p. 128, Hendey 1958, p. 48.
Description: Length 88–96 μm, breadth 68–96 μm in pervalvar axis (girdle view).
Distribution: Rare. Found on slide 333.
Comments: A cosmopolitan species (?).

B. vesiculosa (Ag.) Boyer. Fig. 44

References: Lebour 1930, p. 181, pl. 4, fig. 1.
Description: Length 91–104 μm, breadth 52 μm in pervalvar axis (girdle view).
Distribution: Rare. Found on slides 4, 278.

Caloneis Cleve 1891

C. alpestris (Grun.) Cl. Fig. 45

References: Patrick & Reimer 1966, p. 587, pl. 54, fig. 9.
Description: Length 73 μm, breadth 15 μm, 20 striae in 10 μm.
Distribution: Rare. Found on slide 12.

C. bacillum (Grun.) Cl. Fig. 46

References: Cleve-Euler 1955, 5(4), p. 102, fig. 1147 a–c; Patrick & Reimer 1966, p. 586, pl. 54, fig. 8.
Description: Length 21–25 μm, breadth 10–12 μm, 21–23 striae in 10 μm.
Distribution: Not common. Found on slides 341, 350.
Comments: A cosmopolitan species. Freshwater.

C. egena (A. Sch.) Cl. Fig. 47

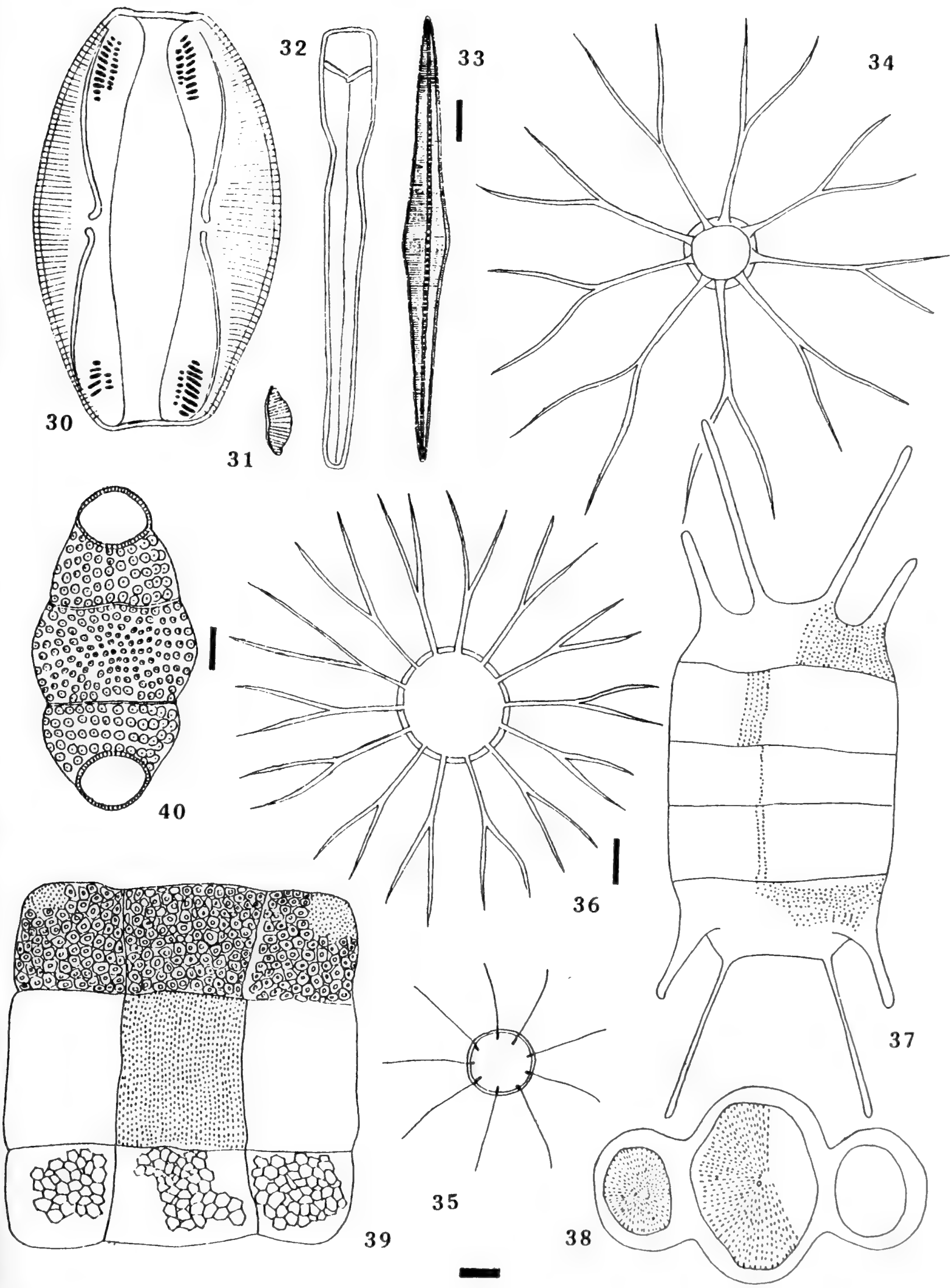
References: Cleve 1894–95, 26(2) p. 66; Foged 1984, p. 24, pl. 44, fig. 10.
Description: Length 25 μm, breadth 6 μm.
Distribution: Rare. Found on slide 345.

C. liber (W. Sm.) Cl. Fig. 48

References: Cleve 1894–95, 26(2) p. 54; Hendey 1964, p. 229, pl. 29, fig. 2.
Description: Length 39 μm, breadth 11 μm, 18 striae in 10 μm.
Distribution: Rare. Slide 31.

C. linearis (Grun.) Boyer. Fig. 49

References: Hendey 1964, p. 230, pl. 29, fig. 3; Foged 1984, p. 26, pl. 44, figs. 4, 5.



Figs. 30–40 (horizontal common scale bar and those of Figs. 33, 36 and 40 = 10 μm)

Fig. 30. ***Amphora valida.*** Fig. 31. *A. wisei.* Fig. 32. *Asterionella japonica.* Fig. 33. ***Bacillaria paradoxa*** var. ***tumidula.*** Fig. 34. ***Bacteriastrum delicatulum.*** Fig. 35. *B. elongatum.* Fig. 36. *B. hyalinum.* Fig. 37. ***Biddulphia mobiliensis***, girdle view. Figs. 38–39. *B. petitiana*, valve view and girdle view. Fig. 40. *B. biddulphiana*, valve view.

Description: Length 48 μm, breadth 8 μm.
Distribution: Not common. Found on slide 345.
Comments: A cosmopolitan species.

Campylodiscus Ehrenb. 1841

C. fastuosus Ehrenb. Fig. 50

References: Hendey 1964, p. 290, pl. 40, fig. 13.
Description: Diameter 54–68 μm.
Distribution: Not common. Found on slides 141, 339, 343, 345, 357.
Comments: Common on sandy beaches of all North Sea coasts (Hendey, 1964).

C. hypodromus Brun & Tempére. Fig. 51

References: Hendey 1964, p. 291.
Description: Diameter 62–113 μm, 2–3 costae in 10 μm.
Distribution: Rare. Found on slide 345.

C. ralfsii W. Sm. Fig. 52

References: Hendey 1970, p. 161, pl. 5, fig. 53; 1964, p. 291.
Description: Diameter 28–56 μm, 2–3 costae in 10 μm.
Distribution: Not common. Found on slides 79, 345, 347.

Chaetoceros Ehrenb. 1844

C. danicum Cl. Fig. 53

References: Hendey 1964, p. 122, pl. 10, fig. 5.
Description: Diameter 25–31 μm. Solitary or in chains.
Distribution: Common. Found on slide 317.

C. lorenzianum Grun. Fig. 54

References: Gran 1905, p. 76, fig. 90; Hendey 1964, p. 124, pl. 26, fig. 1.
Description: Diameter 17 μm. Solitary or in chains.
Distribution: Not common. Found on slide 323.
Comments: A cosmopolitan species.

C. peruvianum Brightw. Fig. 55

References: Hendey 1964, p. 123, pl. 9, fig. 3; Priddle & Fryxell 1985, p. 40.
Description: Diameter 30 μm. Solitary or in chains.
Distribution: Not common. Found on slide 323.
Comments: A cosmopolitan species.

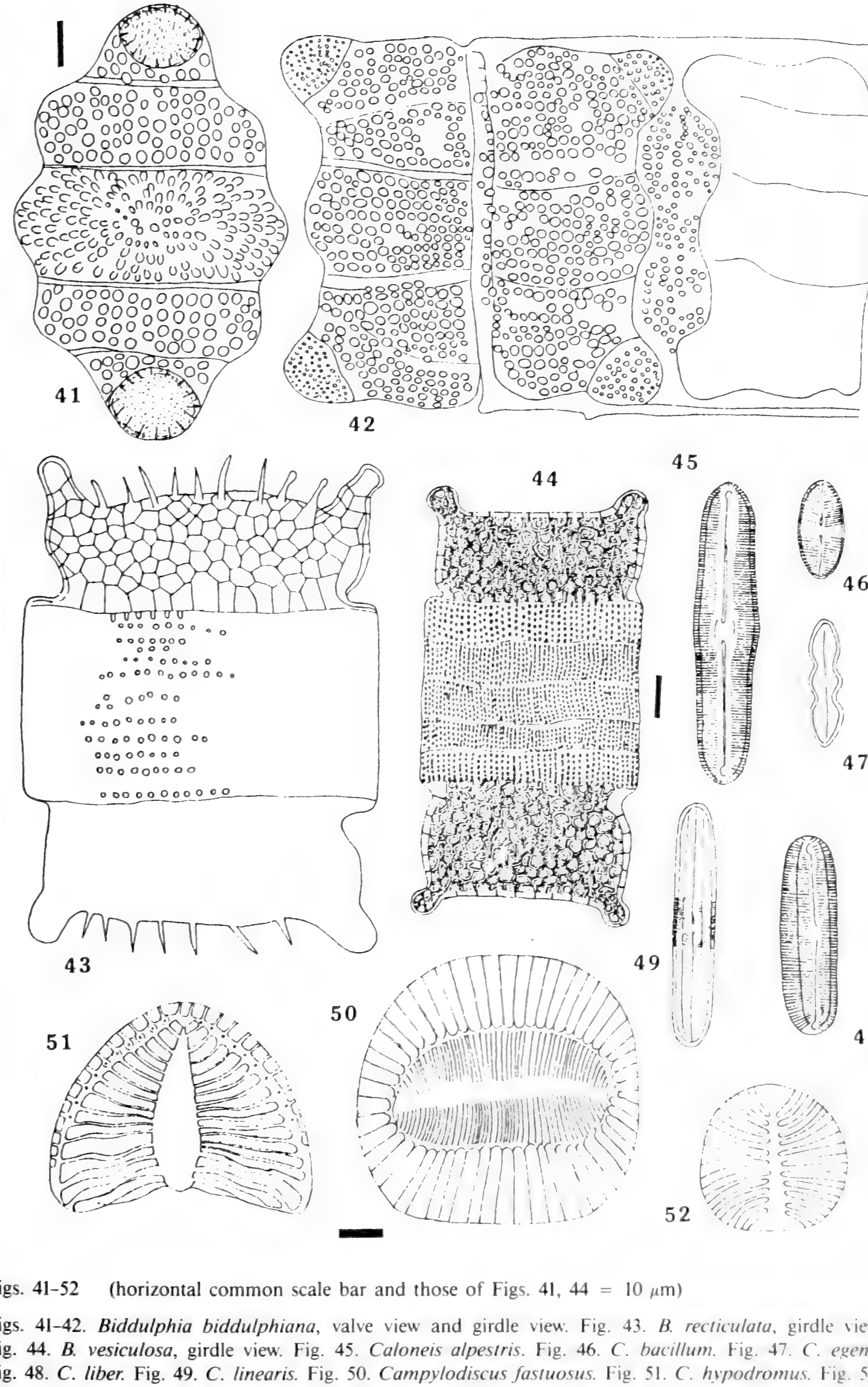
C. tetrastichon Cl. Fig. 56

References: Hendey 1964, p. 123, pl. 11, fig. 1.
Description: Diameter 16 μm. United to form chains.
Distribution: Rare. Found on slide 323.

Climacosphenia Ehrenb. 1841

C. moniligera Ehrenb. Figs. 57–58

References: Cupp 1943, p. 178, fig. 128.



Figs. 41–52 (horizontal common scale bar and those of Figs. 41, 44 = 10 μm)

Figs. 41–42. ***Biddulphia biddulphiana***, valve view and girdle view. Fig. 43. *B. recticulata*, girdle view. Fig. 44. ***B. vesiculosa***, girdle view. Fig. 45. *Caloneis alpestris*. Fig. 46. *C. bacillum*. Fig. 47. *C. egena*. Fig. 48. *C. liber*. Fig. 49. *C. linearis*. Fig. 50. *Campylodiscus fastuosus*. Fig. 51. *C. hypodromus*. Fig. 52. *C. ralfsii*.

Description: Length 295–493 μm, broadest breadth 29–32 μm, 18–19 striae in 10 μm. Solitary or in fan-shaped colonies.
Distribution: Common. Found on slides 1, 116, 343.
Comments: A cosmopolitan species. Common in warm seas.

Cocconeis Ehrenb. 1838

C. dirupta Greg. Fig. 59

References: Hustedt 1959, 7(2), p. 354, fig. 809; Cleve-Euler 1953, 4(5), p. 12. fig. 499.
Description: Length 42–52 μm, breadth 28–35 μm, 17–20 striae in 10 μm.
Distribution: Common. Found on slides 175, 257, 335, 343, 350, 353.
Comments: A cosmopolitan species.

C. disculoides Hust. Fig. 60

References: Hendey 1964, p. 178, pl. 28, figs. 21, 22.
Description: Length 19–22 μm, breadth 11–13 μm, 8 costae in 10 μm.
Distribution: Not common. Found on slides 1, 93, 124, 257, 341, 350.

C. heteroidea Hantz. Fig. 61

References: Cleve 1894–95, 27(3), p. 178; Hustedt 1959, 7(2), p. 356, fig. 811; Foged 1984, p. 29. pl. 31, fig. 6.
Description: Length 48–64 μm, breadth 38–50 μm, 17–18 striae in 10 μm.
Distribution: Common. Found on slides 273, 278, 335, 350, 357.
Comments: A cosmopolitan species. Mainly in tropical seas.

C. pelta Schmidt. Fig. 62

References: Hustedt 1959, 7(2), p. 361, fig. 815; Cleve-Euler 1953, 4(5), p. 13, fig. 502.
Description: Length 25 μm, breadth 17 μm, 18 striae in 10 μm.
Distribution: Rare. Found on slide 12.

C. placentula var. *euglypta* (Ehrenb.) Cl. Fig. 63

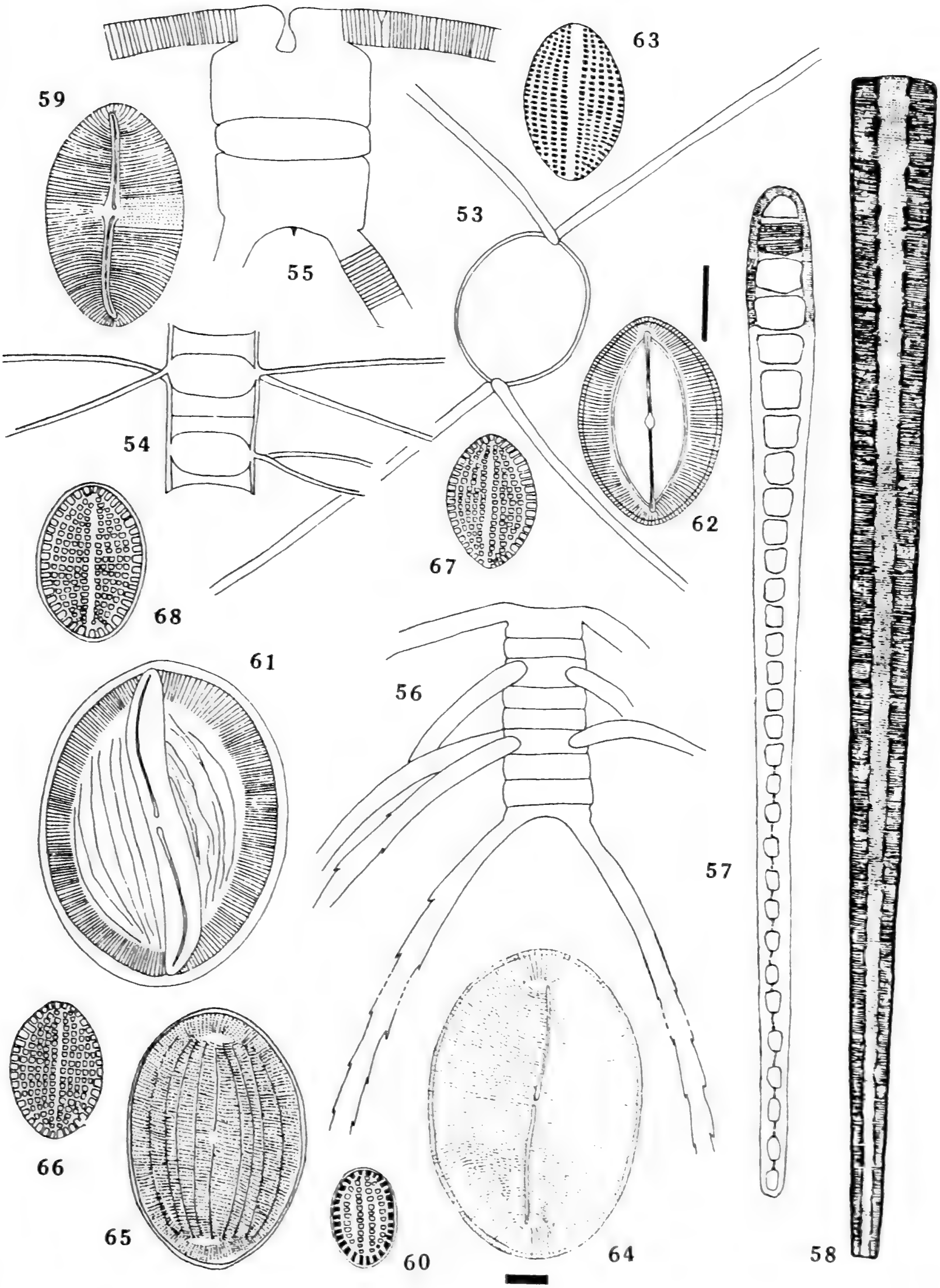
References: Cleve 1894–95, 27(3), p. 170; Patrick & Reimer 1966, p. 241, pl. 15, fig. 8.
Description: Length 17–19 μm, breadth 10–12 μm, 19 lower, 17 upper striae in 10 μm.
Distribution: Common. Found on slides 1, 12, 130, 339, 347, 350.
Comments: A cosmopolitan species. Freshwater to brackish to marine.

C. pseudomarginata var. *intermedia* Grun. Figs. 64–65

References: Cleve 1894–95, 27(3), p. 178; Hendey 1964, p. 179, pl. 28, fig. 20.
Description: Length 46–63 μm, breadth 32–46 μm, 11–17 striae in 10 μm.
Distribution: Common. Found on slide 2, 257, 337, 339, 343, 347.
Comments: A cosmopolitan species.

C. speciosa Greg. Figs. 66–67

References: Cleve-Euler 1953, 4(5), p. 7, fig. 489f, g; Hendey 1964, p. 180, pl. 28, fig. 18.
Description: Length 26 μm, breadth 17–18 μm, 5–7 striae in 10 μm.
Distribution: Common. Found on slides 130, 257, 335.



Figs. 53–68 (horizontal common scale bar and that of Fig. 62 = 10 μm)

Fig. 53. *Chaetoceros danicum*, valve view. Fig. 54. *C. lorenzianum*. Fig. 55. *C. peruvianum*. Fig. 56. *C. tetrastichon*. Figs. 57–58. *Climacosphenia moniligera*. Fig. 59. *Cocconeis dirupta*. Fig. 60. *C. disculoides*. Fig. 61. *C. heteroidea*. Fig. 62. *C. pelta*. Fig. 63. *C. placentula* var. *euglypta*. Figs. 64–65. *C. pseudomarginata* var. *intermedia*. Figs. 66–67. *C. speciosa*. Fig. 68. *C. sublittoralis*.

C. sublittoralis Hend. Fig. 68

References: Hendey 1964, p. 181, pl. 28, figs. 14–17.
Description: Length 24–34 μm, breadth 10–22 μm, 5–6 lower, 6–7 upper areolae in 10 μm.
Distribution: Rare. Found on slide 33, 119.

Coscinodiscus Ehrenb. 1838

C. argus Ehrenb. Fig. 69

References: Prowse 1962, p. 8, pl. 1, figs. j, l–m.
Description: Diameter 64–100 μm, 5 small and 3 large areolae in 10 μm.
Distribution: Very common. Found on slides 12, 79, 81, 124, 359.

C. decipiens Grun. Fig. 70

References: Prowse 1962, p. 8, pl. 3, fig. c.
Description: Diameter 14–34 μm.
Distribution: Very common. Found on slides 12, 79, 273, 278.

C. decrescens Grun. Fig. 71

References: Hustedt 1930, 7(1), p. 430, fig. 233; Hendey 1964, p. 77.
Description: Diameter 34 μm, 4 areolae in 10 μm in the middle.
Distribution: Rare. Found on slide 120.

C. marginatus Ehrenb. Fig. 72

References: Hendey 1964, p. 78, pl. 22, fig. 2.
Description: Diameter 72–78 μm, 9–10 striae in 10 μm.
Distribution: Very common. Found on slides 321, 355.

C. nodulifer Schmidt. Figs. 73–74

References: Allen & Cupp 1935, p. 116, figs. 9, 9a; Hendey 1964, p. 77, pl. 22, fig. 10.
Description: Diameter 31–100 μm, 4–8 marginal striae in 10 μm.
Distribution: Very common. Found on slides 1, 120, 124, 129, 138, 351, 355, 359.
Comments: A cosmopolitan species.

C. oculus-iridus Ehrenb. Fig. 75

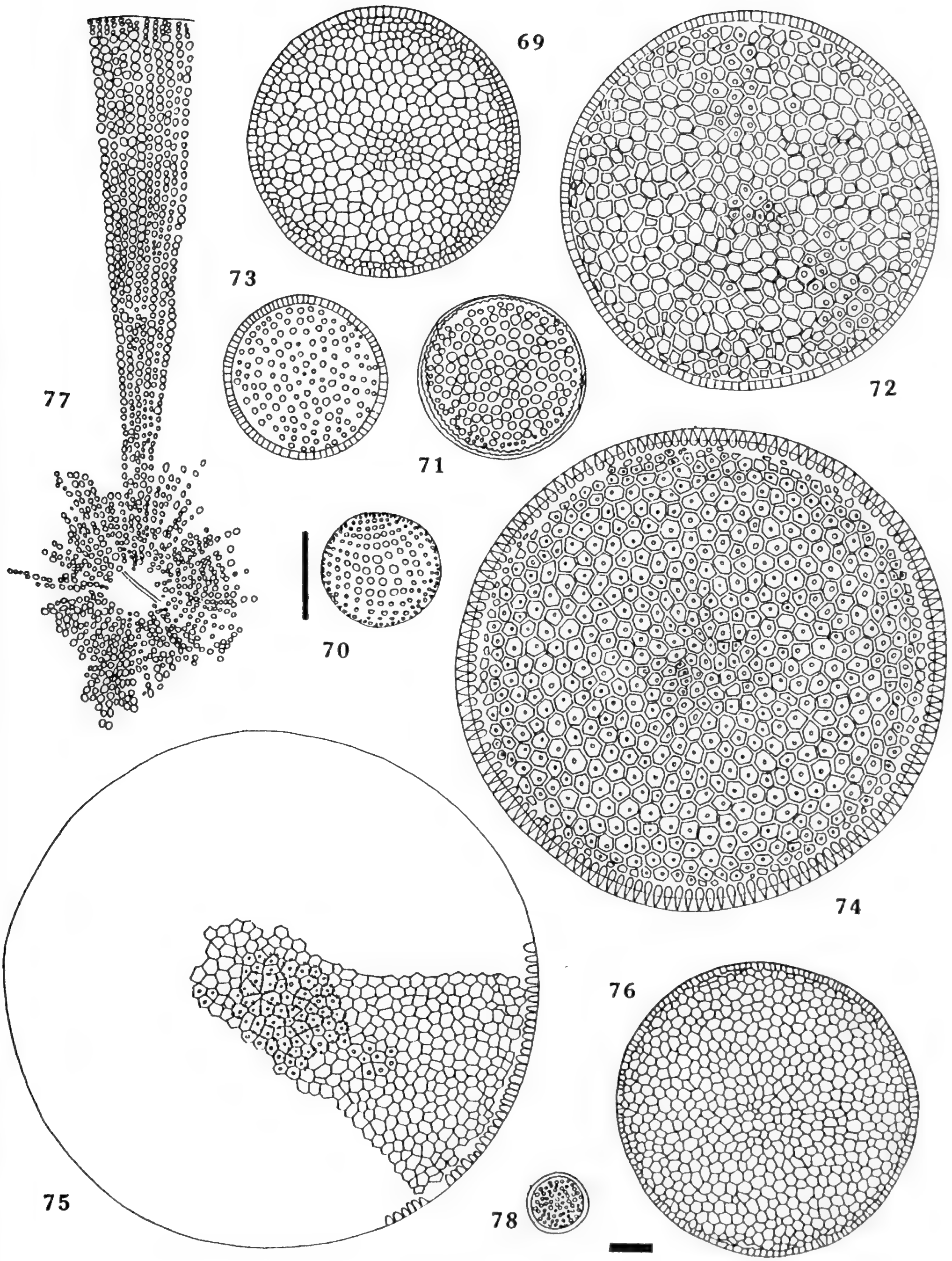
References: Cupp 1943, p. 62, fig. 26; Hendey 1964, p. 78, pl. 24, fig. 1.
Description: Diameter 100 μm, 7–8 marginal striae in 10 μm.
Distribution: Not common. Found on slide 350.
Comments: A cosmopolitan species.

C. radiatus Ehrenb. Fig. 76

References: Cupp 1943, p. 56, fig. 20; Hendey 1964, p. 76, pl. 22, fig. 7.
Description: Diameter 78–88 μm, marginal striae 10–11, areolae 2–4 in 10 μm.
Distribution: Common. Found on slides 81, 116, 333, 359.
Comments: A cosmopolitan species.

C. wailesii Gran & Angst. Fig. 77

References: Gran & Angst. 1931, p. 448, fig. 26; Cupp 1943, p. 58, fig. 23.
Description: Diameter 221 μm, 6 areolae in 10 μm.
Distribution: Rare. Found on slide 323.



Figs. 69–78 (horizontal common scale bar and that of Fig. 70 = 10 μm)

Fig. 69. *Coscinodiscus argus*. Fig. 70. *C. decipiens*. Fig. 71. *C. decrescens*. Fig. 72. *C. marginatus*. Figs. 73–74. *C. nodulifer*. Fig. 75. *C. oculus-iridus*. Fig. 76. *C. radiatus*. Fig. 77. *C. wailesii*. Fig. 78. *Coscinosira oestrupii*.

Coscinosira Gran 1900

C. oestrupii Osten. Fig. 78

References: Hendey 1964, p. 89; Simonsen 1974, p. 10, pl. 1, figs. 3–5.
Description: Diameter 13–27 μm, 4–9 areolae in 10 μm.
Distribution: Very common. Found on slides 79, 116, 333, 357.

Cyclotella (Kütz.) Bréb. 1834

C. kützingiana Thw. Fig. 79

References: Hustedt 1930, 7(1), p. 338, fig. 171; Prowse 1962, p. 7, pl. 2, fig. i, j.
Description: Diameter 11–40 μm, radial striae 7–10 in 10 μm. Freshwater.
Distribution: Very common. Found on slides 31, 33, 40, 75, 141, 257, 319.

C. menghiniana Kütz. Figs. 80–81

References: Prowse 1962, p. 7, pl. 1, fig. e, pl. 2, fig. h.
Description: Diameter 10–32 μm, 8–10 radial striae in 10 μm.
Distribution: Common. Found on slides 12, 351.
Comments: A cosmopolitan species. Freshwater to marine.

C. operculata (Ag.) Kütz. Fig. 82

References: Tiffany & Britton 1952, p. 220, fig. 6.
Description: Diameter 29 μm, 10 radial striae in 10 μm.
Distribution: Rare. Found on slide 12.
Comments: A cosmopolitan species (?). Freshwater to brackish.

C. striata (Kütz.) Grun. Figs. 83–85

References: Prowse 1962, p. 8, pl. 1, fig. f, pl. 2, figs. b, g; Gerloff & Natour 1982, p. 160, pl. 1, figs. 5, 6.
Description: Diameter 23–58 μm, radial striae 7–10 in 10 μm.
Distribution: Common. Found on slides 12, 38, 79, 357.
Comments: A cosmopolitan species. Freshwater to marine.

C. stylorum Brightw. Fig. 86

References: Hustedt 1927–66, p. 348, fig. 179; Foged 1975, p. 20, pl. 6, fig. 4.
Description: Diameter 41–87 μm, 8–10 radial and 2–4 peripheral striae in 10 μm.
Distribution: Very common. Found of slides 12, 79, 323, 355.
Comments: A cosmopolitan species.

Cymatosira Grun. 1862

C. lorenziana Grun. Fig. 87

References: Navarro 1982, p. 13, pl. 6, figs. 6–8; Foged 1984, p. 31, pl. 28, figs. 1–3, 7.
Description: Length 55 μm, breadth 15 μm, 6 striae in 10 μm. Solitary or colonial.
Distribution: Rare. Found of slide 257.
Comments: A cosmopolitan species.

Cymbella Ag. 1830

C. pusilla Grun. Fig. 88

References: Cleve 1894–95, 26(2) p. 162; Patrick & Reimer 1975. p. 25, pl. 3, fig. 18.

Description: Length 46–62 μm, breadth 8–12 μm, 18–20 dorsal, 15–16 ventral striae in 10 μm.
Distribution: Not common. Found of slide 339.
Comments: A cosmopolitan species.

Delphineis Kütz. 1844

D. surirella (Ehrenb.) G.A. Andrews (=*Rhaphoneis*). Figs. 89–90

References: Hendey 1964, p. 155, pl. 26, figs. 11–13; Andrews 1981.
Description: Length 16–26 μm, breadth 12–18 μm, 8–10 striae, 12 puncta, in 10 μm.
Distribution: Very common. Found of slides 12, 91, 259, 273, 335, 337, 343.

Denticula Kütz. 1844

D. subtilis Grun. Fig. 91

References: Patrick & Reimer 1975, p. 172, pl. 22, figs. 10–11.
Description: Length 11 μm, breadth 3 μm, 8 costae, 27–28 striae in 10 μm.
Distribution: Found of slides 12, 339.
Comments: A brackish species.

Diploneis Ehrenb. 1844

D. bombiformis Cl. Figs. 92–93

References: Cleve 1894–95, 26(2) p. 87, pl. 1, fig. 26.
Description: Length 40–42 μm, breadth 15–17 μm, 10–11 μm at the constriction, 7–8 striae in 10 μm.
Distribution: Common. Found of slides 129, 273.

D. bombus Ehrenb. Fig. 94

References: Patrick & Reimer 1966, p. 416, pl. 38, fig. 13; Hendey 1970, p. 140, pl. 5, fig. 49.
Description: Length 56–86 μm, breadth 29–34 μm, 16–24 μm at constriction, 4–5 striae in 10 μm.
Distribution: Not common. Found of slides 12, 175.
Comments: A cosmopolitan species.

D. bombus var. *densestriata* A.S. Fig. 95

References: Cleve 1894–95, 26(2) p. 90.
Description: Length 50 μm, breadth 21 μm, 12 μm at constriction, 7 striae in 10 μm.
Distribution: Rare. Found of slide 12.

D. chersonensis (Grun.) Cl. Fig. 96

References: Cleve 1894–95, 26(2) p. 91; Hendey 1970, p. 142, pl. 5, fig. 48.
Description: Length 65–76 μm, breadth 27–32 μm, 16–18 μm at constriction, 5–7 striae in 10 μm.
Distribution: Rare. Found on slides 93, 124.
Comments: A cosmopolitan species. According to Podzorski & Håkansson (1987), this species is widespread in all seas, with the larger specimens limited to tropical waters.

D. coffaeiformis A.S. Fig. 97

References: Cleve 1894–95, 26(2) p. 81.
Description: Length 22–48 μm, breadth 11–24 μm, 8–12 striae in 10 μm.
Distribution: Very common. Found on slides 335, 341, 343, 347.

D. crabro Ehrenb. Fig. 98

References: Cleve 1894–95, 26(2) p. 100; Hendey 1970, p. 141, pl. 3, fig. 29.
Description: Length 69–82 μm, breadth 26–32 μm, 15–24 μm at constriction, 4–5 striae in 10 μm.
Distribution: Very common. Found on slides 48, 315, 335, 345, 350.
Comments: Common in tropical coastal waters.

D. exemta var. *digrediens* Cl. Fig. 99

References: Cleve 1894–95, 26(2) p. 86.
Description: Length 48–64 μm, breadth 18–20 μm, 10–11 μm at constriction, 7–9 striae in 10 μm.
Distribution: Common. Found on slides 125, 175, 335, 341.

D. gravelleana Hagelst. Fig. 100

References: Navarro 1982, p. 34, pl. 22, figs. 6–8; Foged 1984, p. 36, pl. 41, fig. 2.
Description: Length 19–30 μm, breadth 9–10 μm, 4–5 μm at constriction, 13–15 striae in 10 μm.
Distribution: Common. Found on slides 175, 335, 339.

D. incurvata (Greg.) Cl. Fig. 101

References: Cleve 1894–95, 26(2) p. 84.
Description: Length 58–71 μm, breadth 17 μm, 10 μm at constriction, 10–11 striae in 10 μm.
Distribution: Common. Found on slides 37, 91, 341, 351.
Comments: A cosmopolitan species (?).

D. interrupta (Kütz.) Cl. Figs. 102–103

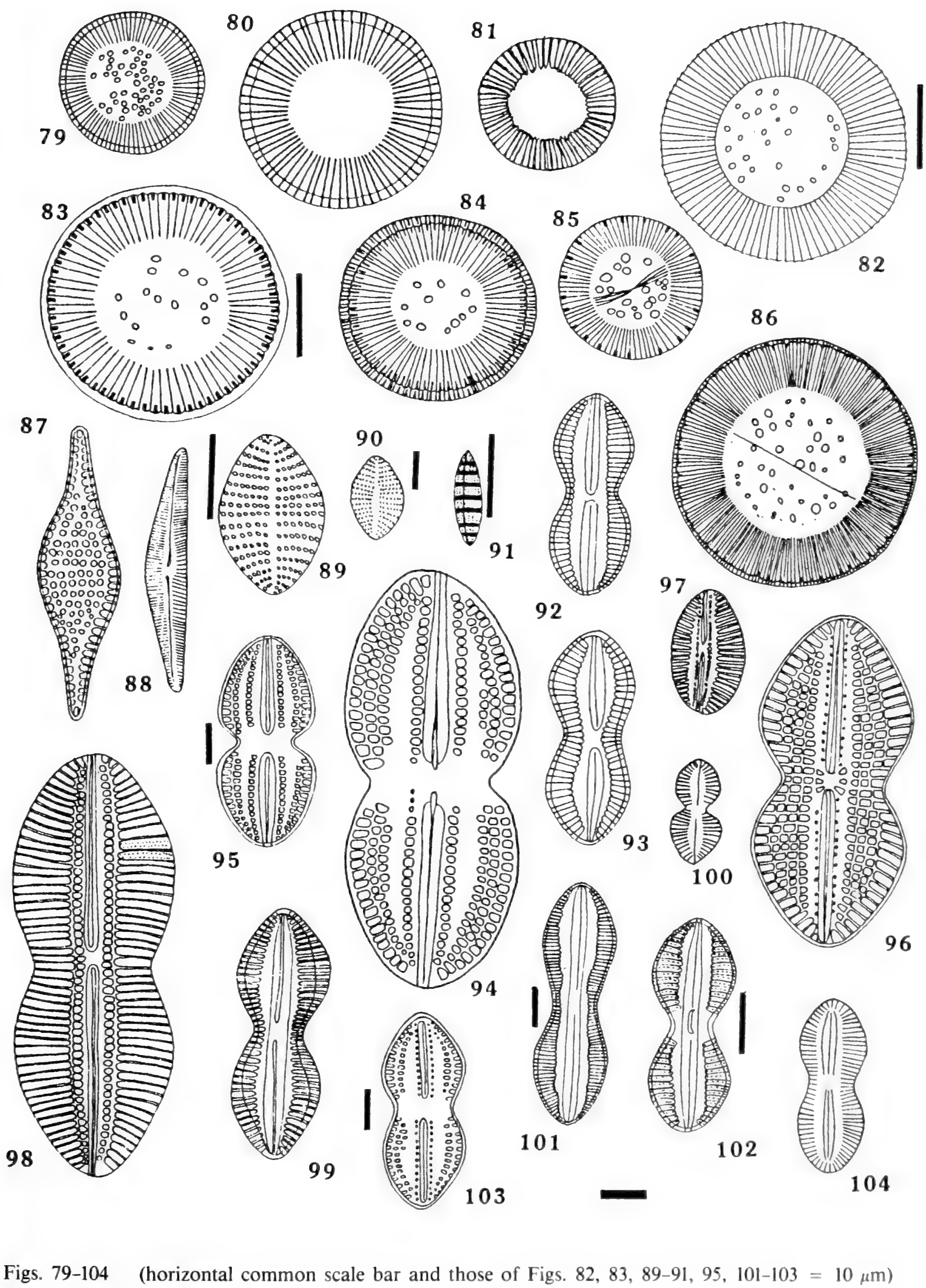
References: Cleve 1894–95, 26(2) p. 84; Prowse 1962, p. 34, pl. 9, fig. k.
Description: Length 27–80 μm, breadth 10–24 μm, 7–13 μm at constriction, 7–8 striae in 10 μm.
Distribution: Rare. Found on slide 12.
Comments: A cosmopolitan species. Freshwater to marine.

D. interrupta var. *gorjanovicii* Pant. Fig. 104

References: Cleve 1894–95, 26(2) p. 84.
Description: Length 24–42 μm, breadth 12–17 μm, 7–11 μm at the constriction, 8–13 striae in 10 μm.
Distribution: Very common. Found on slides 125, 259, 347.
Comments: Brackish to marine.

D. litoralis (Donk.) Cl. Figs. 105–106

References: Cleve-Euler 1953, 4(5), p. 80, fig. 649; Hendey 1964, p. 226, pl. 32, fig 9.
Description: Length 35–36 μm, breadth 17–18 μm, 11–14 striae in 10 μm.



Figs. 79–104 (horizontal common scale bar and those of Figs. 82, 83, 89–91, 95, 101–103 = 10 μm)

Fig. 79. *Cyclotella kützingiana.* Figs. 80–81. *C. menghiniana.* Fig. 82. *C. operculata.* Figs. 83–85. *C. striata.* Fig. 86. *C. stylorum.* Fig. 87. Cymatosira lorenziana. Fig. 88. *Cymbella pusilla.* Figs. 89–90. *Delphineis surirella.* Fig. 91. *Denticula subtilis.* Fig. 92–93. *Diploneis bombiformis.* Fig. 94. *D. bombus.* Fig. 95. *D. bombus* var. *densestriata.* Fig. 96. *D. chersonensis.* Fig. 97. *D. coffaeiformis.* Fig. 98. *D. crabro.* Fig. 99. *D. exemta* var. *digrediens.* Fig. 100. *D. gravelleana.* Fig. 101. *D. incurvata.* Figs. 102–103. *D. interrupta.* Fig. 104. *D. interrupta* var. *gorjanovicii.*

Distribution: Common. Found on slide 12.
Comments: A cosmopolitan species.

D. nitescens (Greg.) Cl. Fig. 107

References: Hustudt 1959, 7(2), p. 640, fig. 1047; Cleve-Euler 1953, 4(5), p. 85, fig. 658.
Description: Length 48–54 μm, breadth 28–33 μm, 5–6 costae in 10 μm.
Distribution: Not common. Found on slides 120, 343.
Comments: A cosmopolitan species.

D. notabilis (Grev.) Cl. Fig. 108

References: Hendey 1964, p. 224, pl. 32, fig. 11.
Description: Length 54 μm, breadth 42 μm, 5–6 costae in 10 μm.
Distribution: Rare. Found on slide 119.
Comments: A cosmopolitan species (?). Freshwater.

D. oculata (Bréb.) Cl. Fig. 109

References: Patrick & Reimer 1966, p. 412, pl. 38, fig. 6.
Description: Length 17–18 μm, breadth 7–9 μm, 20–22 striae in 10 μm.
Distribution: Not common. Found on slide 343.
Comments: A cosmopolitan species. Freshwater.

D. puella (Schum.) Cl. Fig. 110

References: Cleve 1894–95, 26(2) p. 92; Patrick & Reimer 1966, p. 414, pl. 38, fig. 9.
Description: Length 27–34 μm, breadth 11–17 μm, 10–13 striae in 10 μm.
Distribution: Common. Found on slides 91, 350.

D. smithii (Bréb.) Cl. Figs. 111–112

References: Cleve 1894–95, 26(2) p. 96; Patrick & Reimer 1966, p. 410, pl. 38, fig. 2.
Description: Length 48–76 μm, breadth 22–36 μm, 5–9 costae in 10 μm.
Distribution: Not common. Found on slides 12, 93, 130, 175, 337, 345, 359.
Comments: A cosmopolitan species. Freshwater to marine.

D. smithii var. *rhombica* Meresch. Fig. 113

References: Hendey 1964, p. 225; Kaczmarska & Rushforth 1983, p. 20, pl. 17, fig. 1.
Description: Length 53 μm, breadth 23 μm, 9 to 11 costae in 10 μm towards poles.
Distribution: Rare. Found on slide 37.
Comments: A cosmopolitan species.

D. subovalis Cl. Fig. 114

References: Cleve 1894–95, 26(2) p. 96, pl. 1, fig. 27; Foged 1979, p. 45, pl. 21, figs. 5, 6 & 11.
Description: Length 31–49 μm, breadth 18–26 μm, 8–9 costae in 10 μm.
Distribution: Not common. Found on slides 125, 355, 357.
Comments: A cosmopolitan species. Freshwater to marine.

D. vetula Cl. Fig. 115

References: Cleve 1894–95, 26(2) p. 85; Hendey 1964, p. 224, fig. 6.
Description: Length 33 μm, breadth 12 μm, 10 μm at constriction, 10 costae in 10 μm.

Distribution: Not common. Found of slides 259, 341.
Comments: Podzorski & Hakânsson (1987) report its presence in Palawan, although they state that it is common in the European coastal waters.

D. weissflogii (A.S.) Cl. Figs. 116–117

References: Cleve 1894–95, 26(2) p. 91; Hustedt 1959, 7(2), p. 703, fig. 1085.
Description: Length 29–74 μm, breadth 11–24 μm, 7–12 μm at constriction, 6–9 costae in 10 μm.
Distribution: Common. Found of slides 335, 350, 359.
Comments: A cosmopolitan species.

Donkinia Ralfs 1888

D. recta (Donk.) Grun. Fig. 118

References: Cleve 1965, 26(2) p. 119; Hendey 1964, p. 251, pl. 35, fig. 7.
Description: Length 108–312 μm, breadth 22–38 μm, 18–20 striae in 10 μm.
Distribution: Rare. Found of slides 79, 93.
Comments: A cosmopolitan species.

Eunotogramma Weisse 1854

E. laeve Grun. Figs. 119–120

References: Foged 1979, p. 52, pl. 6, fig. 2.
Description: Length 25–35 μm, breadth 6–8 μm, 2–3 septa in 10 μm.
Distribution: Not common. Found on slides 120, 132.

Fragilaria Lyng. 1819

F. cylindrus Grun. Figs. 121–122

References: Cleve-Euler 1953, 4(1), p. 51, fig. 363a–k; Hendey 1964, p. 153.
Description: Length 29–38 μm, breadth 5–6 μm, 8–12 striae in 10 μm. Colonial, united into ribbons; attached by mucilage stalk; rare.
Distribution: Common in the Arctic seas. Found on slide 12.

F. lapponica Grun. Fig. 123

References: Hustedt 1959, 7(2), p. 170, fig. 678; Patrick & Reimer 1966, p. 130, pl. 4, fig. 17.
Description: Length 38–66 μm, breadth 4–6 μm, 7–10 striae in 10 μm. Colonial, united into ribbons.
Distribution: Common. Found on slides 75, 273, 357.
Comments: Freshwater to marine.

F. leptostauron var. *dubia* (Grun.) Hust. Fig. 124

References: Cleve-Euler 1953, 4(1), p. 36, fig. 347p–u; Patrick & Reimer 1966, p. 124, pl. 4, fig. 3.
Description: Length 20 μm, breadth 6 μm, 5 costae in 10 μm. Colonial, united into straight to zigzag filamentous chains.
Distribution: Rare. Found on slide 48.
Comments: A cosmopolitan species.

F. oceanica Cl. Fig. 125

References: Cleve-Euler 1953, 4(1), p. 52, fig. 365, Hendey 1964, p. 153.
Description: Length 37 μm, breadth 5 μm, 11 costae in 10 μm. Colonial, united to form ribbon-like chains.
Distribution: Rare. Found on slide 12.
Comments: Common in the Arctic seas.

F. schulzi Brockmann. Fig. 126

References: Hendey 1964, p.154, pl. 26, fig. 16.
Description: Length 25 μm, breadth 5 μm, 13 striae in 10 μm.
Distribution: Rare. Found on slide 257.

Grammatophora Ehrenb. 1839

G. hamulifera Kütz. Figs. 127–128

References: Hendey 1964, p. 171.
Description: Length 17 μm, breadth at girdle 13 μm, 18 striae in 10 μm. Colonial.
Distribution: Very common. Found on slides 93, 337, 343, 347.
Comments: A cosmopolitan species.

G. marina var. *adriatica* Grun. Fig. 129

References: Cupp 1943, p. 174, fig. 125B.
Description: Length 73–80 μm, breadth at valve 5–7 μm and girdle 17–21 μm, 25–30 striae in 10 μm. Colonial, joined into zig-zag chains.
Distribution: Very common. Found on slides 1, 79, 273, 335, 339, 359.
Comments: A cosmopolitan species.

G. oceanica Ehrenb. Figs. 130–131

References: Cupp 1943, p. 176, fig. 126; Hendey 1964, p. 170.
Description: Length 25–48 μm, breadth 5–7 μm, 22–24 striae in 10 μm. Colonial.
Distribution: Common. Found on slides 1, 116, 345.
Comments: A cosmopolitan species.

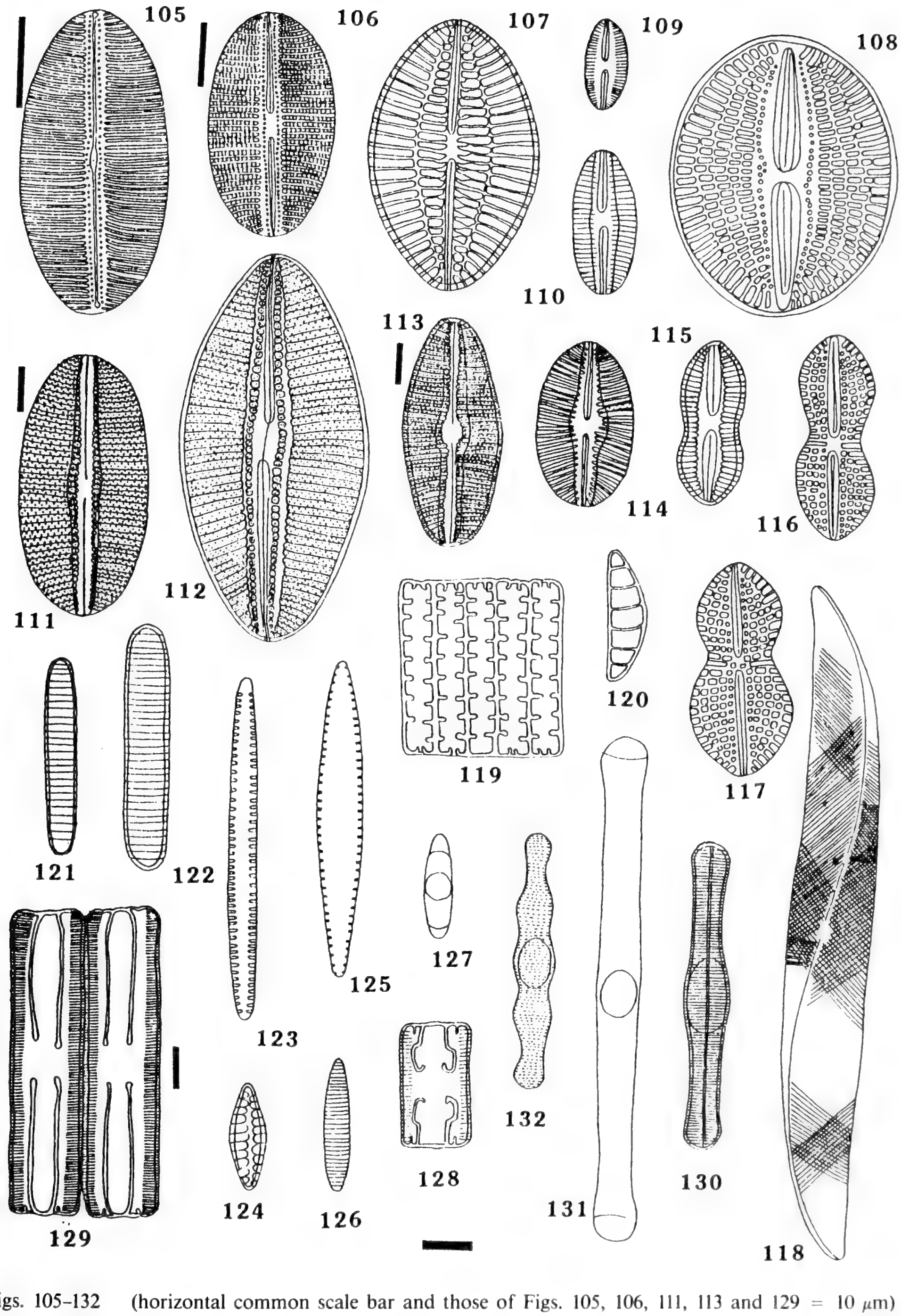
G. undulata Ehrenb. Fig. 132

References: Boyer 1926–27, p. 156; Foged 1984, p. 45, pl. 24, fig. 4.
Description: Length 40–48 μm, breadth 7–8 μm, 20–21 striae in 10 μm. Colonial.
Distribution: Rare. Found on slides 333, 337.
Comments: A cosmopolitan species.

Gyrosigma Hassall 1845

G. balticum (Ehrenb.) Rabh. Figs. 133–134

References: Hendey 1964, p. 248, pl. 35, fig. 9; Patrick & Reimer 1966, p. 324, pl. 25, fig. 1.
Description: Length 280–332 μm, breadth 28–30 μm, 11–12 transverse/longitudinal striae in 10 μm. Occurring in large colonies.
Distribution: Rare. Found on slide 95.
Comments: A cosmopolitan species.



Figs. 105–132 (horizontal common scale bar and those of Figs. 105, 106, 111, 113 and 129 = 10 μm)

Figs. 105–106. *Diploneis littoralis.* Fig. 107. *D. nitescens.* Fig. 108. *D. notabilis.* Fig. 109. *D. oculata.* Fig. 110. *D. puella.* Figs. 111–112. *D. smithii.* Fig. 113. *D. smithii* var. *rhombica.* Fig. 114. *D. subovalis.* Fig. 115. *D. vetula.* Figs. 116–117. *D. weissflogi.* Fig. 118. *Donkinia recta.* Figs. 119–120. *Eunotogramma laeve,* girdle and valve view. Figs. 121–122. *Fragilaria cylindrus.* Fig. 123. *F. lapponica.* Fig. 124. *F. leptostauron* var. *dubia.* Fig. 125. *F. oceanica.* Fig. 126. *F. schulzi.* Figs. 127–128. *Grammatophora hamulifera,* valve view and girdle view. Fig. 129. *G. marina* var. *adriatica,* two cells in girdle view. Figs. 130–131. *G. oceanica.* Fig. 132. *G. undulata.*

G. distortum (W. Sm.) Griff & Henfr. Fig. 135

References: Cleve 1894–95, 26(2) p. 116; Patrick & Reimer 1966, p. 324, pl. 24, fig. 6.
Description: Length 32 μm, breadth 9 μm, 23–24 transverse, 25–26 longitudinal striae in 10 μm. Solitary or colonial.
Distribution: Rare. Found on slide 12.

G. exile (Grun.) Reim. Fig. 136

References: Patrick & Reimer 1966, p. 322, pl. 24, fig. 4.
Description: Length 46 μm, breadth 8 μm, 25–28 transverse, 30–32 longitudinal striae in 10 μm. Rare. Freshwater to brackish.
Distribution: Found on slide 12.

G. fasciola var. *sulcata* (Grun.) Cl. Fig. 137

References: Hendey 1964, p. 249; Patrick & Reimer 1966, p. 328, pl.26, fig. 4.
Description: Length 52 μm, breadth 9 μm, 20 transverse, 17 longitudinal striae in 10 μm. Solitary or colonial.
Distribution: Rare. Found on slides 12, 351, 353.
Comments: A cosmopolitan species.

G. grovei Cl. Fig. 138

References: Cleve 1894–95, 26(2) p. 118.
Description: Length 163–351 μm, breadth 23–28 μm, 9–10 transverse, 12 longitudinal striae in 10 μm.
Distribution: Rare. Found on slides 19, 95, 353, 357.
Comments: Brackish to marine.

G. simile (Grun.) Boyer. Fig. 139

References: Hustedt 1955, p. 34, pl. 10, fig. 3.
Description: Length 54–71 μm, breadth 8–13 μm, 15 transverse, 16 longitudinal striae in 10 μm.
Distribution: Common. Found on slides 125, 357, 359.

Hantzschia Grun. 1880

H. amphioxys var. *capitata* O. Müll. Fig. 140

References: Tiffany & Britten 1952, p. 289, pl. 75, fig. 887; Prowse 1962, p. 64, pl. 19, fig. t.
Description: Length 58–80 μm, breadth 10 μm, 16–24 striae, 5–7 fibulae in 10 μm.
Distribution: Rare. Found on slide 31.
Comments: A cosmopolitan species. Freshwater to marine.

H. virgata (Roper) Grun. Fig. 141

References: Hendey 1964, p. 285, pl. 39, fig. 1; Foged 1979, p. 63, pl. 40, fig. 10.
Description: Length 102 μm, breadth 10 μm, 14 striae, 5–6 fibulae in 10 μm.
Distribution: Rare. Found on slide 38.
Comments: A cosmopolitan and common littoral species of clean, sandy shores (Hendey, 1964).

Huttoniella Karsten 1928

H. reichardtii (Grun.) Hust. Fig. 142

References: Hendey 1964, p. 114 (as *Huttonia reichardtii* Grun.); Foged 1984, p. 47, pl. 25, fig. 6.
Description: Length 20 μm, breadth 15 μm.
Distribution: Rare. Found on slide 91.

Isthmia Ag. 1827

I. enervis Ehrenb. Fig. 143

References: Boyer 1926–27, p. 140; Hendey 1964, p. 110, pl. 25, fig. 2.
Description: Length 200 μm, breadth 32 μm in girdle view, 3–4 areolae in 10 μm. United into short chain.
Distribution: Common. Found on slides 1, 3, 116.
Comments: A cosmopolitan species.

Licmophora Ag. 1827

L. abbreviata Ag. Figs. 144–145

References: Hendey 1964, p. 167.
Description: Length 55–64 μm, 8–13 μm at broadest part, 10–16 striae in 10 μm. Solitary or colonial.
Distribution: Common. Found on slides 1,3, 116, 337.
Comments: A cosmopolitan species.

L. ehrenbergii (Kütz.) Grun. Figs. 146–148

References: Hustedt 1959, 7(2), p. 70, fig. 593; Hendey 1964, p. 168.
Description: Length 60–101 μm, 12–14 at the broadest part, 8–12 (middle), 12–14 (upper end) striae in 10 μm. Colonial.
Distribution: Common. Found on slides 1, 91, 333.
Comments: A cosmopolitan species.

L. flabellata (Carm.) Ag. Figs. 149–150

References: Hendey 1964, p. 168, pl. 26, fig. 5; Foged 1975, p. 27, pl. 10, fig. 7.
Description: Length 77 μm, breadth 15 μm (girdle), 6 μm (valve). In fan-shaped colonies.
Distribution: Not common. Found on slide 347.
Comments: A cosmopolitan species.

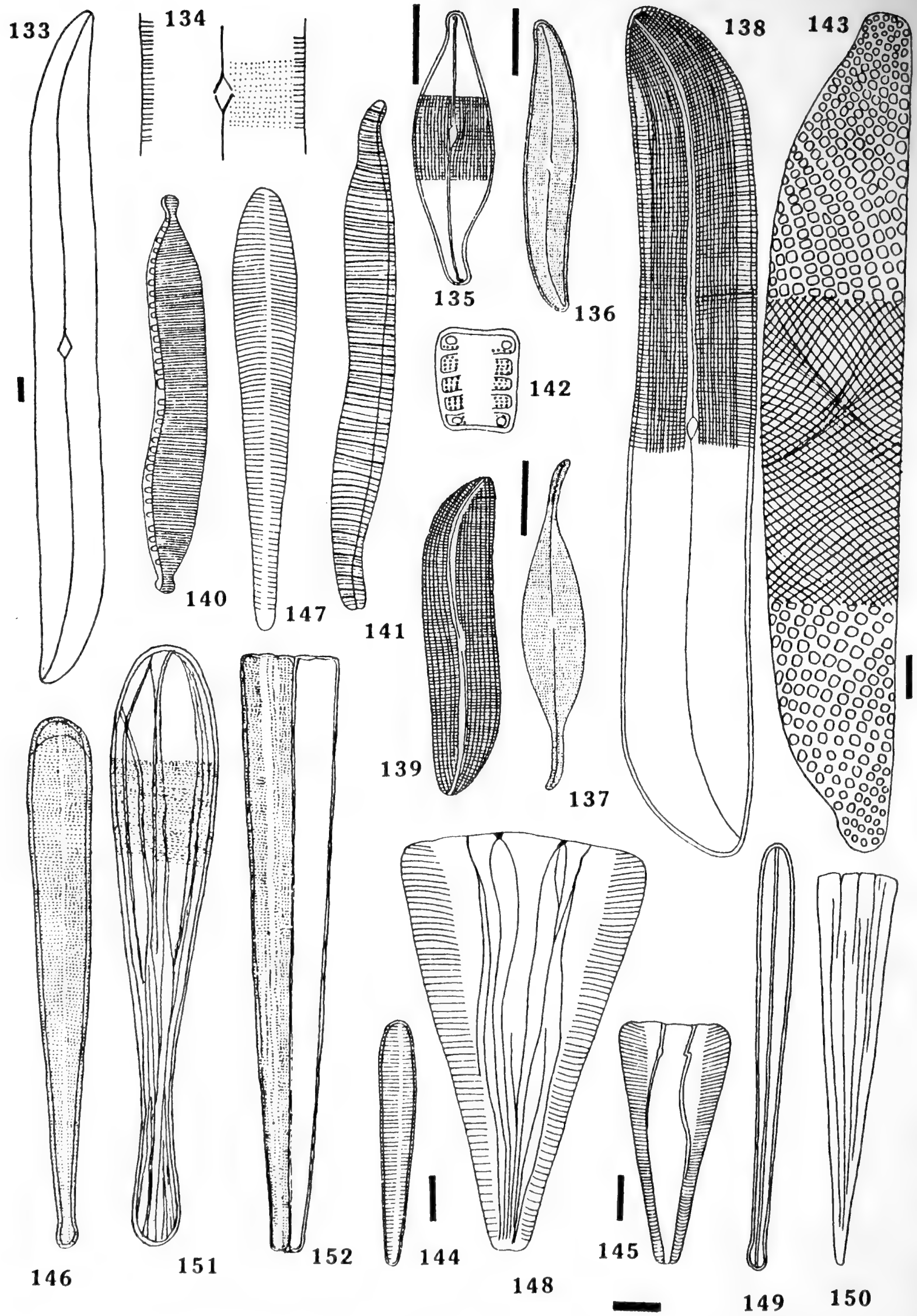
L. gracilis (Ehrenb.) Grun. Figs. 151–152

References: Boyer 1926–27, p. 167; Hendey 1964, p. 167.
Description: Length 144 μm, breadth 24 μm (valve), 20 striae in 10 μm. In fan-shaped colonies, attached by a mucous stipe.
Distribution: Rare. Found on slide 116.
Comments: A cosmopolitan species.

Mastogloia Thwaites 1856

M. angulata Lewis Fig. 153

References: Cleve 1894–95, 27(3), p. 147; Foged 1975, p. 28, pl. 12, fig. 2, pl. 13, figs. 1, 2.



Figs. 133–152 (horizontal common scale bar and those of Figs. 133, 135–137, 143, 144 and 145 = 10 μm)

Figs. 133–134. *Gyrosigma balticum*, valve view and details of striations. Fig. 135. *G. distortum*. Fig. 136. *G. exile*. Fig. 137. *G. fasciola* var. *sulcata*. Fig. 138. *G. grovei*. Fig. 139. *G. simile*. Fig. 140. *Hantzschia amphioxys* var. *capitata*. Fig. 141. *H. virgata*. Fig. 142. *Huttoniella reichardtii*, girdle view. Fig. 143. *Isthmia enervis*, girdle view. Figs. 144–145. *Licmophora abbreviata*, valve view and girdle view. Figs. 146–148. *L. ehrenbergii*, valve views and girdle view. Figs. 149–150. *L. flabellata*, valve view and girdle view. Figs. 151-152. *L. gracilis*, valve view and girdle view.

Description: Length 55–76 μm, breadth 28–34 μm, 8–10 striae, 1 loculi in 10 μm.
Distribution: Not common. Found on slides 125, 341.
Comments: A cosmopolitan species.

M. binotata (Grun.) Cl. Fig. 154

References: Hendey 1964, pl. 37, fig. 11; Foged 1975, p. 29, pl. 12, figs. 6–9.
Description: Length 21–36 μm, breadth 15–23 μm, 12–13 striae, 11 puncta in 10 μm.
Distribution: Not common. Found on slides 93, 341, 343, 347.
Comments: Common in warm coastal and temperate waters.

M. citrus Cl. Figs. 155–156

References: Cleve 1894–95, 27(3), p. 157, pl. 2, fig. 6.
Description: Length 46 μm, breadth 21 μm, 18 middle and 22 polar striae, 7–8 loculi in 10 μm.
Distribution: Common. Found on slides 124, 335, 337, 345, 350.
Comments: Common in tropical seas.

M. fimbriata (Brightw.) Cl. Fig. 157

References: Hendey 1970, p.146, pl. 1, fig. 11; Gerloff & Natour 1982, p. 184.
Description: Length 47–63 μm, breadth 34–54 μm, 6–8 striae, 4–6 loculi in 10 μm.
Distribution: Very common. Found on slides 2, 124, 335, 343, 345, 347.
Comments: A cosmopolitan species.

M. ovata Grun. Fig. 158

References: Cleve 1894–95, 27(3), p. 156.
Description: Length 43 μm, breadth 32 μm, 15–16 striae, 3–4 loculi in 10 μm.
Distribution: Common. Found on slide 333.
Comments: Common in warm coastal waters.

M. quinquecostata Grun. Fig. 159

References: Cleve 1894–95, 27(3), p. 161; Foged 1975, p. 33, pl. 15, figs. 7, 8.
Description: Length 38–56 μm, breadth 18 μm, 16 striae, 2–3 loculi in 10 μm.
Distribution: Not common. Found on slides 91, 341, 345.

Melosira Ag. 1824

M. granulata (Ehrenb.) Ralfs. Figs. 160–161

References: Prowse 1962, p. 6, pl. 1, figs. a–b.
Description: Length 10–22 μm, diameter 10–11 μm, 8–9 striae in 10 μm.
Distribution: Not common. Found on slide 175.
Comments: A cosmopolitan species. Freshwater to marine.

M. nummuloides (Dillw.) Ag. Fig. 162

References: Cleve-Euler 1951, 2(1), p. 32, figs. 28a–d.; Hendey 1964, p. 72.
Description: Diameter 22–40 μm.
Distribution: Very common. Found on slides 3, 79, 116, 175, 257, 339, 343, 359.
Comments: A cosmopolitan species.

Navicula Bory 1824

N. brasiliensis Grun. Fig. 163

References: Cleve-Euler 1953, 4(5), p.110, fig. 718; Hendey 1970, p. 133, pl. 4, fig. 40.
Description: Length 52–98 μm, breadth 29–40 μm, 8–10 striae in 10 μm, 9–10 punctae in 10 μm.
Distribution: Very common. Found on slides 37, 91, 175, 333, 357.

N. clavata Greg. Fig. 164

References: Cleve 1894–95, 27(3), p. 61; Hustedt 1927–66, p. 3–444, fig. 1509 a–c; Gerloff & Natour 1982, p. 187, pl. 14, fig. 1.
Description: Length 56–88 μm, breadth 30–38 μm, 9–12 striae in 10 μm, 8–10 punctae in 10 μm.
Distribution: Common. Found on slides 12, 91, 93, 119.

N. cuspidata Kütz. Fig. 165

References: Cleve 1894–95, 26(2) p. 109.
Description: Length 61 μm, breadth 14 μm, 13 transverse, 25 longitudinal striae in 10 μm.
Distribution: Rare. Found on slide 350.
Comments: A cosmopolitan species. Freshwater to marine.

N. distans W. Sm. Fig. 166

References: Cleve 1965, 27(3), p. 35; Hendey 1964, p. 203, pl. 27, fig. 13.
Description: Length 94 μm, breadth 17 μm, 4 striae, 21 lineolae in 10 μm.
Distribution: Rare. Found on slide 12.

N. forcipata var. *suborbicularis* Grun. Fig. 167

References: Cleve 1894–95, 27(3), p. 66.
Description: Length 23 μm, breadth 14 μm, 15 striae in 10 μm.
Distribution: Rare. Found on slide 273.
Comments: A cosmopolitan species.

N. glacialis Cl. Fig. 168

References: Cleve 1894–95, 27(3), p. 40; Cleve-Euler 1953, 4(5), p. 110, fig. 719.
Description: Length 84–98 μm, breadth 36–50 μm, 9–12 striae, 6–9 puncta in 10 μm.
Distribution: Not common. Found on slides 93, 119.
Comments: A cosmopolitan species.

N. grundleri Cl. Fig. 169

References: Cleve 1878, p.7, pl. 2, fig. 10; Cleve 1894–95, 27(3), p. 51.
Description: Length 50–51 μm, breadth 12–13 μm, 10 striae, 11 puncta in 10 μm.
Distribution: Common. Found on slides 12, 278, 337.

N. halophila (Grun.) Cl. Figs. 170–171

References: Cleve 1894–95, 26(2) p. 109; Patrick & Reimer 1966, p. 467, pl. 44, fig. 4.
Description: Length 38–54 μm, breadth 10–11 μm, 15–25 striae in 10 μm.
Distribution: Not common. Found on slides 12, 278.
Comments: A cosmopolitan species. Freshwater.

N. lyra Ehrenb. Fig. 172

References: Hendey 1964, p. 209, pl. 33, fig. 2; Patrick & Reimer 1966, p. 443, pl. 39, figs. 5-6.
Description: Length 92–144 μm, breadth 39–61 μm, 9–10 striae, 8–11 puncta in 10 μm.
Distribution: Common. Found on slide 125.
Comments: A cosmopolitan species.

N. menaiana Hend. Fig. 173

References: Hendey 1964, p. 207, pl. 31, fig. 13.
Description: Length 52 μm, breadth 20 μm, 10 striae in 10 μm.
Distribution: Common. Found on slide 38, 353.

N. monilifera Cl. Fig. 174

References: Hustedt 1961–66, 7(3), p. 711, fig. 1699a; Hendey 1964, p. 206, pl. 31, figs. 4–5.
Description: Length 50–83 μm, breadth 26–44 μm, 9–10 striae in 10 μm.
Distribution: Very common. Found on slides 37, 93, 124, 138.
Comments: A cosmopolitan species (?).

N. monilifera var. *constricta* (Perag.) Hust. Fig. 175

References: Cleve 1894–95, 27(3), p. 43; Hustedt 1961–66, 7(3), p. 712, fig. 1699b.
Description: Length 95–101 μm, breadth 49–50 μm, 7–8 striae, 6–8 puncta in 10 μm.
Distribution: Common. Found on slides 2, 38, 122.
Comments: This is a littoral species of the mediterranean and northern Europe (Podzorski & Håkansson, 1987).

N. nicaeensis Perag. Fig. 176

References: Cleve 1894–95, 27(3), p. 36.
Description: Length 63 μm, breadth 15 μm, 8 striae in 10 μm.
Distribution: Rare. Found on slide 12.

N. pennata A. Sch. Fig. 177

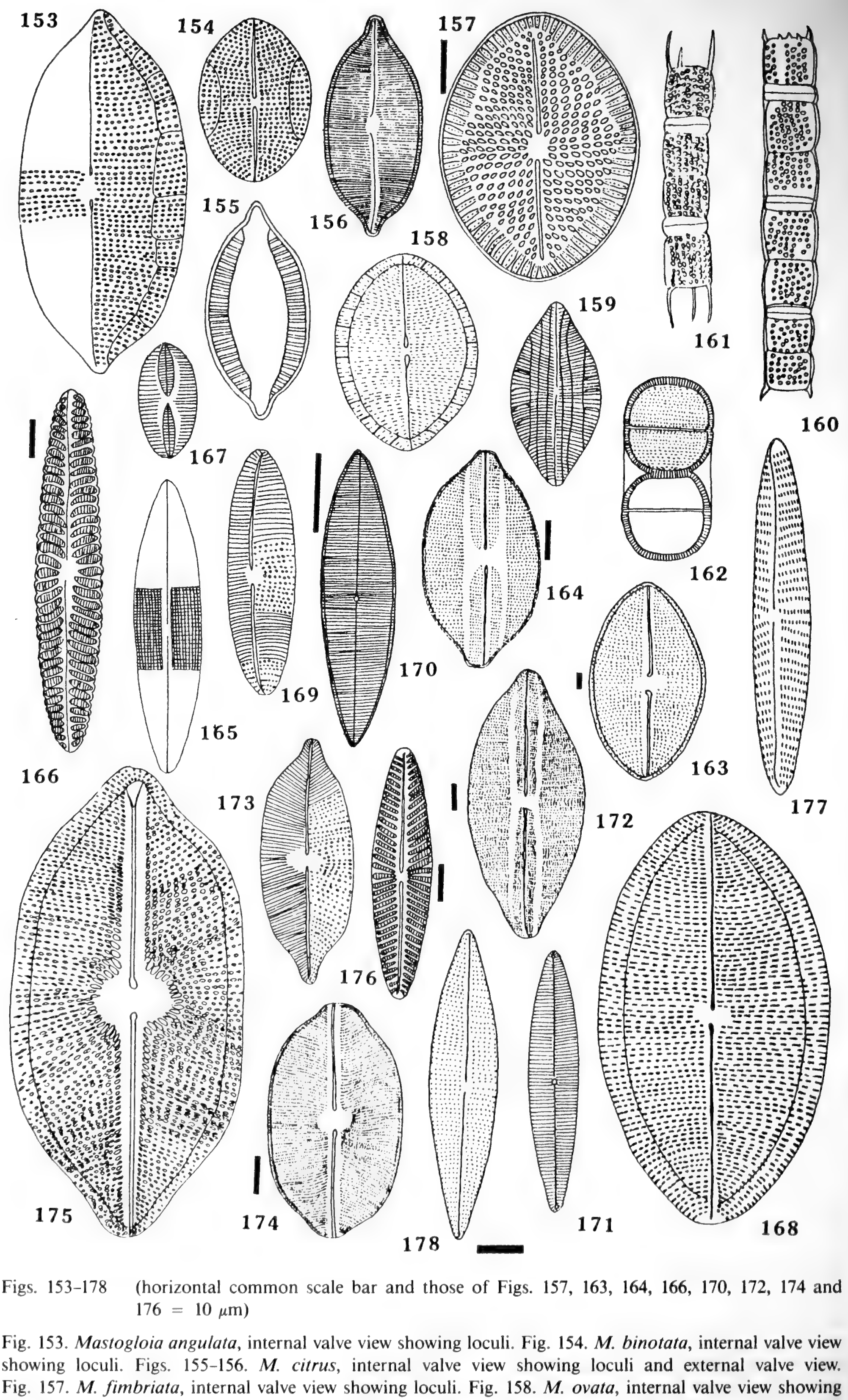
References: Cleve 1894–95, 27(3), p. 32; Hendey 1964, p. 203, pl. 30, fig. 21.
Description: Length 54–74 μm, breadth 9–12 μm, 5–7 middle and 6–8 polar striae in 10 μm.
Distribution: Found on slide 125.

N. pi Cl. Fig. 178

References: Cleve 1894–95, 27(3), p. 50.
Description: Length 64 μm, breadth 14 μm, 11 middle and 12 polar striae, 12 puncta in 10 μm.
Distribution: Rare. Found on slide 81.

N. platessa Cl. Fig. 179–180

References: Cleve 1894–95, 27(3), p. 36.
Description: Length 25–43 μm, breadth 13–21 μm, 5–9 striae in 10 μm.
Distribution: Very common. Found on slides 12, 38, 175, 259, 343, 350, 359.



Figs. 153–178 (horizontal common scale bar and those of Figs. 157, 163, 164, 166, 170, 172, 174 and 176 = 10 μm)

Fig. 153. *Mastogloia angulata*, internal valve view showing loculi. Fig. 154. *M. binotata*, internal valve view showing loculi. Figs. 155–156. *M. citrus*, internal valve view showing loculi and external valve view. Fig. 157. *M. fimbriata*, internal valve view showing loculi. Fig. 158. *M. ovata*, internal valve view showing loculi. Fig. 159. *M. quinquecostata*, internal valve view showing loculi. Figs. 160–161. *Melosira granulata*, cells showing colony formation. Fig. 162. *M. nummuloides*, cells showing colony formation. Fig. 163. *Navicula brasiliensis*. Fig. 164. *N. clavata*. Fig. 165. *N. cuspidata*. Fig. 166. *N. distans*. Fig. 167. *N. forcipata* var. *suborbicularis*. Fig. 168. *N. glaciàlis*. Fig. 169. *N. grundleri*. Figs. 170–171. *N. halophila*. Fig. 172. *N. lyra*. Fig. 173. *N. menaiana*. Fig. 174. *N. monilifera*. Fig. 175. *N. monilifera* var. *constricta*. Fig. 176. *N. nicaeensis*. Fig. 177. *N. pennata*. Fig. 178. *N. pi*.

N. platyventris Meist. Fig. 181

References: Foged 1975, p. 41, pl. 20, fig. 17.
Description: Length 16 μm, breadth 7 μm, 9 striae in 10 μm.
Distribution: Rare. Found on slide 125.

N. plicata Donk. Fig. 182

References: Hustedt 1961–66, 7(3), p. 328, fig. 1443; Hendey 1964, p. 193.
Description: Length 74 μm, breadth 17 μm, 19 middle and 20–21 polar striae in 10 μm.
Distribution: Rare. Found on slide 116.

N. praetexta Ehrenb. Fig. 183

References: Cleve 1894–95, 27(3), p. 55; Hendey 1964, p. 213, pl. 33. fig. 1.
Description: Length 48 μm, breadth 26 μm, 8 striae in 10 μm.
Distribution: Rare. Found on slide 33.
Comments: A cosmopolitan species.

N. pusilla var. *jamalinensis* Grun. Fig. 184

References: Cleve 1894–95, 27(3), p. 41; Patrick & Reimer 1966, p. 453, pl. 41, fig. 8.
Description: Length 50–56 μm, breadth 20–23 μm, 10–12 middle, 14–16 pole striae, 12 punctae in 10 μm.
Distribution: Not common. Found on slide 175.
Comments: A cosmopolitan species. Freshwater to marine.

N. radiosa Kütz. Fig. 185

References: Cleve 1894–95, 27(3), p. 17; Caljon 1983, p. 133, pl. 26, fig. 23.
Description: Length 42–55 μm, breadth 8–9 μm, 10–12 striae in 10 μm.
Distribution: Not common. Found on slide 339.
Comments: A cosmopolitan species. Freshwater to marine.

N. ramosissima (Ag.) Cl. Fig. 186

References: Cleve 1894–95, 27(3), p. 26; Hendey 1964, p. 194, pl. 30, fig. 9.
Description: Length 46–59 μm, breadth 10–12 μm, 11 striae in 10 μm.
Distribution: Not common. Found on slides 273, 345.
Comments: A cosmopolitan species.

N. ramosissima var. *caspia* Grun. Fig. 187

References: Cleve 1894–95, 27(3), p. 26; Hendey 1964, p. 194, pl. 30, fig. 9.
Description: Length 44 μm, breadth 7 μm, 12 striae in 10 μm.
Distribution: Common. Found on slide 259.
Comments: A cosmopolitan species.

N. reichardtii Grun. Fig. 188

References: Cleve 1894–95, 27(3), p. 65.
Description: Length 21 μm, breadth 9 μm, 16 striae in 10 μm.
Distribution: Rare. Found on slide 273.
Comments: A cosmopolitan species.

N. rhaphoneis (Ehrenb.) Grun. Fig. 189

References: Cleve 1894–95, 27(3), p. 36, pl. 1, fig. 27; Foged 1975, p. 42, pl. 20, fig. 13.
Description: Length 19–36 μm, breadth 9–14 μm, 7–10 striae, 18–20 linolae in 10 μm.
Distribution: Common. Found on slides 12, 341, 351, 259.

N. transfuga Grun. Fig. 190

References: Cleve 1894–95, 27(3), p. 48; Hustedt 1961–66, 7(3), p. 697, fig. 1693.
Description: Length 90–126 μm, breadth 40–61 μm, 8–10 striae and 6 puntae in 10 μm.
Distribution: Common. Found on slide 79.

N. transitans Cl. Fig. 191

References: Cleve 1894–95, 27(3), p. 27.
Description: Length 59–84 μm, breadth 12–16 μm, 7–8 striae in 10 μm.
Distribution: Not common. Found on slide 345.

N. yarrensis Grun. Figs. 192–193

References: Cleve 1894–95, 27(3), p. 69; Foged 1984, p. 72, pl. 46, fig. 1.
Description: Length 60–115 μm, breadth 18–33 μm, 3–5 middle and 5–7 polar striae in 10 μm.
Distribution: Rare. Found on slide 19.
Comments: A cosmopolitan species.

N. zostereti Grun. Fig. 194

References: Cleve 1894–95, 27(3), p. 31; Foged 1984, p. 72, pl. 45, fig, 13 & pl, 46, figs. 3 & 4.
Description: Length 66–74 μm, breadth 13–17 μm, 6–8 striae in 10 μm.
Distribution: Common. Found on slides 12, 125, 175, 335, 337, 343.
Comments: A cosmopolitan species.

Nitzschia Hassall 1845

N. amphibia Grun. Figs. 195–196

References: Foged 1979, p. 85, pl. 42, fig. 6; pl. 43, figs. 10 & 11; Navarro 1982, p. 52, pl. 34, fig. 6.
Description: Length 19–22 μm, breadth 3–5 μm, 14–15 striae, 7–10 fibulae in 10 μm.
Distribution: Common. Found on slide 12.
Comments: A cosmopolitan species. Freshwater to marine.

N. apiculata (Greg.) Grun. Fig. 197

References: Hendey 1964, p. 279; Foged 1984, p. 74, pl. 24, fig. 10.
Description: Length 29–62 μm, breadth 8–10 μm, 16 striae, 13–14 fibulae in 10 μm.
Distribution: This species is common and widespread in muddy shores (Hendey, 1964). Common. Found on slides 12, 333, 337.
Comments: A cosmopolitan species.

N. bilobata var. *minor* Grun. Fig. 198

References: Cupp 1943, p. 200, fig. 152.
Description: Length 99–160 μm, breadth 6–11 μm, 24–28 striae, 7–11 fibulae in 10 μm.
Distribution: Not common. Slide 278, 341.
Comments: Brackish to marine.

N. brebissonii var. *borealis* Grun. Fig. 199

References: Cleve 1896, p. 21, pl. 1, figs 28–32.
Description: Length 122 μm, breadth 10 μm, 16–18 striae, 6–7 fibulae in 10 μm.
Distribution: Not common. Found on slide 278.

N. cocconeiformis Grun. Fig. 200

References: Foged 1975, p. 45, pl. 29, fig. 6.
Description: Length 27–59 μm, breadth 16–26 μm, 4–6 costae, 4–6 fibulae in 10 μm.
Distribution: Rare. Found on slides 323, 339.
Comments: A cosmopolitan species. Freshwater to marine.

N. commutata Grun. Fig. 201

References: Tiffany & Britton 1952, p. 288, pl. 77, fig. 903.
Description: Length 30–80 μm, breadth 5–10 μm, 20–24 striae, 6–10 fibulae in 10 μm.
Distribution: Not common. Found on slide 337.
Comments: A cosmopolitan species. Freshwater.

N. constricta (Greg.) Grun. Figs. 202–203

References: Prowse 1962, p. 65, pl. 19, fig. d; Navarro 1982, p. 53, pl. 34, fig. 8.
Description: Length 16–31 μm, breadth 6–11 μm, 14–20 striae, 8–10 fibulae in 10 μm.
Distribution: Common. Found on slides 1,2, 257, 273, 278, 341, 345, 347, 357.
Comments: A cosmopolitan species.

N. granulata Grun. Figs. 204–206

References: Hendey 1964, p. 278; Foged 1979, p. 87, pl. 40, figs. 14 & 15.
Description: Length 24–48 μm, breadth 14–17 μm, 4–6 puncta in 10 μm.
Distribution: Not common. Found on slides 339, 357.
Comments: A cosmopolitan species.

N. ignorata Krasske. Fig. 207

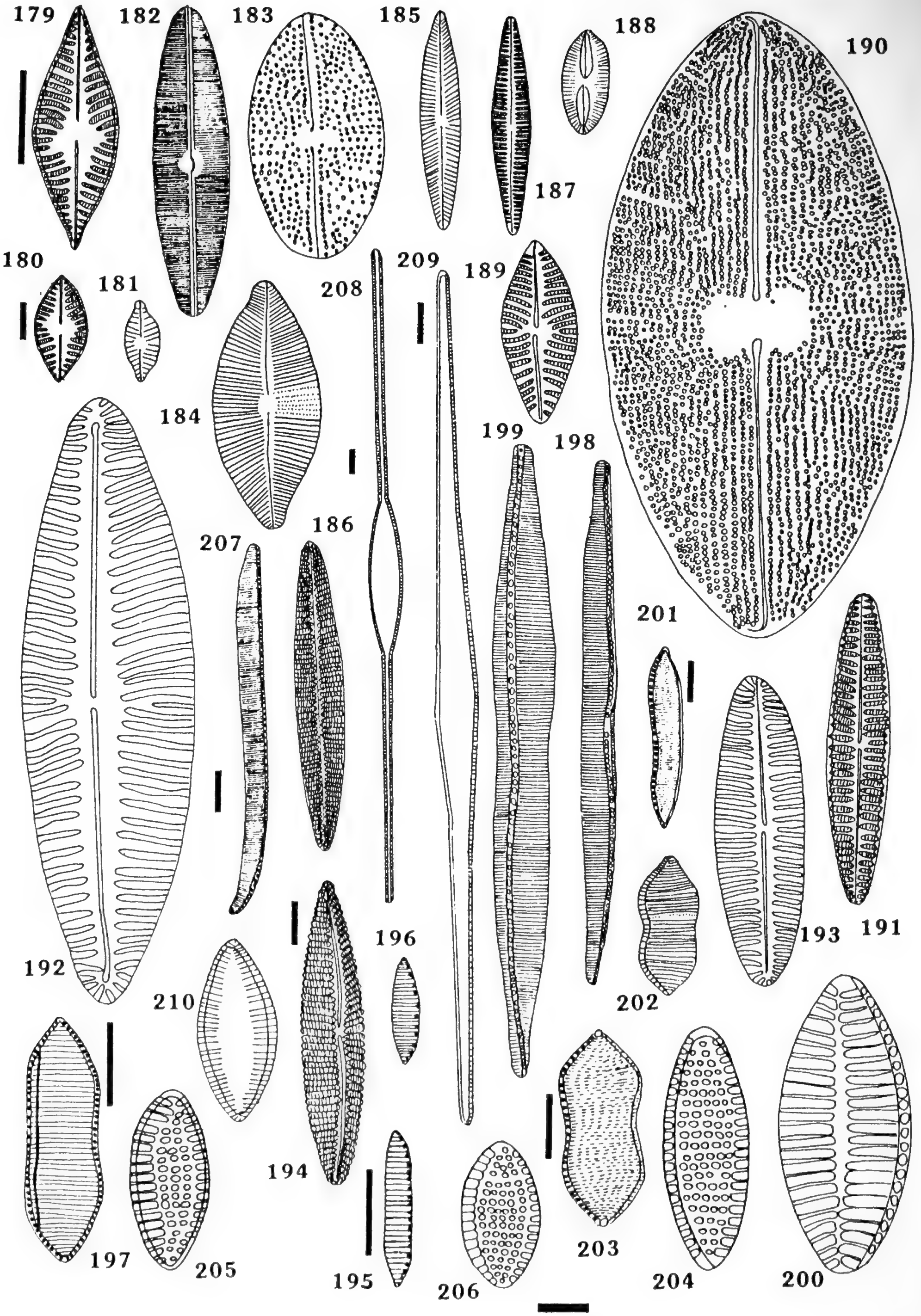
References: Foged 1966, p. 121, pl. 24, fig. 5; Foged 1979, p. 87, pl. 43, figs. 5 & 6.
Description: Length 87 μm, breadth 5 μm, 28 striae, 7–10 fibulae in 10 μm.
Distribution: Common. Found on slide 12.
Comments: A cosmopolitan species. Freshwater to marine.

N. longissima (Bréb.) Ralfs. Figs. 208–209

References: Hendey 1964, p. 283; Foged 1975, p. 46, pl. 29, fig. 7.
Description: Length 202–311 μm, breadth 10–13 μm, 6–12 fibulae in 10 μm.
Distribution: Common. Found on slides 1, 3.
Comments: A cosmopolitan species.

N. navicularis var. *typica* Mh. Fig. 210

References: Cleve-Euler 1952, 3(3), p. 56, fig 1427a.
Description: Length 34–37 μm, breadth 15–16 μm, 6–7 striae in 10 μm.
Distribution: Not common. Found on slides 129, 339.
Comments: A cosmopolitan species.



Figs. 179–210 (horizontal common scale bar and those of Figs. 179, 180, 194, 195, 197, 201, 203 and 207–209 = 10 μm)

Figs. 179–180. *Navicula platessa.* Fig. 181. *N. platyventris.* Fig. 182. *N. plicata.* Fig. 183. *N. praetexta.* Fig. 184. *N. pusilla* var. *jamalinensis.* Fig. 185. *N. radiosa.* Fig. 186. *N. ramosissima.* Fig. 187. *N. ramosissima* var. *caspia.* Fig. 188. *N. reichardtii.* Fig. 189. *N. rhaphoneis.* Fig. 190. *N. transfuga.* Fig. 191. *N. transitans.* Figs. 192–193. *N. yarrensis.* Fig. 194. *N. zostereti.* Fig. 195–196. *Nitzschia amphibia.* Fig. 197. *N. apiculata.* Fig. 198. *N. bilobata* var. *minor.* Fig. 199. *N. brebissonii* var. *borealis.* Fig. 200. *N. cocconeiformis.* Fig. 201. *N. commutata.* Figs. 202–203. *N. constricta.* Figs. 204–206. *N. granulata.* Fig. 207. *N. ignorata.* Figs. 208–209. *N. longissima,* valve view and girdle view. Fig. 210. *N. navicularis* var. *typica.*

N. panduriformis Greg. Fig. 211

References: Hendey 1964, p. 279; Foged 1975, p. 47, pl. 29, figs. 12 & 13.
Description: Length 36–66 μm, breadth 13–30 μm, 14–16 striae, 6–10 fibulae in 10 μm.
Distribution: Common. Found on slides 100, 141, 343.
Comments: A cosmopolitan species.

N. parvula var. *terricola* Lund. Fig. 212

References: Foged 1979, p. 89; pl. 43, fig. 18.
Description: Length 40 μm, breadth 5 μm, 7–8 fibulae in 10 μm. Freshwater.
Distribution: Common. Found on slide 257.

N. punctata (W. Sm.) Grun. Fig. 213

References: Hendey 1964, p. 278. pl. 39, fig. 11; Foged 1979, p. 89, pl. 40, fig. 13; pl. 41, fig. 7; pl. 42, fig. 3.
Description: Length 32–33 μm, breadth 19–20 μm, 6 striae in 10 μm.
Distribution: Rare. Found on slide 95.
Comments: A cosmopolitan species.

N. punctata var. *coarctata* Grun. Fig. 214

References: Hendey 1964, p. 278; Foged 1984, p. 80, pl. 56, fig. 7.
Description: Length 28–35 μm, breadth 10–12 μm, 11–12 striae in 10 μm.
Distribution: Common. Found on slides 1, 259, 350, 353.
Comments: A cosmopolitan species. Occasionally found in freshwater.

N. sigma var. *rigida* (Kütz.) Grun. Figs. 215–218

References: Hendey 1964, p. 282; Caljon 1983, p. 140, pl. 30, figs. 11–12.
Description: Length 43–108 μm, breadth 5–10 μm, 20 striae, 6–8 fibulae in 10 μm.
Distribution: Common. Found on slides 12, 93, 175, 333, 337, 341, 345, 347, 357, 359.
Comments: A cosmopolitan species.

N. sigmoidea (Ehrenb.) W. Sm. Fig. 219

References: Cleve-Euler 1952, 3(3), p. 72; Gerloff & Natour 1982, p. 200, pl. 19, fig. 1.
Description: Length 164–331 μm, breadth 11–13 μm, 23–25 striae 5–7 fibulae in 10 μm.
Distribution: Not common. Found on slides 1, 175, 355.
Comments: A cosmopolitan species. Freshwater to marine.

N. subtilis (Kütz.) Grun. Fig. 220

References: Prowse 1962, p. 71, pl. 19, fig. p; pl. 20, fig. f.
Description: Length 56–127 μm, breadth 4–5 μm, 28–30 striae 8–10 fibulae in 10 μm.
Distribution: Not common. Found on slides 12, 257.
Comments: A cosmopolitan species (?). Freshwater.

N. tryblionella var. *victoriae* Grun. Fig. 221

References: Foged 1975, p. 47, pl. 28, fig. 4; Fungladda, Kaezmarska & Rushforth 1983, p. 44, fig. 274.
Description: Length 73 μm, breadth 40 μm, 5 costae, 16 striae, 9 fibulae in 10 μm.
Distribution: Rare. Found on slide 12.
Comments: A cosmopolitan species. Freshwater to marine.

N. vermicularis (Kütz.) Hantz. Fig. 222

References: Tiffany & Britton 1952, p. 286, pl. 76, fig. 890.
Description: Length 127 μm, breadth 4–5 μm, 7–9 fibulae in 10 μm.
Distribution: Rare. Found on slides 1, 81, 333.
Comments: A cosmopolitan species. Freshwater to brackish.

Odontella Ag. 1832

O. aurita (Lyngb.) Ag. (=*Biddulphia*) Figs. 223–225

References: Hustedt 1930, 7(1), p. 846, fig. 501; Hendey 1964, p. 103, pl. 24, fig. 6.
Description: Length 27–54 μm, breadth 22 μm, puncta 9–12 in 10 μm. Usually in long chains, sometimes free-floating.
Distribution: Very common. Found on slides 2, 3, 81, 100, 259, 278.
Comments: A cosmopolitan species.

O. aurita var. *obtusa* (Kütz.) Hust. (=*Biddulphia*). Fig. 226

References: Caljon 1983, p. 107, pl. 15, fig. 21.
Description: Length 42–56 μm, breadth 50–54 μm, puncta 9–10 in 10 μm. Solitary or united into long chains.
Distribution: Common. Found on slides 278, 355.
Comments: A cosmopolitan species.

Opephora Petit 1888

O. martyi Hérib. Figs. 227–228

References: Patrick & Reimer 1966, p. 115, pl. 3, fig. 3; Caljon 1983, p. 114, pl. 18, figs. 5, 6.
Description: Length 14–30 μm, breadth 5–6 μm, 9–10 striae in 10 μm.
Distribution: Rare. Found on slides 273.
Comments: A cosmopolitan species.

O. schwartzii (Grun.) Petit. Fig. 229

References: Hendey 1964, p. 159, pl. 36, figs. 8,9; Patrick & Reimer 1966, p. 116, pl. 3, fig. 1.
Description: Length 45–53 μm, breadth 10 μm, 4–5 striae in 10 μm.
Distribution: Rare. Found on slides 38, 273.
Comments: A cosmopolitan species (?).

Paralia Heiberg 1863

P. sulcata (Ehrenb.) Cl. Figs. 230–231

References: Boyer 1926–27, p. 25; Hendey 1964, p. 73, pl. 23, fig. 5.
Description: Diameter 15–55 μm.
Distribution: Very common. Found on slides 38, 79, 141, 341, 343, 351, 355.
Comments: A cosmopolitan species.

Plagiodiscus Grun. & Eulenst. 1867

P. nervatus Grun. Fig. 232

References: Hendey 1970, p. 160, pl. 4, fig. 39; Foged 1975, p. 49, pl. 31, figs. 4,5.

Description: Length 46–51 μm, breadth 24 μm, 3–4 costae, 12–13 striae in 10 μm.
Distribution: Not common. Found on slides 333, 345.

Plagiogramma Grev. 1859

P. staurophorum (Greg.) Heiberg. Fig. 233

References: Hendey 1964, p. 166, pl. 36, fig. 1.
Description: Length 35 μm, breadth 8 μm, 17 puncta in 10 μm. Solitary or colonial.
Distribution: Rare. Found on slides 38, 116.

Pleurosigma W. Sm. 1852

P. aestuarii (Bréb.) W. Sm. Figs. 234–235

References: Cleve 1894–95, 26(2) p. 42; Hendey 1964, p. 247, pl. 36, fig. 5, pl. 41, fig. 5.
Description: Length 112–188 μm, breadth 26–40 μm, 19–21 striae in 10 μm.
Distribution: Not common. Found on slides 357, 359.
Comments: Common in temperate waters.

P. delicatulum W. Sm. Fig. 236

References: Cleve 1894–95, 26(2) p. 37; Patrick & Reimer 1966, p. 336, pl. 28, figs. 4a–b.
Description: Length 153 μm, breadth 15 μm, 25 striae in 10 μm.
Distribution: Rare. Found on slide 2.
Comments: A cosmopolitan species (?). Freshwater, brackish to marine.

P. elongatum W. Sm. Fig. 237

References: Gonzalves & Gandhi 1953, 2-p. 244, fig. 70; Patrick & Reimer 1966, p. 334, fig. 1a–c.
Description: Length 124–154 μm, breadth 23–26 μm, 17–19 transverse, 16–17 oblique striae in 10 μm.
Distribution: Not common. Found on slide 91.
Comments: A cosmopolitan species. Freshwater to marine.

P. formosum W. Sm. Fig. 238

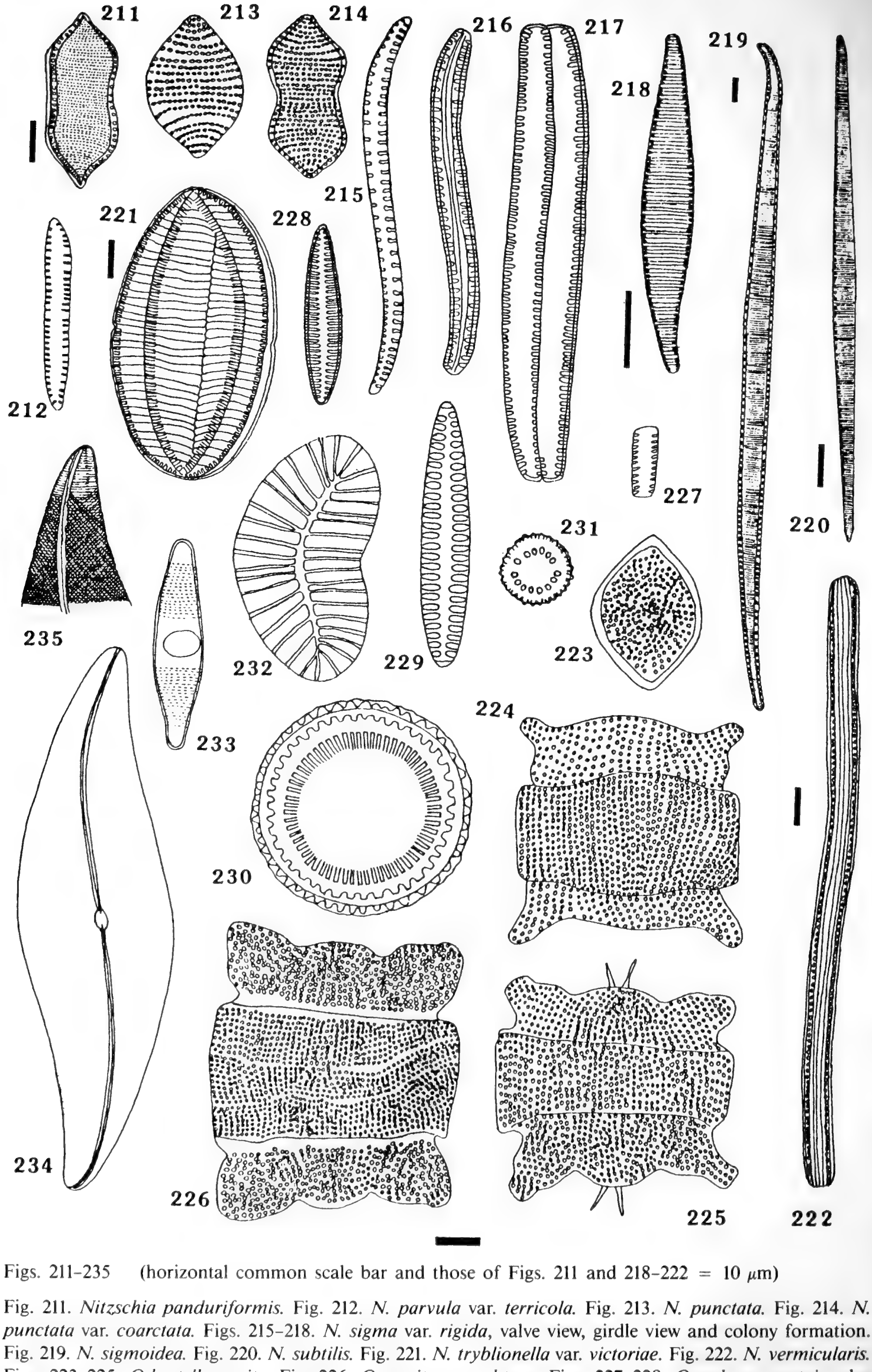
References: Cleve 1894–95, 26(2) p. 45, Hendey 1964, p. 242.
Description: Length 125–326 μm, breadth 22–36 μm, 14–15 transverse, 10–14 oblique striae in 10 μm.
Distribution: Common. Found on slides 319, 343, 345, 347.
Comments: A cosmopolitan species.

P. intermedium W. Sm. Fig. 239

References: Cleve 1894–95, 26(2) p. 34, Hendey 1964, p. 244.
Description: Length 166–196 μm, breadth 17–19 μm, 20 striae in 10 μm.
Distribution: Common. Found on slide 278.
Comments: Common in temperate seas.

P. majus Grun. Figs. 240–241

References: Cleve 1894–95, 26(2) p. 44, pl. 4, fig. 15.
Description: Length 295–348 μm, breadth 40–45 μm, 15 transverse, 12 oblique striae in 10 μm.
Distribution: Rare. Found on slides 3, 79.



Figs. 211–235 (horizontal common scale bar and those of Figs. 211 and 218–222 = 10 μm)

Fig. 211. *Nitzschia panduriformis.* Fig. 212. *N. parvula* var. *terricola.* Fig. 213. *N. punctata.* Fig. 214. *N. punctata* var. *coarctata.* Figs. 215–218. *N. sigma* var. *rigida*, valve view, girdle view and colony formation. Fig. 219. *N. sigmoidea.* Fig. 220. *N. subtilis.* Fig. 221. *N. tryblionella* var. *victoriae.* Fig. 222. *N. vermicularis.* Figs. 223–225. *Odontella aurita.* Fig. 226. *O. aurita* var. *obtusa.* Figs. 227–228. *Opephora martyi*, valve view and girdle view. Fig. 229. *O. schwartzii.* Figs. 230–231. *Paralia sulcata.* Fig. 232. *Plagiodiscus nervatus.* Fig. 233. *Plagiogramma staurophorum.* Figs. 234–235. *Pleurosigma aestuarii.*

P. marinum Donk. Fig. 242

References: Cleve 1894–95, 26(2) p. 37, Hendey 1964, p. 247, pl. 35, fig. 8.
Description: Length 128 μm, breadth 27 μm, 21 transverse, 18 oblique striae in 10 μm.
Distribution: Not common. Found on slide 278.

P. normanii Ralfs. Fig. 243

References: Cleve 1894–95, 26(2) p. 40; Hendey 1964, p. 244.
Description: Length 128–132 μm, breadth 26–31 μm, 20 transverse, 17–22 oblique striae in 10 μm.
Distribution: Rare. Found on slides 12, 183.

P. nubecula var. *mauritiana* Grun. Fig. 244

References: Cleve 1894–95, 26(2) p. 35.
Description: Length 127 μm, breadth 13 μm, 22 striae in 10 μm.
Distribution: Not common. Found on slide 2.
Comments: A cosmopolitan species (?).

P. salinarum (Grun.) Cl. Figs. 245–246

References: Cleve 1894–95, 26(2) p. 39; Patrick & Reimer 1966, p. 333, pl. 27, figs. 2a–c.
Description: Length 107 μm, breadth 19 μm, 25 transverse, 30 oblique striae in 10 μm.
Distribution: Not common. Found on slides 2, 257.
Comments: A cosmopolitan species. Freshwater to brackish.

P. salinarum var. *boyeri* (Keeley) Reim. Figs. 247–248

References: Patrick & Reimer 1966, p. 334, pl. 27, figs. 4a–c.
Description: Length 92–100 μm, breadth 11–14 μm, 24–25 transverse, 30 oblique striae in 10 μm.
Distribution: Rare. Found on slide 116.
Comments: Freshwater to marine.

Podocystis Kütz. 1844

P. adriatica Kütz. Fig. 249

References: Hendey 1964, p. 169, pl. 27, fig. 4; Foged 1984, p. 89, pl. 28, fig. 9; pl. 30, figs. 7–8.
Description: Length 64–74 μm, breadth 48–57 μm, 3–4 costae, 5–7 areolae in 10 μm.
Distribution: Common. Found on slides 333, 345.
Comments: A cosmopolitan species.

Psammodiscus Kütz. 1844

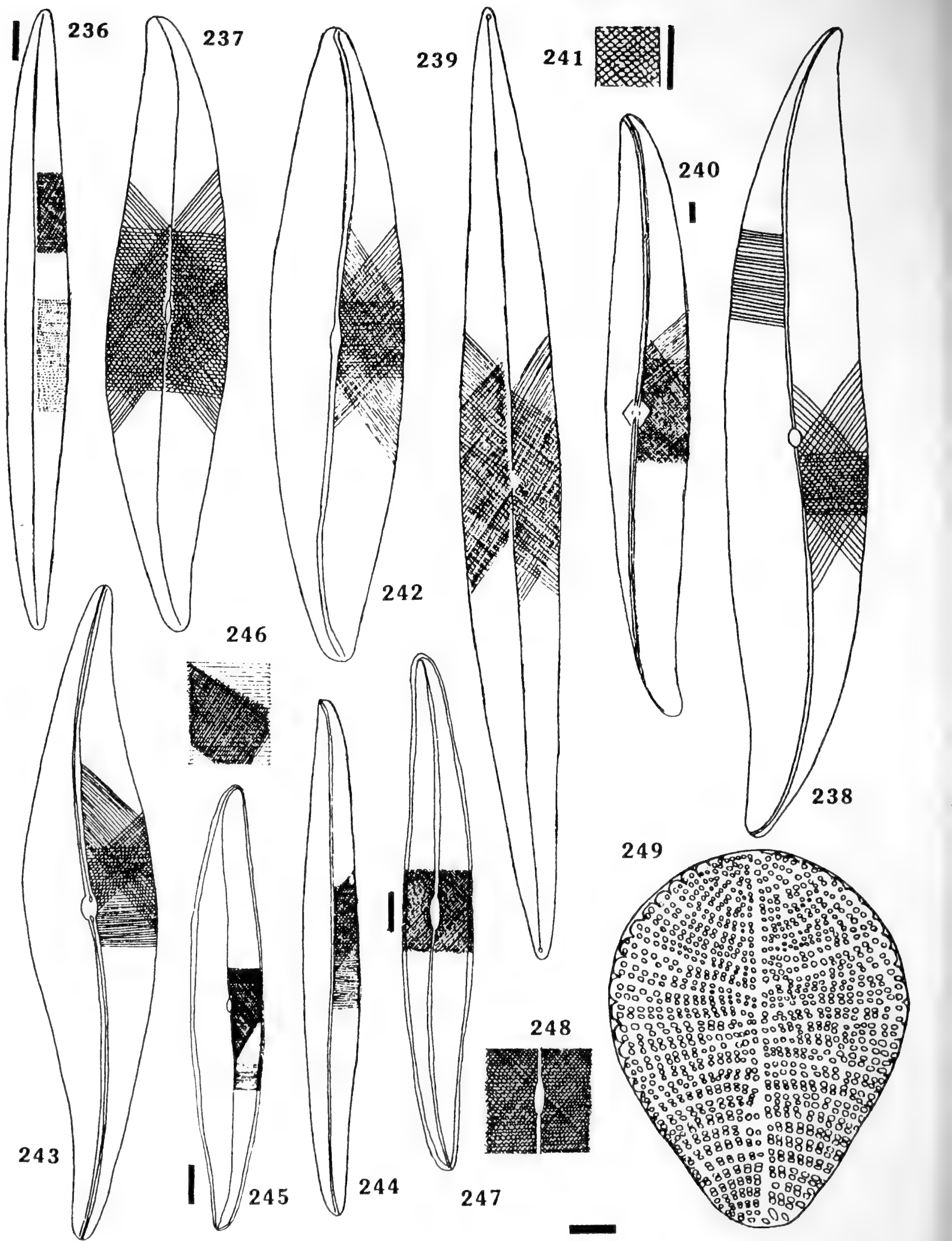
P. nitidus (Greg.) Round & Mann. Figs. 250–251

References: Hendey 1964, p. 76, pl. 23, fig. 12; Round & Mann, 1980.
Description: Diameter 29–50 μm.
Distribution: Not common. Found on slides 12, 48, 120.
Comments: A cosmopolitan species.

Pyxidicula Ehrenb. 1833

P. africana Cholnoky. Fig. 252

References: Schoeman 1972, p. 86, figs. 7, 8.



Figs. 236–249 (horizontal common scale bar and those of Figs. 236, 240, 241, 245 and 247 = 10 μm)

Fig. 236. *Pleurosigma delicatulum.* Fig. 237. *P. elongatum.* Fig. 238. *P. formosum.* Fig. 239. *P. intermedium.* Figs. 240–241. *P. majus.* Fig. 242. *P. marinum.* Fig. 243. *P. normanii.* Fig. 244. *P. nubecula* var. *mauritiana.* Figs. 245–246. *P. salinarum*, valve view and details of striations. Figs. 247–248. *P. salinarum* var. *boyeri*, valve view and details of striations. Fig. 249. *Podocystis adriatica.*

Description: Diameter 22–48 μm, 5–7 rows of areolae and 12 marginal striae 10 μm.
Distribution: Very common. Found on slides 3, 79, 278, 339, 351.

Rhabdonema Kütz. 1844

R. adriatícum Kütz. Fig. 253

References: Hendey 1964, p. 172.
Description: Length 88 μm. Colonial.
Distribution: Not common. Found on slides 2, 3, 91, 116.

Rhaphoneis Ehrenb. 1844

R. amphiceros Ehrenb. Fig. 254

References: Hendey 1964, p. 154, pl. 26, figs. 1–4; Navarro 1982, p. 24, pl. 13, fig. 9.
Description: Length 30–42 μm, breadth 16–28 μm, 5–8 striae in 10 μm.
Distribution: Common. Found on slides 49, 91, 93, 125.
Comments: A cosmopolitan species.

R. amphiceros var. *tetragona* Grun. Fig. 255

References: Hendey 1970, p. 122, pl. 4, fig. 41; Foged 1975, p. 51, pl. 11, figs. 10, 11.
Description: Length of side 32–36 μm, 6 striae in 10 μm.
Distribution: Not common. Found on slides 91, 119.

R. castracanii Grun. Fig. 256

References: Wood 1963, p. 279, pl. 11, fig; 228.
Description: Length 21–43 μm, breadth 21–26 μm, 4–6 striae in 10 μm.
Distribution: Not common. Found on slides 91, 132.

Rhopalodia O. Müller 1897

R. gibba var. *ventricosa* (Kütz.) H. & M. Perag. Fig. 257

References: Hendey 1964, p. 272; Patrick & Reimer 1975, p. 190, pl. 28, figs. 3, 4.
Description: Length 48–54 μm, breadth 12–15 μm, 5 costae, 12–13 striae in 10 μm.
Distribution: Common. Found on slide 12.
Comments: A cosmopolitan species. Freshwater to marine.

R. gibberula (Ehrenb.) O. Müll. Figs. 258–259

References: Prowse 1962, p. 62, pl. 22, fig. a; Patrick & Reimer 1975, p. 191, pl. 28, fig. 6.
Description: Length 28–55 μm, breadth 16–31 μm in girdle, 7–12 μm in valve, 3–5 costae, 16–17 striae in 10 μm.
Distribution: Common. Found on slides 12, 91, 337, 339, 350.
Comments: A cosmopolitan species. Freshwater to marine.

R. gibberula var. *vanheurckii* O. Müll. Fig. 260

References: Patrick & Reimer 1975, p. 192, pl. 28, fig. 7.
Description: Length 20–38 μm, breadth 11–12 μm in girdle, 5–7 μm in valve, 2–5 costae, 14 striae in 10 μm.
Distribution: Rare. Found on slide 343.
Comments: A cosmopolitan species. Freshwater and brackish.

Stauroneis Ehrenb. 1841

S. membranaceae (Cl.) Hust. Fig. 261

References: Hendey 1964, p. 221; Navarro 1982, p. 325, figs. 106–107.
Description: Length 58 μm, pervalvar axis 55 μm, 25 striae in 10 μm.
Distribution: Rare. Found on slide 4.

Stephanopyxis Grun. 1884

S. turris var. *polaris* Grun. Fig. 262

References: Hustedt 1930, 7(1), p. 306, fig. 144.
Description: Diameter 65–72 μm, 1 1/2–1 3/4 areolae in 10 μm. Solitary or united to form short chains.
Distribution: Not common. Found on slides 95, 141.

Striatella Ag. 1832

S. unipunctata (Lyng.) Ag. Fig. 263

References: Cleve-Euler 1953, 4(1), p. 8, fig. 300; Hendey 1964, p. 161, pl. 26, figs 17, 18.
Description: Length 72 μm, breadth 18 μm, 25–30 oblique striae in 10 μm. Colonial.
Distribution: Rare. Found on slide 37.
Comments: A cosmopolitan species.

Surirella Turpin 1828

S. amoricana Perag. Fig. 264

References: Hendey 1964, p. 289, pl. 40, fig. 6; Foged 1975, p. 53, pl. 30, figs. 3–5.
Description: Length 34–56 μm, breadth 21–42 μm, 12–13 marginal striae, 1.5–2 costae in 10 μm.
Distribution: Common. Found on slides 75, 93, 345.

S. fastuosa (Ehrenb.) Kütz. Fig. 265

References: Cleve-Euler 1952, 3(3), p. 115, fig. 1571; Hendey 1964, p. 288, pl. 40, fig. 4.
Description: Length 56–104 μm, breadth 42–66 μm, 14 marginal striae, 1–3 costae in 10 μm.
Distribution: Common. Found on slides 4, 343, 347, 350.
Comments: A cosmopolitan species.

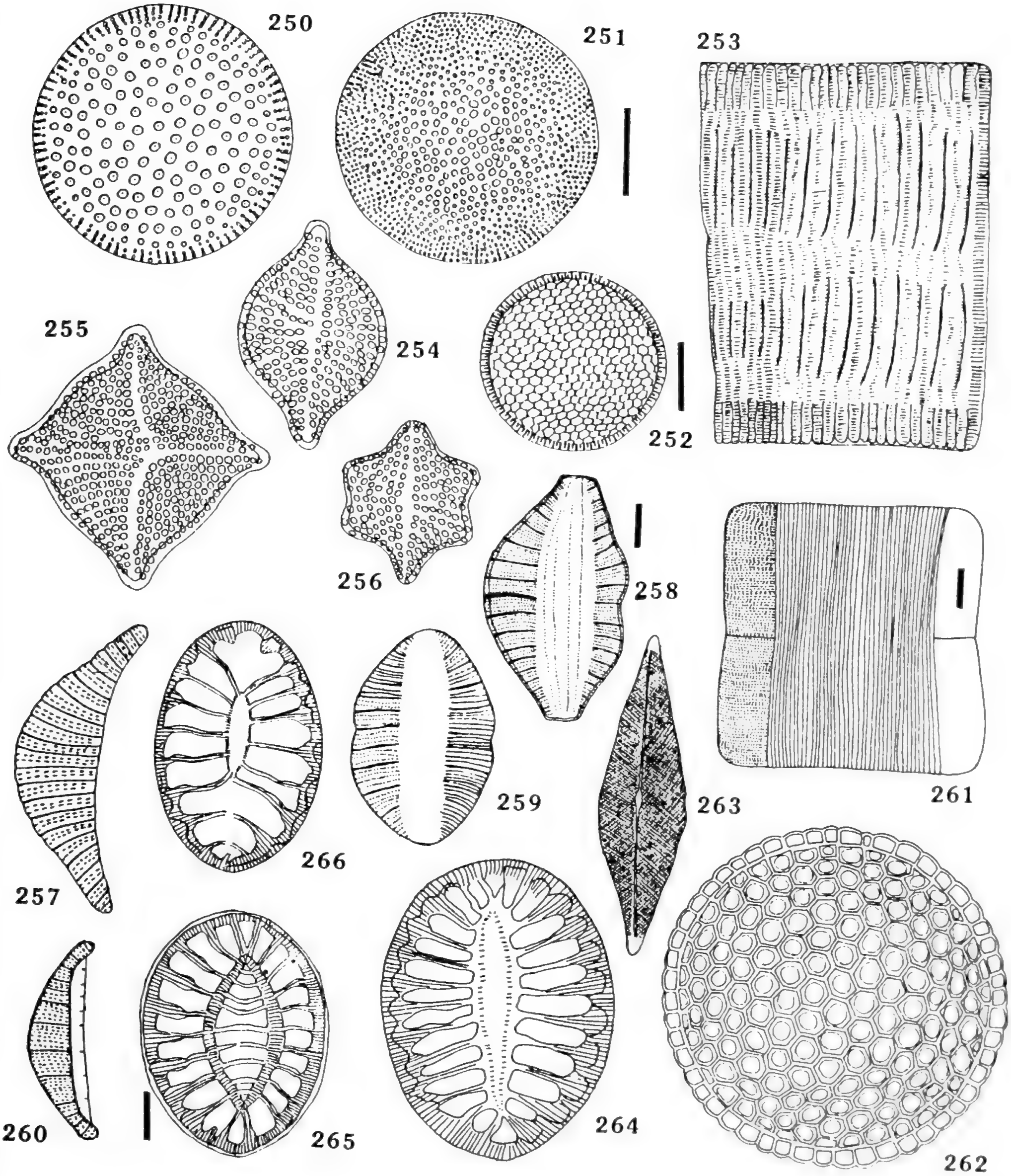
S. fastuosa var. *recedens* (A. Sch.) Cl. Fig. 266

References: Cupp 1943, p. 208, fig. 160.
Description: Length 38–47 μm, breadth 24–34 μm, 16–18 marginal striae, 2–3 costae in 10 μm.
Distribution: Not common. Found on slides 1, 12, 138, 343.

Synedra Ehrenb. 1830

S. amphicephala Kütz. Fig. 267

References: Patrick & Reimer 1966, p. 138, pl. 5, fig. 7.
Description: Length 64–82 μm, breadth 5–6 μm, 12–13 striae in 10 μm.
Distribution: Not common. Found on slides 337, 351.
Comments: Freshwater.



Figs. 250–266 (horizontal common scale bar and those of Figs. 251, 252, 258, 261, 265 = 10 μm)

Figs. 250–251. ***Psammodiscus nitidus.*** Fig. 252. ***Pyxidicula africana.*** Fig. 253. ***Rhabdonema adriaticum***, colony forming ribbon-like chain. Fig. 254. ***Rhaphoneis amphiceros.*** Fig. 255. ***Rhaphoneis amphiceros*** var. ***tetragona.*** Fig. 256. ***R. castracanii.*** Fig. 257. ***Rhopalodia gibba*** var. ***ventricosa.*** Figs. 258–259. ***R. gibberula.*** Fig. 260. ***R. gibberula*** var. ***vanheurckii.*** Fig. 261. ***Stauroneis membranaceae***, girdle view. Fig. 262. ***Stephanopyxis turris*** var. ***polaris.*** Fig. 263. ***Striatella unipunctata.*** Fig. 264. ***Surirella amoricana*** Fig. 265. ***S. fastuosa.*** Fig. 266. ***S. fastuosa*** var. ***recedens.***

S. crystallina (Ag.) Kütz. Fig. 268

References: Hendey 1964, p. 164; Patrick & Reimer 1966, p. 157, pl. 8, figs. 4a–c.
Description: Length 110–195 μm, breadth 10–17 μm, 9 striae in 10 μm.
Distribution: Not common. Found on slides 1, 4.
Comments: A cosmopolitan species.

S. demerare Grun. Fig. 269

References: Boyer 1926–27, p. 206; Patrick & Reimer 1966, p. 139, pl. 5, fig. 10.
Description: Length 68–124 μm, breadth 6–9 μm (girdle), 8–9 striae in 10 μm.
Distribution: Very common. Freshwater. Found on slides 257, 273, 335, 337, 343, 345.

S. fasciculata var. *truncata* (Grev.) Patr. Figs. 270–271

References: Patrick & Reimer 1966, p. 142, pl. 5, fig. 16.
Description: Length 42–54 μm, breadth 5–8 μm, 9–14 striae in 10 μm.
Distribution: Very common. Found on slides 1, 75, 257, 273, 335, 337, 355.
Comments: A cosmopolitan species. Freshwater to marine.

S. formosa Hantz. Figs. 272–273

References: Boyer 1926–27, p. 209; Navarro 1982, p. 260, figs. 61–63.
Description: Length 280–614 μm, breadth 16–29 μm, 8–9 striae in 10 μm.
Distribution: Common. Found on slides 1, 116, 124, 335, 343, 350, 357.
Comments: A cosmopolitan species.

S. gaillonii (Bory) Ehrenb. Fig. 274

References: Hendey 1964, p. 163; Patrick & Reimer 1966, p. 148, pl. 6, fig. 16.
Description: Length 69–111 μm, breadth 5–6 μm, 9–10 striae in 10 μm.
Distribution: Rare. Found on slides 278, 335.
Comments: A cosmopolitan species.

S. hennedyana Greg. Fig. 275

References: Hendey 1964, p. 164, pl. 26, fig. 7.
Description: Length 809 μm, breadth 11 μm.
Distribution: Not common. Found on slides 1, 116, 132, 333.
Comments: A cosmopolitan species.

S. provincialis var. *tortuosa* Grun. Fig. 276

References: Foged 1975, p. 54, pl. 10, fig. 10.
Description: Length 94 μm, breadth 6 μm.
Distribution: Very common. Found on slide 341.

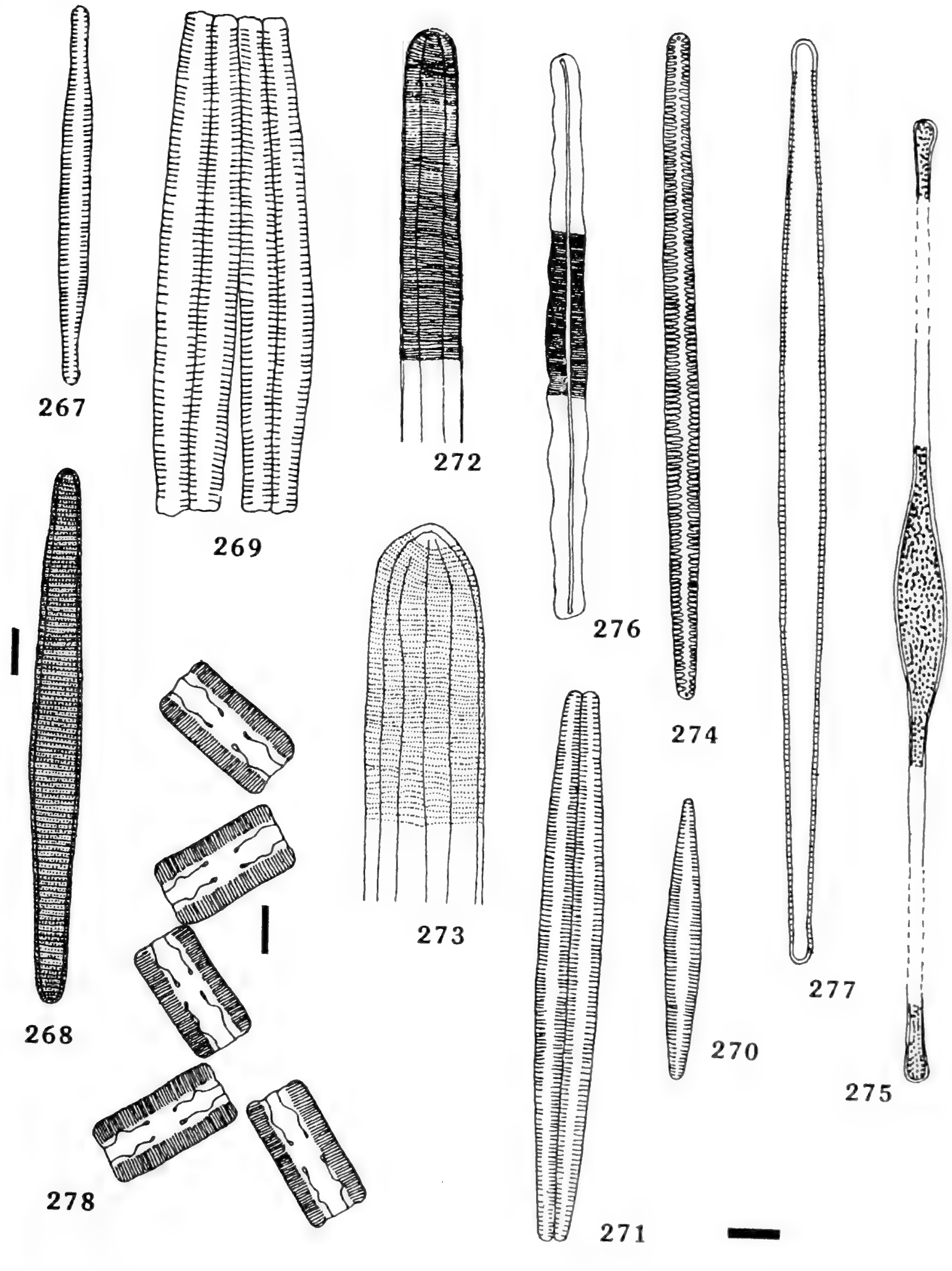
S. tabulata var. *grandis* Mereschk. Fig. 277

References: Hustedt 1959, 7(2), p. 219, fig. 710g.
Description: Length 155 μm, breadth 7 μm, 12 striae in 10 μm.
Distribution: Not common. Found on slide 350.
Comments: A cosmopolitan species.

Tabellaria Ehrenb. 1839

T. fenestrata (Lyng.) Kütz. Fig. 278

References: Patrick & Reimer 1966, p. 103, pl. 1, figs. 1–2.



Figs. 267–278 (horizontal common scale bar and those of Figs. 268 and 278 = 10 μm)

Fig. 267. ***Synedra amphicephala.*** Fig. 268. *S. crystallina.* Fig. 269. *S. demerare*, a four-celled colony. Figs. 270–271. *S. fasciculata* var. *truncata.* Figs. 272–273. *S. formosa.* Fig. 274. *S. gaillonii.* Fig. 275. *S. hennedyana.* Fig. 276. *S. provincialis* var. *tortuosa.* Fig. 277. *S. tabulata* var. *grandis.* Fig. 278. *Tabellaria fenestrata*, cells in zig-zag chain, girdle view.

Description: Length 26–38 μm, 15–20 striae in 10 μm.
Distribution: Very common. Found on slides 1, 93, 257, 273, 319, 337, 351, 355.
Comments: A cosmopolitan species.

Thalassionema Grun. 1880

T. nitzschioides Hust. Figs. 279–280

References: Hendey 1964, p. 165; Schoeman 1972, p. 88, figs. 2–4.
Description: Length 26–42 μm, breadth 4–5 μm, 8–12 puncta in 10 μm. Solitary or colonial.
Distribution: Common. Found on slides 12, 319, 321, 337, 339, 347.
Comments: A cosmopolitan species.

Thalassiosira Cl. 1873

T. eccentrica (Ehrenb.) Cl. Fig. 281

References: Foged 1979, p. 112, pl. 4, fig. 4.
Description: Diameter 24–60 μm, 10–17 marginal striae, 4–7 areolae in the middle and 6–9 near the margin, 2–4 irregular teeth in 10 μm.
Distribution: Common. Found on slides 3, 33, 278, 315; 351.
Comments: A cosmopolitan species. Fig. 45.

Trachyneis Cl. 1894

T. antillarum Cl. Fig. 282

References: Cleve 1878, p. 8, pl. 2, fig. 11; Cleve 1894–95, 26(2) p. 193.
Description: Length 149 μm, breadth 36 μm, 8 striae in 10 μm.
Distribution: Not common. Found on slide 359.
Comments; A cosmopolitan species (?).

T. antillarum var. *kurzii* Grun. Fig. 283

References: Cleve 1878, p. 8, fig. 12a; Cleve 1894–95, 26(2) p. 193.
Description: Length 83–98 μm, breadth 37–40 μm, 9–11 striae in 10 μm.
Distribution: Common. Found on slides 345, 351, 353, 357.
Comments: Brackish to marine.

T. aspera (Ehrenb.) Cl. Figs. 284–285

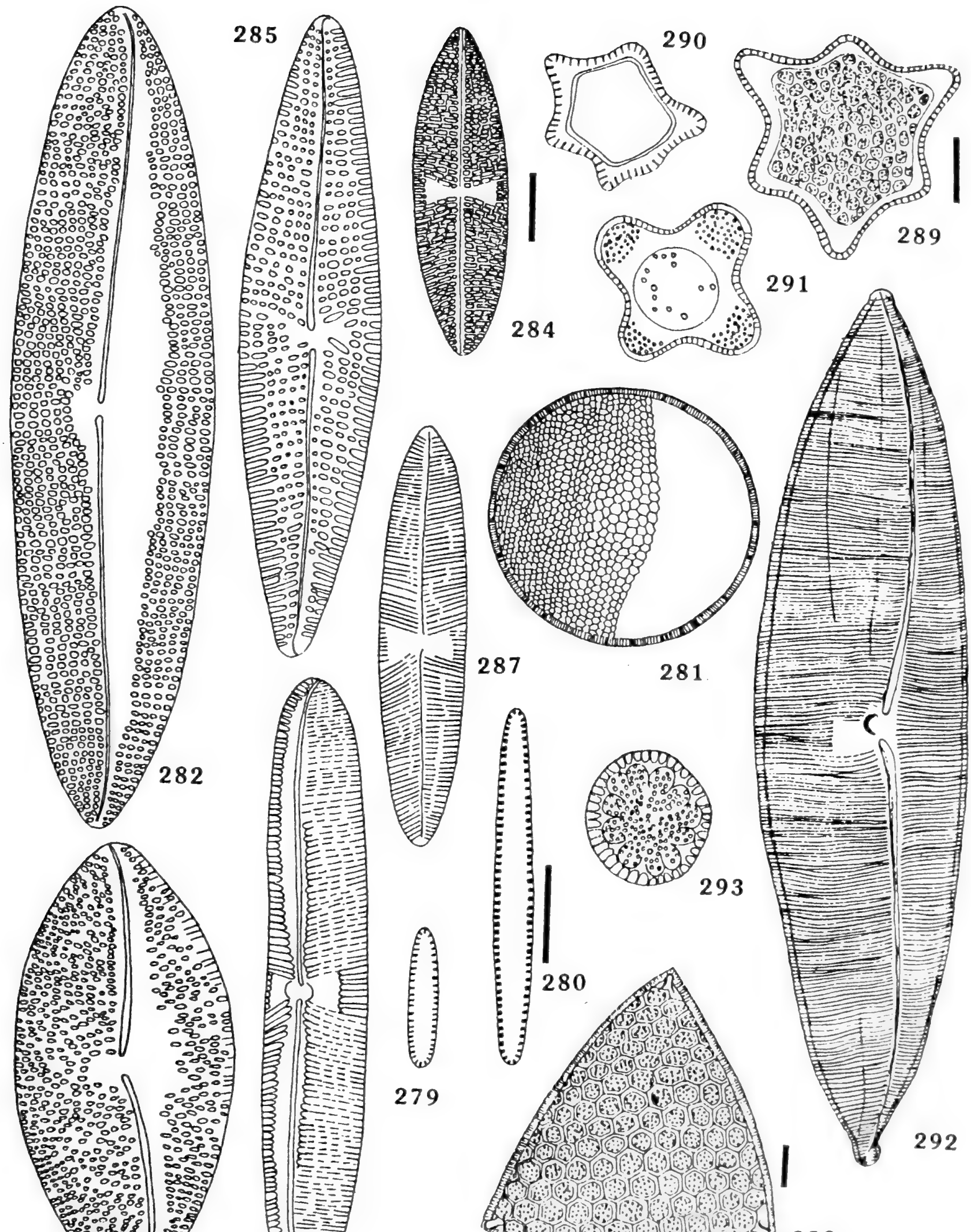
References: Cleve 1894–95, 26(2) p. 191; Hendey 1970, p. 148, fig. 52.
Description: Length 50–126 μm, breadth 14–28 μm, 9–14 striae in 10 μm.
Distribution: Common. Found on slides 2, 12, 116, 333, 335, 343, 347, 350.
Comments: A cosmopolitan species.

T. aspera var. *intermedia* (Grun.) Cl. Fig. 286

References: Cleve 1894–95, 26(2) p. 192; Hendey 1964, p. 237.
Description: Length 111–182 μm, breadth 18–24 μm, 6–9 striae in 10 μm.
Distribution: Not common. Found on slides 100, 350.

T. aspera var. *pulchella* W. Sm. Fig. 287

References: Cleve 1894–95, 26(2) p. 191.
Description: Length 64–120 μm, breadth 17–22 μm, 11–12 striae in 10 μm.



Figs. 279–293 (horizontal common scale bar and those of Figs. 280, 284, 288, 289 = 10 μm)

Figs. 279–280. *Thalassionema nitzschioides.* Fig. 281. *Thalassiosira eccentrica.* Fig. 282. *Trachyneis antillarum.* Fig. 283. *T. antillarum* var. *kurzii.* Figs. 284–285. *T. aspera.* Fig. 286. *T. aspera* var. *intermedia.* Fig. 287. *T. aspera* var. *pulchella.* Fig. 288. *Triceratium broeckii.* Figs. 289–290. *T. dubium.* Fig. 291. *T. zonulatum.* Fig. 292. *Tropidoneis maximan.* Fig. 293. *Trybliophychus cocconeiformis.*

Distribution: Not common. Found on slides 116, 125, 175.
Comments: A cosmopolitan species.

Triceratium Ehrenb. 1841

T. broeckii Leud.-Fortm. Fig. 288

References: Hustedt 1930, 7(1), p. 802, fig. 465; Hendey 1970, p. 118.
Description: Length of side 66–74 μm.
Distribution: Common. Found on slides 3, 116, 351.
Comments: A cosmopolitan species (?).

T. dubium Brightw. Figs. 289–290

References: Boyer 1926–27, p. 128; Hustedt 1930, 7(1), p. 806, fig. 285.
Description: Length of diagonal 33 μm.
Distribution: Common. Found on slides 3, 79, 80, 81, 116, 323, 355, 359.
Comments: A cosmopolitan species.

T. zonulatum Grev. Fig. 291

References: Foged 1975, p. 57, pl. 2, figs. 5, 6.
Description: Length of diagonal 34 μm.
Distribution: Rare. Found on slide 120.

Tropidoneis Cl. 1891

T. maximan (Greg.) Cl. Fig. 292

References: Cleve 1894–95, p. 26; Hendey 1964, p. 256.
Description: Length 166 μm, breadth 38 μm, 11–12 striae in 10 μm.
Distribution: Rare. Found on slide 124.
Comments: A cosmopolitan (?) species.

Trybliophychus Hendey 1958

T. cocconeiformis (Cl.) Hend. Fig. 293

References: Hendey 1958, p. 46, pl. 2, fig. 10.
Description: Length 25 μm, breadth 22 μm, 8 puncta in 10 μm.
Distribution: Rare. Found on slides 116, 347.

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References

Allen, W.E., Cupp, E.E. (1935). Plankton diatoms of the Java Sea. *Ann. Fard, Bot. Buitenz,* 44: 101–74.

Andrews, G.A. (1981). Revision of the diatom genus *Delphineis* and morphology of *Delphineis surirella* (Ehrenberg) G.W. Andrews, n. comb. In: (R. Ross, ed.) *Proc. 6th Symp. Recent & Fossil Diatoms.* pp. 81–92. Koeltz Pub., Koenigstein.

Boyer, C.S. (1926–27). Synopsis of North American Diatomaceae. *Proc. Acad. Nat. Sci. Philad.*, 78 (*suppl*): 1–228 (Part 1), 79 (*suppl*): 229–583 (Part 2).

Caljon, A.G. (1983). *Brackish-water phytoplankton of the Flemish Lowland.* 272 pp. W. Junk, The Hague.

Cleve, P.T. (1878). Diatoms from the West Indian Archipelago. *Bih. svensk. Vetensk-Akad. Handl.* 5(8): 1–22.

_____. (1894–95). *Synopsis of the naviculoid diatoms.* 26(2): 194 pp; 27(3): 219 pp. A. Asher, Amsterdam (1965 reprint).

_____. (1896). Diatoms from Baffin Bay and Davis Strait. *Bih. Svensk. VetenskAkad. Handl.* 22, No. 4.

Cleve-Euler, A. (1951). Die Diatomeen von Schweden und Finnland. *Kungl. Svenska Vetenskapsakademiens Handlingar* 2(1): 161 pp. J. Cramer, New York (1968 reprint).

_____. (1952). Die Diatomeen von Schweden und Finnland. *Kungl. Svenska Vetenskapsakademiens Handlingar* 3(3): 153 pp. J. Cramer, New York (1968 reprint).

_____. (1953). Die Diatomeen von Schweden und Finnland. *Kungl. Svenska Vetenskapsakademiens Handlingar* 4(1): 158 pp; 4(5): 255 pp. J. Cramer, New York (1968 reprint).

_____. (1955). Die Diatomeen von Schweden und Finnland. *Kungl. Svenska Vetenskapsakademiens Handlingar* 5(4): 232 pp. J. Cramer, New York (1968 reprint).

Cupp, E.E. (1943). Marine plankton diatoms of the west coast of North America. *In*: (C. Eckart & L. H. Miller eds.) *Bull. Scripps Inst. Oceanogr.* 5: 273 pp. University of California Press.

Foged, N. (1966). Freshwater diatoms from Ghana. *Biol. Skr. Dan. Selsk.* 15: 1–169.

_____. (1975). Some littoral diatoms from the coast of Tanzania. *Biblio. Phycolog.* 16: 127 pp.

_____. (1979). Diatoms in New Zealand, the North Island. *Biblio. Phycolog.* 47: 225 pp.

_____. (1984). Freshwater and littoral diatoms from Cuba. *Biblio. Diatomolog.* 5: 243 pp.

Fungladda, N., Kaczmarska, I. and Rushforth, S.R. (1983). A contribution to the freshwater diatom flora of the Hawaiian Islands. *Biblio. Diatomolog.* 2: 103 pp.

Gerloff, J. and Natour, R.N. (1982). Diatoms from Jordan II. *In*: (H. Håkansson & J. Gerloff eds.) *Diatomaceae* 3: 157–210. J. Cramer, Vaduz.

Gonzalves, E.A. and Gandhi, H.P. (1953). A systematic account of the diatoms of Bombay and Salsette. 2. *J. Ind. Bot. Soc.* 32: 239–263.

Gran, H.H. (1905). *Diatomeen.* in *"Nordisches Plankton"* (Brundt K., and Apstein, C.), 19: 1–146.

Gran, H.H. and Angst, E.C. (1931). Plankton diatoms of Puget Sound. *Publ. Puget Sd. Mar. (biol.) Sta.*, 7: 417–519.

Hendey, N.I. (1958). Marine diatoms from some West African ports. *J. R. Micr. Soc.* 77: 28–85.

_____. (1964). *An introductory account of the smaller algae of the British coastal waters. Part 5: Bacillariophyceae (diatoms).* Min. Agric., Food and Fisheries, London. 317 pp. 1976 reprint, Otto Koeltz, Koenigstein.

_____. (1970). Some littoral diatoms of Kuwait. *Nova Hedwigia* 31: 101–161.

Hustedt, F. (1930). *Die kieselalgen Deutschlands, österreichs und der Schweiz unter P. rucksichtigung der ubrigen Lìnder Europas sowie der angrenzenden Meeresgebiete.* 7(1): 920 pp. Otto Koeltz Sci. Pub., West Germany (1977 reprint).

_____. (1959). *Die kieselalgen Deutschlands, österreichs und der Schweiz unter Berucksichtigung der ubrigen Lìnder Europas sowie der angrenzenden Meeresgebiete.* 7(2): 845 pp. Otto Koeltz Sci. Pub., West Germany (1977 reprint).

_____. (1961–66). *Die kieselalgen Deutschlands, österreichs und der Schweiz unter Berucksichtigung der ubrigen Lìnder Europas sowie der angrenzenden Meeresgebiete.* 7(3): 816 pp. Otto Koeltz Sci. Pub., West Germany (1977 reprint).

_____. (1955). Marine littoral diatoms of Beaufort, North Carolina. *Duke Univ. Mar. Stat. Bull.* 6: 1–67.

Kaczmarska I. and Rushforth, S.R. (1983). The diatom flora of Blue Lake Warm Spring, Utah, U.S.A. *Biblio. Diatomolog.* 2: 123 pp.

Lebour, M. (1930). The planktonic diatoms of Northern Seas. *Ray Soc. Publ.*, No 116, 1–244.

Mann, A. (1925). Marine diatoms of the Philippine Islands. *Bull. U.S. Nat. Mus.*, 100: 1–182.

Navarro, J.N. (1982). Marine diatoms associated with mangrove prop roots in the Indian River, Florida, U.S.A. *Biblio. Phycolog.* 61: 1–151.

Patrick, R. and Reimer, C.W. (1966). *The diatoms of the United States (exclusive of Alaska and Hawaii).* Vol. 1. Monogr. 13, Acad. Sci Phildel. 688 pp.

_____. (1975). *The diatoms of the United States (exclusive of Alaska and Hawaii).* Vol. 2, Pt. I. Monogr. 13, Acad. Sci Phildel. 213 pp.

Podzorski, A.C. and Hakansson, H. (1987). Freshwater and marine diatoms from Palawan (a Philippine island). *Biblio. Diatomolog.* 13: 245 pp.

Priddle, J. and Fryxell, G. (1985). *Handbook of the common plankton diatoms of the Southern Ocean. Centrales except the Genus Thalassiosira.* Br. Antarct. Surv., Natural Environm. Res. Council.

Prowse, G.A. (1962). Diatoms of Malayan freshwaters. *Gdns' Bull., Singapore.* 19: 1–104.

Round, F.E. and Mann, D.G. (1980). *Psammodiscus* nov. gen. based on *Coscinodiscus nitidus. Ann. Bot.* 46: 367–373.

Schoeman, F.R. (1972). Diatoms from the sewage works in the Republic of South Africa and South West Africa, Revistad. *Revista de biologie*, 8: 57–95.

Simonsen, R. (1974). The diatom plankton of the Indian Ocean expedition of R/V "Meteror" 1964–1965. "Meteror" Forschunngsergebnisse, Reihe D, No. 19. *Revis. Biolog.* 1–66.

Takano, H. (1960). Diatoms in pearl shell fishing grounds in the Arafura Sea. *Bull. Tokai reg. Fish Res. Lab.* 27: 1–6.

Tiffany, L.H. and Britton, M.E. (1952). *The algae of Illinois.* University of Chicago Press. 407 pp.

Wah, T.T. and Wee, Y.C. (1988). Diatoms from mangrove environments of Singapore and Southern Peninsular Malaysia. *Bot. Mar.* 31: 317–327.

Wood, E.J.F. (1963). Studies on Australian and New Zealand diatoms. IV. Tropical and subtropical species. *Trans. Roy. Soc. New Zealand (Botany)* 2: 189–218.

Additions to the Flora of Singapore, I

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Abstract

From field and hebarium studies, two new fern and 23 angiosperm taxa were found to have been previously overlooked or newly discovered in Singapore. Brief notes on their description, distribution and collecting localities are made for each.

Introduction

A comprehensive list of vascular plant species has been compiled for Singapore (Turner *et al.*, 1990) from literature and herbarium work. In the course of field work and examination of specimens at the Herbarium, Singapore Botanic Gardens (SING) and the Herbarium, Department of Botany, National University of Singapore (SINU), new records of species were made. Voucher specimens for each newly discovered taxon have been deposited in SINU and/or SING.

New Records

Adiantaceae

1. *Adiantum fructuosum* Spreng.

A large ornamental fern with bipinnate fronds which can grow up to 100 cm long. It originates from the rainforest of tropical America where it is found from Mexico and the West Indies, southern Peru and Brazil. It appears to be naturalized in Singapore and occurs on shaded earth banks along Seton Close and Cluny Road. Here, the plants are about 40 cm tall and freely fertile. (Specimen – Y.C. Wee 451)

2. *Adiantum latifolium* Lam.

A tropical American fern, occurring naturally from Mexico to South America, as well as the Greater Antilles, Virgin Islands and Trinidad. It was introduced into the country as an ornamental during the last ten years and has now established itself in shaded earth banks or flat ground in rural areas. It has also been observed around the southern periphery of the Bukit Timah Nature Reserve and Pulau Ubin. (Specimens – M.Y. Kok 32; Y.C. Wee 452)

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Acanthaceae

1. *Hemigraphis primulaefolia* (Nees) Fern.-Vill.

This species was first collected in Singapore in 1950 by J. Sinclair outside the Botanic Gardens at Cluny Road. A native of the Philippines and Moluccas, it was probably introduced as an ornamental as it is an attractive plant with lilac corollas and leaves, dark jade green above and reddish purple below. It has since spread from the Gardens and can also be seen in many areas in the National University of Singapore campus grounds at Kent Ridge. (Specimens — J. Sinclair S.F. No. 38918; Ali bin Ibrahim AI 46; K.S. Chua and H.T.W. Tan 312; E.M. Sim & L.P. Ng 39)

Asclepiadaceae

1. *Secamone elliptica* R.Br. (*S. micrantha* (Decne.) Decne.)

A slender, twining climber with opposite, chartaceous, narrowly elliptic or lanceolate leaves. Flowers are tiny in short-peduncled or sessile cymes and pale yellow, each producing two spreading, terete, narrow and elongated follicles. This species has been found in the Sungei Buloh area at the fringes of prawn ponds. Its natural range includes Malesia, New Guinea, northern and eastern tropical to subtropical Australia and New Caledonia (Forster and Harold, 1989). (Specimen — K.S. Chua, H.T.W. Tan & M.F. Choong 758)

Balsaminaceae

1. *Hydrocera triflora* (L.) Wight & Arnott

Hydrocera is a monotypic genus which ranges from South India, Sri Lanka, Hainan, Thailand, Cambodia, Laos, the Malaysian Peninsula, South West Celebes and Java (Grey-Wilson, 1980). The species is an erect, aquatic herb with angular and hollow stems which are sometimes floating. Its red flowers are fairly similar to the commonly cultivated balsam (*Impatiens balsamina* L.) but differs from the latter by having five free sepals and five free petals instead of three sepals and having four petals fused into two pairs. The fruit of *H. triflora* is also a five-seeded, indehiscent berry and that of *I. balsamina*, a many-seeded, explosively dehiscent capsule. It is quite common along the shores of Seletar Reservoir. (Specimens — Ali bin Ibrahim AI 139; K.S. Chua, H.T.W. Tan & I.M. Turner 742)

Cannaceae

1. *Canna indica* L.

A stout, perennial herb with more or less erect, glaucous leaves and a creeping and branching rhizome which accounts for its gregarious habit. The flowers have bright red tepals and the fruit is a bristly, globose capsule. It is commonly found in rural areas along roadsides, sides of ditches or drains and even reclaimed land. This species is a native of tropical and sub-tropical America and presumably was introduced here as an ornamental. It has since run wild. (Specimens — K.S. Chua 604; M. Chan 30)

Celastraceae

1. *Maytenus emarginata* (Willd.) D. Hou

A shrub up to 4 m tall. Branches bear short shoots terminated by a spine. Leaves are spirally arranged, obovate to subspathulate with entire to shallowly crenate margins. Flowers are borne in axillary cymes, and white. This species is found behind the beach or mangrove. It ranges from Sri Lanka, South-East Asia to North Queensland, and in Peninsular Malaysia, only recorded from Johor (Hou, 1962). In Singapore, it is found at the back of mangroves near the Kranji Dam. (Specimen – K.S. Chua, H.T.W. Tan, I.M. Turner & J. Yong 792)

Compositae

1. *Porophyllum ruderale* (Jacq.) Cass.

A small, erect, aromatic, weakly branching herb with somewhat fleshy, glaucous leaves. Flowers are in elongated heads up to 2.5 cm long. Plants have been found on reclaimed land or beaches on the mainland and Southern Islands of Singapore. This species is a native of Central and South America. (Specimens – H. Keng 4447; J.F. Maxwell 81-26; K.S. Chua & I.M. Turner 657)

Convolvulaceae

1. *Ipomoea obscura* (L.) Ker-Gawl.

A slender, herbaceous twining or creeping climber which bears ovate to orbicular, cordate leaves. Inflorescences are axillary, one- to few-flowered. The corolla is funnel-shaped, white or yellowish-white with darker midpetalline bands and a dark purple centre. In Singapore, *I. obscura* is found in wasteland or fringes of secondary forest. This species ranges from eastern tropical Africa, Mascarene Islands, tropical Asia, throughout Malesia to Northern Australia and Fiji (van Ooststroom, 1953). (Specimen – K.S. Chua 633)

2. *Ipomoea pes-tigridis* L.

A lacticiferous, twining, sometimes prostrate, herbaceous annual climber, with pure white, funnel-shaped corollas and 5–7 lobed, palmate leaves. This is rare in Singapore, having been collected only twice before; in 1933 by Z. Teruya and in 1941 by E.J.H. Corner. It is a weed and was collected in wasteland on all three occasions. The species ranges from tropical East Africa, Mascarene Islands, continental tropical Asia, and throughout Malesia (van Ooststroom, 1953). (Specimens – Z. Teruya 2332; E.J.H. Corner, s.n. 4 Aug 1991; K.S. Chua 303)

3. *Neuropeltis racemosa* Wall.

This is a large woody climber and was first collected in Singapore by N. Wallich (Ridley, 1923). Keng (1990) doubted the occurrence and noted that this species was "doubtfully recorded in Singapore." Recently, capsules and bracts of this species were collected from the forest floor at Bukit Timah Nature Reserve and confirmed Ridley's observation. It also occurs in Hainan, Thailand and Borneo (van Oostroom, 1953). (Specimen – Ali bin Ibrahim AI 138)

Dipterocarpaceae

1. *Dipterocarpus sublamellatus* F.W. Foxworthy

This is an overlooked species and previous collections were made by H.N. Ridley on Pulau Ubin in 1890 and J. Sinclair at MacRitchie Reservoir on 22 Feb 1957 from a "70 ft. high" tree. Ashton (1982) indicated that this species occurs in Peninsular Malaysia, Sumatra and Borneo but there are no previous records that it occurs in Singapore. (Specimens – H.N. Ridley s.n. 1890; J. Sinclair S.F. No. 8916)

Gramineae

1. *Pennisetum polystachyon* (L.) Schult. (*P. setosum* (Sw.) Rich.)

A tufted and erect plant, up to 2 m tall. The inflorescence, a spike-like panicle, is terminal, golden brown, somewhat lax and nodding. In habit, this species closely resembles *P. purpureum* Schumach. but the latter is a much larger plant, often reaching 5–6 m in height. Also the apex of the anther cells of *P. purpureum* is bearded, whereas in *P. polystachyon* they are glabrous. This species was previously cultivated in the Botanic Gardens (C.X. Furtado s.n. 10 Apr 1929; Md. Nur. s.n. 26 Oct 1929), presumably escaped and now occurs frequently in open wasteland. (Specimen – K.S. Chua 624; Roslina 16)

2. *Setaria barbata* (Lam.) Kunth

An overlooked species, this was first collected by Mahmud Awang in 1971 and more recently collected along Cluny Road and Lorong Gambas. This species is widely distributed from tropical Asia to Africa. (Specimens – Mahmud Awang s.n., 29 Dec 1971; K.S. Chua 329; K.S. Chua 397)

3. *Thysanolaena latifolia* (Roxb. ex Hornem.) Honda

A strongly tufted perennial with erect or slightly spreading culms. This massive reed-like grass has solid culms and bamboo-like leaf blades that are very broad and shortly stalked. The inflorescence is a large open panicle with literally thousands of spikelets which are tiny and gaping with long, silky, spreading hairs.

The tribe Thysanolaeneae is monotypic and occurs in tropical Asia. Gilliland (1971) indicated that *T. latifolia* is cultivated in Singapore but has now escaped and been sighted in the Bukit Timah Nature Reserve, the Central Catchment Area and Pulau Ubin. (Specimens – K.S. Chua 617; A. Ho & E.M. Sim 19)

Leguminosae

1. *Aeschynomene americana* L.

An erect, semi-woody, weakly branched herb which bears pinnate leaves. The papilionaceous flowers are borne in racemes and are mostly yellow. The legumes are mostly curved, jointed and incised on one side. This is a native of tropical America and used as forage crop. It appears to have become naturalized in Singapore. It is commonly found in reclaimed or wasteland. (Specimens – A. Santiago 4413; K. Jumali s.n. 15 Jan 1978; K.S. Chua & H.T.W. Tan 452; K.S. Chua & I.M. Turner 667)

2. *Desmanthus virgatus* (L.) Willd.

A member of the subfamily Mimosoideae, it is also a new generic record for Singapore. The plant is an erect, semi-woody plant with pinnate leaves. Flowers are in globose heads with white petals, stamens and styles. This species is native to tropical America and appears to be fairly well established in reclaimed land. (Specimen – K.S. Chua & H.T.W. Tan 416)

Loranthaceae

1. *Scurrula parasitica* L. (*S. fusca* (Blume) G. Don)

A shrubby, semi-woody, semi-parasite, bearing elliptic to oblong, decussate leaves. Flowers are in racemes, hairy and reddish brown. This species is similar to the much more common *S. ferruginea* (W. Jack) Danser but differs from the latter by its more glabrous abaxial lamina surface (completely red-brown hairy in *S. ferruginea*) and yellowish fruit pulp (greenish in *S. ferruginea*). It has been found only in Pulau Ubin in one location, growing on *Mangifera foetida*. It is distributed in tropical South-east Asia (Danser, 1938). (Specimen – P.T. Chew & A.S. Chew 46)

Lythraceae

1. *Ammania baccifera* L.

An erect, annual herb with apetalous flowers, densely packed at the axils of the dark green, coriaceous leaves. The plant grows up to about 0.6 m and often, much branched at the base. The leaves are mostly decussate except for the higher ones which are opposite and more or less two-ranked. This species grows in wasteland or wet areas. It is of Asian origin. (Specimen – K.S. Chua & H.T.W. Tan 415)

Pedaliaceae

1. *Sesamum radiatum* Schumach.

This is a hairy, erect annual herb which is strongly scented. The corolla is violet with a white blotch with purple streaks inside the lower lip. This species was collected on 2 Oct 1989 on Pulau Ubin in wasteland and is probably an escape from cultivation or a weed. It has also been sighted in a few other locations on the mainland. It is very similar to *S. orientale* L. which is the source of sesame seed oil and distinguished from the latter by having fruits with rounded or very obtuse apices and lower leaves which are simple and neither deeply lobed nor palmately compound. This species is also grown for its oil-containing seeds in its native tropical West Africa. In Malesia, Backer (1951) noted that it is rare, occurring in the Peninsular Malaysia, Sumatra and North Borneo. (Specimen – K.S. Chua & H.T.W Tan 82)

Polygonaceae

1. *Polygonum orientale* L.

An erect, hairy annual bearing flowers with white corollas borne in pseudo-spikes which are arranged in few-branched panicles. This species was collected in 1991 in wasteland off Mandai Road and has become established as a weed. It is native of the old world tropics. (Specimens – Ali bin Ibrahim 136; Ali bin Ibrahim 136A)

Portulacaceae

1. *Talinum paniculatum* (Jacq.) Gaertn.

A semi-erect, fleshy herb which becomes semi-woody especially in the lower parts of the terete stems and branches when older. Leaves are somewhat fleshy, dark green, elliptic to obovate, and spirally arranged. Small flowers bearing pink petals are found in terminal inflorescences. This is a pantropical weed which is native of tropical America (Geesink, 1971). In Singapore, it has been seen in many locations as a weed. (Specimen – M.F. Choong 57)

Rubiaceae

1. *Hedyotis pumila* L.fil. (*Oldenlandia pumila* (L.fil.) DC.)

This species has been seen in various localities and its presence probably depends on dispersal opportunities. Its tiny seeds and viability of up to 72 weeks (Tan and Corlett, 1987) are probably very important for its spread as a weed. It is found in sunny areas including lawns and car parks. It is free-flowering and has a reproductive cycle of three to four months. It was first seen in 1979 in Sian Tuan Avenue then more recently in various other localities since, including Jurong West. Bremekamp (1974) has noted that this species ranges from East Africa to India and has been introduced as a weed in Jamaica. Backer and Bakhuizen van den Brink (1965) also indicated its occurrence in Java. (Specimen — H.T.W. Tan 2/12.12.79)

Typhaceae

1. *Typha angustifolia* L.

A half-submerged freshwater macrophyte that can reach 3 m tall. This robust aquatic has a creeping rhizome and long linear, emergent leaves which are coriaceous. The numerous, tiny flowers are packed into two unisexual spikes. The long and narrow male spike is placed above the sausage-like female spike.

T. angustifolia was accidentally introduced into Singapore in the 1930s. One plant was growing together with a clump of *Cyperus papyrus* which a certain Mr Lee Peck Hoon received from Bangkok. Later he presented it to the Singapore Botanic Gardens, and the clump was planted in one of the lakes. Since then the plant has become naturalized in Singapore. The plants can be found in many stagnant pools or bodies of water in open fields, reclaimed land or construction sites. This species ranges from the arctic circle to 35 °S (Backer, 1951). *T. angustifolia* is the only naturally occurring member of its genus in Malesia. (Specimens — I.H. Burkill s.n., 11 Jul 1932; Md. Nur s.n., 10 Nov 1938; R.E. Holttum s.n., 30 Oct 1941; I.M. Turner 117)

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References

Ashton, P.S. (1982). Dipterocarpaceae. *Flora Malesiana*, I, 237–600.

Backer, C.A. (1951). Typhaceae. *Flora Malesiana*, I, 4, 242–244.

Bremekamp, C.E.B. (1974). A new species of *Oldenlandia* (Rubiaceae) from India with remarks on its inflorescence morphology. *Kew Bull.* 29, 359–361.

Danser, B.H. (1938). The Loranthaceae of French Indo-China and Siam. *Bull. Jard. Bot. Buit.* III, 16, 1–63.

Forster, P.I. and Harold, K. (1989). *Secamone* R.Br. (Asclepiadaceae: Secamonoideae) in Australia. *Austrobaileya* 3, 69–78.

Geesink, R. (1971). Portulacaceae. *Flora Malesiana*, I, 7, 121–133.

Gilliland, H.B. (1971). *A Revised Flora of Malaya. Vol. III. Grasses of Malaya*, Botanic Gardens, Singapore; Singapore.

Grey-Wilson, C. (1980). *Hydrocera triflora*, its floral morphology and relationship with *Impatiens*: studies in Balsaminaceae: V. *Kew Bull.* 35, 213–219.

Hou, D. (1962). Celastraceae — I. *Flora Malesiana*, I, 6, 227–291.

Keng, H. (1990). *The Concise Flora of Singapore*, Singapore Univ. Press; Singapore.

Ridley, H.N. (1923). *The Flora of the Malay Peninsula. Vol. III. Gamopetalae*, L. Reeve & Co.; Ashford, Kent.

Tan, H.T.W. and Corlett, R.T. (1987). Seed germination in *Hedyotis* species (Rubiaceae). *Biotropica* 19, 286–288.

Turner, I.M., Chua, K.S. and Tan, H.T.W. (1990). A checklist of the native and naturalized vascular plants of the Republic of Singapore. *J. Sing. Nat. Acad. Sci.* 18 & 19, 58–88.

Van Oostroom, S.J. (1953). Convolvulaceae. *Flora Malesiana*, I, 4, 388–512.

Karyomorphology of Some Myrtaceae from Singapore

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Abstract

Karyomorphology of five species in three genera of Myrtaceae, namely *Callistemon*, *Melaleuca*, and *Syzygium*, is investigated. All five species examined have similar chromosome features at mitotic interphase, prophase, and metaphase. Mitotic metaphase of their somatic cells consistently show $2n=22$, of which 18 chromosomes have centromeres at median position and four at subterminal or terminal position. *Syzygium aromaticum* has a secondary constriction in the longest pair of chromosomes as in several other related and unrelated species of the family, a fact suggesting that the presence of the secondary constriction may be of some taxonomic use.

Introduction

The Myrtaceae consists of about 144 genera and 3,000 species native to tropical and subtropical regions throughout the world (Thorne, 1992). Their infrafamilial relationships are becoming clearer but additional information on systematic characters for detailed study is needed (Johnson and Briggs, 1984). In this paper, we report on the karyomorphology of five species in three genera *Callistemon*, *Melaleuca*, *Syzygium*. The basic chromosome number of the family is $x=11$ (Raven, 1975). However our knowledge on chromosome numbers is still restricted to less than 20 per cent of the species (i.e., some 450 species of 50 genera) largely on the basis of species from Australia and India (Smith-White, 1942, 1948, 1950, 1954; Atchison, 1947; Rye, 1979). Very little information is available on chromosome morphology at metaphase, and nothing is known concerning chromosome features at interphase and prophase.

Materials and Methods

Five species in three genera *Callistemon citrinus*, *Melaleuca cajuputi*, *M. genistifolia*, *M. dealbata*, and *Syzygium aromaticum*[1] (= *Eugenia caryophyllus* [Sprengel] Bullock

[1]Fourty species of "*Eugenia*", all or most of which have synonyms under the generic name *Syzygium*, are reported from Singapore (Keng, 1990). Morphologically and anatomically, a primarily Old World genus *Syzygium* is now clearly distinguished from (Schmid, 1972; Tobe and Raven, 1983), and may even be distantly related to (Johnson and Briggs, 1984), *Eugenia* which is a primarily New World genus. Therefore we adopt *Syzygium aromaticuum*, a synonym under *Syzygium* of "*Eugenia caryophyllus.*" According to Bullock and Harrison (1958), "*Eugenia caryophyllata* Thunb.," a name used occasionally in other studies (Vijayakumar and Subramanian, 1985), is an illegitimate name.

& Harrison; *Eugenia caryophyllata* Thunb.) were investigated in this study. The data collected is presented in Table 1 along with their chromosome numbers. Somatic chromosomes were examined following methods presented elsewhere (Tanaka and Oginuma, 1986). Chromosome numbers and morphology at metaphase were determined using at least three to five cells of young leaves for each collection.

Table 1
Studied taxa, and their collections and chromosome numbers.
Vouchers are preserved at KYO.

Species	Collection	Chromosome number
Callistemon citrinus Skeels	*Oginuma 9101*	$2n=22$
Melaleuca cajuputi Powell	*Oginuma 9103*	$2n=22$
M. genistifolia Sm.	*Oginuma 9104*	$2n=22$
M. dealbata S.T. Blake	*Oginuma & Lum 9201*	$2n=22$
Syzygium aromaticum (L.) Merr. & Perry	*Oginuma 9102*	$2n=22$

Observations

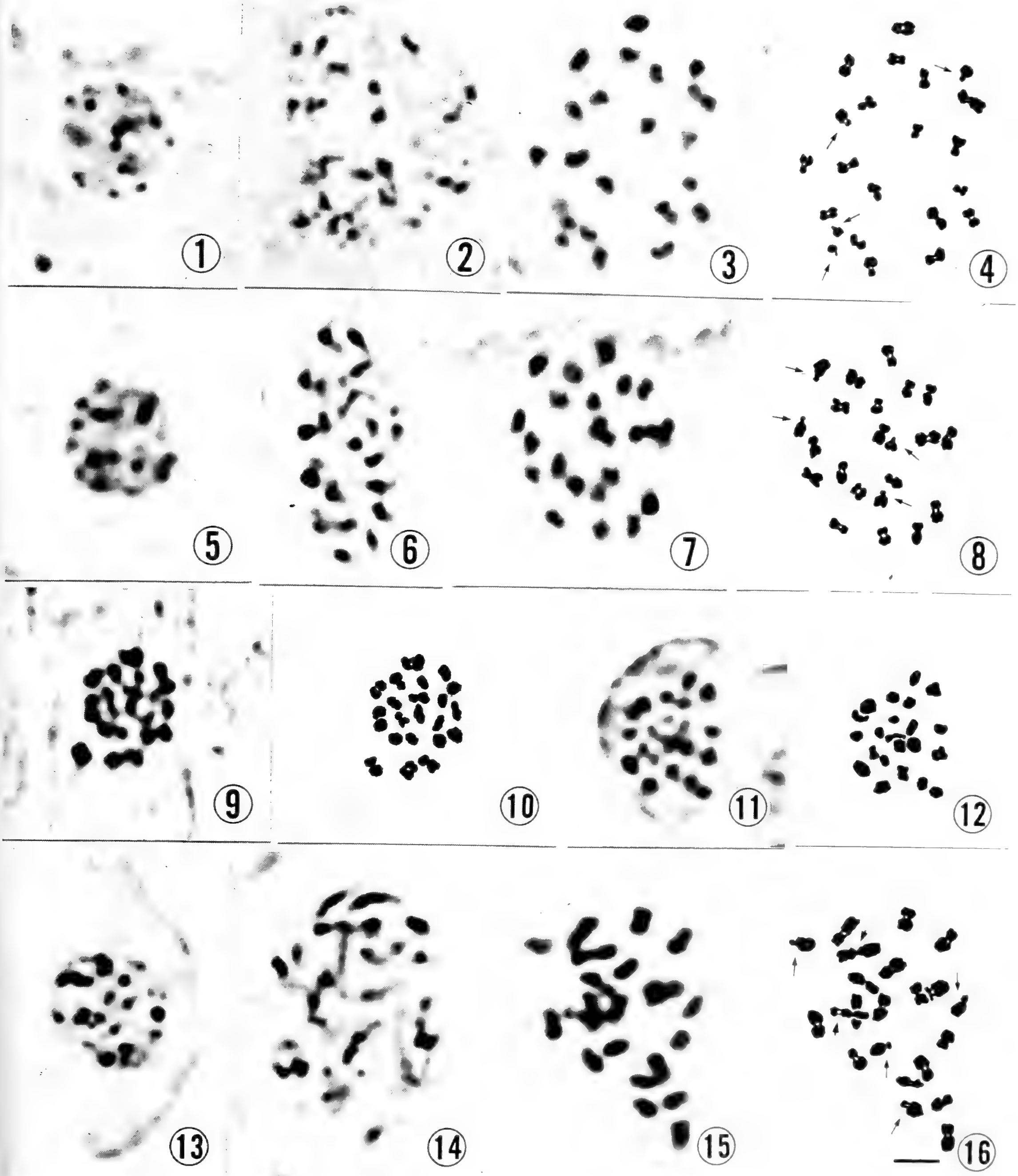
We reconfirmed the earlier report of $2n=22$ in *Callistemon citrinus* (Figs. 1–4) and *Syzygium aromaticum* (Fig. 13–16) (Smith-White, 1948; Vijayakumar and Subramanian, 1985), and further observed $2n=22$ in *Melaleuca cajuputi* (Figs. 5–8) and *M. genistifolia* (Figs. 9–10) (Brighton and Ferguson, 1976; Moussel, 1965).

Chromosomal features at both interphase and prophase are similar in all the species examined. The interphase nucleus (Figs. 1, 5, 13) has 16–20 dark-stained, condensed (heterochromatin) blocks along with chromatin threads and chromomeric granules. As such condensed blocks are fewer than the chromosome number, the nucleus is assigned to the "simple chromocenter type" as defined by Tanaka (1971, 1980). Chromosomes at prophase are differentiated by the presence of both early and late condensed segments (Figs. 2, 6, 14). In most chromosomes the early condensed segments are confined to the proximal regions of two arms, showing a clear transitional state into late condensed segments.

Chromosomes at metaphase are small and gradually vary in a range from about 1.8 μm. to about 0.3 μm. In all the species examined, except in *Melaleuca dealbata* and *M. genistifolia* whose detailed chromosome morphology are not studied, 18 of 22 chromosomes have centromeres at median position, and the remaining four at subterminal or terminal position. A secondary constriction is observed only at the proximal region of a long arm of the longest pair of chromosomes of *Syzygium aromaticum* but not in any chromosome of the other species examined. Satellite chromosomes are not observed.

Discussion

Chromosomal features are nearly consistent in all the five species of *Callistemon*, *Melaleuca*, and *Syzygium* examined. Interphase nuclei belong to the "simple chromocenter type," and chromosomes at metaphase are $2n=22$ ($x=11$) in agreement with most earlier reports on chromosome numbers of these genera. The morphology of



Figs. 1–16. Somatic chromosomes at interphase nucleus (1, 5, 13), prophase (2, 6, 14), and metaphase (3, 4, 7–21, 15, 16) in Myrtaceae. 1–4. *Callistemon citrinus* ($2n=22$). 5–8. *Melaleuca cajuputi* ($2n=22$). 9, 10. *M. genistifolia* ($2n=22$). 11, 12. *M dealbata* ($2n=22$). 13–16. *Syzygium aromaticum* ($2n=22$). Arrows point out chromosomes with centromeres at subterminal or terminal position. Arrowheads point out chromosomes with secondary constriction. Figures 4, 8, 10, 12 and 16 are drawings of respective preceding photographs. Scale = $2\mu m$.

chromosomes at metaphase are also similar: that is, 18 of 22 chromosomes have centromeres at median position, and the remaining four at subterminal or terminal positions. The frequency of chromosomes having centromeres at subterminal or terminal position is consistently 18 per cent in the five species examined, in constrast with a higher frequency of 36 per cent in *Callistemon lanceolatus* and 36–45 per cent in three species of *Syzygium* (including *S. aromaticuum* [= *Eugenia caryophyllata* Thunb.]) (Viyayakumar and Subramanian, 1985). Such a difference in the chromosome morphology between this and the earlier observation needs confirmation in more careful observations in future studies.

Despite consistent chromosome numbers $2n = 22$ in the five species of *Callistemon*, *Melaleuca*, and *Syzygium*, a conspicuous difference is found among them in the presence or absence of secondary constriction at the long arm of the longest chromosomes. Such a secondary constriction is found in *Syzygium aromaticum* but not in the remainder. This feature is also known in a few other related and unrelated species such as *Rhodomyrtus tomentosa*, *Syzygium iambolanum*, and *Eucalyptus citriodora*, which all have $2n = 22$ (Vijayakumar and Subramanian, 1985). The presence of the secondary constriction in such species suggests that it may be useful in considering species or generic relationships.

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References

Atchison, E. (1947). Chromosome numbers in the Myrtaceae. *Amer. J. Bot.* 34: 159–164.

Brighton, C.A. and Ferguson, I.K. (1976). Chromosome counts in the genus *Melaleuca* (Myrtaceae). *Kew Bull.* 31: 27–32.

Bullock, A.A. and Harrison, S.G. (1958). Nomenclatural notes: IV. *Kew Bull.* 13: 409.

Johnson, L.A.S. and Briggs, B.G. (1984). Myrtales and Myrtaceae — a phylogenetic analysis. *Ann. Missouri Bot. Gard.* 71: 700–756.

Keng, H. (1990). *The Concise Flora of Singapore. Gymnosperms and Dicotyledons.* Singapore University Press, Singapore.

Moussel, B. (1965). Contribution à l'étude cytotaxinomique des Myrtacées. *Mem. Mus. Nat. Hist. Nat. Ser.* B 16: 91–125.

Raven, P.H. (1975). The bases of angiosperm phylogeny: cytology. *Ann. Missouri Bot. Gard.* 62: 724–764.

Rye, B.L. (1979). Chromosome numbers in the Myrtaceae. *Amer. J. Bot.* 34: 159–164.

Schmid, R. (1972). A resolution of the *Eugenia-Syzygium* controversy (Myrtaceae). *Amer. J. Bot.* 423–436.

Smith-White, S. (1942). Cytological studies in the Myrtaceae. I. Microsporogenesis in several genera of the tribe Leptospermoideae. *Proc. Linn. Soc. N. S. Wales* 67: 335–342.

______. (1948). Cytological studies in the Myrtaceae. II. Chromosome numbers in the Leptospermoideae. *Proc. Linn. Soc. N. S. Wales* 73: 16–36.

______. (1950). Cytological studies in the Myrtaceae. III. Cytology and phylogeny in the Chamaelaucoideae. *Proc. Lin. Soc. N. S. Wales* 75: 99–121.

______. (1954). Cytological studies in the Myrtaceae. IV. The sub-tribe Euchamaelaucinae. *Proc. Linn. Soc. N. S. Wales* 79: 21–29.

Tanaka, R. (1971). Types of resting nuclei in Orchidaceae. *Bot. Mag. Tokyo* 84: 118–122.

______. (1980). The karyotype. In, H. Kihara, Ed., *Plant Genetics*. I. pp. 335–358. Shokabo Book Co., Tokyo. (In Japanese.)

______. and Oginuma, K. (1986). A method for the observation of chromosomes in woody plants. In, H Kitaura *et al.*, Eds., *Development of New Technology for Identification and Classification of Tree Crops and Ornamentals. Fruit Tree Research Station Reports* (Ministry of Agriculture, Forestry and Fisheries), pp. 69–72. Maeda Print Co., Tsukuba.

Thorne, R.F. (1992). An updated phylogenetic classification of the flowering plants. *Aliso* 13: 365–389.

Tobe, H. and Raven, P.H. (1983). An embryological analysis of Myrtales: its definition and characteristics. *Ann. Missouri Bot. Gard.* 70: 71–94.

Vijayakumar, N. and Subramanian, D. (1985). Cytotaxonomical Studies in South Indian Myrtaceae. *Cytologia* 50: 513–520.

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