CHAPTER IV

FLORA

1. *Introduction*

INDIA COMPRISES THREE well defined geological regions: the Himālayas, the Indo-Ganga plain and the Southern Peninsula. Peninsular India is geologically old and some 110 million years ago it probably formed part of a gigantic southern continent called Gondwānaland. This was separated from a similar northern continent, called Laurasia, by the Tethys sea. Subsequently, Gondwānaland broke up and parts of it now form South America, Africa, India and Australia. The change seems to have occurred after the flowering plants had come into existence so that the flora of India has some genera in common with Africa and South America. After the disintegration of Gondwānaland, the small fragment that was to form Peninsular India drifted north-east over distance of 1,500 kilometres. The Himālayas arose later from the bed of the Tethys sea. Their uplift resulted in a deep trough between them and Peninsular India in which the alluvium of several rivers has been accumulating to give rise to the third major geological region of India, the Indo-Ganga plain, comprising nearly 700,000 square kilometres of very fertile land. The great desert of Thar in Rājasthān represents a culmination of the vast arid belt extending from the Sahara eastward through Arabia and Baluchistān.

Few other countries of comparable size possess such a rich and varied vegetation as India. A situation between 8°4′N. and 37°6′N. of the Equator gives this country a great latitudinal spread which means a wide range of temperature conditions. Altitudinally, the extremes are even greater, ranging from sea level to the loftiest mountains of the world. Thus, between the plains and the mountains of India we have practically all the climatic zones from the torrid to the arctic. While in the plains the temperatures are never unfavourable for continuous plant activity, the highest peaks of the Himālayas are well above the limits of vegetation and are perpetually covered with snow. The humidity and rainfall range from the lowest level in the desert of Rājasthān to the maximum in the hills of Assam where Cherrapunji with an annual rainfall of nearly 1,080 cm. is reputedly the rainiest spot in the world.

The rainfall in India is governed mainly by the South-west monsoon from May-June to September-October, during which we receive much of the annual rainfall, and the north-east monsoon whose influence is felt for only a short period during the rest of the year. The climate in general is also strongly influenced by the physiography of the country, particularly the following ranges of mountains and hills: (1) the Great Himālayan range with its high and low mountains, forming an almost unbroken and effective barrier on the north; (2) the Western Ghāts running parallel and very close to the west coast of Peninsular India together with the Nīlgiris and adjoining hills of Southern India; and (3) the great complex of mountain ranges flanking the Himālayas in the north-eastern corner of the country and descending into the northern parts of Burma. Of lesser and more local influence are: (1) the Arāvalli hills extending diagonally across North-western India; (2) the Vindhyan and Sātpura escarpment lying across Central India; and (3) the Eastern Ghāts and outlying hills of Peninsular India. Stretching between the mountains under their direct or indirect influence are the Indo-Ganga plain, the semi-arid and arid plains of Western Rājasthān and adjoining areas with the Thar desert as its nucleus, the narrow coastal plains of Peninsular India, and the Deccan plateau.

2. *Botany and Plants of Ancient India*

India has been inhabited by man since almost prehistoric times. One of the earliest known civilizations flourished on Indian soil at a time when large parts of the world were still inhabited by savage men. Remains of the Indus Valley Civilization prove that rice, wheat, barley and cotton were already in cultivation in that remote period

Many plants yielding food, fibre and wood were known to the ancient Hindus. Several others were recognized because of their real or imaginary curative properties in the treatment of the diseases of man. It is well known that even today, amongst primitive peoples, it is the tribal doctor who is better acquainted with the wild plants of the neighbourhood than other people. Early plant lore was, therefore, primarily utilitarian. Plants were classified into those which were wholesome to eat and others which were unwholesome or even injurious because of the poisons they contained. Decoctions of certain plants were used to alleviate pain, heal wounds or sores, create pleasurable excitement or act as

narcotics. Early Hindu treatises like the *Āyurveda*, *Caraka Saṁhitā* and *Suśruta Saṁhitā* deal with plants mainly in relation to medicine, agriculture and horticulture. The story goes that more than 2,500 years ago, Bhikṣu Ātreya, a well known professor at the University of Taxila, asked one of his pupils, named Jīvaka, who later became the physician of King Bimbisāra of Magadha, to collect, identify and describe the properties of all the plants growing within a distance of four *yojanas* from the University. Dhanvantari and Nāgārjuna were other well known persons with an intimate knowledge of the characteristics of medicinal plants. *Rauvolfia*, which has now been rocketed to world-wide popularity, finds mention in ancient Hindu manuscripts as well as in the monumental work of Caraka; the plant is described under its Sanskrit name of *sarpagandhā* as a useful antidote for snake bites and insect stings. Because of its curative effects in cases of insanity, it has long been known in Hindī as *pāgal-ki-dawā*. The great importance of this drug has been realized only recently in western medical therapy.

The sciences of Arboriculture, Horticulture and Silviculture were highly developed in ancient India. Methods of plant propagation by seed, cutting, layering, grafting and budding were prevalent and find mention in the Vedas, *Arthaśāstra* and *Bṛhat Saṁhitā*. Jacolliot rightly remarked: "We should not forget that India, that immense and luminous centre in olden times, was in constant communication with all the peoples of Asia and that all the philosophers and sages of antiquity went there to study the science of life."

To a small extent, there also existed the scientific study of plants irrespective of their economic value. Branches of Botany analogous to present-day Taxonomy, Morphology, Anatomy, Physiology, Ecology, Evolution and Heredity were not wholly unknown. It appears that the ancient Hindus, like the Babylonians, had some inkling of the presence of sex in plants. For example the male plants of *Pandanus odoratissimus* L. f. were called *Ketakīviphala* or *Dhulipuṣpikā*, the female as *Svarṇaketakī*, and the male and female together as *Ketakīdvayam* (or a pair of *Ketakīs*). Something about the method of production of seeds in plants is also discussed in the *Hārita Saṁhitā*. Plants were classified on the basis of their external morphology, medicinal properties and environmental associations.

In ancient India the human population was much less than what it is today. Famines were few and life was quite happy with adequate quantities of wheat, barley, rice and sugar-cane; gumes like pea, gram, *mūng* and *masūr*; and fruits such sale

mango, jack, pomegranate, date, banana, water-melon and various limes and oranges. Among condiments, ginger, black pepper, cardamom, tamarind, onion and garlic were certainly there; and sesame was the most important source of oil, supplemented later by mustard and coconut. Of course, all the articles of food we now know were not there in early times. For example, papaya, custard-apple, pineapple, guava, sapota, cashew-nut, ground-nut, maize , tomato, coffee, potato, tapioca and sweet potato were unknown at that time, having been introduced from other parts of the world in comparatively recent times. Chilli, a common flavouring material of so many of our dishes, and tobacco were also unknown.

Of the greatest importance, as an article of export, was black pepper, a native of the western coast of India. It was well known to the Greeks and was later taken to Europe by Arab traders either through the Persian Gulf, Mesopotamia and Syria, or through the Red Sea and the Gulf of Suez. At one time pepper was weighed against silver and gold, and it was the high price of pepper which acted as the chief incentive for Europeans to find a sea-route to India.

Among beverages, our ancestors had neither tea, nor coffee nor cocoa, but there were the health-giving juices of many fruits such as mango, pomegranate, coconut, citron, *jāmun* and grape. Fermented drinks were also known and there was *somarasa*, the drink of the gods. It was realized early that these drinks had an exhilarating and activating effect; they were believed to increase the power of concentration and cure numerous maladies. In spite of its special virtue of giving immortality, the origin of *somarasa* remains unknown. As to the other drinks, *sidhu* was prepared from the flowers of the *mahua* tree, *kharjūra* from juice of date palm, and *surā* from cereals.

As for clothing, Indians were perhaps far ahead of other countries. They were the first to weave cloth from cotton. Although cotton is now common in Egypt, this was not so 2,000 years ago. All the mummies have been found wrapped in linen, woven from the fibres of flax. In the 5th century B. C. Herodotus gave testimony that "India has wild trees that bear fleeces as their fruit and of these the Indians make their clothes." A curious myth prevailed among the Greeks of those times that certain trees in India bore fruits which burst to produce little lambs whose soft white fleece was used to weave the finest cloth. In medieval times the muslin of Dacca was famous. It is said that this cloth could be woven so fine that a whole sheet could be folded and passed through a ring. The story goes that

when the Mughal Emperor Aurangzeb once admonished his daughter for being so thinly dressed, the princess remonstrated that she was actually clad in seven folds of the finest muslin. The British finally put an end to this indigenous industry since it competed with factory-made cotton goods of British manufacture.

Among the coarser fibres were the sun-hemp, *muñja*, and many others; and for stuffing, use was no doubt made of the soft silky fibre of *śālmalī* or *semal* (*Salmalia malabarica* Schott et Endl.) and the seed-hairs of *ak* (*Calotropis*). There is evidence however, that the Aryans knew the *Cannabis* fibre and *bhāṅg* prepared from its leaves was often used as an intoxicant.

Dyes of plant origin were widely used to render colour to life. The most important dye, which was also exported to other countries, was indigo—it gave a rich blue colour of great beauty and permanence. Madder obtained from the roots of a plant known *as manjiṣṭhā* (*Rubia cordifolia* L.), which is quite common in the Himālayas and in South India, was used to give a bright red colour (especially popular in the *hemanta* season) and is still utilized by traders for dyeing the cloth used to bind their account books. Besides these, there were numerous flowers, wood and barks which gave a rich variety of colours, utilized by both men and women to make their dress more attractive.

Plants also featured in personal adornment and beautification of the home. *Tāmbūla* or *pān* with all its ingredients (*katthā*, *supārī*, cardamom, etc.) was in common use to sweeten the breath. Girls wore flowers of *Campaka* and jasmine in their hair and those of *śiriṣ* in their ears. They made garlands of many kinds of flowers and painted their foreheads and cheeks with *candana* or sandal paste obtained from *Santalum album* L. Kālidāsa makes frequent reference to these in his writings. The devouts used rosaries and bracelets of the seeds of *rudrākṣa* (*Elaeocarpus ganitrus* Roxb.) or the wood of *tulasī* (*Ocimum sanctum* L.).

The rich and the fastidious anointed their bodies before bathing with various fragrant pastes made of camphor, sandalwood, *aguru* and the roots of *khas*. *Henna* or *mehndī*, a later introduction by the Muslims, was not known in those days; but women used the lac dye to colour the soles of their feet, thus reddening the flights of their steps. They also painted their lips with it and then besmeared them with a powder prepared from *lodhra* wood, which they also used as a face powder. In the *Bṛhot*

Saṁhitā there are references to various types of tooth-picks, hair oils, perfumes and recipes for dyeing the hair.

According to Vātsyāyana, all big houses and palaces of kings had a pleasure garden—*vṛkṣavāṭikā* or *puṣpavāṭikā*—attached to them. Season flowers like dahlia, aster, hollyhock and calendula, shrubs like bougainvillea, and trees like eucalyptus and gulmohur were not to be found then, since all these are recent introductions. However, there were other fine trees, shrubs and climbers. Among the trees, one of the most beautiful was the red-flowered *Saraca indica* L. , popularly known as the *aśoka.* It is said that Sītā was confined by Rāvaṇa in a grove of *aśoka* trees. Another favourite tree of those days was the *kadamba* (*Anthocephalus cadamba* Miq.), whose flowers appear in golden balls. It was closely connected with the life of Śrī Kṛṣṇa and its abundance in the past near Mathura and Vrindāvan is perhaps an evidence of a more humid climate in this area in those days.

Among smaller plants, *tulasī* had the pride of place and is still grown in many Hindu homes. Of climbers, *mādhavīlatā* (*Hiptage benghalensis* Kurz) receives frequent mention in Kālidāsa's plays, and among sweet-scented shrubs there were (as now) various kinds of jasmine, the musk-mallow (*Hibiscus abelmoschus* L.), and the garland-flower (*Hedychium coronarium* Koen.).

Among flowers, the sacred lotus (*Nelumbo nucifera* Gaertn.) was the most important and numerous references to it occur in Sanskrit literature. According to the Purāṇas, Brahmā emerged from the lotus which grew out of the navel of Viṣṇu. Lakṣmī, the goddess of wealth and prosperity, has always been shown as standing on a lotus flower. The diurnal opening of the flower was attributed to its love for the sun, which is also responsible for the name *sūrya-vikāsi.* In the days of Mohenjodaro, lotus blossoms were wreathed over the head of the sun-god.

The Hindus were so fond of trees that some of them were actually deified and worshipped. Besides *aśoka*, *padma*, and *tulasī*, the *pīpal* and banyan were given a very high place. The tree at Buddh Gayā, under which Gautama attained enlightenment was a *pipāl*; its branches were taken far and wide and planted to give rise to new trees. The Hindus do not readily cut the tree since it is sacred.

There are many references to the forest trees of India in Vālmīki's *Rāmāyaṇa.* The poet lists several plants of the Citrakūṭa hills, while describing the journey of Rāma, Lakṣmaṇa and Sītā.

3. *Angiosperms**

A knowledge of the flora of India, in the modern sense, began with the zealous efforts of many European naturalists and botanist who visited India in the 17th, 18th and 19th centuries, in the wake of the struggle among European nations first for trade and then for political supremacy over the country. Heinrich van Rheede, J.G. Koenig, Robert Kyd, William Roxburgh, Nathaniel Wallich, Buchanan-Hamilton, J. F. Royle, Robert Wight and J. D. Hooker were among those who laid the foundations of Botany in India. The only comprehensive flora of India so far is *A Sketch of the Flora of British India* compiled by J. D. Hooker between 1872 and 1897. This covers not only modern India but also Burma, Ceylon, Malaya and Pākistān, and has formed the groundwork for all the later regional floras of the country of which special mention may be made of the following : *Flora of the Presidency of Madras* by Gamble, *Flora of the Upper Gangetic Plain and of the Adjacent Siwalik and Sub-Himalayan Tracts* by Duthie, *Flora of Bengal* by Prain, *Flora of the Presidency of Bombay* by Cooke, *The Botany of Bihar and Orissa* by Haines, *Flora Simlensis* by Collett, and *Flora of Assam* by Kanjilal *et al.* For a detailed bibliography on the Indian flora the reader is referred to Santapau (1958).

Hooker estimated some 174 families and 17,000 species of angiosperms and 600 species of ferns and fern allies in the flora of India. About 15,900 species of flowering plants have been described in the *Flora of British India.* As far as species are concerned, the ten dominant families are the Orchidaceae, Leguminosae, Gramineae, Rubiaceae, Euphorbiaceae, Acanthaceae, Compositae, Cyperaceae, Labiatae and Urticaceae (including Moraceae). Excepting Labiatae and Compositae, all the rest of these ten families are more tropical than temperate. The Orchidaceae alone have a representation of more than 1,600 species in the Indian region. The greater number of Indian orchids are tropical, epiphytic and endemic. The East Himālayan region abounds in orchids, but in other parts of India they are outnumbered by the Leguminosae, Gramineae and Euphorbiaceae. The Compositae, which is the largest family in the world and predominates in the flora of many countries,takes only the seventh

*The numbers given for families, genera and species of angiosperms in the following pages are to be considered purely approximate and tentative because of the revisions that these families, genera and species have undergone since the numbers were originally published by authors like Hooker, Chatterjee, and others. This is also true of the endemic ratios. Further, these earlier authors included in their floristic treatments, regions like Burma, Ceylon and Pākistān which are adjacent to, but now politically, not parts of India.

place in India. In fact, but for its numerous representatives in the temperate and alpine zones in the Himālayas, this family would occupy a still lower place in the list.

The ten genera each with a hundred or more species are : *Bulbophyllum*, *Carex*, *Dendrobium*, *Eria*, *Eugenia*, *Ficus*, *Habenaria*, *Impatiens*, *Pedicularis* and *Strobilanthes*. *Impatiens* is the largest with about 241 species distributed discontinuously in the Himālayas and the mountains of Peninsular India. Four of the genera are orchids, with *Dendrobium* (200 species) leading the list. *Eugenia*, *Strobilanthes** and *Pedicularis* have undergone a revision of generic limits since Hooker wrote about them.

The proportion of monocotyledons to dicotyledons is approximately 1 : 2 . 3 . in genera and 1 : 7 in species. There are some 100 recorded species of palms and 120 species of bamboos.

ENDEMISM :—It is important here to take into consideration the endemic content of the flora of India, i.e., species or genera restricted in distribution to a relatively small area. The available data are, however, confined to the dicotyledons. Nevertheless, whatever findings are available on endemism are significant in that they have a direct bearing on the floristic affinity of the Indian region with the adjoining areas of the world. Two kinds of endemics are generally recognized. The palaeo-endemics or epibiotics are the surviving remnants of once successful and widespread groups and are thus on their way to extinction. The neo-endemics are new and recent forms, still in the process of extending themselves.

Islands, far removed from other areas by the ocean, show high percentages of endemic species. High mountains and very dry deserts also serve as barriers to the free spread of plants and thus bring about isolation and endemism. The high Himālayan range is effectively isolated from Northern Asia by the dry Tibetan plateau to the north and warmer alluvial plains to the south. Consequently, the temperate and alpine vegetation of the Himālayas contain several species that have been unable to migrate either north or south. Peninsular India is bounded on the north by the broad Indo-Ganga plain, and on three sides by the sea. Both these areas have a high endemic content. For the region as a whole (including Pākistān and Burma), 61·5% of the dicotyledons are endemic. Endemic species in certain other areas are: Ceylon 30%, New Zealand 72%, Australia 80%, Hawaii Island 82%, and California 40% In comparison with

*The genus *Strobilanthes* has since been split up into at least 25 genera even as it is related to Indian species alone. In fact, as now understood this genus has hardly a few species in India.

these, 61.5% is a rather high figure for a continental area like India with land connections in three directions, east, north and west. The two regions contributing most to this high endemic content are the Himālayas with 3,165 and Peninsular India with 2,045 endemic species. The number of endemic species common to both regions is 533. The Indo-Ganga plain and the desert regions of Rājasthān form an area which is extremely poor in its content of endemics. To what extent land connections between Malaysia, India and Africa have influenced the present flora of the Deccan Peninsula is difficult to indicate with any degree of precision.

The non-endemics or "wides", totalling about 38.5% of the species, are widespread and extend to other countries also. According to Chatterjee they fall into three categories: (1) those which are chiefly tropical and subtropical and of fairly wide distribution in Asia and sometimes beyond it; (2) a considerable number extending just beyond the boundaries of our area into South-western China, Thailand, Tibet and Afghānistān; (3) cultivated and introduced plants.

The dicotyledons in India are represented by 171 families. Of these, seventy-nine families (A) contain less than 20 species each; twenty-seven(B) have 20 or more species, of which more than 50% are non-endemics or wides; and sixty-five(C) have 20 or more species of which more than 50% are endemics.

The families in category (A) are as follows, the figures in brackets indicating the number of species in each occurring in the Indian region: Dilleniaceae (15), Schisandraceae (5), Lardizabalaceae (5), Nymphaeaceae (11), Resedaceae (4), Bixaceae (1) Cochlospermaceae (1), Pittosporaceae (8), Xanthophyllaceae (7), Frankeniaceae (1), Portulacaceae (6), Tamaricaceae (8), Elatinaceae (6), Ancistrocladaceae (5), Linaceae (8), Erythroxylaceae (6), Malpighiaceae (17), Zygophyllaceae (9) Oxalidaceae (14), Simarubaceae (15), Ochnaceae (9), Burseraceae (13), Dichapetalaceae (3), Olacaceae (18), Opiliaceae (4), Staphyleaceae (4), Hippocastanaceae (2), Sabiaceae (19), Coriariaceae (1), Droseraceae (4), Hamameldaceae (7), Haloragaceae (14) , Rhizophoraceae (16), Hernandiaceae (1), Lecythidaceae (12), Crypteroniaceae (3) Sonneratiaceae (5), Passifloraceae (7), Caricaceae (1), Turneraceae (1), Datiscaceae (2), Cactaceae (6), Aizoaceae (16), Alangiaceae (6), Cornaceae (12), Nyssaceae (2), Dipsacaceae (17), Stylidaceae (3), Goodeniaceae (2), Monotropaceae (3), Diapensiaceae (1), Plumbaginaceae (8), Styracaceae (9), Salvadoraceae (5), Menyanthaceae (1), Polemoniaceae (1), Hydrophyllaceae (1), Pedaliaceae (4), Plantaginaceae (13), Nyctaginaceae (8), Illecebra-

ceae (2), Podostemaceae (16,) Nepenthaceae (1), Cytinaceae (1), Aristolochiaceae (13), Chloranthaceae (3), Myristicaceae (14), Proteaceae (7), Elaeagnaceae (12), Santalaceae (15), Balanophoraceae (6), Buxaceae (6), Ulmaceae (16), Cannabinaceae (2), Platanaceae (1), Juglandaceae (4), Myricaceae (1), Casuarinaceae (1), and Ceratophyllaceae (1).

The Dilleniaceae, Pittosporaceae and Proteaceae have their greatest development in Australia. Along with such families as the Haloragaceae, Myristicaceae and to some extent Santalaceae, they represent the Malaysian and Australian elements in the Indian flora. The occurrence in Assam of *Nepenthes*, a genus of insectivorous plants, is interesting because this area represents the northernmost limit reached by the genus. The range of its distribution indicates a certain relationship between Madagascar and Malaysia through Ceylon and the Khāsi hills of Assam. The genus *Ancistrocladus* is distributed discontinuously in West Africa on the one hand and India, Burma and Malaysia on the other. These are two examples of a close association between the Indian and the African flora.

The Rhizophoraceae and Sonneratiaceae are predominantly mangrove families. Floristically, the Indian mangroves come under the Eastern mangrove formation extending from the east coast of Africa to Australia. The genus *Blepharistemma* is endemic to India.

The family Malpighiaceae, comprising many tropical lianas, is predominantly South American. Its presence in the Indian region (7 endemic species) and in Malaysia is remarkable; a few species are also found in Africa and Madagascar.

The Podostemaceae are remarkable plants living on rocks in rushing water. The vegetative plant body is quite unlike that of a flowering plant and recalls an alga, moss or lichen. The family is mostly tropical, and in India its chief centre of distribution is in the south with occasional species in the Khāsi hills. Of the 16 species, only 5 are wides and the rest are endemic, with 9 species endemic in South India alone.

Families like the Hamamelidaceae, Oxalidaceae, Olacaceae, Cornaceae, Dipsacaceae, Styracaceae and Elaeagnacae show the North-east Asiatic influence on the Indian flora. The Styracaceae have three centres of distribution, two of them being in America. The third, which extends from Japan to Java, touches Sikkim and the Khāsi hills where, along with other species, we find a monotypic genus, *Parastyrax*. The Hamamelidaceae extend from North America through Japan and China to Sikkim and the Khāsi hills. The Elaeagnaceae have a much wider distribution throughout the temperate regions and have touched the North Indian region.

The following families come under category (B): Menispermaceae (42), Violaceae (25), Polygalaceae (32), Malvaceae (111), Sterculiaceae (80), Tiliaceae (78), Elaeocarpaceae (42), Geraniaceae (28), Rutaceae (71), Aquifoliaceae (34), Sapindaceae (54), Connaraceae (20), Caesalpiniaceae (124), Mimosaceae (96), Myrtaceae (116), Lythraceae (48), Cucurbitaceae (87), Convolvulaceae (177), Solanaceae (58), Scrophulariaceae (273), Orobanchaceae (29), Bignoniaceae (31), Verbenaceae (115), Amarantaceae (48), Chenopodiaceae (40), Thymelaeaceae (22), and Moraceae (113). Most of the members of these 27 families are distributed rather widely and also include a few temperate species.

The Violaceae, Polygalaceae and Thymelaeaceae have low endemic values because of their wide distribution. Species of *Viola* occur in the mountains but *Hybanthus enneaspermus* Müll. is also met with in the plains. Species of Polygalaceae have flowers which might at first sight be mistaken for those of the Papilionaceae. In the Thymelaeaceae the genus *Daphne* is represented in the Himālayas and the Khāsi hills with some six species which are all endemic. Other genera of wide distribution, which occur in the Indian region, are *Thymelaea*, *Edgeworthia*, *Wikstroemia*, *Stellera* and *Lasiosiphon*.

The Menispermaceae, Malvaceae, Sterculiaceae, Tiliaceae Caesalpiniaceae, Mimosaceae, Convolvulacea and Scrophulariaceae (in large part) form a tropical group with a wide distribution, and it is to be expected that they do not have a high percentage of endemics in any particular region of India.

In the Moraceae, the tropical genus *Ficus* with a large number of species in our area (about 86) is worthy of comment. The chief centre of development of the genus may well be Malaysia and South Burma. Our two most popular species are *Ficus religiosa* L. (pipal) and *F. benghalensis* L. (banyan), both of which are held in religious veneration and are widely planted. *Ficus Krishnae* C. DC. has peculiar ascidiform leaves which, according to Hindu belief, Kṛṣṇa used as cups to scoop out butter. Many species of *Ficus* begin as epiphytes on temples, old buildings, or on other plants, often between the persistent leaf bases of palms like *Phoenix*. They send down aerial roots which eventually establish contact with the soil. In this process the supporting plant is gradually killed, or the temple or building wrecked. The behaviour of the aerial roots varies. They may form buttresses radiating outward in all directions, or pillars and props supporting the horizontal branches. In the epiphytic and climbing species they may clasp and surround the supporting trunk. Both the pipal and the banyan are believed to live to a great age. In some old trees,

the main trunk may become hollow and disintegrate, leaving the crown supported like a canopy by the numerous root pillars. The famous banyan tree at the Indian Botanical Garden, Sibpur, Calcutta, is said to be only about 200 years in age, but has 666 aerial roots supporting a vast canopy nearly 335 m. in circumference and looking more like a small forest than a single tree. Many Indian roads are lined with avenues of banyan trees stretching for several kilometres and forming an archway of shade from the hot tropical sun.

The inflorescence in *Ficus* is a syconium which ripens into the familiar fig. As is well known, the mode of pollination is extraordinary, there being a special insect (*Blastophaga*, a small wasp) adapted to *Ficus* flowers. Some species of *Ficus* show cauliflory, *i. e.*, they have their inflorescences borne directly on the trunk or older branches.

Of the Myrtaceae, the most important genus found in India is *Eugenia* (including *Syzygium* and *Jambosa*) with 103 species distributed mostly in Peninsular India. Species of *Eucalyptus* found in the hill-stations of India are all introductions from Australia which, with South America, is the chief centre of development of the Myrtaceae.

The Cucurbitaceae, Solanaceae, Amarantaceae, Chenopodiaceae and Rutaceae (in part) contain many species which have found their way to India as weeds of cultivation and have subsequently become naturalized.

The family Aquifoliaceae is represented in this country by only one genus, *Ilex*, with 34 species. It is also found in North and South America, Asia, Africa and Europe. Most of the Indian species are found also in the adjoining parts of Asia. The endemicity of *Ilex* in India is 38 per cent.

The following are the 65 families falling under the Category (C) some being tropical and others temperate: Ranunculaceae (165), Magnoliaceae (36), Annonaceae (129), Berberidaceae (35), Cruciferae (178), Fumariaceae (66), Papaveraceae (45), Capparidaceae (65), Flacourtiaceae (21), Caryophyllaceae (107), Hypericaceae (26), Guttiferae (40), Ternstroemiaceae (39), Dipterocarpaceae (51) Balsaminaceae (242), Icacinaceae (25), Meliaceae (62), Celastraceae (84), Hippocrateaceae (27), Rhamnaceae (53), Ampelidaceae (69), Leeaceae (27), Aceraceae (20), Anacardiaceae (67), Papilionaceae (867), Rosaceae (257), Saxifragaceae (114), Crassulaceae (64), Melastomaceae (127), Combretaceae (52), Onagraceae (39), Samydaceae (20), Begoniaceae (71), Umbelliferae (180) Araliacease (56), Caprifoliaceae (55), Rubiaceae (551), Valerianacease(20), Compositae (696), Campanulaceae (71), Vacciniaceae (68),

Ericaceae (146), Primulaceae (208), Myrsinaceae (94), Sapotaceae (32), Ebenaceae (58), Symplocaceae (51), Oleaceae(97), Apocynaceae (89), Asclepiadaceae (234), Loganiaceae (40), Gentianaceae (189), Boraginaceae (145), Lentibulariaceae (30), Gesneriaceae (133), Acanthaceae (514), Labiatae (421), Polygonaceae (110), Piperaceae (104), Lauraceae (172), Loranthaceae (73), Euphorbiaceae (444), Urticaceae (109), Cupuliferae (64), and Salicaceae (44).

RANUNCULACEAE (Buttercup family):—Most of the Indian representatives of this family are found in the Himalāyas and the temperate regions of the Nilgiri hills. The main centre of development is in the temperate regions of the northren hemisphere. The degree of endemicity of certain genera in India is as follows: *Ranunculus* 36%, *Anemone* 43%, *Clematis* 76%, *Thalictrum* 79%, *Delphinium* 71% and *Aconitum* 90%. The first four of these have actinomorphic flowers and the last two have zygomorphic flowers. The low percentage endemicity in *Ranunculus* may well be due to the weedy character of many of its members, accounting for a considerable number of wides. *Actaea spicata* L. and *Cimicifuga foetida* L. are two other plants which occur in the Himālayas and also North Asia, Europe and North America. In marked contrast to these genera are those with a restricted distribution, such as *Calathodes* occurring in the Eastern Himālayas.

MAGNOLIACEAE (Magnolia family):—This family, generally regarded by botanists as very primitive, shows a discontinuous distribution in the temperate and subtropical regions of the world. However, it comprises several endemic species. All the Indian species of *Illicium*, *Talauma* and *Magnolia* are endemic; and *Manglietia* and *Michelia* show an endemicity of 80 and 73 percent respectively. Thus, while the family itself is very old, many of the species have remained localized. Most of the Indian members of this family occur in the Eastern Himālayan and Assam regions.

ANNONACEAE (Custard-apple family):—The plants belonging to this family are confined to the Tropics,sepecially the rain forests of Brazil, Western Africa, Ceylon, South Burma and Malaysia. However, while the members of the Old World are usually of a climbing or straggling nature and occur in dense forests, those of tropical America are nearly all shrubby or arboreal and grow on open grassy plains. In India the Annonaceae are confined to the tropical parts of the Deccan and to Assam, and not a single species is found in the temperate regions of the Himālayas. Sixty percent of the Indian species are endemic. *Polyalthia*, *Artabotrys* and *Annona* spp. (custard-apple, *sītāphal*, *rāmphal*) are familiar in India. The last mentioned are introductions.

BERBERIDACEAE (Barberry family):—The genera *Berberis* and *Mahonia* are interesting from the point of view of endemism. They extend from North Asia and Northern Europe to North America and to some extent to South America. There is a very large number of endemics, for 97 per cent of the Indian species are not found elsewhere. The general habit of *Berberis* suggests xerophytic conditions; yet in India most species of the genus are found in the humid Central and Eastern Himālayas. Very few are found in the dry North-west Himālayas. The Indian species of *Berberis* and *Mahonia* show a relationship with the Chinese species of Yunnan and adjoining areas.

CRUCIFERAE (Mustard family):—This family finds its chief development in the Western Himālayas and the plains of North-west India. There are a few species in the Eastern Himālayas and the plains of North India, but in the whole of South India there are only the cultivated species and a few weeds associated with them. A much greater concentration occurs in the Mediterranean region, to which the Indian area is possibly connected through Afghānistān and Irān. Some of the common plants of this family, which are found extending from the Mediterranean region to India via West Asia, are as follows: *Matthiola odoratissima* R. Br. *Nasturtium officinale* R. Br., *Cardamine impatiens* L. and species of *Sisymbrium* and *Capsella bursa-pastoris* Medic. The total endemic percentage in India is 56, which is rather high for a widespread family like Cruciferae. Some genera show particularly high endemicity in India, e. g., *Draba* 83%, *Cardamine* 70%, and *Arabis* 71%. Almost all of these occur in high alpine zones.

FUMARIACEAE:—*Corydalis* is the most important genus in the Western Himālayan and West Chinese areas. 48 species out of 61 are endemic, which brings the percentage to 79. There is evidence to suggest that the main development of *Corydalis* has taken place in Central Asia and the Himālayas, from where it has migrated east and west. A somewhat localized genus, *Dactylicapnos* Wall. (syn. *Dicentra*), ranges from Kumaun to the Khāsi hills and Yunnan. *Hypecoum* and *Fumaria* seem to have come to India from the West. *Fumaria indica* Pugsley is found as a weed of cultivation in several parts of India.

PAPAVERACEAE (Poppy family):—There are 26 species of the genus *Meconopsis*, and all except one are endemic—that brings the figure of endemics to 96 per cent. *Argemone mexicana* L. (Mexican poppy), a native of tropical America, has become widely naturalized in the Indian plains. *A. ochroleuca* Sweet sub-sp. *ochroleuca* is less common but this too has established itself in some parts of India.

CAPPARIDACEAE (Caper family):—This family, which is mainly tropical and subtropical, has a relatively smaller endemic figure of 54 per cent. *Capparis* is the largest genus with 38 species. The family is characteristic of the drier western and southern parts of the country and has a similar distribution in Africa and West Asia. *Gynandropsis*, *Cleome*, *Cadaba*, and *Crataeva* are other faimiliar genera.

FLACOURTIACEAE (Flacourtia family):—The Indian members are on the whole related to the Malaysian group, except perhaps the genus *Gynocardia*, which is endemic in Sikkim and Assam. Seeds of Hydnocarpus *Kurzii* Warb yield the Chaulmoogra oil useful in the treatment of leprosy.

CARYOPHYLLACEAE (Pink family):—This family has about 57 per cent endemicity in India, chiefly in the Himālayas where it is mostly found in the temperate and alpine zones. The Mediterranean region seems to be the chief centre of distribution, and some of the species common with India through Western Asia are as follows: *Dianthus caryophyllus* L., D. *fimbriatus* Biebr., *Silene conoidea* L., *S. araneosa* C. Koch., *Stellaria* aquatica *Scop.*, *S. bulbosa* Wulf., *Cerastium trigynum* Vill., *C. dahuricum* Fisch., *C. vulgatum* L., *Arenaria serpyllifolia* L., *Drymaria cordata* Willd. and *Polycarpaea spicata* W. et A., *Stellaria media* Cyrill, and *Spergula arvensis* L. are two cosmopolitan weeds which occur in several parts of the country.

GUTTIFERAE (Garcinia family):—*Poeciloneuron* is endemic in South India. *Garcinia*, *Calophyllum*, *Kayea* and *Mesua* extend from tropical Africa to Malaysia. The general endemic percentage for the family in India is 50, and most of the wides are in Malaysia. This suggests that a South East Asian influence is responsible for the Guttiferae in our area.

TERNSTROEMIACEAE (Tea family) :—This family, sometimes called Theaceae, is discontinuously distributed in tropical Asia and tropical America. Its representatives are almost wanting in Africa and absent from Australia. The endemic percentage of the Indian species is 54. *Camellia sinensis* O. Ktze. is the tea plant of commerce, extensively grown in the North-eastern and the South-western parts of the country.

DIPTEROCARPACEAE (Sal family):—This is a tropical family characteristics of the Indo-Malayan region, but a few genera also occur exclusively in South India and Ceylon. They are very useful forest trees, the most familiar of which is the sal (*Shorea robusta* Gaertn. f.).

BALSAMINACEAE (Balsam family):—As already mentioned, *Impatiens* is the largest genus of flowering plants in the Indian

region, with about 241 species. The greatest concentration of the species is in the humid Eastern Himālayas and Burma; a large assemblage is also found in South India and Ceylon. *Impatiens* provides a striking example in this country of discontinuous distribution of a taxon; not a single species is common to the Himālayas and South India, although each of these areas contains a very large number of forms. The genus as such seems to be a very old one and the two groups, the Himālayan and South Indian, must have been separated from each other for a very long time and developed in mutual isolation. The number of endemic species of *Impatiens* in India is 220 out of 241, bringing the endemic percentage to 91.

CELASTRACEAE:—This family is distributed in the lower hills and the plains of Peninsular India, Assam and the Eastern Himālayas, with a high concentration in South India. The genus *Euonymus* has 27 endemic species out of 32, bringing the endemic percentage to 84. The majority of species of *Gymnosporia* are endemic in South India and the Eastern Himālayas.

PAPILIONACEAE (Pea family):—This is the largest family of dicotyledons in India. The total number of species is at least 867 including 372 wides and an endemic percentage of 57. The plants are of varied habit. Thus, the arborescent *Dalbergia* contrasts strongly with the small herbaceous species found in the Himālayas. *Crotalaria* and *Tephrosia* have their greatest development in South India. *Millettia* is distributed mainly in Assam and North Burma where as many as 16 species are found as endemics. *Caragana* and *Astragalus* are well developed in the dry Western Himālayas. The endemic percentage of *Astragalus* in the Himālayas is 75 and most of the species are found at high altitudes.

The family belongs predominantly to drier regions and suffers a marked diminution when we come to areas of heavy rainfall. The Assam species show a relationship with those of South East Asia; the Himālayan, with West and North Asia; and the South and West Indian with North Africa.

ROSACEAE (Rose family):—This is a family chiefly of the Northern hemisphere. In India it is mainly distributed in the temperate regions of the Himālayas and other mountains. The total number of species is 257 with 179 endemics so that the endemic percentage is 70. Most of the species are found in the alpine regions of the Himālayas, there being only a few in South India and the Indo-Ganga plain. Representative genera of the North-western Himālayas are *Prunus*, *Rubus*, *Rosa*, *Potentilla* and *Cotoneaster*, while those of the Eastern Himālayas are *Eribotrya*, *Photinia* and *Pyeum*.

SAXIFRAGACEAE (Hydrangea family):—*Saxifraga* is the most important genus and is chiefly found in the temperate and alpine parts of the Eastern Himālayas. Of its 58 species, 51 are endemic, giving a percentage of 88. The genus is not found in other areas outside the Himālayas. The general endemic figure for the family in India is 76 per cent.

RUBIACEAE (Coffee family):—One of the largest among the dicotyledons, this family is well represented in Peninsular India, Assam and the subtropical regions of the Himālayas. The main centre of development for our country is in South India and Ceylon, and to a lesser extent in the rain forests of Assam. The total number of Indian species is 551, of which 364 are endemic, the percentage thus coming to 67.

The coffee plant, *Coffea arabica* L., a native of Africa, is grown in the hills of South India. *Cinchona*, a native of South America, has been introduced in recent times into India and is grown in North-eastern and South India.

COMPOSITAE (Sunflower family):—This family, the largest of the flowering plants, comprises about 700 species in India, but half of this number are wides and the endemic percentage is only about 52. The plants range from the tropical region to the high alpines, and in their species content South India and the Himālayas are approximately equivalent.

The South Indian Compositae generally recall those of Africa, and the Himālayan recall those of North Asia and China. The Indo-Ganga plain chiefly has species of very wide distribution. Several members are grown as ornamentals. The flowers of *Carthamus tinctorius* L. (safflower) are used in dyeing. Attempts are being made to grow *Chrysanthemum cinerariaefolium* Vis., source of the contact insecticide pyrethrum.

VACCINIACEAE (Blueberry family):—The Eastern Himālayas and Assam are the richest in Vacciniaceae. Out of a total of 68 species, 64 are endemic in these areas and in Burma. *Agapetes* is the most common genus.

ERICACEAE (Rhododendron family):—*Rhododenbdron* is a conspicuous element of the Eastern Himālayan temperate and alpine zones. A few species extend to the North-western Himālayas, to the Khāsi hills and even to the Nīlgiris. Out of a total of 126 species from India and Burma, 64 are endemic in the Himālayas and 44 in Upper Burma. The endemic ratio is as high as 90 per cent.

PRIMULACEAE (Primrose family):—The two chief genera of this family, *Primula* and *Androsace*, are found only in the Himālayas.

About 148 species of *Primula* seem to be endemic to the Himālayas, giving the high percentage of 91. *Androsace* is more prominent in the dry north-west of the Himālayas. *Omphalogramma* and the monotypic genus *Bryocarpum* are confined to the Eastern Himalayas and adjoining areas of China and Burma.

ASCLEPIADACEAE (Milkweed family):—The total number of species is estimated to be 234. Of these 172 are endemic, which gives a percentage endemic value of 73. The genus *Caralluma* is best developed in Africa and Madagascar and its occurrence in India is an example of an African element in our flora. *Ceropegia* has 40 species in India; of these 26 are endemic in South India. *Hoya*, on the other hand, is chiefly found in the Himālayas. *Utleria*, an arborescent genus with only one species, is endemic in South India. *Dischidia rafflesiana* Wall. Occurs in Assam and is epiphytic like other speices of this genus. *Calotropis procera* L. and *C. gigantea* L. are widespread weeds of drier areas.

GESNERIACEAE:—The family is found chiefly in the subtropical regions of the Eastern Himālayas, Khāsi hills, Burma and Malaysia. Out of 27 genera, 7 are endemic. Most of the species occur at moderate elevations in the more moist hills (914 to 1,524 m.). *Didissandra* and *Aeschynanthus* are the only genera found at higher altitudes. Species of the latter often occur as epiphytes.

ACANTHACEAE:—India is one of the richest regions for this family. There are 80 genera and 514 species occurring chiefly in the tropical and subtropical regions. They are particularly abundant in the Peninsular region, where as many as 188 species are endemic. The number of endemic genera is 14, and the general endemic figure for the family is 82 per cent. In the genus *Strobilanthes* (many of the species have recently been segregated into separate genera) 146 species are endemic out of a total of 152. Several species are characterized by a gregarious flowering at definite intervals. *S. kunthianus* T. And. (now *Phlebophyllum kunthianum* Nees) flowers once every 12 years in the Nīlgiris.

LABIATAE (Mint family):—This is a useful family because of the volatile aromatic oils that many of its members contain. *Ocimum sanctum* L. (*tulasī*) is held in religious veneration and is commonly grown in Hindu homes. *Mentha* (*pudīnā*, mint) is a culinary herb prized for its flavour and aroma. Oils and perfume are obtained from *Pogostemon* (patchouly), *Lavandula* (lavender), etc.

There are 69 genera and 421 species occurring chiefly in comparatively dry areas and moderate altitudes; of these 261 are endemic. The two chief centres of concentration are the Deccan and North-western India. The South Indian development of the

Labiatae is very remarkable, recalling the Balsaminaceae. But while the latter have mostly developed in the moist Malabār region, the Labiatae have multiplied in the dry eastern half of South India. The following genera show high endemicity: *Plectranthus, Anisochilus, Pogostemon, Nepeta, Leucas, Elsholtzia, Salvia, Dracocephalum, Phlomis and Gomphostemma. Anisochilus, Pogostemon* and *Leucas* are well represented in South India; *whereas Nepeta, Elsholtzia, Salvia, Dracocephalum* and *Phlomis* are better developed in the Himālayas.

POLYGONACEAE (Buckwheat family):—The genus *Polygonum* contains 88 species in the Indian area; 78 are endemic. Almost all the species found in the hills show high endemism and some of them cover a great range of altitude. *Polygonum viviparum* L. shows the greatest vertical range in distribution and is found from 1,524 to 5,484 m. In contrast to this *P. perpusillum* Hook. f. and *P. hookeri* Meissn. have a very restricted range in the Himālayas

Antigonon, Muehlenbeckia and *Coccoloba* are cultivated as. ornamentals in Indian gardens. However, none of them is indigenous to this country.

LORANTHACEAE (Mistletoe family):—This is a family of tropical and subtropical semi-parasites. In the Old World the greatest development is seen in the Malaysian region. Of the 73 species in the Indian region, 47 are endemic. The chief concentration is in Malabār and in the moist rain forests of Assam.

EUPHORBIACEAE (Castor family):—Plants of this family are widely distributed in the tropical and subtropical regions of the world. The major concentration is in the Deccan Peninsula. Only 5 out of the 70 genera are endemic.

The genus *Euphorbia* shows a strong representation and 41 species are endemic out of a total of 63 which seem to be rather well balanced between Peninsular India and the Himalayas. Several of the Himālayan species are found at high altitudes, extending even to the alpine zone. Some of the species are fleshy and resemble cacti in their vegetative habit. However, they can be readily distinguished by their stipular thorns which occur in pairs at the nodes, as also by the presence of latex. Similar fleshy euphorbias occur in Africa.

The rubber plants, *Hevea brasiliensis* Müll.-Arg. is the most useful member of this family and a native of tropical America. It is grown on a fair scale in the Malabār region. Another useful introduction is *Manihot esculenta* (tapioca, cassava), which is also a native of tropical America. The castor, *Ricinus Communis* L., is a native of tropical Africa but is now more or less naturalize in this country. *Emblica officinalis* Gaertn. (*āmlā*), is also a verys

Plant, its fruits being a rich source of vitamin C. *Poinsettia* and *Codiaeum* (popularly called croton) are widely grown as ornamentals.

A comparable study of the monocotyledons is not available so far.* About 38 families are represented in India. Of these, Orchidaceae (*c.* 1,600 species), Gramineae (*c.* 750 *species*) and Cyperaceae (*c.* 377 species) are the most important. Further, the Orchidaceae is the largest family of flowering plants in the Indian region. The Liliaceae, Araceae and Palmaceae have about a 100 species each, or more; the Commelinaceae have about 70 and the Juncaceae about 30. Most of the other families of monocotyledons have less than 30 species in this country. Of course, a few are very small families anywhere in the world and consist of only one genus and one species.

HYDROCHARITACEAE (Frogs-bit family):—There are 8 genera and 12 species in India, all being submerged aquatics. *Hydrilla*, *Vallisneria*, *Lagarosiphon*, *Blyxa* and *Ottelia* occur in fresh water; *Enhalus* and *Halophila* are marine plants.

BURMANNIACEAE:—*Burmannia* is represented by about 6 species which are chiefly saprophytic. They occur mainly in South India.

ORCHIDACEAE (Orchid family):—As already indicated, the Orchidaceae are represented by about 1,600 species in the Indian region. The largest number of species occur in the Eastern Himalayan and Assam regions. *Dendrobium*, *Bulbophyllum*, *Eria* and *Habenaria* have each about a hundred or more species in the Indian region.

The family is of great biological interest for several reasons. It is one of the largest families of flowering plants with 10,000—15,000 species widely distributed but especially abundant in the Tropics, where most of them occur as epiphytes in the evergreen rain forests. Some are saprophytes like *Neottia*, *Gastrodia* and *Epipogum* with fungi associated with their roots as mycorrhiza. Several of the epiphytes have aerial roots with the velamen helpful in water absorption. The flowers of orchid shows remarkable adaptations for pollination by insects. Some of them are so specialized for insects of certain kinds that in their absence pollination fails to occur. However, using artificial methods, several orchids belonging to different genera can be readily hybridized. Thus, *Brassocattlaelia* is a multigeneric hybrid involving three genera, *Brassavola*, *Cattleya* and *Laelia*.

*Chatterjee (1960) estimates that about 1,000 species of monocotyledons are endemic in the Himālayas and about 500 in South India.

Each fertile orchid fruit produces a dust-like mass of an enormous number of exceedingly small and light seeds which easily become wind-borne and hence, among other causes, the epiphytic habit of so many orchids.

Because of their beautiful and gorgeous flowers, the orchids are highly prized favourites in horticulture all over the world. But the numerous wild orchids of India have not so far received, in their own country, the attention they deserve. It may be hoped that interest will be stimulated with the establishment of the National Orchidarium at Shillong.

MUSACEAE (Banana family):—This family belongs to the Tropics of the Old World. *Musa* is a useful genus, the banana (*Musa paradisiaca* L.) being one of the most important food plants which is widely grown in the warmer parts of the country. The cultivated varieties are usually triploid and produce no seeds. The plant is a large herb with rhizomes which are used for vegetative propagation. The inflorescence springs from the rhizome underground and emerges at the top of a false aerial stem formed mainly of the sheaths of the large leaves. The blades of the leaves are readily torn from the edges and thus wind and rain soon reduce them to a ragged condition.

ZINGIBERACEAE (Ginger family):—The plants of this family are perennial herbs, usually with sympodial fleshy tuberous rhizomes. The family is chiefly Indo-Malayan and is well represented in the Himālayas. *Hitchenia* with 4 species is endemic to India. The rhizomes of *Curcuma* (turmeric and zeodary) and *Zingiber* (ginger) are of economic value. *Elettaria cardamomum* Maton yields the cardamom of commerce and is cultivated in the mountains of South India. The fruits of *Amomum* are also used as flavouring material. Other genera of the family found in India are: *Globba*, *Hedychium*, *Kaempferia*, *Alpinia*, *Costus* and *Roscoea*.

CANNACEAE (Canna family):—*Canna*, the only genus of this family, is represented by a few species in India which are doubtfully indigenous. The family is essentially tropical and subtropical American. Several varieties of hybrid origin are garden favourities.

MARANTACEAE (Arrowroot family):—*Phrynium* and *Clinogyne* are the only Indian genera of this predominantly American family.

IRIDACEAE (Iris family):—About a dozen species of *Iris*, which is chiefly north temperate in distribution, occur in the Himālayas. *Crocus sativa* L. is cultivated in Kashmīr for saffron, which is composed of the dried stigmas of this plant and is used for flavouring and colouring food. *Iris*, *Gladiolus*, *Freesia* and *Belamcanda* are cultivated as ornamentals.

HYPOXIDACEAE:—*Hypoxis aurea* Lour. occurs in the hills and mountains of India. There are half a dozen species of *Curculigo*.

AMARYLLIDACEAE (Amaryllis family):—About a dozen species of *Crinum* and half a dozen of *Pancratium* occur in India. *Crinum, Pancratium, Zephyranthes* and *Narcissus* are cultivated in gardens.

AGAVACEAE:—Several species of *Agave*, among them A. *Sisalana Perr.* and *A. Vera-Cruz* Mill, have been introduced and naturalized in some parts of India. Ornamental varieties of this genus as well as of *Yucca* and *Dracaena* are planted in gardens.

TACCACEAE:—Three species of *Tacca occur* in the country.

DIOSCOREACEAE (Yam family):—Some 16 species of *Dioscorea* and one species of *Trichopus* are the only representatives of this family in India.

STEMONACEAE:—Two species of *Stemona* and one of *Stichoneuron* occur in India. The family as a whole consists of only three genera.

LILIACEAE (Lily family):—This is a large family. There are about 160 species in India, mostly occurring in the Himālayas. Many of the species are bulbous, scapigerous herbs. Species of *Smilax* are tendril climbers. *Asphodelus tenuifolius* Cav. is a winter weed in the plains. The large orange red flowers of *Gloriosa superba* L. are so beautiful that this plant is frequently grown in gardens. Onion (*Allium cepa* L.) and garlic (*Allium sativum* L.) are widely cultivated for their bulbs. The corms of *Colchicum autumnale* L. yield the alkaloid colchicine. Several other plants of this family are garden favourites.

PONTEDERIACEAE:—This is a small family of aquatics, of which *Monochoria* is represented in this country by two species. *Eichhornia crassipes* Solms is an introduced plant now naturalized in this country (see also p. 225).

PHILYDRACEAE:—*Philydrum lanuginosum* Banks occurs in the Andaman Islands eastward to Burma and Malaysia.

XYRIDACEAE:—Half a dozen species of *Xyris* occur in India.

COMMELINACEAE:—This family is predominantly tropical and subtropical. Nearly 70 species occur in this country; some 28 of them belong to *Aneilema* and 20 to *Commelina*. *Cyanotis* is another large genus of the family. *Commelina benghalensis* L., one of the commonest species, has subterranean cleistogamous flowers. *Rhoeo, Tradescantia* and *Zebrina*, all from the New World, are cultivated in gardens.

FLAGELLARIACEAE:—*Flagellaria indica* L. occurs throughout India. It climbs by means of its leaf tips.

JUNCACEAE (Rush family):—This is a family of the temperate regions. As might be expected, it is found in India in damp and

cold places, mostly in the Himālayas. There are about 26 species of *Juncus* and 4 species of *Luzula*. *Juncus bufonius* L. and *J. prismatocarpus* R. Br. occur also in the plains of Northern India.

PALMACEAE (Palm family):—The palms are a characteristic feature of tropical vegetation and landscape. They are of great economic importance, particularly in the Tropics. There are about 100 species of this family in India. While most of them have the distinctive palm form, some are climbers or scramblers, like *Calamus* (the largest genus of the family) and *Plectocomia*. In these the stem may attain an immense length and the leaves are provided with hooks or spines by which the stem is able to take hold of the surrounding vegetation. The rattan canes, used for making chair bottoms, baskets and cables are the stripped stems of *Calamus*. *Nipa fruticans*, Wurmb. occurs in the tidal forests of the Sundarbans in West Bengal. *Plectocomia himalayana* Griff. and *Trachycarpus martiana* Wendl. occur up to 1,520-2,188 m. in the Eastern Himālayas. The coconut (*Cocos nucifera* L.) and the betel-nut palm (*Areca catechu* L.) are cultivated in the hot damp regions of India, the former especially near the sea. The date palm (*Phoenix dactylifera* L.) has been introduced in North-western India. The palmyra palm (*Borassus flabellifer* L.) is cultivated throughout the plains of this country. The talipot palm (*Corypha*) is the most majestic palm of India but it is rare and confined in distribution. Many other palms are grown in gardens for ornamental purposes.

The palms are of considerable geological age. A number of palm genera are endemic with narrow ranges of distribution. The endemism of the species is even more marked; it has been estimated that 95 per cent of all the species in this family are narrowly distributed. In some of the tropical islands, all the native species are endemic and even in some continental regions the percentage is over 90. In a letter to Darwin, Hooker described the Palmaceae as "a very ancient group and much dislocated, structurally and geographically".

PANDANACEAE (Screw-pine family):—They are woody plant often with a palm-like habit. As already indicated on page 167 the unisexual nature of the flowers of *Pandanus* seems to have been sensed by the ancient Hindus. There are about 6 species of the genus in India and one of *Freycinetia*. The sweetly scented flowers and spathes are used for ornament and as a source of perfume.

TYPHACEAE (Cat's-tail family):—*Typha*, the only genus of this small family, is represented by three species, all grass-like marsh herbs with spongy leaves.

SPARGANIACEAE:—This, like the above, has a single genus, *Sparganium*. There are two species of it in North-western India and the Eastern Himālayas.

ARACEAE (Aroid family):—The aroids are represented by more than a 100 species in India. The flowers are unisexual or bisexual and borne typically on a cylindrical spadix which is enclosed by a green or coloured spathe. While most of the species are terrestrial herbs, a few are climbers like *Pothos*, or epiphytes with aerial roots. *Pistia* is a floating aquatic, and *Acorus* and *Cryptocoryne* are usually marsh plants. There are several species of *Arisaema* (cobra plant, jack-in-the-pulpit) in the Himālayas and mountains of South India. *Lagenandra* with five species is endemic to South India and Ceylon. The corm-like rhizomes of *Amorphophallus*, *Colocasia* and *Alocasia* are edible. The rhizome of *Acorus* is aromatic, and is useful in medicine and for flavouring.

LEMNACEAE (Duckweed family):—These are small, floating water plants with a thalloid plant body which is often purplish beneath. The flowers are minute and unisexual and located in grooves under the edge. The plants usually propagate themselves vegetatively and so rapidly as to cover the entire surface of the water with a dense green carpet-like mass. *Spirodela* and *Lemna* have roots; species of *Wolffia*, the smallest of flowering plants, are rootless.

TRIURIDACEAE:—Two species of *Sciaphila* are reported, one from Kerala and the other from Assam. They are slender saprophytes with scale leaves.

ALISMACEAE:—These are marsh or water plants of various habits. *Alisma*, *Limnophyton*, *Sagittaria* and *Wisneria* are represented by a few species in India.

BUTOMACEAE:—Like the Alismaceae, these are water or marsh plants. *Butomus* and *Butomopsis* are two well known genera. The latter should perhaps be transferred to the Alismaceae.

SCHEUCHZERIACEAE:—Two species of *Triglochin* occur in temperate and alpine Himālayas. They are scapigerous marsh herbs with a rush-like appearance.

APONOGETONACEAE:—*Aponogeton*, the only genus of the family, is represented by four species of which *A. monostachyon* L. and *A. Crispum* Thunb are widespread, scapigerous plants with tuberous rootstocks.

POTAMOGETONACEAE:—They are all partly or wholly submerged aquatic plants. *Potamogeton* is represented by about 10 species occurring in fresh waters. *Ruppia* is found in brackish water and *Cymodocea* is marine.

ZANNICHELLIACEAE:—The single genus *Zannichellia* has two species, both cosmopolitan, and occurring in fresh or brackish waters.

NAJADACEAE:—*Najas*, the only genus of this family, is represented by four species, but this number needs revision. They are submerged aquatic plants of fresh or brackish waters.

ERIOCAULACEAE:—There are about 34 species of *Eriocaulon* reported from India. They are marsh or aquatic scapigerous herbs. This family is especially well developed in South America.

CYPERACEAE (Sedge family):—Sedges are grass-like plants, chiefly of marshy habitats. Like grasses, they are also very widely distributed throughout the world but with a narrower ecological range, being a counterpart as it were of the Gramineae in rather damper conditions. More than 377 species occur in India; nearly 130 of them belong to the genus *Carex*. They occur chiefly in the Himālayas, some at very high alpine altitudes. Of *Cyperus*, which is mainly tropical and the second largest genus, there are about 60 species, and of *Fimbristylis* about 50 species. From the pith in the culms of *Cyperus papyrus* L. (paper-reed) a riverside plant, the Egyptians, as early as 2400 B.C. made the ancient writing paper, papyrus. The rhizomes and root tubers of several species of *Cyperus* are edible and the stems are used in basketry; but, on the whole, the family is of little economic value.

GRAMINEAE (Grass family):— One of the largest families of flowering plants, the Gramineae is also the most widely distributed in all regions of the globe. In temperate regions, the grasses are a conspicuous element of the vegetation, forming grasslands, called prairies or steppes. While most grasses are herbaceous, the bamboos are woody and may attain a size of as much as 30 m. Grasses are readily recognized but are difficult to identify botanically. There are about 750 species in India. As regards usefulness to man and animals, the pride of place should certainly go to the grasses. The following quotation from Pohl (1954) aptly summarizes their importance: "Of all the world's flowering plants, the grasses are undoubtedly the most important to man. They contribute tremendously to the earth's green mantle of vegetation; they are the source of the principal foods of man and his domestic animals. Without the grasses, agriculture would be virtually impossible: grain, sugar, syrup, spice, paper, perfume, pasture, oil and timber, and a thousand other items of daily use are products of various grasses. They hold the hills, plains and mountains against the destructive erosive forces of wind and water. In the end, they form the sod that covers the sleeping dead."

4. *Gymnosperms*

Out of a total of about 65 living genera of gymnosperms only 14 occur in India. This is because they are mainly temperate plants and in this country only the Himālayas afford the main temperate region. Here they grow luxuriantly and some of them form extensive forests. Since the group is economically important and mostly consists of trees, it has received considerable attention at the hands of silviculturists.

Of the six living orders, four—Cycadales, Coniferales, Ephedrales and Gnetales—are represented in India, the Coniferales being the dominant order. *Ginkgo biloba* L., the sole living representative of the Ginkgoales, is Chinese although a few trees are being grown in scattered places having a mild climate.

CYCADALES:—*Cycas* is the only genus of this order in India. There are four species—*C. beddomei* Dyer, *C. circinalis* L., *C. pectinata* Griff. and *C. rumphii* Miq. *C. beddomei* is restricted to the dry hills of the Cuddapah District of Andhra Pradesh. *C. circinalis* is widely distributed in the dry deciduous forests of Southern India. Sago is extracted from its stem and seeds. *C. pectinata* is found in several parts of Eastern India and *C. rumphii* in the Andaman and Nicobar Islands. *C. revoluta* Thunb., a Japanese species, is frequently cultivated as an ornamental plant in North India. It is vegetatively propagated and generally the plants are all female.

CONIFERALES:—The order is represented by 11 genera—*Abies, Cedrus, Cephalotaxus, Cupressus, Juniperus, Larix, Picea, Pinus, Podocarpus, Taxus* and *Tsuga*. Except *Podocarpus* all the other conifers are restricted to the Himālayas. There is a clear demarcation between the West and East Himālayan conifers. There are only a few of them which occur in both regions. Their distribution is mainly governed by altitude and they grow in very characteristic formations. For example at 2,500 m. above sea level in the Western Himālayas, the tree community chiefly comprises *Cedrus deodara* Loud., *Pinus wallichiana* A. B. Jack., and *Abies pindrow* Royle along with some angiosperms like the oaks. At 1,000 m. the dominant conifer is *Pinus roxburghii* Sarg.

Abies has four species. Of these *A. pindrow* Royle and *A. spectabilis* Spach grow in the Western Himālayas and *A. densa* Griff. and *A. delavayi* Franchet in the Eastern Himālayas They form extensive forests at high altitudes, occurring above 2,300 m. They yield a useful light wood which is used for making sleepers.

Cedrus comprises a single species, *C. deodara* Loud., occurring gregariously in the Western Himālayas at 1,200-3,300 m. At places it attains gigantic dimensions, and the oldest known tree exceeds 704 years in age. As ornamentals there are few trees in the world which compare with deodar. It is the strongest of Indian coniferous timbers being very resistant to white ants and fungi. *Cupressus torulosa* D. Don is a common associate of deodar but it does not occur in abundance.

There are two species of *Cephalotaxus*—*C. mannii* Hk. f. and *C. grifithii* Hk.f.—both being small trees of the evergreen forests of the eastern Himālayas.

The genus *Juniperus* comprises six species—*J. communis* L., *J. coxii* A. B. Jack., *J. macropoda* Boiss., *J. recurva* Buch.-Ham., *J. squamata* Buch.-Ham. and *J. wallichiana* Hk. f. ex Parl. which are found in the inner valleys and higher ranges, above the tree limit. They are small trees or shrubs and the twigs of many of them are burnt for incense in temples.

Larix has one species, *L. griffithiana* Hort. ex. Carr. growing as a tall tree in Eastern Nepāl, Sikkim and Bhutān at 2,400-3,650m. It is the only deciduous conifer of our country.

Picea smithiana Boiss. is the West Himālayan spruce while *P. spinulosa* Henry belongs to the Eastern Himālayas. The former is a frequent associate of *Abies pindrow* Royle and attains a height of nearly 60 m. Its wood is used for cheap joinery but the bulk of the supply is utilized by the railways for treated sleepers.

Pinus is the most important genus from the point of view of forestry. Three species—*P. gerardiana* Wall. ex Lamb., *P. roxburghii* Sarg. and *P. wallichiana* A. B. Jack.—occur in the Western Himālayas and two species—*P. insularis* Endl. and *P. armandi* Franchet—are found in the Eastern Himālayas. *P. roxburghii* is the conifer of lower altitudes. It occurs in great quantities and is put to a variety of uses. Cheap joinery in North India mostly depends on its timber. The tree is also extensively tapped for turpentine which is distilled to obtain the turpentine oil and rosin. *P. wallichiana* is an associate of *Cedrus deodara* and *Abies pindrow*. Its wood is superior to that of *P. roxburghii*. *P. gerardiana* grows in the dry inner valleys of the Western Himālayas and is well known for its edible seeds (*Chilgoza*) which are very nutritious.

Podocarpus neriifolius D. Don is a graceful tree occurring up to 900 m. in the Eastern Himālayas and the Andamans. It is an inhabitant of the evergreen climax forests of these regions. *P. wallichianus* Presl. has a discontinuous distribution. It occurs from Nīlgiris southwards and in Assam.

Taxus baccata L. grows in moist shady places above 1,800 m. all along the Himālayas, Khāsi-Jaintia hills and Nāga hills. The wood is very durable but is not available in large quantities.

Tsuga dumosa Eichler is a tall pyramidal tree with gracefully drooping branches distributed in Central and Eastern Himālayas chiefly at 2,440-3,050 m. Its common associates are the spruce and the fir.

Mention may also be made here of the many introduced conifers which have now become naturalized. *Cryptomeria japonica* D. Don was introduced by seeds from Japan around the middle of the 19th century. Its cultivation was started in Darjeeling which has now extensive forests of this tree. Here it grows quickly and yields a valuable light wood. It has also become naturalized in the Western Himālayas. *Cupressus funebris* Endl. is a Chinese species and is frequently planted in the hills in graveyards and cemetries due to its "weeping" habit. *C. cashmeriana* Royle ex Carr. comes from Tibet and is now widely cultivated in India. It also has a fast growth rate. *Callitris cupressiformis* Vent. was introduced from Australia into the Nīlgiris in 1885. It is now the finest hedge plant of this area. *Thuja orientalis* L. has a vertical arrangement of its branches and is a common ornamental shrub in the plains of North India.

EPHEDRALES:—*Ephedra*, the sole representative of the Ephedrales, contains erect or climbing shrubs or perennial herbs. The genus has become important in recent times because of the drug ephedrine which is extracted from some species and is used against asthma and other bronchial troubles. *E. foliata* Boiss. et Kotschy, *E. gerardiana* Wall., *E. intermedia* Schrenk et *Mey.*, *E. nebrodensis* Tineo, *E. regeliana* Florin and *E. saxatilis* Royle ex Florin occur in India. *E. foliata* is a scrambling shrub found in the drier parts of Rājasthān while the other species occur at high altitudes in the Himālayas. *E. gerardiana* and *E. nebrodensis* contain good quantities of ephedrine and are being commercially exploited for this purpose.

GNETALES:—The order Gnetales is represented by the genus *Gnetum* with five species—*G. contractum* Mgf. , *G. gnemon* L., *G. latifolium* Bl., *G. montanum* Mgf. and *G. ula* Brongn. Of thse *G. ula* is the most common. This is an extensive woody climber occurring in the evergreen forests of the Western Ghāts, Andhra Pradesh and Orissa. *G. contractum* is a scandent shrub occurring in Kerala and the Nīlgiri hills. *G. gnemon* is an erect shrub found in the rain forests of Eastern India. *G. montanum* grows wild in Assam, Sikkim, and parts of Orissa, and *G. latifolium* is known from the Andamans.

The gymnosperm flora of India is limited and fairly well known but details of their structure and life history have not been worked in all cases.

5. *Pteridophytes*

The pteridophytes include a vast assemblage of elegant plants distributed throughout the globe, although best represented in the mountains of the Tropics. Their immense variety and very ancient lineage—going back to the Palaeozoic era—have made them a very interesting group for students of evolution.

The Himālayas, particularly the wetter eastern areas, abound in the richness and variety of ferns and their allies. As one proceeds westwards, the number of species and individuals dwindle and only a few species are found in the extreme western parts of the Himālayan range such as Kulu and Kashmīr. In Rājasthān and Saurāshtra the fern flora is insignificant. Along the Western Ghāts, due to higher precipitation, a rich variety of ferns are met with.

In the year 1863, Beddome published a well illustrated volume on *The Ferns of Southern India*, followed by volumes entitled *Handbook to the Ferns of British India* in 1865-1870 and 1876. Later (1883), he summed up all the information in his *Handbook to the Ferns of British India, Ceylon and the Malay Peninsula*, and added a supplement in 1892. Clarke (1880) reviewed the ferns of Northern India and Hope (1899-1902) published a series of papers on *The Ferns of North-Western Himalayas.* Blatter & d'Almeida (1922) wrote on the fern flora of Bombay. Stewart (1942, 1945) gave an account of the ferns of Mussoorie, Dehra Dūn and Kashmīr. Mehra (1939) described the ferns of Mussoorie, and Panigrahi (1960, 1961) of Eastern India. Alston (1948) enumerated 58 species of the genus *Selaginella* from India and 8 more have been recorded recently from the eastern parts of the country. Several workers have recently studied the ferns of Assam, Naini Tāl, Mount Abu, Simla, Darjeeling and the Sikkim Himālayas.

The ferns show a wide range of habit, from the delicate filmy ferns (*Hymenophyllum*, *Mecodium* and *Trichomanes*) to arborescent forms (*Alsophila* and *Cyathea*) with woody trunks which sometimes attain a height of 9-12 m. or more. These tree-ferns are more common at elevations between 150 and 2,130 m. and are generally found in the shade of moist evergreen forests on mossy banks along streams.

Many ferns grow as epiphytes on trees. Among them are species of *Araiostegia*, *Arthromeris*, *Asplenium*, *Ctenopteris*, *Davallia*, *Dryonoglossum*, *Drynaria*, *Lemmaphyllum*, *Lepisorus*, *Leptochilus*, *Lindsaya*, *Loxogramme*, *Mecodium*, *Microsorium*, *Nephrolepis*, *Oleandra*, *Phymatodes*, *Polypodium*, *Pyrrosia* and *Vittaria*. Of the climbing forms the most notable are *Lygodium flexuosum* Sw., *L. japonicum* Sw., *L. scandens* Sw., *Microsorium normale* Ching and *Stenochlaena palustris* Bedd.

A great many species, such as *Adiantum capillus-veneris* L., *Ampelopteris prolifera* Kze., *Cyclosorus* spp., *Diplazium* spp., *Thelypteris brunnea* Ching and *T. ciliata* Ching flourish on gravelly soil by the banks of streams. Others like *Abacopteris multilineata* Ching, *Angiopteris evecta* Hoffm., *Asplenium unilaterale* Lam. var. *rivale*, *Diplazium esculentum* Sw., *Osmunda regalis* L. and *Woodwardia radicans* Sm. grow along water courses. *Ceratopteris thalictroides* Brongn. is met with in tanks, streams and swampy ground and has marked aquatic adaptations. *Helminthostachys zeylanica* Hk. is seen in marshy places. *Acrostichum aureum* L. is characteristic of areas affected by tidal waters and along backwaters and is very common in most mangrove vegetations along the coast of Kerala.

Several ferns such as *Actiniopteris radiata* Link., *Adiantum caudatum* L., *Aleuritopteris albo-marginata* Panigrahi, *A. anceps* Panigrahi, *A. farinosa* Fee, *Blechnum orientale* L., *Cheilanthes tenuifolia* Sw., *Dryopteris crenata* Ktz., *Gleichenia glauca* Hk., *Hypodermatium crenatum* Kuhn and *Schizoloma ensifolium* J. Sm. grow on exposed rocks and show marked adaptations against drought. *Athyrium falcatum* Bedd. and *Pteridum aquilinum* Kuhn are met with in dry grassy places at higher elevations in the Western Ghāts, *Schizaea digitata* Sw. occurs in the plains and at moderately high elevations in Kerala.

There is a considerable altitudinal variation in the fern flora of India. *Actiniopteris radiata* Link., *Ampelopteris prolifera* Kze., *Ceratopteris thalictroides* Brongn., *Cheilanthes tenuifolia* Sw., *Diplazium esculentum* Sw., *Drymoglossum heterophyllum* C. Chr., *Drynaria quercifolia* J. Sm., *Hemionitis arifolia* Moore, *Lygodium scandens* Sw., *Microlepia speluncae* Moore, *Nephrolepis cordifolia* Pr., *N. exaltata* Schott., *Pteris longifolia* L., *Schizoloma ensifolium* J. Sm., *Stenochlaena palustris* Bedd., *Tectaria fuscipes* C. Chr. and *T. polymorpha* Copel. are met with up to a height of 600 m. *Abacopteris multilineata* Ching, *Ampelopteris prolifera* Kze., *Araiostegia pulchra* Copel., *Asplenium lunulatum* Sw., *Cyathea spinulosa* Wall., and *Dryopteris cochleata* C. Chr.

occur at 600-900 m., *Adiantum capillus-veneris* L., *Araiostegia pseudocystopteris* Copel., *A. pulchra* Copel., *Ceterach dalhousiae* C. Chr., *C. officinarum* DC., *Cyathea spinulosa* Wall., *Dicranopteris linearis* Und., *Lindsaya cultrata* Sw., *Oleandra musifolia* Pr., *O. neriiformis* Cav., and *Pteridum aquilinum* Kuhn at 900-1,525 m., *Adiantum venustum* D. Don, *Alsophila latebrosa* Wall., *Cheilanthes mysurensis* Wall., and *Osmunda claytoniana* L. occur at 1,525-2,135 m; *Drynaria mollis* Bedd., *Dryopteris chrysocoma* C. Chr., *Lemmaphyllum sub-rostratum* Ching and *Vittaria himalayensis* Ching at 2,135-2,750 m.; and *Leucostegia hookeri* Bedd., *Cryptogramma brunoniana* Wall., *Dryopteris barbigera* Ktz., *D. fibrillosa* C. Chr., *D. panda* C. Chr., *D. serrato-dentata* Hay. *Gymnopteris vestita* Und. and *Pteris wallichiana* Ag. at 2,750-3,660 m. At very high altitudes, between 3,660 and 4,875 m. and above, occur *Cystopteris fragilis* Bernh., *Dryopteris serrato-dentata* Hay. *Notholaena marantae* R. Br., *Polypodium subrostratam* C. Chr., *Polystichum prescottianum* Moore and *Woodsia lanosa* Hk. In and about glaciers and glaciated beds and on rocks covered by snow at high altitudes grow *Asplenium septentrionale* Hoffm., *Cystopteris fragilis* Bernh., *Osmunda claytoniana* L. and *Polystichum lachenense* Bedd.

The aquatic and floating ferns are represented by *Azolla pinnata* R. Br., *Salvinia cucullata* Roxb. and *S. natans* All. Some species of *Marsilea* grow in ponds and ditches and along the edges of puddles and on muddy flats. *Isoetes* is generally met with in lowlands and ponds and thrives well under submerged conditions.

PSILOTALES :—*Psilotum nudum* Beauv. is only species occurring in India. It may be terrestrial, epiphytic or saprophytic. It enjoys a fairly wide distribution in Kerala, the Nīlgiri hills and the Godāvari District of Andhra Pradesh. It is also known from various parts of the Deccan, West Bengal, Madhya Pradesh, the Sundarbans and Assam. In the Himālayas it is found in Kumaun, extending up to Punjab and rarely to Kashmīr. It is also known from the Laccadive and Minicoy Islands, and in the Barren Island it has been reported from the interior of a crater.

LYCOPODIALES :—At least 34 species of *Lycopodium* grow in different parts of India. *L. hamiltonii* Spring., *L. phlegmaria* L., *L. phyllanthum* Hk., et Arn., *L. setaceum* Hamilt, and *L. squarrosum* Forst. are epiphytic while *L. cernuum* L., *L. clavatum* L., *L. serratum* Thunb. and *L. wightianum* Wall. are the common terrestrial forms. *L. alpinum* L. and *L. lucidulum* Michx. grow at higher elevations above 3,000 m. and *L. selago* L. reaches up to 4,900 m. *L. phlegmaria* L. is a pendulous epiphyte generally

growing on trees and is also found in mangrove swamps in the Sundarbans and the Andaman Islands.

SELAGINELLALES:—About 66 species of *Selaginella* are known from India. They are generally found in moist mountainous tracts. However, some species like *S. bryopteris* Bak. and S. *repanda* Spring occur at low elevations and under xerophytic conditions. Some of these xerophytic species curl up and turn brown on drying but remarkably revive on being moistened whence the common name "resurrection plants" for such species. The better known Indian species of the genus are *S. chrysocaulos* Spring, *S. pallidissima* Spring, *S. involvens* Spring, *S. subdiaphana* Spring, *S. pentagona* Spring, *S. monospora* Spring and *S. wightii* Hieron. Generally the species are of restricted distribution and only a few like *S. subdiaphana* Spring and *S. repanda* Spring are fairly widespread. Several species have been recorded in comparatively recent years. Most of these new records are from Assam and the NEFA.

ISOETALES:—*Isoetes* is typically a marsh plant occurring in shallow waterlogged depressions or along the margins of ponds and pools in the drying mud. Since the plants look very much like the sedges and grasses with which they often grow associated, it is not easy to locate them in the field. *I. coromandelina* L. f. is widely distributed both in South and North India and for a long time it was the only species of *Isoetes* known from this country. However, recently five new species have been described. They are *I. sahyadrii* Mahabale and *I. dixiti* Shende from Mahārāshtra, *I. sampathkumarani* L. N. Rao from Mysore, and *I. indica* Pant et Srivastava and *I. panchananii* Pant et Srivastava from Madhya Pradesh.

EQUISETALES:—Several species of *Equisetum* occur in India; *E. arvense* L., *E. debile* Roxb., *E. diffusum* Don, *E. palustre* L. and *E. ramosissimum* Desf. Of these, *E. debile* is the most common and is met with all over India. Its variety *pashan* occurs along river banks in Poona. *E. arvense* and *E. palustre* ascend up to 3,660 m. and *E. ramosissimum* up to 3,050 m. *E. ramosissimum* var. *altissimum* grows abundantly at Mussoorie and Darjeeling at an altitude of about 1,500 m.

OPHIOGLOSSALES:—Several species of *Ophioglossum* occur in India: *O. aitchisonii* d'Almeida, *O. costatum* R. Br., *O. gramineum* Willd., *O. japonicum* Prantl, *O. lusitanicum* L., *O. nudicaule* L., *O. pendulum* L., *O. pedunculatum* Desv., *O. reticulatum* L. and *O. vulgatum* L. The last ascends up to 2,740 m. in Eastern Himālayas. It can be found up to 2,000 m. at Mussoorie. *O. pendulum* is an epiphytic species occurring in Kerala. Most of the other species have also been collected from Kerala.

Four species of *Botrychium* occur in mountainous parts They are *B. daucifolium* Wall., *B. lanuginosum* Wall., *B. lunaria* Sw. and *B. ternatum* Sw. *B. lunaria* is a high altitude species, occurring generally above 2,700 m. and up to 3,900 m. in Sikkim. *B. lanuginosum* reaches up to 3,000 m. in Nepāl and is also common in hill-stations like Kodaikānal and Manaar in South India. The other species are met with at comparatively lower elevations, between 1,200 m. and 2,400 m.

Helminthostachys zeylanica Hk. is met with in marshy areas in the Sundarbans, Upper Assam, Bengal and Kerala, and in the Western Ghāts up to an elevation of 990 m. Recently it has also been collected from Gorakhpur in Uttar Pradesh.

MARATTIALES:—This order is represented in India by two genera, *Angiopteris* and *Marattia*. *A. evecta* Hoffm is widely distributed at 600-1,500 m. in the Himālayas and South India, *M. fraxinea* Sm. occurs in some parts of the Western Ghāts at 1,200-1,800 m.

FILICALES:—The order Filicales includes the largest group of pteridophytes comprising several families. The Osmundaceae are represented by three species of *Osmunda* of which *O. regalis* L. is the most common. *O. cinnamomea* L. has been recorded from the NEFA. The Schizaeaceae are represented by *Aneimia tomentosa* Sw., four species of *Lygodium*, and two species of *Schizaea*. There are two genera of the Gleicheniaceae: *Gleichenia glauca* Hk. forms extensive thickets at high altitudes in North-East India; and *Dicranopteris linearis* Und. has a wider distribution being found even in the South. The Plagiogyriaceaè is a monogeneric family with *Plagiogyria euphlebia* Mett. as the more common form. The filmy-ferns (Hymenophyllaceae) are represented by several species belonging to the genera *Cephalomanes, Crepidomanes, Didymogolossum, Hymenophyllum, Mecodium, Meringium, Pleuromanes, Trichomanes* and *Vandenboschia*. Nearly all are epiphytes growing in dense rain forests on moss-covered tree trunks or moist rocks. *Mecodium polyanthos* Copel. is the most widely distributed species, ranging from 900 m. to 3,600 m. The Dicksoniaceae are represented by *Cibotium barometz* J. Sm. in Eastern India. The Cyatheaceae is a family of tree-ferns represented by two genera, *Alsophila* and *Cyathea;* both are arborescent forms found in the tropical rain forests of North-east India and the Western Ghāts.

In the Polypodiaceae the more important genera are *Arthromeris, Cheiropleuria, Colysis, Crypsinus, Drynaria, Drymoglossum, Lemmaphyllum, Lepisorus, Leptochilus, Loxogramme, Mic rosorium, Phymatodes, Platycerium, Polypodium, Pseudodrynaria*

and *Pyrrosia*. They are nearly always epiphytic. The Dipteridoid group is represented by the terrestrial species *Dipteris wallichii* Moore of Assam.

The family Grammitidaceae is represented by some small epiphytes, mostly restricted to Assam. *Grammitis* and *Ctenopteris* are the more common genera. In the Thelypteridaceae, *Ampelopteris prolifera* Kze is the most widespread member of the family, apart from several species of *Cyclosorus* and *Thelypteris*. *Sphaerostephanos, Mesochlaena, Stegnogramma* and *Dictyocline* are also represented.

Among the different subfamilies of the Dennstaedtiaceae, the Dennstaedtioideae is represented by *Dennstaedtia scabra* Moore and *D. appendiculata* J. Sm.-both occurring in the Himālayas. The Lindsayoideae are represented by *Lindsaya repens* Bedd. and *L. cultrata* Sw. and species of *Schizoloma* and *Sphenomeris*. The Davallioideae include several epiphytic forms and occur mainly in Eastern India. The most common genera are *Araiostegia, Davallia, Davallodes, Humata* and *Leucostegia*. Of the Oleandroideae there are three species of *Oleandra—O. wallichii* Presl., *O. musifolia* Pr. and *O. neriiformis* Cav., growing in Eastern India and 5 species of *Nephrolepis*. *Oleandra neriiformis* occurs in the Western Ghāts also. The Pteridoideae is a large subfamily with nearly 24 genera of which *Acrostichum, Actiniopteris, Microlepia, Pteridium, Pteris* and *Stenochlaena* are the most important. A dozen species of *Bolbitis* and half a dozen of *Egenolfia* represent the Lomariopsidoideae. The Elaphoglossoideae are represented by 5 species of *Elaphoglossum*.

The Parkeriaceae is a monotypic family represented by the widespread water fern *Ceratopteris thalictroides* Brongn. which is assigned by some authors to the Gymnogrammoideae.

In the Adiantaceae the Gymnogrammoideae are represented by several species of *Adiantum, Aleuritopteris, Cheilanthes, Hemionites, Onychium* and *Pityrrogramma* all of which are fairly well distributed over the country. The Vittarioideae include two genera. *Vittaria* has about 8 species distributed in Eastern India and in Kerala while the small and epiphytic *Antrophyum* is comparatively rare. Of the Blechnoideae, *Blechnum, Doodia* and *Woodwardia* are common. In the Asplenioideae the genus Asplenium embraces nearly 50 species spread all over India; *Ceterach officinarum* DC. is common in the Western Himālayas. *Athyrium, Cystopteris* and *Diplazium* are the commonly met members of the Athyrioideae. In the Woodsioideae three species of *Woodsia—W. elongata* Hk., *W. alpina* Gray and *W. lanosa* Hk.—occur mostly n North-western Himālayas.

Several species of *Dryopteris* and *Polystichum* represent the subfamily Dryopteridoideae. The monotypic genera *Acrophorus Diacalpe, Lithostegia* and *Peranema* are found in the hill ranges, of North-eastern India. In the Tectarioideae, *Ctenitis, Hypodermatium* and *Tectaria* are the most important.

MARSILEALES:—Some 10 species of *Marsilea* are recorded from India. *M. minuta* L. is the commonest species, widely distributed all over India. It grows in a wide range of habitat, from higher altitudes at Mussoorie to xeric surroundings in Bikaner. *M. brachypus* A. Br. and *M. coromandelica* Burm. occur in the Madras State. *M. ballardii* Gupta and *M. aegyptiaca* Willd. are reported from Rājasthān and *M. poonensis* Kolhat. from Mahārāshtra. *M. quadrifolia* L. is widely distributed in North India.

SALVINIALES:—This order is represented by *Azolla pinnata* R. Br., *Salvinia cucullata* Roxb. and *S. natans* All. They occur in ponds and swampy fields in West Bengal, Chota Nāgpur, Uttar Pradesh, Assam and other parts. Both species of *Salvinia* are widely distributed in Kerala. The plants spread quickly in the backwaters, rivers and paddy fields and are a growing menace to agriculture and water transport. *S. natans* All. occurs abundantly in the Dal lake in Srīnagar.

ECONOMIC IMPORTANCE:—The chief value of the Pteridophytes is in their ornamental nature. A few are recognized as useful medicinal plants. The leaves of *Adiantum caudatum* L. are said to be good for cough and fever, and those of *A. capillus-veneris* L. are administered with honey for catarrhal afflictions. The rhizomes of *A. lunulatum* L. are prescribed in fever and dysentery. Plants of *Actiniopteris radiata*. Link., *Tectaria polymorpha* Copel. and the rhizome of *Blechnum orientale* L. are said to have anthelmintic properties. *Drynaria quercifolia* J. Sm., an epiphytic fern, is believed to be useful in typhoid fever, hectic fever and cough The rhizomes and leaf bases of *Dryopteris chrysocoma* C. Chr. are a good substitute for *D.* filix-mas Schott. for use as a taenifuge, and species of *Lygodium—L. flexuosum* Sw. and *L. japonicum* SW.—as expectorants. The roots of *L. flexuosum*, boiled with mustard oil, are good for rheumatism, sprains, eczema and cut wounds. *Osmunda regalis* L. is used as a tonic and styptic. Recently. marsiline, a sedative and anti-convulsant principle, has been isolated from the leaves and whole plants of *Marsilea minuta* L. An oil prepared from *Ophioglossum vulgatum* L. is useful for the treatment of wounds and haemorrhages. An extract from the plants of *Lycopodium clavatum* L. is used as a kidney stimulan, and that from *Equisetum arvense* L. as a diuretic.

6. *Bryophytes*

The Bryophytes include two major groups: The Hepaticae (liverworts) and the Musci (mosses). The mosses are the more numerous and more widely distributed than the liverworts, and are especially conspicuous in colder areas where they often constitute a prominent feature of the vegetation. However, both liverworts and mosses are at their optimum in the broad-leaved, temperate forests at an altitude of 2,000-2,500 m. Places like Dalhousie, Simla, Mussoorie, Darjeeling, Shillong and Ootacamund are very rich in their bryophytic flora. As we go higher up there is a fall in the number of species.

HEPATICAE:—The liverworts are of two types, thallose and foliose. A large number of the thallose forms occur in moist places, some occur on exposed slopes, and a few are aquatic. *Ricciocarpus natans* Corda is an interesting floating liverwort of the Dal lake in Kashmīr and has also been collected from Naini Tāl and Kapūrthala. *Riccia fluitans* L. has been collected from the Khajiar lake (near Dalhousie), Darjeeling and from South India. The foliose or leafy forms are generally common in shady and moist places on rocks, and some grow as epiphytes. The epiphyllous forms are common in Cherrapunji and some other humid regions in Assam and in South India. Some new genera of liverworts discovered from the Western Himālayas are *Aitchisoniella, Sewardiella* and *Stephensoniella.*

Among the alpine liverworts of the Himālayas the best known are *Blepharostoma trichophyllum* Dum., *Lophozia alpestris* Evans., *Marchantia polymorpha* L., *Plagiochasma articulatum* Kash., *Preissia quadrata* Nees, *Riccia crystalina* L., *Sauteria alpina* Nees, *S. spongiosa* Hatt. and *Scapania purpurea* Kash. some of which reach an altitude of over 4,575 m. In the temperate Himālayas occur species of *Athalamia, Marchantia, Pellia, Riccardia, Fossombronia, Sewardiella, Madotheca, Lophocolea. Reboulia* and *Solenostoma.* The subtropical and tropical belts of the Eastern Himālayas and other mountains are rich in species of *Calypogeia, Jungermannia, Plagiochasma, Plagiochila, Preissia, Mastigobryum, Lepidozia, Frullania, Lejeunea* and *Anthoceros.*

From the Nepāl Himālayas are reported *Bryopteris trinitensis* L. et L., *Frullania wallichiana* Mitt.,.*Marchantia linearis* L. et L. *Plagiochasma cordatum* L. et L., *Madotheca revoluta* L. et L. and *Radula javanica* G.

Examples from Kumaun are *Anthoceros himalayensis* Kash., *Metzgeria furcata* Dum. *Notothylas levieri* Schiffn., *Plagiochasma appendiculatum* L. et L. and *P. articulatum* Kash.

Among the major forms in Assam mention may be made of *Anthoceros glandulosus* L. et L., *A. punctatus* L., *Frullania apiculata* Nees, *Plagiochasma articulatum* kash., *Ptychanthus striatus* Nees and *Thysanthus spathulistipus* Lindb.

In the mountains of South India occur forms like *Madotheca nilgerriensis* Mont., *Dumortiera hirsuta* R. Bl. et Nees, *Frullania glomerata* L. et L., *Lunularia cruciata* Dum., *Marchantia nitida* L. et L., *Reboulia hemispherica* Raddi, *Schistochila aligera* St., *Strepsilejeunea neelgherriana* St., *Anthoceros erectus* Kash. and some 8 other species, *Mastigolejeunea repleta* St. and *Targionia hypophylla* L.

The epiphyllous liverworts of India are very imperfectly known. They occur on the leaf surface of trees mostly of wet evergreen forests of South India, Eastern Himālayas, Assam and the Andamans. About 27 species of these are so far known to occur in this country. Examples are *Leptocolea lanciloba* St., *Radula javanica* G., *Taeniolejeunea peraffinis* Zwickel, *Cololejeunea hispidissima* Herz. and *Leptolejeunea Himalayensis* Pande et Misra.

Mitten's (1861) enumeration of hepatics included at least 39 genera with 205 species from India. Stephani (1885-1924) reported about 410 species from India. Kashyap, who was for many years the leading botanist in India on liverworts, described several new genera and species and further additions were made by others. By 1952 (see Pande & Bharadwaj, 1952) the list of Indian liverworts rose to 550 species, and at present the figure is about 672. The Eastern Himālayas with about 330 representatives are the richest, South India has 225 species, ınd Western Himālayas have 170. The East Himālayan hepatic flora shows distinct affinities with that of the Malayan region and some members are common with China (12 species), Japan (26 species) and Australia (11 species). The Hepatic flora of Sikkim is remarkably similar to that of Yunnan and the Malayan region. South India has some species in common with Malaya and a few with China (7 species), Japan (23 species) and East Africa (17 species). The West Himālayan species show a greater affinity with Europe, and less with China (12 species) and Japan (13 species). The liverworts of the Western Ghāts have affinities with those of Africa, and of the Eastern Ghāts with those of Malaya, Java, Formosa, Sumatra and Borneo.

In the end, it must be said that many of our genera and species of liverworts are in need of critical study and monographic treatment.

MUSCI:—The mosses flourish in a variety of habitats. On the dry faces of cliffs of gneiss and granite occur *Anoectangium walkeri* Broth., *Anomobryum cymbifolium* Broth., *Barbula* comosa Doz. et Molk., *Brachymenium walkeri* Broth., *Campylopus gracilis* Jaeg., *Hyophila cylindrica* Jaeg. and *Weisia edentula* Mitt. On pegmatite, lime and black loam occur *Barbula indica* Brid., *Hyophila involuta* Jaeg. and *Rhodobryum giganteum* Par. A number of mosses, such as *Brachythecium procumbens* Jaeg., *Bryum wightii* Mitt., *Dicranella heteromalla* Schimp., *Fissidens lutescens* Broth., *Garckea phascoides* C. Müll. and *Trematodon ceylonensis* C. Müll., grow on the banks of streams and on clay in shady places. On comparatively dry banks we meet *Bryum ramosum* Mitt., *Campylopodium khasianum* Par., *Dicranella pomiformis* Jaeg. and *Funaria hygrometrica* Dill. var. *calvascens.*

Bryum apalodictyoides C. Müll., *Fissidens anomalus* Mont., *Leucobryum wightii* Mitt., *Leucoloma walkeri* Broth., *Tayloria schmidii* C. Müll. and *Trichosteleum monostictum* Broth. grow on dead and decayed tree trunks. On trees in dry open jungles we find *Brachymenium nepalense* Hk., *Leucobryum hamillimum* Cardot, *Macromitrium leptocarpum* Broth., *Trachypus blandus* Mitt. and *T. crispatulus* Mitt. In very dense jungles, several mosses grow as felts on large trees and their branches and may loosely hang down like festoons. As examples may be mentioned *Aerobryum speciosum* Doz. et Molk., *Leucoloma renauldii* Broth., *Macromitrium moorcroftii* Schw., *M. sulcatum* Brid. and *Trichostomum hyalinoblastum* Broth. Some mosses form mats on tree trunks. *Brachymenium weisia* Hk., *Campylopus goughii* Jaeg., *Meteorium reclinatum* Mitt., and *Thamnium alopecurum* Bry. are examples of such mosses. A few species occur on plantation crops—*Papillaria fuscescens* Jaeg. on Orange trees; and *Acrocryphaea concavifolia* Bry. and *Meteorium brevirameum* Broth. on coffee bushes. Species of *Sphagnum* are characteristic of bogs. *Fissidens grandifrons* Brid. grows on rocks directly under waterfalls.

Several species are known from the mountains. Of those growing between 1,200 m. and 1,800 m. the most important are *Bryum argenteum* L., *Mnium lycopodioides* Hk., *Philonotis falcata* Mitt. and *Tortula inermis* Mont. Between 1,800 m. and 2,700 m. grow *Bryum turbinatum* Hedw., *Desmatodon latifolium* Brid., *Funaria hygrometrica* Dill., *Grimmia leucophaea* Grew., *Plagiopus oederi* Limpr. and *Mnium medium* Br. et Sch. Among

important species occurring between 2,700 m. and 3,300 m. are *Amphidium lapponicum* Schimp., *Barbula recurvifolia* Mitt., *Grimmia commutata* Hubn., *Trichosteleum brachypelma* Broth. and *Orthotrichum anomalum* Hedw. The high altitude (3,000 m.) mosses from Nepāl Himālayas include *Bryum ventricosum* Dicks., *Dicranum himalayanum* Mitt., *Pleurozium schreberi* Mitt., and *Trachypodopsis crispatula* Fleisch. *Rhytidium rugosum* Kindb., grows at an altitude of 4,600 m. and species of *Andreaea* are seen at about 4,900 m.

Several species occurring in India are also met with in other parts of the world. Among others *Distichium inclinatum* Br. et Sch., *Fissidens grandifrons* Brid., *Grimmia ovata* Web. et Mohr., *Mnium lycopodioides* Hk. and *Weisia wimmeriana* Bry. occur in Europe. Species in common with North America are *Barbula vinealis* Brid., *Dicranum undulatum* Enrh., *Ditrichun tortile* Lindb., *Sphagnum teres* Angs. and *Timmiella anomala* Limpr. *Campylopus comosus* Bry., *Dicranella heteromalla* Schimp. and *Herpetineurum toccoae* Card. are common with South America. The species in common with Africa are *Anoectangium euchloron* Mitt., *Ditrichum flexifolium* Hamp., *Grimmia commutata* Hube. and *Trichostomum cylidricum* C. Müll. and with Madagascar there are *Floribundaria floribunda* Fleisch. and *Philonotis laxissima* Mitt. The mosses in common with Australia and New Zealand are *Bartamia pomiformis* Hedw. and *Gymnostomum calcareum* Hornsch.

The following species occur in India as well as Indonesia, Malaysia part of Borneo and the Philippines : *Dicranella setifera* Jaeg., *Fissidens splachnobryoides* Broth., *Leucobryum aduncum* Doz. et Molk., *Leucobryum javense* Mitt., *Microdus brasiliensis* Ther., *Philonotis falcata* Mitt., *P. fontana* Brid. and *Rhodobryum giganteum* Par. Species in common with China are *Cleistostoma ambigua* Mitt., *Dicranum perfalcatum* Broth., *Fissidens nobilis* Griff., *Macromitrium nepalense* Schw., *M. sulcatum* Brid., *Orthotrichum hookeri* Mitt., *Papillaria fuscescens* Jaeg., *Ptychomitrium tortula* Mitt., *Rhacopilum schmidii* C. Müll., *Sphagnum junghuhnianum* Doz. et Molk., *Tortella fragilis* Limpr. and *Trachypodopsis crispatula* Fleisch. In common with Japan we have *Anisothecium rufescens* Lindb., *Brothera leana* C. Müll., *Leucobryum nilghiriense* C. Müll., *Leucoloma nitens* Par., *Sphagnum acutifolium* Enrh, and *Thysanomitrium blumei* Broth.

Out of 17 species of *Sphagnum* occurring in India, 7 are indigenous. The latter are as follows—*Sphagnum acutifolioides* Warns., *S. contortum* Wils., *S. cuspidatum* Enrh., *S. griffithianum* Warns, *S. khasianum* Mitt., *S. obtusifolium* Griff. and *S. ovatum*

Hampe var. *cymbifolium*. *Bryum*, *Campylopus* and *Fissidens* are large genera, each with over 50 species. The Archidiaceae is a monogeneric family with the genus *Archidium* having 3 species in Kanara and the Palni hills. Similarly, the Encalyptaceae has only the genus *Encalypta* having 5 species in Punjab, Kashmīr, North-western Himālayas and Ladākh.

Some new genera and species of mosses have been described from India. Among the former are *Dendrocyathophorum* and *Ortholobium*. Of the several new species discovered in this country mention may be made of the following few: *Barbula dharwarensis* Dix., *Ctenidium stereodontoides* Dix., *Dicranum orthophylloides* Dix., *Duthiella mussooriensis* Reimers., *Fissidens karwarensis* Dix., *Macromitrium nilgirense* C. Müll., *Physcomitrellopsis indica* Dix. and *Splachnobryum indicum* C. Müll. It must be noted that, so far, mosses have been collected and described only from certain restricted areas of this country. Extensive and systematic collections from all over the country and preparation of keys and checklists for easy identification of our common local mosses is long overdue.

7. *Algae*

The algae constitute a large group of plants in which the plant body generally exhibits little or no differentiation of the vegetative organs into true stems, roots and leaves. They vary from simple unicellular forms, like *Euglena*, *Chlamydomonas*, *Protosiphon*, *Botrydium*, and the desmids and diatoms, to more complex multicellular forms. Many of the simpler forms are faultlessly symmetrical and are among the most beautiful objects in the world. In the largest forms the plant body may be differentiated into a blade, stipe (sometimes extremely long) and a specialized holdfast sometimes also accompanied by considerable internal differentiation. Particularly interesting are species of *Sargassum* for here the plant body is divisible into structures resembling leaves, stems, and branches. There are also bladders which look like tiny berries so that superficially the plants have the appearance of an aquatic angiosperm.

Algae occur in a variety of climatic and edaphic conditions in tropical, temperate, arctic, antarctic and alpine zones. They also occur in fresh water, brackish water, in marine situation, and on damp earth, walls,bricks, tree trunks, barks and leaves. Some

forms are lithophytic, epiphytic, endophytic, symbiotic, parasitic or endozoic.

Some algae also occur at high altitudes. Among them are species of *Zygnema*, *Oedogonium* and *Vaucheria* together with some desmids and diatoms. *Hydrurus* and *Batrachospermum* occur as lithophytes up to 2,500 m. At slightly lower elevations we have *Oocystis solitaria* Wittr., *Staurastrum cuspidatum* Breb. and a few species of *Cosmarium* and *Closterium*. Marine planktonic forms like *Hornellia marina* Subrahmanyam, *Trichodesmium erythraeum* Ehrenb. and some Dinophyceae are responsible for the yellow-green or green "discoloration", or "red tides", and phosphorescence of the sea.

Algae are classified into several phyla of which the more important are : Cyanophyta (blue-green algae), Chlorophyta (green algae), Charophyta (stoneworts), Euglenophyta (euglenoids) Pyrrophyta (cryptomonads and dinoflagellates), Chrysophyta (yellow-green, golden-green algae and diatoms), Phaeophyta (brown algae), and Rhodophyta (red algae).

CYANOPHYTA:—Members of the Cyanophyta are found in a great variety of situations exhibiting extremes of environmental and ecological conditions. In India there are more than 85 genera and 750 species belonging to 18 families. Of these the largest number of genera (15) fall under the Oscillatoriaceae. There is a new family Mastigocladopsidaceae of Indian origin with seven genera—*Camptylonemopsis*, *Iyengariella*, *Mastigocladopsis*, *Parsarthella*, *Spirulinopsis*, *Thackerella* and *Westiellopsis*.

Some interesting forms are known to inhabit the shells of molluscs, gastropods and barnacles. Some occur in dead corals. Some salt tolerant Myxophyceae of the genera *Anabaena*, *Anabaenoposis*, *Arthrospira*, *Myxosarcina* and *Synchococcus* form dense planktonic populations in the Sāmbhar lake in Rājasthān.

A few species of the Myxophyceae are known from hot springs at temperatures ranging from 30° C to 54° C. The more important among them are species of *Anabaena*, *Aphanocapsa*, *Aulosira*, *Gloeocapsa*, *Oscillatoria*, *Phormidium*, *Plectonema* and *Scytonema*. Many of the blue-green algae occur in the soil. Among these the following are known to be nitrogenfixers: *Anabaena ambigua Rao*, *A. fertilissima* Rao, *Aulosira fertilissima* Ghosh, *Cylindrospermum sphaerica* Prasad, *Nostoc paludosum* Kutz. and *Tolypothrix tenuis* Jhos. Species of *Nostoc* and *Anabaena* live symbiotically in association with other plants such as *Anthoceros*, *Azolla* and *Cycas*. Some of the blue-green algae living in soil have been considered useful in reclaiming "ūsar" lands in Uttar Pradesh.

Several forms occur as plankton, sometimes in such abundance as to colour the entire body of water and form a fairly thick layer. The chief components of these waterblooms, mostly found only in alkaline waters, are *Microcystis*, *Arthrospira*, *Spirulina*, *Anabaena*, *Oscillatoria* and *Trichodesmium*. When in great abundance, they not only harm fishes and animals but also offer serious problems in drinking water supplies by choking the sand filters.

CHLOROPHYTA:—Significant contributions have been made by Indian algologists on the green algae of paddy fields, hot springs, fresh and marine waters, and desiccated areas. Among new genera special mention may be made of *Characiosiphon*, *Chloranomala*, *Cylindrocapsopsis*, *Dendrocystis*, *Ecballocystopsis*, *Fritschiella*, *Gloeotilopsis*, *Heterotrichopsis*, *Hormidiella*, *Oocystaenium*, *Sirocladium*, and *Willeella*. Many botanists consider that land plants must have evolved from algae through a form like *Fritschiella*. *Characiosiphon is also unique*.

The Zygnemataceae and Desmidiaceae are large groups with a wide distribution. Among the latter, a new genus *Triplastrum* has been described from South India.

Species of *Chlamydomonas* and *Dunaliella* constitute major blooms in the Sāmbhar lake in brine of 17° to 26° Baumē, and *Dunaliella salina* Teod. grows in salt pans on the coast of Saurāshtra in water having a salt concentration of 26° to 30° Baumē.

On an approximate estimate, at least 34 genera are marine : 9 are from the east coast and 28 genera from the west coast. The more well known of these are: *Acetabularia*, *Anadyomene*, *Avrainvillea*, *Boergesenia*, *Boodlea*, *Bryopsis*, *Caulerpa*, *Chaetomorpha*, *Chamaedoris*, *Cladophora*, *Codium*, *Dictyosphaeria*, *Enteromorpha*, *Halicystis*, *Halimeda*, *Microdictyon*, *Neomeris*, *Struvea*, *Trichosolen*, *Tydemania*, *Udotea*, *Ulva*, *Valonia*, and *Valoniopsis*. The total number of species is about 100. In inland fresh waters many of the Chlorophyta (especially desmids, Volvocales and Chlorococcales) form important constituents of the phytoplankton.

CHAROPHYTA:—The members of this group form extensive underwater meadows in ponds and rivers and have structures which bear a superficial resemblance to roots, stems and leaves. Until 1822 only two genera of the Charophyta were known from India : *Chara* and *Nitella*. *Nitellopsis*, *Lychnothamnus* and *Tolypella* were reported later. Thus the group is now represented in India by *Chara* (26 species), *Nitella* (34 species), *Lychnothamnus* (1 species), *Nitellopsis* (1 species), and *Tolypella* (3 species). Sixteen species of *Chara* and one of *Nitellites* are represented in the Deccan Intertrappean fossil beds.

CHRYSOPHYTA:—The genus *Vaucheria* is represented by 11 species. Of these *V. hamata* Walz. is very common on the soil in the spring season. *V. terrestris* Lyngbye em Walz. occurs in Kashmīr in the Amarnāth cave at 3,885 m. and *V. sessilis* (Vanch.) Dc. in the cave-like vaults on the sides of the Verināg spring. *Botrydium* is characteristic of drying mud and is represented by *B. granulatum* Grev., *B. tuberosum* Iyn. and *B. divisum* Iyn. *Hydrurus, Synura, Dinobryon, Mallomonas* and *Chrysodictyon are* the chief members of the Chrysophyceae. Of these *Hydrurus* is found only in the cool waters of mountain streams as in Kashmīr.

The diatom flora of inland as well as marine waters has been studied by several botanists. A large number of new species have been recorded for which reference must be made to other sources.

EUGLENOPHYTA:—The Euglenophytes are all inhabitants of foul water. There are 11 freshwater genera and 1 marine genus *Protoeuglena.* An interesting report is that of *Cladospongia* which is a colourless form belonging to the order Protomastigineane. One or two species of *Euglena* are frequently responsible for the red scums of stagnant inland waters.

PHAEOPHYTA:—Apart from *Sargassum,* there are at least 30 other genera with 75 species. All of these are marine and include *Chnoospora, Cladostephus, Colpomenia, Cystophyllum, Dictyota, Dictyopteris, Ectocarpus, Hecatonema, Hormophysa, Hydroclathrus, Mesogloea, Myriogloea, Nemacystus, Padina, Spathoglossum, Sphacelaria, Streblonema, Turbinaria* and *Zonaria. Iyengaria* is a new genus with the species *I. stellata* Boerg.

RHODOPHYTA:—No less than 125 genera with about 300 species occur in India. The chief of these are *Acanthophora, Agardhiella, Amphiroa, Antithamnion, Asparagopsis, Batrachospermum, Botryocladia, Caloglossa, Ceramium, Champia, Chondria, Chrysymenia, Claudea, Coelarthrum, Corallina, Dasya, Dictyurus, Enantiocladia, Galaxaura, Gastroclonium, Gelidiella, Gelidium, Gigartina, Gracilaria, Grateloupia, Gymnothamnion, Halymenia, Helminthocladia, Heterosiphonia, Hypnea, Hypoglossum, Laurencia, Lemanea, Liagora, Neurymenia, Nitophyllum, Polysiphonia, Porphyra, Rhodymenia, Sarcodia, Sarcomenia, Sarconema, Scinaia, Spyridia, Thorea* and *Vanvoorstia.* A new family Corynomorphaceae has been created for the genus *Corynomorpha.*

While most of the red algae are marine, a few freshwater representatives are also known. Among the latter are *Acrochaetium, Batrachospermum, Compsopogon, Sirodotia* and *Thorea. Compsopogon* is represented by three species, *C. coeruleus* Mont., *C. hookeri* Mont. and *C. iyengarii* Krish.

Ecology and Distribution of the Marine Forms

There are several places, both on the Peninsular coast and in the nearby islands and archipelagos, which show a rich algal vegetation. Among these are : Dwārka, Mul Dwārka and Okha in the Kutch-Saurāshtra area ; Bombay, Mālvan and Kārwār further down the Western Coast; Kanniyākumāri at the southernmost extremity; Rāmeswaram, Pāmban, Kursadi, Shingla and neighbouring islands; Tuticorin, Hare Island and Church Island, all in the southern part of the eastern coast; and Mahābalipuram, Madras and Waltair further up on the eastern coast. In addition, the Laccadives, the Andamans and the Nicobars also provide rich algal collections.

In the various islands in the Gulf of Manaar and in the Laccadives, the substratum is mostly coralline conglomerate or sandstone. In the Andamans and Nicobars coralline and other rocky substrata are met with. In the other localities, particularly on the Peninsular coast, rocks of laterite, sandstone, altered traps, gneiss or schists serve as substrata. Certain localities like Long Island and Port Blair in the Andamans, Kursadi, Hare Island, Shingle Island and Church Island on the eastern peninsular coast, and Okha-Dwārka on the western coast are particularly favourable for algal collections as a large stretch of the coast is uncovered at low tide.

In all areas favourable for luxuriant algal growth, species belonging to the Chlorophyta, Phaeophyta and Rhodophyta are well represented. Although it is often difficult to demarcate clear-cut zones due to the complexity of the associations, it is nevertheless possible in most areas to divide the algal vegetation into some broad belts, viz., the infra-littoral belt, extending from low water-mark to deeper waters; the littoral belt, extending between high and low water marks and which may often show three clear zones (the lower littoral, the mid-littoral and the upper littoral); and the supra-littoral belt lying above high watermark:

Of the red algae, *Chrysymenia uvaria* J. Ag., *Halymenia dilatata* Zan., *Dictyurus purpurascens* Bory, *Neurymenia fraxinifolia* J. Ag., *Scinaia carnosa* Harv. are some of the typical forms met with in the infra-littoral region. Others like *Halymenia venusta* Boergs., *Asparagopsis taxiformis* Coll. et Herv. and *Botryocladia leptopoda* Kylin, though characteristic of the infra-littoral belt, are sometimes found further up in the littoral region. The lower littoral zone is populated mostly by species of *Gelidium*, *Polysiphonia*, *Ceramium*, *Laurencia* and *Gracilaria*, while the mid-

littoral and upper littoral regions show more of brown and green algal communities and comparatively fewer red algae. *Colpomenia sinuosa* Derb. et Sol., *Iyengaria stellata* Boergs. and *Hydroclathrus clathratus* Howe and species of *Padina*, *Sargassum* and *Dictyota* are some of the typical brown algae of this region. The green algae are represented by *Codium*, *Caulerpa*, *Ulva*, *Enteromorpha*, *Chaetomorpha*, and *Cladophora*. Within the tidal limits, there are rock pools of different sizes and depths which harbour interesting algal associations. In the very deep rock pools are seen red algae like *Botryocladia leptopada* Kylin and *Galaxaura oblongata* Lamx. intermingled with brown and green algae. In pools higher up we see the red algae-like species of *Amphiroa*, *Jania* and *Gracilaria* along with *Champia parvula* Harv., *Heterosiphonia muelleri* De Toni, and *Liagora ceranoides* Lamour.; species of *Padina*, *Sargassum* and *Dictyota* and other brown algae; and green algae like *Acetabularia mobii* Solms-Labauch, *Chamaedoris auriculata* Boergs. and species of *Enteromorpha*, *Ulva*, *Caulerpa*, and *Chaetomorpha*. In the supra-littoral region the rocks, exposed to heavy swell and surf, harbour a characteristic flora comprising species of *Chaetomorpha*, *Cladophora* and *Halimeda* of the green algae; *Ectocarpus*, *Myriogloea*, *Namacystus*, and *Chnoospora*, of the brown algae; *Porphyra*, *Liagora*, *Sarcodia*, *Grateloupia*, *Gracilaria* of the red algae; and blue-green algae like species of *Lyngbya*, *Microcoleus* and *Calothrix*. *Boergesenia*, *Udotea* and at places *Avrainvillea* are found on reefs and coralline substrata heavily silted with fine sand and mud to form flats which frequently get exposed at low tide. In such situations *Acetabularia* and *Neomeris* are also found at times growing on fragments of dead corals. In shallow lagoons, several brown algae like *Cystophyllum muricatum* J. Ag., *Dictyopteris delicatula* Lamour., *Hormophysa triquetra* Kutz., *Spathoglossum asperum* J. Ag., *Stoechospermum marginale* Kutz, and species of *Turbinaria*, *Sargassum* and *Padina* occur associated with red algae like *Dictyurus*, *Acanthophora*, *Gracilaria* and *Hypnea*.

The brackish water mangrove swamps and salt marshes which occur scattered all along the coast also show very characteristic algal communities in which all the major groups are represented.

From the available information on the marine algal flora of Indian coasts it appears that there is considerable affinity with the flora of Mauritius (35.8% of the species are common to both floras) and the Atlantic coasts of the USA and Europe (22.7% of the species are common to both floras). About 22.5% of the species are common to Indonesia and India, and 22% to the West Indies and India. In the Pacific zone, Australia claims more

species in common with India (20.3%) than Japan (20.1%). Thus, the Indian coast harbours a complex variety of algal vegetation, comprising many species which have extensive distribution both in tropical and temperate seas, and a few even extending to the Arctic seas. In comparison with the Peninsular flora, those of the Laccadives and Andamans have a number of species peculiar to each and not in common with the Indian coastal flora although some of these species have a very wide geographical distribution.

ECONOMIC IMPORTANCE:—Several marine forms and a few freshwater ones are edible. Special mention may be made of *Caulerpa*, *Enteromorpha*, *Gracilaria*, *Hydroclathrus* and *Ulva*. *Ulva fasciata* Delile is found in quantity on the Gujarāt coast and has a protein content of dry seaweed of 31%. There is, therefore, the possibility of cultivating this species for food purpose in sea water.

Among the genera that can be used as sources of agar the most important are *Gelidium*, *Gracilaria*, *Hypnea* and *Sarconema*. The Indian agar potential is estimated at 13 metric tonnes annual, with an average yield of 28% on dry seaweed of the different species of agarophytes, while the Indian consumption is about 30 metric tonnes annually.

8. *Fungi*

The systematic study of fungi in India began only in the last quarter of the 19th century. Until about 1875 all collections of Indian fungi were being sent for study and identification to Europe, and for many years M. J. Berkeley was the chief determiner of Indian fungi. From 1875 onward such work began to be undertaken in India itself. D. D. Cunningham and A. Barclay were the pioneers in this field, and their studies on the Mucorales, the Ustilaginales and the Himālayan rusts are still looked upon with high regard. K. R. Kirtikar studied the agarics and the Gasteromycetes. The arrival of E. J. Butler in India at the turn of the present century gave a special impetus to the subject. Before his return to the U.K. in 1920, his all time classic—*Fungi and Disease in Plants*—had already been published. He also laid the foundation of the *Herbarium Cryptogamiae Indiae Orientalis*, which is now our national herbarium for fungi and is located in the Indian Agricultural Research Institute in New Delhi. During the last 40 years Indian mycologists have taken an increasing share in a taxonomic study of fungi and among them special mention may be

made of the following; J. F. Dastur, J. H. Mitter, B. B. Mundkur, C. V. Subramanian, and M. J. Thirumalachar. The year 1931 saw the publication of the first all India list of fungi—*The Fungi of India*—by E. J. Butler and G. R. Bisby. Recently it has gone through a new edition and is now a valuable work of reference.

Due to the diversity of the Indian climate we have many representatives of the fungal flora of Europe as well as of the Tropics. However, in comparison with the phanerogams, the fungi are still only partially explored and the total number so far known is just about five thousand.

The Myxomycetes or slime fungi have received a fair amount of attention in recent times and over 205 species are now recorded. The commonest genera are *Arcyria*, *Badhamia*, *Ceratiomyxa*, *Comatricha*, *Craterium*, *Cribraria*, *Diachea*, *Dictydium*, *Diderma*, *Didymium*, *Fuligo*, *Hemitrichia*, *Lamproderma*, *Lycogala*, *Perichaena*, *Physarella*, *Physarum*, *Reticularia*, *Stemonitis* and *Trichia*.

Of the Phycomycetes there are 324 species included under 64 genera. Among the lower Phycomycetes the genus *Synchytrium* is represented by more than 58 species and the genus *Physoderma* by 18 species. The Blastocladiales have 4 species under *Allomyces* and 4 under *Blastocladia*. Among the Peronosporales, the chief genera—*Albugo*, *Bremia*, *Peronospora*, *Phytophthora*, *Plasmopara*, *Pythium* and *Sclerospora*—are each represented by several species. Fifteen genera of the Mucorales are known of which the commonest are *Absidia*, *Choanephora*, *Cunninghamella Mucor*, *Pilobolus*, *Rhizopus* and *Syncephalis*. There are two genera representing the Entomophthorales : *Conidiobolus* and *Entomophthora*.

The Hemiascomycetes are represented by *Eremascus*, *Hansenula*, *Nematospora*, *Saccharomyces*, *Taphrina*, *Protomyces* and *Protomycopsis*. Most of the apothecial fungi are represented by a single species except genera like *Ascobolus*, *Dasyscypha*, *Humaria*, *Morchella*, *Peziza* and *Pseudopeziza*. *Morchella esculenta* Pers. grows in Kashmīr, parts of Punjab and Naini Tāl and is eaten in North India as a delicacy. The Sphaeriales are represented by a large number of genera of which *Chaetomium*, *Glomerella*, *Mycosphaerella*, *Physalospora*, *Rosellinia* and *Xylaria* are the most common. *Phyllachora* has as many as 62 species. *Claviceps purpurea* Tul., the ergot fungus, is cultivated on rye in the Nīlgiris and Darjeeling. Most of the genera of the Erysiphaceae are present, although their perfect stages are not always seen except in the cooler areas of North India. There are no less than 58 species of *Meliola*.

The Ustilaginales and the Uredinales are very well represented. *Ustilago* has 56 species; *Sphacelotheca* has 53; and *Urocystis, Tilletia, Entyloma* and *Sorosporium* have also several species each. *Puccinia* is represented by 234 species, *Uromyces* by 83, *Ravenelia* by 28, *Melampsora* by 14, *Phakopsora* by 15 and *Hemileia* by 11 species. Among the important genera of the Agaricales may be mentioned *Agaricus, Armillaria, Boletus, Collybia, Daedalea, Fomes, Ganoderma, Hydnum, Lentinus, Lenzites, Lepiota, Polyporus, Polystictus* and *Poria* whereas *Lycoperdon, Podaxis, Scleroderma* and *Tylostoma* represent the Gasteromycetes. Many of the agarics are edible and are widely distributed in India. *Cantharellus cibarius* Fr. is particularly common in the hills of the northern and eastern parts. It grows during the rainy season and is regarded as a delicacy. Another edible mushroom, *Volvaria diplasia* Sacc., occurs in Bengal and Madras. *Phellorinia inquinans* Berk. and *Calvatia gigantea* Fr. (Gasteromycetes) are found in the plains of North India. The latter looks like a pumpkin and is eaten only in the young stage when the inner portion is still white.

Among the Deuteromycetes the Moniliales have the largest number of species. *Cercospora* has 270 species while *Helminthosporium, Fusarium* and *Alternaria* are also large genera. Common representatives of the other orders are *Ascochyta, Colletotrichum, Diplodia, Macrophoma, Pestalotiopsis, Phoma, Phyllosticta* and *Septoria.*

During recent years several new genera have been discovered from different parts of the country. Among these are *Saksenaea* (Mucorales), *Bagcheea* (Sphaeriales), *Mundkurella, Zundelula Narasimhania* (Ustilaginales), *Dasturella, Ceropsora, Kernella Didymopsorella* (Uredinales), *Alpakesa, Bahusandhika, Dwayabeeja, Pseudotorula* and *Anthasthoopa* (Deuteromycetes).

Plant Diseases caused by Fungi

Of the fungal diseases the most important is the wheat rust which is estimated to cause an annual loss of about 500 lakh rupees. The Bengal famine of 1942 has been partly attributed to the helminthosporium disease of rice, while the red rot of sugar-cane has been responsible for several epidemics from time to time.

The club root of crucifers, caused by *Plasmodiophora brassicae* Wor., is common in the hills of South India. The "damping

off" of tobacco, tomato, and crucifers, caused by *Pythium debarya num* Hesse and *P. aphanidermatum* Fitzp., is widespread. These two fungi also cause the fruit rot of cucurbits, foot rot of papaya and soft rot of ginger. The late blight of potato, caused by *Phytophthora infestans* de Bary, occurs regularly in the hills and occasionally in the plains when the weather conditions are moderate. *P. palmivora* Butler causing the bud rot of palms causes much damage on the east coast of South India. It is also responsible for the fruit rot and nut fall (Koleroga) of areca in Western Peninsular India and Assam. *Peronospora* causing the downy mildew of several winter crops and *Albugo* causing the white rust of crucifers are common but the diseases are not serious. *Sclerospora graminicola* Schröt., is responsible for the green ear disease of *bājra* which is quite damaging at times.

The stem gall of coriander (*Protomyces macrosporus* Ung.) is widespread and sometimes affects seed setting in this crop. *Taphrina deformans* Tul. causes the leaf curl of peaches in Kashmīr, Kulu, Kumaun, Simla, Nīlgiri and Palni hills. *T. maculans* Butler, causing the leaf-spot of turmeric, is very troublesome in Gujarāt, the Northern Circārs, Orissa and Andhra Pradesh. *Aspergillus niger* Van Tiegh. causes a soft rot of appleas in Uttar Pradesh and seedling blight of ground-nut in North India. *Erysiphe polygon* DC. is a common mildew affecting the pea, lentil, and other leguminous crops. *E. graminis* DC., the powdery mildew of cereals, does much harm to wheat and barley in the hills and submontane districts. The powdery mildew of vines is also common but not in an epidemic form. *Glomerella tucumanensis* Arx et Müll causes the red rot of sugar-cane which is very serious in North and East India. Gram blight, caused by *Mycosphaerella rabiei* Kov. is damaging in North India. *Helminthosporium oryzae* Breda de Haan is widespread on rice in Assam, Bengal and parts of Madras.

There are smuts affecting all the important graminaceous crops. *Ustilago tritici* Jens. causing the loose smut of wheat, is common in most tracts. *Tilletia indica* Mitra (Karnal bunt) causes a partial bunt of wheat in the submontane regions of Punjab and Uttar Pradesh. The flag smut of wheat occurs in the Punjab and the root smut gall of mustard is found in Bihār. Both the diseases are caused by *Urocystis*. All the three rusts of wheat are widespread but the alternate hosts do not play any role in their perpetuation. The rusts of linseed, coffee and gram are common. The conifers are also subject to a number of rusts. *Cronartium himalayense* Bagchee is endemic and parasitises *Pinus roxburghii Sarg.* The blister blight of tea (causal organism—*Exobasidium vexans* Massee) is prevalent in a serious form in Darjeeling and Madras.

Pellicularia salmonicolor Dast. causes the pink disease of orange in Madhya Pradesh. It is widespread among other plantation crops such as tea, rubber, coffee, cinchona and mango. *Ganoderma lucidum* Karst., causing spongy rot, has been recorded from various parts of India on *Casuarina equisetifolia* Forst., *Areca catechu* L., *Pongamia pinnata* Pierre, *Guazuma tomentosa* H.B.K., *Acacia spp.*, *Pterocarpus marsupium* Roxb., *Cocos nucifera* L. and several others. *Trametes pini* Lloyd causes the red ring rot of many Himālayan conifers. Other wood rotting fungi of India are *Armillaria mellea* Quel., *Fomes badius* Berk., *F. senex* Nees et Mont., *Polyporus gilvus* Schwein. and *P. palustris* Berk. et Curt.

Among the Deuteromycetes the most important fungal pathogens are *Fusarium* and *Piricularia*. *P. oryzae* Cavara causes the blast of paddy which is especially destructive in Madras, the losses being 30-35% in certain localities. *Fusarium udum* Butler causing the wilt of pigeon peas, does much harm in parts of Mahārāshtra, Madhya Pradesh, Uttar Pradesh and Bihār. *F. vasinfectum* Atkins. is prevalent in the black cotton soil area of the Deccan and Gujarāt. The stem rot of jute caused *by Macrophomina phaseoli* Ashby is a limiting factor in the successful cultivation of this valuable crop.

Till 1931, only 2,351 species of fungi were known with 75 species under the Phycomycetes, 476 under the Ascomycetes, 1,339 under the Basidiomycetes, and 461 under the Fungi Imperfecti. By 1938 this number increased to 2,868, and in 1951 to 3,680. During the last 11 years, 64 new genera and 1,150 new species have been recorded—a good indication of the activity of mycologists and plant pathologists throughout the country.

9. *Lichens*

Although lichens occur in abundance in the mountains of India, their study has so far received only scant attention. C. Montagne, C. Babington, W. Nylander, J. Müller Argoviensis, J. Stirton, A. Jatta, R. Paulson and A. L. Smith made the initial contributions to the lichen flora of India. G. L. Chopra (1934) gave a comprehensive and illustrated account of 75 lichens collected from Darjeeling and the Sikkim Himālayas. Presently, D. D. Awasthi at Lucknow has taken much interest in a study of the Indian lichens.

The chief interest of lichens lies in their comprising two distinct symbiotic partners, a fungus and an alga. The algal cells are enveloped in the intricate felted mass of fungal hyphae, and the two members mutually benefit by this assosiation. The fungal element generally belongs to the Ascomycetes (only three genera are basidiomycetous and of these only one is known from India), the algal partner being a member of the Myxophyceae or the Chlorophyceae. The lichens form incrustations (crustos forms), foliaceous masses (foliose forms), or branching forms (fruticose forms) on rocks, soil, tree-trunks, leaves and other suitable substrata.

Over 800 species are known from the Indian subcontinent (including Nepāl) and the Andamans. Of these the following families are represented by a large number of species : Usneaceae (78 spp.), Parmeliaceae (74 spp.), Graphidaceae (71 spp.), Lecanoraceae (62 spp.), Physciaceae (61 spp.), Lecideaceae (60 spp.), Cladoniaceae (53 spp.), and Pyrenulaceae (45 spp.). The other families which have a smaller number of species are Collemaceae (28 spp.), Stictaceae (18 spp.), and Peltigeraceae (15 spp.) while families like the Dermatocarpaceae, Caliciaceae, Sphaerophoraceae, Diploschistaceae, and Teloschistaceae are represented by less than 5 species each.

The crustose lichens occur abundantly in India in deciduous and mangrove forests and alpine regions on tree and rocky surfaces. Only the temperate regions are really favourable for the best growth of lichens, and some species reach up to an altitude of 5,000 m. A few also inhabit snow and glacial beds, growing as lithophilous forms on rocks and can withstand a burial under the snow for the greater part of the year. *Dermatocarpon miniatum* Th.-Fr. grows on exposed rocks, and *Caloplaca murorum* Th.-Fr. on volcanic rocks. *Endocarpon pusilum* Hedw., *Peltigera malacea* Ach. and *Cladonia rangiformis* Hoffm. grow on hard and dry soil. *Rinodina sophodes* Th.-Fr. occurs in salt marshes and *Cetraria ambigua* Bab. on hard soil in alpine belts. A good number of species such as *Lobaria pulmonaria* Hoffm., *Peltigera polydactyla* Hoff. and *Sticta fuliginosa* Ach. grow on the barks of various trees along with mosses. Altitudinally, *Coccocarpia pellita* Müll-Arg. and *Sticta weigeli* Wain. are the common forms between 1,220 m. and 1,525 m.; *Leptogium saturninum* Nyl. at 1,830 m.; *L. menziesii* Mont., *Lobaria pulmonaria* Hoffm. and *Peltigera canina* Willd. between 2,130 m. and 2,440 m.; *Cladonia furcata* Schrad. at about 2,740 m.; *Parmelia conspersa* Ach. at 3,655 m.;

Lobaria retigera Trevis. between 4,000 m. and 4,500 m.; and *Stereocaulon tomentosum* Fr. at 5,000 m.

A few species are of economic importance: *Lobaria pulmonaria* Hoffm. is used for asthma and lung troubles, *Parmelia perforata* Ach. as a diuretic, *P. saxatilis* Ach. for epilepsy and *Peltigera canina* Willd. for hydrophobia and jaundice. Several species yield dyes: *Diploschistes scruposus* Norm., *Parmelia physodes* Ach. (a brown dye), *Gyrophora lecanocarpoides* Th.-Fr. *Umbilicaria pustulata* Tuck. (a red brown dye) and *Parmelia olivacea* Nyl. (a yellow dye). *Parmelia physodes* Ach. and *Ramalina fraxinea* Ach. are considered suitable substitutes for gum-arabic, and *Ramalina farinacea* Ach. and *R. fraxinea* Ach. are used for making cosmetics. *Lobaria pulmonaria* Hoffm. is used in tanning and brewery, and *Dermatocarpon moulinsii* A. Zahlbr. is a substitute for cork for lining entomological collecting boxes. *Cladonia alpestris* Rabh. which occurs at higher elevations of the Himālayas, has been used in the Arctic areas as an article of food for the reindeer.

10. *Botanical Regions of India and their Floristic Compositions*

In their *Introductory Essay to the Flora Indica*, Hooker and Thomson (1855) attempted a phytogeographical analysis of the Indian flora as a whole; this was later incorporated by Hooker in *The Imperial Gazetteer of India* (1907).

Hooker divided the then British possessions of India into nine botanical regions, using the number of species of the ten largest families in each region as the most important criterion for his classification. The nine regions are: (1) the Eastern Himālayas extending from Sikkim to the Mishmi hills in Upper Assam; (2) the Western Himālayas extending from Kumaun to Chitrāl; (3) the Indus plain including the Punjab, Sind and Rājasthān west of Arāvalli range and Yamuna river; Kutch; and Northern Gujarāt; (4) the Ganga plain, from the Arāvalli hills and Yamuna river to Bengal; the Sundarbans; the plains of Assam and the low country of Orissa north of the Mahānadi river; (5) Malabār, the humid belt of hilly or mountainous country extending along the western side of the Peninsula from Southern Gujarāt to Cape Comorin, including Southern Gujarāt, the southern half of Kāthiāwār, the Konkan, Kanara, Kerala and the, Laccadive Islands; (6)the Deccan, the comparatively dry elevated tableland of the

Peninsula east of Malabä and south of the Ganga and Indus plains, together with, as a sub-region, the lowlying strip of coastland extending from Orissa to the Tirunelveli District known as the Coromandel Coast; (7) Ceylon and the Maldive Islands; (8) Burma; and (9) the Malaya Peninsula. Hooker was not sure where to place the Andaman and Nicobar Islands.

In the delimitation of these areas, it is difficult sometimes to apportion large areas into one or the other of two contiguous botanical regions. This is to be expected, since the changes in environmental conditions are gradual and not sudden. For instance, the north-western half of Käthiäwär is botanically similar to Sind, and the south-eastern to the Konkan. Nor is it possible to draw an absolute boundary line between the floras of the Indus and of the Ganga plains. A number of Upper Ganga plants intrude into the Indus plain and those of the Rājasthān desert into the Ganga plain. Again, the eastern limit of the Malabär region is undefinable, because of the number of spurs and valleys from its hills which project far into the Deccan region, almost crossing it. They carry with them types of the Malabär flora, which towards its northern limit, mingle with the floras of the Deccan and of the Indus and the Ganga plains.

Calder (1937) recognized only six main divisions of India: (1) the North-western Himälayas, (2) the Eastern Himälayas, (3) the Indus plain, (4) the Ganga plain, (5) the Deccan (with one eastern sub-province), and (6) Malabär.

Chatterjee (1939) based his divisions mainly on the endemic content of the dicotyledons in the different areas. He excluded Ceylon, the Maldives and Malaysia since these have floras distinctly different from the flora of India. Assam, which was included by Hooker in the Ganga plain region, was considered a separate region because of its distinctive flora (cf. Clarke, 1898). The Himälayas have been divided into three instead of two regions. Further, in consideration of the definitely older geological age of Peninsular India, the Deccan and Malabär regions have been regarded as floristically older. The revised floristic regions of Chatterjee, as applicable to present-day India (excluding Nepäl, Päkist n and Burma), are as follows: (1) Deccan, (2) Malabär, (3) Indus plain, (4) Ganga plain, (5) Assam, (6) Eastern Himälayas and (7) Western Himälayas. The Andamans, may be taken as the eighth botanical region of India.

From the point of view of their relatively low rainfall and humidity, the Deccan, the Indus plain, and the Western Himälayas show a marked contrast with Malabr, Lower Ganga plain

Assam and the Eastern Himālayas. The striking floristic differences between these two groups of regions are, therefore, quite understandable. Altitude is the chief factor in the characterization of the mountain vegetation of India, particularly in the Himālayas. Soil is a factor of more local significance. The members of the Dipterocarpaceae can be cited as a good example of preferential distribution with reference to rainfall and soil. In *Dipterocarpus*, there are species which favour a drier environment, such as *D. obtusifolia* Teysm. and *D. tuberculatus* Roxb., and others which are of a more hygrophilous type such as *D. turbinatus* Gaertn. f., *D. indicus* Bedd., *D. pilosus* Roxb. and *D. alatus* Roxb. In general, these two groups show further contrast in that the xerophilous species almost always occur gregariously and are deciduous, while the hygrophilous species occur sporadically and are evergreen.

Peninsular India, one of the three regions into which India is divisible on the basis of the percentage of endemic species, floristically comprises the Deccan and the Malabār regions, both of which together have a high endemic content next only to the Himālayas.

THE DECCAN REGION:—This comprises the entire, comparatively dry, elevated tableland of the Peninsula east of Malabār and south of the Indo-Ganga plain. The hills of the Vindhyas and Eastern Ghāts fall in this region. The Coromandel Coast extending from Orissa to Tirunelveli may be considered as a sub-region. Over the greater part of the Deccan region, the rainfall is less than 100 cm., and this amount is exceeded only in certain elevated parts which intercept the monsoon currents. However, the Coromandel sub-region (also termed Carnatic sub-region) receives the full benefit of the north-east monsoon and has a rainfall ranging from 62·5 cm. to 162·5 cm.

Among the palms of the Deccan region are *Phoenix sylvestris* Roxb., *P. robusta* Hook. f., *P. acaulis* Roxb., *P. humilis* Royle, *Calamus viminalis* Willd., *C. pseudotenuis* Becc., *C. rotang* L. and *Borassus flabelliefper* L.

Successful *Casuarina* plantations have been raised along the coast on sandy soil.

MALABĀR REGION:—This comprises the excessively humid (rainfall, more than 200 cm.) belt of mountain country running parallel to the west coast of the Peninsula. Itis mostly a hilly country, and except in the north, the mountains often rise abruptly from the flat coast of the Arabian Sea. Its abrupt western face is clothed with a luxuriant, evergreen forest merging towards the

drier north into the elements of the Deccan and the Indus plain floras. The eastern face slopes gradually into the elevated plateau of the Deccan but there are many spurs projecting far into the Deccan region, often enclosing valleys with a Malabār flora. A particularly great break occurs in the chain at the latitude of 11° N where a transverse valley separates Southern Kerala from the mountains north of it and carries species characteristic of the Malabār flora almost across the Peninsula. To this region belong the Nilgiri hills.

The endemic palms of this region are: *Pinangadicksonii* Bl., *Bentinckia coddapanna* Berry, *Calamus rheedei* Griff., *C. huegelianus* Mart., *C. brandisii* Becc., and *C. gamblei* Becc. Among other wild palms are species of *Phoenix*, *Caryota*, *Calamus* and *Corypha*. Of the commercial crops the most important are betel-nut (*Areca catechu* L.). coconut (*Cocos nucifera* L.), palmyra *Borassus flabellifer* L.), pepper (*pipernigrun* L.). coffee (*Coffea* spp.) and tea (*Camellia sinensis* O. Ktze.). In more recent times *Hevea brasiliensis* Müll.-Arg. (rubber), *Anacardium occidentale* L. (cashew-nut) and *Eucalyptus* spp. have been introduced successfully in suitable areas of this region, rubber in the very humid regions, cashew-nut along the coast, and eucalyptus in the Nilgiri and other hills. The coconut forms a major element in the economy of the Kerala State and it is common to see this palm lining the lagoons and canals of the coastline.

The Indo-Ganga plain, which is the poorest in endemic content, is divisible into the Indus plain region and the Ganga plain region.

INDUS PLAIN REGION:—This region comprises the plains of Punjab, Rājasthān west of the Arāvalli range and Yamuna river, Kutch and Northern Gujarāt. The rainfall is less than 75 cm. generally and in the driest regions of the desert area less than 12·5 cm. in the year.

The only indigenous palms in the Indus plain region are *Phoenix sylvestris* Roxb. and *Nannorrhops ritchieana* H. Wendl. The latter finds its north-eastern limit in the Salt Range and the south-western limit in Sind and Baluchistān, both of which areas are now in Pākistān.

Prosopis juliflora DC. and *P. glandulosa* Torr. of the arid regions of Mexico and Central America have been successfully introduced in connection with the soil conservation and afforestation of dry and desert areas.

GANGA PLAIN REGION:—This region stretches from the Arāvalli hills and the Yamuna river eastward to Bengal, including the Sundarbans and the low country of Orissa north of the

Mahānadi river. The bulk of this tract has been under cultivation from very early times. The forests, where they exist, are of widely different types. The sal forests of Oudh are probably mere remnants of the great sub-Himālayan sal belt, which at one time covered a much larger area than now and stretched for some distance into the adjoining plains; the lower Ganga sub-region, comprising both Bihār and Bengal, is much more humid than the upper region. *Areca, Phoenix, Borassus* and *Cocos* are cultivated; of indigenous palms mention may be made of *Corypha, Calamus* and *Daemonorops*. The third sub-region comprises the Sundarbans, which borders on the Bay of Bengal. The chief plants here are: *Heritiera fomes* Buch.-Ham. (Sundri), *Excoecaria agallocha* L., *Sonneratia apetala* Buch.-Ham., *S. caseolaris* Engl., *Xylocarpus molluccensis* Roem., *X. granatum* Koen.; *Amoora cucullata* Roxb., *Aegiceras corniculatum* Blanco, *Cynometra mimosoides* Wall., *Avicennia officinalis* L. and the mangroves *Ceriops tagal* C. B. Robbins, *C. roxburghiana* Arn., *Kandelia rheedii* W. et A., *Rhizophora mucronata* Lam. and *Bruguiera conjugata* Merr. The palm *Nipa fruticans* Wurmb. is gregarious in the swamps and on river banks, and *Phoenix paludosa* Roxb. is found in drier localities. A species of *Calamus* and another of *Daemonorops* are common.

ASSAM REGION:—This comprises the Brahmaputra and Surma valleys together with the intervening hill ranges—the Gāro Khāsi and Jaintia hills, and also the Nowgong, Nāga, Pātkai, Manipur and Lushai hills on the eastern and south-eastern frontiers of Assam. Over the greater part of this region the rainfall exceeds 200 cm., while Cherrapunji in the Khāsi hills, with a normal rainfall of 1,080 cm., is reputedly the rainiest spot in the world. The vegetation is luxuriant and the valleys, where they are not under tea or agricultural crops, are clothed with expanses of tall savannah grass or with dense forest often of an evergreen type.

The hill forests of the Assam region approximate in type to those of the Eastern Himālayan region, except that there is no alpine zone. These hill forests may be separated broadly into evergreen forests, broad-leaved forests and pine forests.

Shifting cultivation has destroyed much of the natural forest growth on these hills. The hill-tops of the Assam region, like those of the Nīlgiris, are open grasslands with trees and shrubs identical with or closely related to those of the Nīlgiris. The mountains to the east are often covered with bamboos.

Among palms of narrow distribution in the Assam region are: *Arecā nagensis* Griff. *Pinanga griffithii* Becc., *P. hookeriana* Becc.,

Didymosperma nana Wendl., *D. gracilis* Hook. f., and *Plectocomia khasyana* Griff. Besides these, there are a number of others of wider distribution, like *Wallichia densiflora* Mart., *Caryota* spp., *Licuala peltata* Roxb., *Phoenix* spp., *Daemonorops* sp., *Zalacca* sp. and several species of *Calamus.*

EASTERN HIMĀLAYAN REGION:—This region, extending from Sikkim eastwards, embraces the most humid portion of the Himālayan range. Darjeeling, Kurseong and other places are located in this part of the Himālayas. The Eastern Himālayan ranges, being at a somewhat lower latitude than parts of the Western Himālayas, are relatively warmer and the timberline, alpine flora and snowline are at slightly higher altitudes than in the Western Himālayas. More important is the humidity factor, precipitation being heavier in this part of the Himālayas. About 4,000 species of flowering plants are estimated to occur in this region, of which 20 are palms. Palms of this zone are species of *Wallichia, Licuala, Caryota, Daemonorops, Phoenix* and *Pinanga.* Sal, when present, occurs chiefly on the ridges, the intervening depressions being under mixed forests often with an abundance of *Dendrocalamus hamiltonii* Nees. At higher altitudes of this zone there appear two trees, *Betula cylindrostachys* Gamble and *Alnus nepalensis* D. Don.

The temperate zone of the Eastern Himālayas extends from 1,524 to 3,657 m. In the lower belt of this zone below 2,742 m. occur a large number of different broad-leaved species, including *Quercus lamellosa* Smith, *Q. lineata* Bl., *Q. pachyphylla* Kurz, and other oaks, *Castanopsis, Michelia excelsa* Bl., *Magnolia* and other Magnoliaceae, *Bucklandia populnea* R. Br., *Cedrela*, many laurels and maples, alder, birch, *Pyrus, Symplocos, Echinocarpus, Elaeocarpus, Meliosma* and *Eurya.* Conifers occur mostly above 2,742 m. They are *Abies webbiana* Lindl., *Picea spinulosa* Beiss., *Larix griffithiana* Hort. ex Carr., *Tsuga brunoniana* Carr. and two junipers. Among other plants of this zone may be mentioned numerous rhododendrons and dwarf willows. The bamboo *Arundinaria recemosa* Munro forms a dense growth in places. Two palms also occur in this zone. One is a scandent rattan (*Plectocomia himalayana* Griff.) and the other a fan palm (*Trachycarpus martiana* Wendl.).

The alpine zone extends from 3,657 m. to about 4,876 m. Several species of rhododendrons occur here and junipers of the upper temperate zone also extend high into this zone.

WESTERN HIMĀLAYAN REGION:—This comprises the sub-Himālayan tract and the Himālayan range from Kumaun to

Kashmir. In general, the Western Himālayas are much cooler and drier than the Eastern. The rainfall varies from 100 to 200 cm. although in some parts of the sub-montane tracts it reaches 250 cm. or more. These inner valleys and the north-western areas of this region have a dry climate. Naini Tāl, Mussoorie, Simla and Kashmīr fall under the Western Himālayan region.

The Sub-montane zone and lower hills, up to 1,524 m. contain an almost continuous belt of sal forest in the eastern portion of the tract as far west as the Yamuna river and to a very small extent beyond. Savannah lands break up the sal belt at intervals. In the western part of this region the forest becomes drier in character, the prevailing species in the sub-montane tracts and outer hills being *Acacia modesta* Wall., *Olea ferruginea* Royle, *Carissa spinarum* L., *Dodonaea viscosa* L. and other xerophytic species. Among palms, only five species occur in contrast to several in the Eastern Himālayas. They are locally found in Kumaun and are *Phoenix sylvestris* Roxb., *P. acaulis* Roxb., *P. humilis* Royle, *Wallichia densiflora* Mart. and *Calamus tenuis* Roxb.

The temperate zone, extending from 1,524 m. to 3,657 m. contains extensive forests of conifers and broad-leaved temperate trees. In the lower elevations, *Pinus roxburghii* Sar. prevails. Soon it gives place to deodar (*Cedrus deodara* Loud.) and blue pine (*Pinus wallichiana* A. B. Jack.); higher up, spruce (*Picea morinda* Link.) and silver fir (*Abies pindrow* Spach.) make their appearance and form forests of large extent between 2,438 and 3,352 m. of other conifers, the yew (*Taxus baccata* L.) is common in some localities. Cypress (*Cupressus torulosa* D. Don) is found locally, and the edible pine (*Pinus gerardiana* Wall.) occurs in the dry inner valleys. Oaks, chiefly *Quercus incana* Roxb., *Q. dilatata* Lindl., and *Q. semecarpifolia* Smith, maples (*Acer* sp.), horsechestnut (*Aesculus indica* Colebr.), popular (*Populus ciliata* Wall., elm (mostly *Ulmus wallichiana* Planch). alder (*Alnus nepalensis* D. Don and *A. nitida* Endl., the latter descending below the zone), birch (*Betula alnoides* Ham.), *Cornus*, *Prunus cornuta* Wall., *Rhododendron arboreum* Sm., and other trees occur. One species of *Trachycarpur* is the only palm occurring in the temperate region and is confined to Kumaun and Garhwāl.

The alpine zone extends from the upper limit of the temperate zone to about 4,572 m. or sometimes higher. The characteristic trees of this zone are the high-level silver fir, the silver birch (*Betula utilis* D. Don), and junipers. Unlike the Eastern Himālayan region, rhododendrons are far less numerous, being represented by only three species.

ANDAMAN REGION :—The flora of the Andaman and Nicobar Islands is related with that of Burma and Malaysia. The hilly tracts do not exceed 731 m. in height. Among palms, *Daemonorops manii* Becc., and *D. kurzianus* Hook. f. are endemic in the Andaman Islands. Four species of palms are endemic in the Nicobar Islands. They are *Ptychoraphis angusta* Becc., *Bentickia nicobarica* Becc., *Calamus nicobaricus* Becc. and *C. unifarius* Wendl. *Calamus andamanicus* Kurz, and *Pinanga manii* Becc. are endemic in both the Andaman and Nicobar Islands.

The main types of forests in this region are mangrove forests, beach forests, evergreen, semi-evergreen and deciduous forests and diluvial forests. The mangrove forests are similar to those found on the Indian mainland.

11. *Some Alien Flowering Plants*

With land connections on three sides, north, east and west, India has acquired a number of plants of other countries. The Himālayan range in the north has no doubt been a barrier; but there are passes in the north-west of Pākistān and north-east of India and they make a limited spread of plants possible. The areas that have contributed most to the alien elements in the Indian flora are Burma, Malaysia, South-west China, Eastern China, West Asia and Africa.

Hooker (1855) recognized the following principal elements in the Indian flora : (1) the Malaysian element which is the most dominant; (2) the European-Oriental element; (3) the African element; (4) the Tibeto-Siberian element; and (5) the Sino-Japanese element. The subcontinent was considered essentially a meeting place of floras from the west, north and east, and with little botanical character of its own. The then known endemic element was small but we have already shown that this is incorrect. Peninsular India and the Himālayas show a high degree of endemicity and hence of floristic distinctiveness. It may be added that almost all the nineteenth century botanists including Hooker obtained a biased view of tropical flora, starting as they did with the impoverished temperate floras of their own countries. The flora of Europe was taken as a starting-point with which floras of newly explored tropical lands were compared. Wulff (1950) said: "Thus Hooker (1855) finds in the flora of the Himālayas and Northern India a European element only because the species forming it are likewise found in the flora of Western Europe,

although, of course, it is perfectly clear that the centres of areas of these species lie precisely in the Himālayas, whence in post-glacial times they spread to Europe. Hence, this element might be designated as Himālayan in the flora of Europe but in no case as a European element in the flora of India."

Ridley (1942) made certain observations on the Indian flora with reference to the ancient Oligocene flora of the world. The Magnoliaceae, Lauraceae, Hamamelidaceae, Cupuliferae, Salicaceae, Ranunculaceae, Berberidaceae, Hypericaceae, Ternstroemiaceae, Rosaceae, Umbelliferae, Cornaceae, Primulaceae, Styracaceae Gentianaceae, Boraginaceae, Chenopodiaceae, *Engelhardtia*, *Carex*, and some other plants had a wide distribution in the Cretaceous times over the entire northern part of the world up to the arctic region. In India, this flora is now practically limited to the Himalayas. Rarely, however, some representatives of these families are seen as far southwards as the mountains of Java and Sumatra.

A considerable flora in the tropical parts of India, consisting chiefly of trees and shrubs of the rain forest type, extends from Malaysia through India to North Africa and reappears in Eastern South America. This flora seems to have originated in the Oligocene period, or at least was in existence even then as far north as Southern Europe. It has now largely disappeared in the heavily populated and long cultivated regions of India and Central Africa and only some relics are preserved in remote mountainous areas. We have additional proofs of the lost forest flora of the Indo-Ganga plain in the presence of the peacock and the ape, both forest-lovers, and preserved only for religious motives. Among the genera of this category we may mention: *Tetracera*, *Salmalia*, *Eriodendron*, *Sterculia*, *Buettneria*, *Erythroxylon*, *Zizyphus*, *Casearia*, *Buddleia*, *Vitex*, *Tragia*, *Elatostemma*, *Burmannia*, *Xyris*, *Sciophila* and many others. *Rhipsalis* is interesting as the only representative of the Cactaceae in the Old World.

After the Miocene the eastern end of the Mediterranean Sea became closed up, desert formation occurred in Arabia and Baluchistān (Pākistān) and a desert flora invaded Sind (Pākistān) and Rājasthān and even as far down as the south. Very characteristic of such desert plants are the Salvadoraceae (*Azima* and *Salvadora*), *Dodonaea*, *Acacia*, *Heliotropium*, *Indigofera*, Crassulaceae, Zygophyllaceae, Capparidaceae and many desert Cruciferae and grasses. Many of the weeds of cultivation common in waste ground all over India are probably due to the invasion from this region.

A number of plants found in Ceylon have come along the South of Asia but have not reached India proper. They show a former land connection between the Malay Islands—probably Sumatra and Ceylon. Of these, the most interesting are *Acrotrema*, *Anaxagorea*, *Cullenia*, *Kurrimia*, *Pometia pinnata* Forst f., *Timonius koenigii* Bl., and *Lagenophora billardieri* Cass. Most members of the Annonaceae and Menispermaceae of Ceylon have affinities with those of Malaysia and not India.

A large proportion of the maritime plants of India seem to have evolved in the coral islands of Polynesia and Malaysia. Their seeds must have drifted along the south coast of Asia, settling on the shores of Ceylon and the Coromandel Coast of India. Some passed on even to East Africa and its islands. Such plants are *Calophyllum inophyllum* L., *Ochrocarpus*, *Samadera*., *Xylocarpus granatum* Koen., *Colubrina asiatica* Brongn., *Desmodium umbellatum* DC., *Derris uliginosa* Benth., *Intsia bijuga* O. Ktze., *Rhizophora candelaria* DC., *Bruguiera sexangula* Pers., *Pemphis*, *Scyphiphora*, *Guettarda*, *Wedelia biflora* DC., *Ochrosia*, *Tournefortia argentea* L.f., *Avicennia officinalis* L., *Cassytha*, *Hernandia*, *Flagellaria*, *Remirea maritima* Aubl. and *Spinifex littoreus* Merr., *Heritiera* and a species of *Dolichandrone*, *D. spathacea* K. Schum., have travelled from the Indian region as far as the Philippines and New Caledonia by sea.

The genus *Scaevola* is mainly Australian. Two of its species, *S. frutescens* Krause and *S. plumieri* Vahl, have spread to the coasts of Peninsular India.

The palm, *Nipa fruticans* Wurmb., is now found in the Bay of Bengal and along Malaysia as far as the Solomon Islands, but is quite absent from Africa and America. In Eocene time, an almost identical species was abundant in Southern England and along the Mediterranean as far as Cairo. *Acanthus ilicifolius* L. and *A. volubilis* Wall. of the Sundarbans and coasts of India had a closely related species in the Isle of Wight in the Oligocene time.

Ridley (1942) states : "No story of plant distribution is complete without a considerable knowledge of tertiary palaeobotany nor can be understood without a comprehension of the position and form of land surfaces during that period, the time of the evolution of flowering plants. The modern Asiatic flora is probably what remains of the Oligocene flora which probably occupied all tropical regions as far north as Europe." Many of the early genera and perhaps families have disappeared on account of the vicissitudes of climatic and geological changes, but some species of

that date seem to have persisted, with little or no alterations, to the present day. Further researches are needed to correlate the extinct and the living groups of flowering plants and probably to fix the date and place of origin of the present Indian flora, and indeed of the floras of the world at large.

Some 38 per cent of the Indian flowering plants have immigrated from foreign lands at various times in the past and have since become naturalized. Some of these aliens have become so well naturalized and successful as to appear really indigenous.

A number of plants originally under cultivation in gardens and fields are now found as escapes that have become thoroughly established by natural agencies like wind, water and animals. Typical examples are: *Lantana camara* var. *aculeata* Mold., *Ipomoea angulata* Lam., *Ageratum conyzoides* L., *Eupatorium glandulosum* H.B. et K., *Helianthus annuus* L., *Tithonia tagetiflora* Desf., *T. diversifolia* A. Gray, *Barleria cristata* L., *Adhatoda vasica* Nees, *Clitoria ternatea* L., *Jatropha gossypifolia* L., *Pedilanthus tithymaloides* Poir., *Eichhornia crassipes* Solms, *Peperomia pellucida* H.B. et K., *Cryptostegia grandiflora* R. Br., *Agave augustifolia* Haw., *Opuntia cochinellifera* Mill. and *Dioscorea alata* L.

Man has been responsible for the import of many alien plants, in some instances deliberately, in others by chance. History tells us that the early Aryan settlers from the countries lying north-west of India brought with them a number of economic plants. It is quite likely that several other plants travelled with them as camp followers, with their seeds or other propagules either mixed with those of the economic plants or stuck to the bodies of the sheep and cattle which these pastoral tribes from the north brought with them. Thus, from almost the dawn of civilization man has been changing the flora of this country by clearing the ground of its primary vegetation and introducing aliens by accident or on purpose.

The great majority of naturalized plant aliens are troublesome weeds competing with cultivated plants or otherwise affecting human welfare. Only in a few instances it is possible to date the actual arrival of a species.

Some weeds have been introduced in comparatively recent times. They have come with foodgrains, ballast, packing materials and seeds of economic plants, or merely by adherence to the clothing of man and the hair of domestic animals. When they arrived in their new homes, they were further distributed by natural causes like wind and water. Their naturalization might

have been further aided by deforestation, faulty methods of pasturage and harvesting,shifting cultivation, construction of roads and railway lines, and continued sowing of impure seed. *Croton bonplandianum* Baill. is a familiar example of a weed which is now widespread in this country. About the year 1897 a ship arrived at Chittagong (now in East Pākistān) from La Plata with a ballast of mud from South America. To get rid of the mud. it was supplied to a local gardener for soil. That mud contained seeds of this plant; they germinated, and the seedlings flowered and fruited. The plant gradually travelled along railway lines and by steamer to Calcutta and is now a common weed chiefly along rail tracks, roads and canal banks. A similar history attaches to the introduction of *Eupatorium odoratum* L. from the West Indies to India, East Pākistān and Burma, by seeds confined to the ballast heaps of cargo boats calling at Singapore. During recent years it has been seen in the teak plantations of the Kerala State. It is believed that the seeds were brought down to Kerala from Assam by labourers returning from the Assam front after the Second World War. The seeds stuck to their beddings and clothes, thus bridging the long distance from Assam to Kerala. The seeds of *Argemone mexicana* L., now widespread in the tropical parts of the world, are said to have been borne to distant places in ship's ballast from Mexico and the West Indies. Recently, another species of this genus. *A. ochroleuca* Sweet sub-sp. *ochroleuca*, has also been found in India. *Aeschynomene americana* L., a native of the West Indies and tropical America, has been recorded from the Hazāribāgh area. It is possible that a few viable seeds of this species might have reached India along with some packing material during the Second World War, when a large number of American army units were stationed in various parts of India.

Lantana camara var. *aculeata* Mold. and *Eichhornia crassipes* Solms are two remarkable examples of plants which were wilfully introduced to this country as ornamentals but subsequently became so well naturalized as to become serious pests. *Lantana* grows rapidly to form impenetrable thickets in forest lands, and these are difficult to clear by hand because of the prickles on the branches of the plants. Birds feed on the fruits and account for the rapid dispersal of the seeds. *Eichhornia crassipes* Solms (water hyacinth) is a native of the Amazon region of Brazil but is now widespread in Tropics throughout the world. It was brought into India towards the end of the 19th century and soon established itself so successfully that it became a nuisance. Hence its nickname, "Terror of Bengal". It grows gregariously, floating on water or rooted when

stranded on wet soil. Rapid vegetative propagation accounts for its profusion, although seeds are also produced. The thick growth of the plant hinders navigation in water channels, chokes drainage, and provides a breeding ground for mosquitoes that spread malaria and other diseases. Eradication of this pest by hand is very laborious. In recent years, certain hormones have been effectively used in some countries for the eradication of this troublesome pest.

The prodigious spread of some of these recent introductions is viewed with awe. To *Lantana* and *Eichhornia* may be added, among others, *Hyptis suaveolens* Poit. which covers whole hill-sides in Western India and other parts of the country, and *Acanthospermum hispidum* DC. which has spread over very large areas in Gujarāt and other parts of India. These alien new-comers find conditions very suitable for their growth and propagation; at the same time they are free from their natural enemies (insect, animal or plant), which in their native countries keep the plants under control. The alien weed has been imported into India, but generally its enemies have been left behind.

The introduction, spread and eventual control of the prickly pears (*Opuntia*) in India is a long and eventful story. Although no record exists to show when the first alien *Opuntia* reached this country, it must have been well before 1800 A.D. since by then it had become widespread in certain parts of India. It is narrated that sailing boats carried the stem of prickly pears to serve as vegetables at a time when anything green, not actually poisonous even if unpalatable, was used to prevent scurvy among sailors. *Opuntia* may thus have found its way from the New World into India via Europe. It is on record that small enclosures, bounded by hedges of *Euphorbia* and *Opuntia*, caused the entanglement of Tipu's horse in the battle of Poongar on the banks of the river Cauvery on September 12, 1790. The practice of making fences out of prickly pears, and the natural dispersal of their seeds by birds after they had eaten the fruits, greatly contributed to the spread of the plants. A long fence of this kind, called the "Salt Wall", was made over miles of the Rājasthān border to prevent smuggling. Prickly pears were also used for the protection of young shade trees along roadsides. All this afforded the plants many new starting points for fresh encroachment and they gradually became a serious pest of garden and field. In some places they formed dense thickets, an excellent shelter for snakes. At the end of the 18th century, the East India Company tried to establish in this country a cochineal dye industry which was till then a Spanish monopoly in America. The cochineal insect feeds on

species of *Opuntia* and through the efforts of the ompany, in collaboration with Dr. James Anderson at Madras and Dr. William Roxburgh at Calcutta, several new species of *Opuntia* were introduced into cultivation in India, along with the cochineal insect. However, the production of the dye was not satisfactory and by 1810 the Government was compelled to discontinue the project, although attempts to introduce cochineal continued till 1883. The insect, introduced into India in 1795, was a blessing in disguise. It spread rapidly on plants of *O. monacantha* Haw. devouring them branch and root, and in the course of twenty years annihilated this pest in South India almost totally. In the north, it took about sixty years for the insect to spread from Bengal up the Ganga plain and over the Indus plains more than 1,200 km. away. *Opuntia monacantha* Haw. had by then become a pest in the Punjab. Sher Singh, ruler of Lahore, inflicted fines on people who allow this plant to grow on their grounds. Within a year of the invasion of the Punjab plain by the cochineal insect, the prickly pear in the area was thoroughly destroyed and a large supply of dye was available to the local Kashmīrī dyers. *Opuntia monacantha* Haw. is now comparatively rare. *Opuntia dillenii* Haw. and *O. elatior* Mill., on the other hand, were immune to the species of cochineal insect originally introduced into India. In comparatively recent times, other species of the cochineal insect were imported into South India in an attempt to eradicate *Opuntia dillenii* Haw. in particular. This measure was successful in bringing this pest also under control.

SELECT BIBLIOGRAPHY

AWASTHI, D. D. Contributions to the Lichen Flora of India and Nepa *Journal of the Indian Botanical Society*, Vol. XXXIX. 1960.

BEDDOME, R. H. *The Ferns of the Southern India ; descriptions and plates of the Ferns of the Madras Presidency.* Madras, 1863.

—— *Handbook to the Ferns of British India, Ceylon and the Malay Peninsula,* Calcutta, 1883.

—— *Handbook to the Ferns of British India, Ceylo : and the Malay Peninsula with Supplement.* Calcutta, 1892.

BLATTER, E & d'ALMEIDA, J. F. *The Ferns of Bombay.* Bombay, 1922.

BOERGESEN, F. Some Indian Green and Brown Algae, especially from the shores of the Presidency of Bombay. *Journal of the Indian Botanical Society* Vol. IX, 1930; Vol. XII, 1933.

—— Some Indian Rhodophyseae especially from the shores of the Presidency of Bombay. *Kew Bulletin*, No. 1, 1931; No. 3, 1932; No. 3, 1933; No. 1, 1934.

—— Contribution to a South Indian Marine Algal Flora. *Journal of the Indian Botanical Society*, Vol. XVI, 1937; Vol. XVII, 1938.

BOR, N. L. *Manual of Indian Forest Botany*. Bombay, 1953.

BRUHL, P. A Census of Indian Mosses. *Records of the Botanical Survey of India*, Vol. XIII, No. 1, 1931.

BURKILL, I. H. Chapters on the History of botany in India. I-VII. *Journal of the Bombay Natural History Society*, Vol. 51, 1953; Vol. 54, 1956; Vols. 58-60, 1961-63.

BUTLER, E. J. Some Indian Forest Fungi. *The Indian Forester*, Vol. XXXI, No. 11, 1905.

—— & BISBY, G. R. *The Fungi of India* : Revised by R. S. Vasudeva. The Indian Council of Agricultural Research. New Delhi, 1960.

CALDER, C. C. An Outline of the Vegetation of India. *An Outline of the Field Sciences of India*. Indian Science Congress Association, Calcutta, 1937.

CHAMPION, H. G. A Preliminary Survey of the Forest Types of India and Burma. *Indian Forest Records*. New Series, Silviculture, Vol. 1, 1936.

CHATTERJEE, D. Studies on the Endemic Flora of India and Burma. *Journal of the Asiatic Society of Bengal*, Vol. V, No. 1, 1939.

—— Floristic patterns of Indian vegetation. *Proceedings of the Summer School of Botany*, Darjeeling (1960), New Delhi, 1962.

CLARKE, C. B. *A Review of the Ferns of Northern India*. London, 1880.

DESIKACHARY, T. V. *Cyanophyta*. The Indian Council of Agricultural Research, New Delhi, 1959.

HOOKER, J. D. *A Sketch of the Flora of British India*. London, 1904.

—— Botany [of British India]. *Imperial Gazetteer of India*, Vol. I, 1907.

—— & THOMSON, T. *Introductory Essay to the Flora Indica*. London, 1855.

HOOKER, W. J. & BAKER, J. G. *Synopsis Filicum or a Synopsis of All Known Ferns*. London, 1868.

KASHYAP, S. R. *Liverworts of the Western Himalayas and the Punjab Plains*, Pt. I. Lahore, 1929; Supplement, Lahore, 1932.

—— & CHOPRA, R. S. *Liverworts of the Western Himalayas and the Punjab Plains*, Pt. II. Lahore, 1932.

MAHESHWARI, J. K. Studies on the naturalized flora of India. *Proceedings of the Summer School of Botany.* Darjeeling (1960). New Delhi, 1962.

MAHESHWARI, P. & KAPIL, R. N. *Fifty years of Science in India ; Progress of Botany.* Indian Science Congress Association. Calcutta, 1963.

MATHUR, C. M. Forest types of Rajasthan. *The Indian Forester,* Vol. 86, No. 12. 1960.

MITTEN, W. Musci Indiae Orientalis (Supplement of Botany, Vol. 1). *Journal of the Proceedings of the Linnean Society,* Vol. IV. 1860.

—— Hepaticae Indiae Orientalis. *Journal of the Proceedings of the Linnean Society,* Vol. V. 1861.

RAIZADA, M. B. & SAHNI, K. C. Living Indian Gymnosperms. Pt. I, (Cycadales, Ginkgoales and Coniferales). *Indian Forest Records,* New Series, Botany, Vol. V, No. 2. 1960.

RAMAKRISHNAN, K. & SUBRAMANIAN, C. V. The Fungi of India. *Journal of the Madras University,* Vol. XXII (B), No. I. 1952.

RANDHAWA, M. S. *Zygnemaceae.* The Indian Council of Agricultural Research. New Delhi, 1959.

RIDLEY, H. N. Distribution Area of the Indian Floras. 150th *Anniversary Volume,* Pt. II. Royal Botanical Garden. Calcutta, 1942.

RAZI, B. A. A Second list of species and genera of Indian Phanerogams not included in J. D. Hooker's Flora of British India. *Records of the Botanical Survey of India,* Vol. XVIII, No. I. 1959.

SANTAPAU, H. Systematic Botany of Angiosperms. *History of Botanical Researches in India, Burma and Ceylon,* P. Maheshwari (Ed.), Pt. II, Bangalore City, 1958.

—— The present state of taxonomy and floristics in India after Independence. *Bulletin of the Botanical Survey of India,* Vol. IV. 1962.

STEBBING, E. P. *The Forests of India,* Vols. I-IV. London, 1922-62.

SUBRAMANYAM, K. *Aquatic Angiosperms.* Council of Scientific and Industrial Research. New Delhi, 1962.

THOTHATHRI, K. Contributions to the flora of Andaman and Nicobar Islands. *Bulletin of the Botanical Survey of India,* Vol. IV. 1962.

TROUP, R. S. *The Silviculture of Indian Trees,* Vols. I-III. Oxford, 1921.

ZAHLBRUCKNER, A. *Catalogus Lichenum Universalis,* Band 1-10. Leipzig/ Berlin, 1922-1940.