The 150th

ANNIVERSARY VOLUME

OF THE

ROYAL BOTANIC GARDEN, CALCUTTA

Parts I and II

Edited by

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Superintendent, Government Printing
Bengal Government Press, Alipore, Bengal
1942

Price—Indian Rs. 12; English, 19s. 6d.

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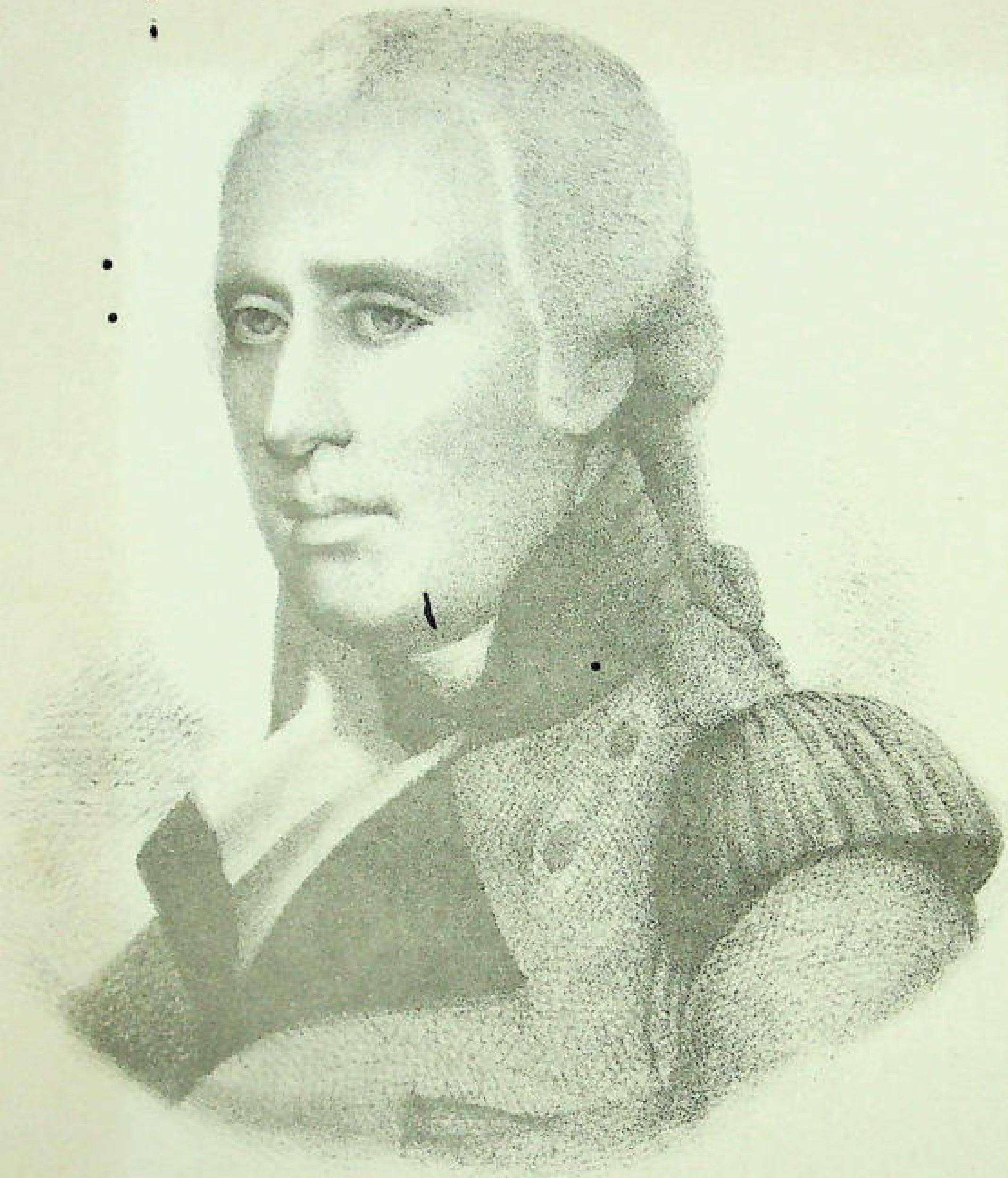

Col. ROBERT KYD,

Honorary Superintendent of the Hon'ble the East India Company's

Botanical Garden at Calcutta,

1786 — 1793.

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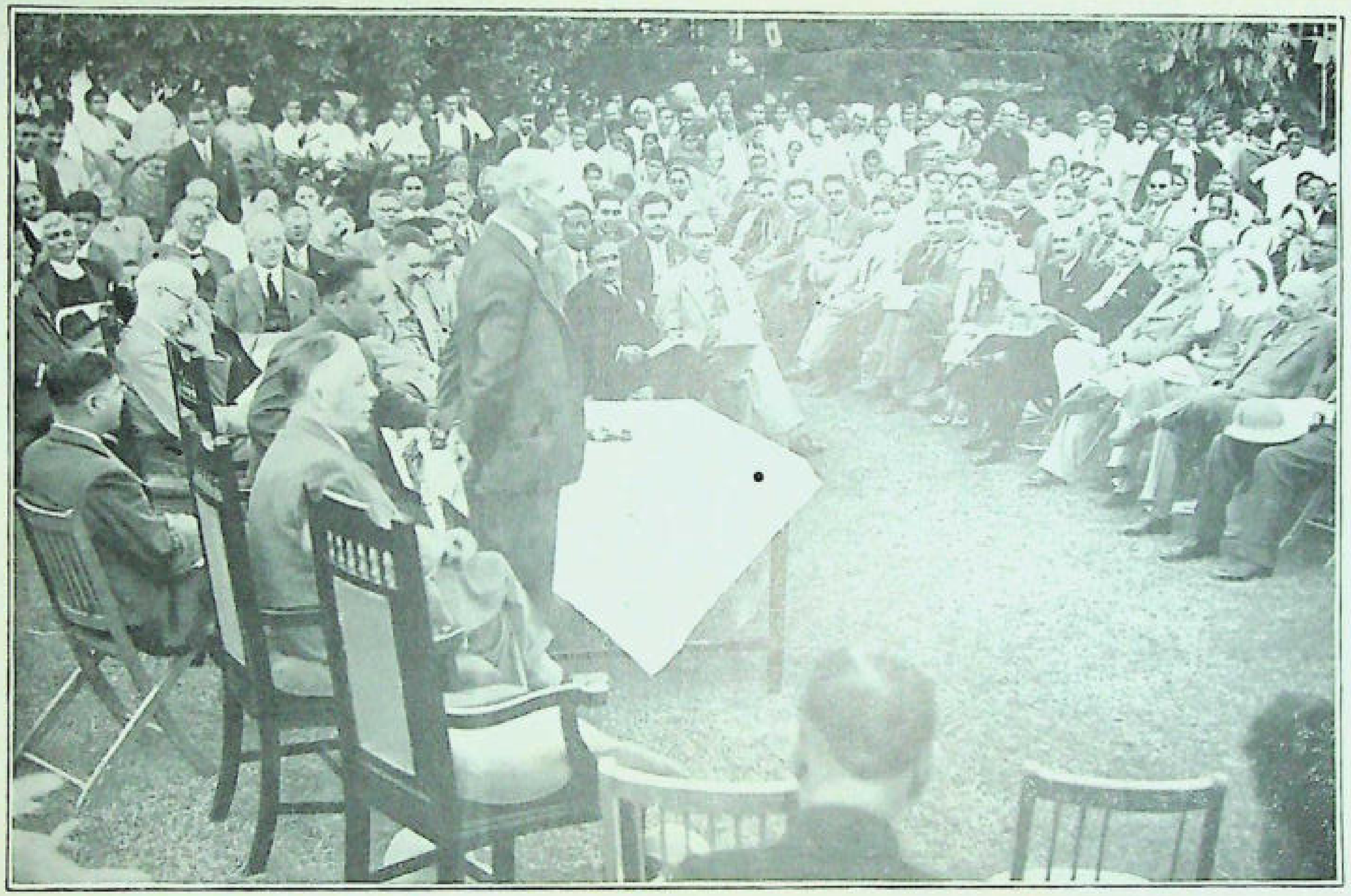
Part I

Photograph of the unique gathering of the British and Indian botanists at the 150th Anniversary of the Royal Botanic Garden, Calcutta



From left to right—(1) Sir James Jeans; (2) Sir Arthur Hill speaking; (3) Dr. K. Biswas; (4) The Hon'ble Nawab Khwaja Habibullah Bahadur, of Dacca, Minister; (5) Professor Blackman of the Imperial College of Science, London, and others.

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Foreword

by

His Excellency Sir John Arthur Herbert, G.C.I.E., Governor of Bengal,

to the 150th Anniversary Volume of the Royal Botanic Garden, Calcutta

The sesqui-centenary anniversary of the Royal Botanic Garden, Calcutta, which fell on the 6th day of January 1938, was indeed a red-letter day in the history of the Garden. Thanks to the presence of several renowned scientists then attending the Silver Jubilee Session of the Indian Science Congress at Calcutta, it was celebrated in a befitting manner, and I cordially welcome the publication of this Volume commemorating that happy and historic occasion. In it are recorded the good wishes of renowned institutions and personalities from all over the world who are interested in the welfare of this Garden, and its value has been greatly enhanced by the inclusion in it of many illuminating contributions, which range over the various aspects of botanical science and have emanated from the pens of a number of eminent botanists.

I associate myself whole-heartedly with the sentiments which have been expressed in appreciation of the continued services rendered by the Royal Botanic Garden, Calcutta, for a period of over 150 years. I wish it many more years of useful service and prosperity, and I confidently hope that when peace and goodwill are once more restored to the world, the Garden and its famous Herbarium will make a still greater contribution to our knowledge of the botanical, horticultural and arboricultural sciences.

J. A. Herbert

Proceedings

The 150th Anniversary of the Royal Botanic Garden, Calcutta, was celebrated in a befitting manner on the 6th January 1938. A distinguished company, which included many of the famous British and Indian scientists then attending the Indian Science Congress, was present. The Hon'ble Nawab Khwaja Habibullah Bahadur, of Dacca, Minister-in-charge, Agriculture and Industries Department, Government of Bengal, presided.

After extending a warm welcome to the guests, Dr. Biswas, M.A., D.SC. (Edin.), F.R.S.E., Superintendent, Royal Botanic Garden, Calcutta, gave a short history of the foundation of the gardens, and their usefulness in the sphere of cultivation of economic products extending for a period of 150 years.

Speaking on behalf of the British delegation, Sir James H. Jeans, O.M., D.SC., SC.D., LL.D., F.R.S., offered his hearty felicitations and good wishes for the future prosperity of the garden. Sir Arthur William Hill, K.C.M.G., M.A., SC.D., D.SC., F.R.S., F.L.S., F.N.Z. Inst., Director, Royal Botanic Gardens, Kew, in his speech commented on the similarity of the situation of Kew Gardens and the Sibpur Botanic Gardens.

Felicitations were also offered among others by Dr. C. D. Darlington, Director, John Innes Horticultural Institution, London; Dr. R. P. Paranjpye, Vice-Chancellor, Lucknow University; Mr. J. van Manen, on behalf of the Royal Asiatic Society of Bengal; Professor P. Parija, Principal, Ravenshaw College, Cuttack; Professor S. P. Agharkar, Head of the Department of Botany, Calcutta University and Professor S. R. Bose, Professor of Botany, Carmichael Medical College and President, Indian Botanical Society.

After a vote of thanks the guests were shown round an exhibition of horticultural and economic plants of the Royal Botanic Garden. They were then treated by Dr. Biswas to light refreshments. Later the guests visited the famous Herbarium and the Library of the Royal Botanic Garden, Calcutta, followed by a visit to the old Great Banyan tree and other interesting spots of the garden.

Messages of goodwill and congratulations were received from distinguished persons, reputed botanists, different Universities, famous botanical and scientific institutions and societies all over the world.

K. BISWAS.

Herbarium, Royal Botanic Garden, Calcutta,
The 6th July 1938.

Dr. Kalipada Biswas

Address of Welcome by Dr. K. Biswas, M.A., D.Sc. (Edin.), F.R.S.E., on the 150th Anniversary of The Royal Botanic Garden, Calcutta (1787-1937).

HON'BLE NAWAB BAHADUR, LADIES AND GENTLEMEN—

I have much pleasure in according you all cordial welcome. It is a happy coincidence that this garden has just completed the 150th year of its existence, and I have taken the golden opportunity to celebrate this anniversary along with the Silver Jubilee Session of the Indian Science Congress Association in Calcutta. I am lucky to have here this afternoon, both my overseas and Indian colleagues taking active part in such a historic event in the long life of this garden. The presence of such distinguished botanists on this occasion is a landmark in the annals of the Royal Botanic Garden, Calcutta. Their presence also adds fresh incentive to the workers of this institution towards its further development.

On behalf of the staff of this institution and on my own behalf I accord you, my overseas friends, most sincere and hearty welcome for your co-operation in this function and for taking such keen interest in the advancement of botanical researches of my motherland. I shall have to approach you again for your scientific contributions for the 150th Anniversary Volume of the Royal Botanic Garden, Calcutta, which will be published in due course.

My grateful thanks are due to all those who have kindly sent messages on this occasion. These messages are fresh source of inspiration to the workers of this institution.

In this gathering I feel the absence of the most respected and distinguished man of science of India, the late Sir Jagadish Chandra Bose. Sir Jagadish used to take a very keen interest in the welfare of this garden and by his occasional visits to the garden inspired me in my work. By offering plant materials and botanical information from time to time during the course of Sir Jagadish's investigation on plant life, this institution feels itself to have been greatly honoured. Sir Jagadish's life was devoted not to professional survival of family honour, but to the pursuit of scientific truth. Sir Jagadish won the love and admiration of every one. Nothing but the most gracious and kindest thoughts can be entertained of Sir Jagadish, the man and the great patriot. The scientific world deplores his death today and we, his countrymen, deeply mourn the irreparable loss we have suffered.

Among those we have sent messages I miss a message from one of the greatest admirers of this garden—Professor Hans Molisch, a colleague and intimate friend of Sir Jagadish who followed his friend in the eternal journey. Professor Molisch used to pay frequent visits to this garden in 1929, when he visited India and worked in Sir J. C. Bose's laboratory. He used to spend long hours in the garden brooding over many an intricate problem of plant life. He described the garden, to quote his own words, " a paradise, a wonderful field for botanists, who should come here and talk to the trees. Life of every species grown here under this climate offers problem of careful investigation." In Professor Molisch I lose a sincere friend, an expert teacher and a respected colleague.

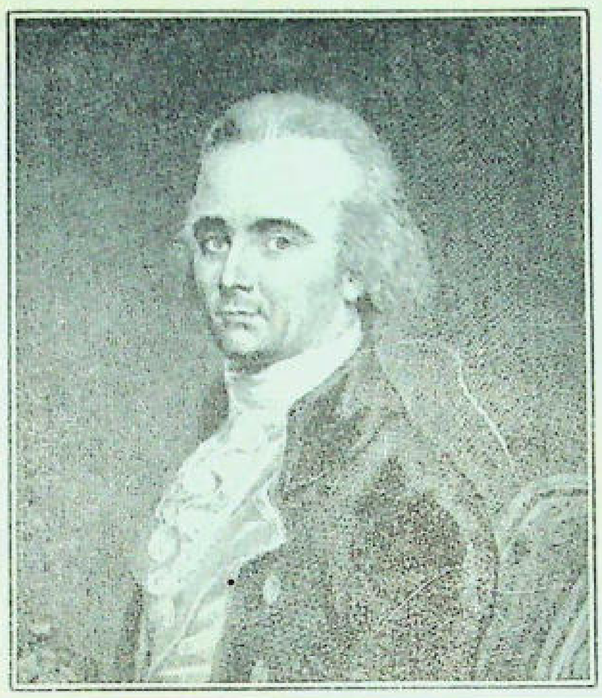
It will not be inappropriate to tell you briefly the history of the garden and the contribution it has made to the botanical science during a period of a century and a half.

THE ROYAL BOTANIC GARDEN, CALCUTTA

The Royal Botanic Garden, Calcutta, is situated on the bank of the river Hooghly and is only a few miles from Calcutta, the second city of the Empire. The Botanic Garden at Sibpur has thus great similarity to the Royal Botanic Gardens, Kew, which is situated on the bank of the river Thames and is only a few miles from London. But the Royal Botanic Garden, Calcutta, has a little different origin from its sister garden, the Royal Botanic Gardens, Kew, which is younger than the Calcutta Garden by about fifty years. The Royal Botanic Gardens, Kew, owes its origin to the interest in botany of royalty. The Royal Botanic Garden, Calcutta, on the other hand, like many other overseas botanic gardens founded in later years of the 18th century, has been founded with economic and scientific aims. Although the Royal Botanic Gardens, Kew, at present can claim to be the largest botanic garden possessing the largest herbarium in the world, it was started with only 15 acres of land in 1841. The Kew Gardens, however, rapidly expanded in the hand of its well-known first Director, Sir William Hooker, who before he became the first Director of Kew was Professor of Botany, Glasgow University. Kew garden at present occupies an area of 288 acres. The Royal Botanic Garden, Calcutta, on the contrary, started with about little over 300 acres of land, and can rightly claim its position as the world's largest and one of the oldest botanic gardens up to the middle of the 19th century. Calcutta Garden at present occupies an area of 273 acres.

Colonel Robert Kyd of the Bengal Infantry, the then Superintendent of the Hon'ble Company's Dockyard and Secretary to the Military Board of Fort William, a keen horticulturist, suggested on the 1st January, 1786, to the Governor-General, Sir John Macpherson, then officiating as Governor-General in the absence of Warren Hastings, to form a botanic garden in Calcutta. Without further delay effect was given to Kyd's proposal and with the subsequent approval of the Court of Directors in England, the present site then measuring about 310 acres immediately below Kyd's private gardens at Shalimar was acquired. Colonel Kyd very appropriately was also appointed as the Honorary Superintendent and the work of developing this area into a botanic garden commenced with Kyd's valuable collection of exotic plants. But Kyd never lived within the garden. He had a town house in Calcutta very likely one of those houses now occupied by Sir David Ezra in Kyd Street. Kyd, however, passed a good deal of his time at Shalimar. The garden was henceforth the property of the East India Company but under the control of the Governor-General in Council. This is the reason why the garden is still known among the local people as the " Company Bagan". When the East India Company dissolved all the rights, duties and privileges were assumed by the Crown and the garden became Her Majesty's Botanic Garden. Apparently, on the constitution of the Province of Bengal in 1834, the control of the garden passed on to the local Government. The epithet " Royal " came to be applied to it after the Queen's Proclamation of 1857. Kyd continued to perform the duties as Superintendent until his death in 1793. A monument was erected to his memory in 1795 on the site selected by Lieutenant-Colonel Robert Kyd himself. On a marble pedestal stands a beautiful marble urn by Banks, the sculptor. The monument bears the carved inscription "*Robert Kyd, Mil. Trib. Horti. Fundatori, posuit A. K. MD. CCXCV*".

Dr. William Roxburgh, the Company's Botanist in Madras, was appointed as the first official Superintendent in 1793. Roxburgh built the present house in 1795. This house is now 146 years old. Roxburgh was the first to draw up a catalogue of 3,500 plants then growing in the garden. This catalogue "Hortus Bengalensis" (in two parts) was published after Roxburgh's departure from India in 1814 by his friend Rev. Dr. William Carey, D.D., the celebrated missionary. Roxburgh's "Flora Indica," his "Plantae Coromandelianae,"



Dr. William Roxburgh

composed of three volumes, and his magnificent large portfolio coloured illustrations numbering 2,382 embodied in 35 volumes, prepared during his period from 1794-1813 with the help of Indian artists, form the basis of Hooker's Flora of British India and many subsequent works on Indian plants. Roxburgh's work justly earned for him the title of "the father of Indian botany". The famous scientific society under the title of "United Brotherhood" was established at this time by Roxburgh's preceptor John Gerad Koenig, a pupil of Linnaeus who was the guiding spirit of proper botanical studies in India. Sir William Jones, the founder of the Asiatic, now the Royal Asiatic Society of Bengal, was one of the members of this Brotherhood. Roxburgh died at Edinburgh in 1815. A monument, by the side of Roxburgh Avenue, erected in 1882 to the north of the big banyan tree, perpetuates his memory. H. T. Colebrook, Francis Hamilton (afterwards Sir Buchanan Hamilton, F.R.S.), James Hare and Thomas Casey successively held charge of the garden from 1813 to 1816.

In 1817, Nathaniel Wallich, an able and energetic botanist, was appointed and he held office until 1846. At this time the eastern portion of the garden measuring 40 acres, including the teak plantation, was given up by Government to the Lord Bishop of Calcutta (Dr. Middleton) as the site for a Christian College known as the Bishop's College. This college, since 1880, is the Bengal Engineering College, Sibpur. In 1836, about 2 acres of land were allotted to the Agricultural and Horticultural Society of India, which was founded in 1820 by Rev. Dr. William Carey its first President. This area expanded to about 25 acres where the Society in co-operation with the garden officers conducted greater part of its operation for about 40 years until 1872, when the Society's garden was transferred to its present site in Alipur near the Viceroy's House (Belvedere).

Dr. Nathaniel Wallich, F.R.S., undertook an extensive survey of a large part of the Indian Empire, particularly in the little known region of Kumaon, Nepal, Sylhet, Tenasserim, Penang and Singapore. His enormous collections were catalogued and named in Europe by himself and with the help of the other botanists. They were then distributed to all the leading botanical institutions in Europe. One of the complete sets of the Wallich's collection belonging to this herbarium is now housed in the Kew herbarium in the original wooden cabinets marked as the East India Company's Collection. A rather incomplete set of this valuable collection, however, is in the Calcutta Herbarium together with Wallich's voluminous irreplaceable catalogue and his correspondence from 1794-1829 which were transferred to the Calcutta Herbarium from the India House, London. Through the munificence of the East India Company, Dr. Wallich published along with others his "Plantae Asiaticae Rariores," three superb volumes of illustrated coloured figures. During Wallich's absence on leave from 1842 to 1844 Dr. William Griffith officiated, and while on botanical expedition in Malaya died in Malacca in 1845. Dr. Griffith suggested many improvements in this garden, the Herbarium and the Library which were subsequently adopted by Dr. King to a certain extent. Griffith's premature death deprived botanical science of its ablest and most meritorious votaries. Griffith's extensive notes and drawings were after his death published by Government in nine volumes. A monument was erected to his memory under *Caesalpinia coriaria* (the Divi Divi tree) in the flower garden adjacent to the large pavilion. *(See page 115, foot-note.)*

Dr. Wallich who was not only Superintendent of East India Company's Gardens but also Professor of Botany at the Medical College, Calcutta, and Superintendent-General of Government Teak Plantation in Bengal, retired after 30 years of service in 1846 and died in 1854. His friends and admirers raised a monument in respect to his memory and a group of conifers (*Pinus longifolia*) was grown around it. Dr. Wallich was followed by Dr. Hugh Falconer, M.D., F.R.S., a Palaeontologist who held office till 1855. Early in 1858 during Dr. G. McClelland's officiating period Sir Joseph Hooker visited the garden on his famous journey to Sikkim and again on his return to Calcutta in 1860. A garden map during McClelland's time shows the nature of the garden as it existed from 1816 to 1850. Falconer was succeeded by Dr. Thomas Thomson, F.R.S., a traveller and a botanist of much ability. Dr. Thomson was also President of the Agri-Horticultural Society (1859-1860), the co-adjutor of Sir Joseph Hooker in the collection and distribution of an extensive and well-known herbarium of East Indian plants and the joint author of the first volume of the Flora Indica. Thomas retired in 1861 and was succeeded by Dr. Thomas Anderson, M.D., whose untimely death in 1870, was caused by a disease contracted during his effort for the introduction of the quinine yielding cinchonas into the Sikkim Himalayas. Dr. Anderson was not only Superintendent of the Royal Botanic Garden, Calcutta, and Professor of Botany, but also

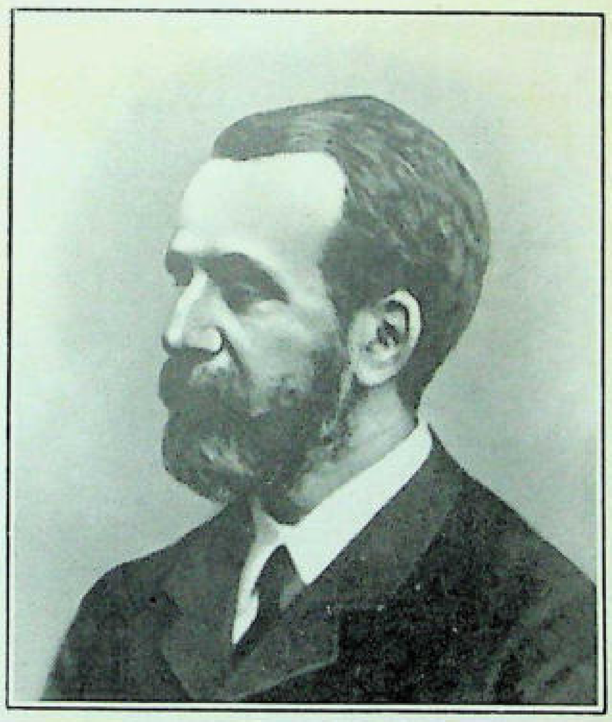
DR. NATHANIEL WALLICH

the first Conservator of Forests for Bengal and held charge of the Introduction and Cultivation of Cinchona in India. For two years (1869-1871) subsequent to Anderson's departure from India, Mr. C. B. Clarke, M.A., F.R.S., an educational officer of the Government of Bengal, acted as Superintendent and during his incumbency he began a series of botanical publications on his vast collections of plants.

In 1864 occurred the great cyclone of Calcutta. It was accompanied by a storm wave from the river Hooghly that laid the greater part of garden under water, in some places to a depth of six or seven feet, and carried two ships into the garden with great violence. Over a thousand trees—at least one-half of the total number in the garden—and innumerable shrubs were prostrated. The survivors were much shattered, and scarcely a vestige of leaf, flower or fruit remained. Three years later a less severe but still very destructive cyclone, in which over 750 of the surviving trees were blown down, completed the ruin. The removal of the wreckage occupied most of Anderson's remaining time in the garden, but before he left in 1868 he had planned and began to give effect to the planting of the garden on a more or less formal systematic arrangement.

In 1871, Dr. George King (afterwards Sir George King, M.D., K.C.I.E., F.R.S.) took charge of the garden which was in a most unpromising state. The devastation wrought by the two cyclones had deprived it of all shade. A large extent was under coarse grass, and large parts were still, as they always had been, little better than swamps. Most of the roads were narrow, subject to flooding and unfitted for carriage traffic, while the present ornamental lakes were represented mostly by unsightly "channels" and "tanks".

Sir George after taking over charge set to remaking of the garden. The whole extent of the grounds has been raised in level, the necessary soil having been obtained from large sheets of ornamental water which have been cut out. These artificial lakes have been connected with each other by underground pipes, and a steam pump (now substituted by an electric pump) has been supplied by which the water in the whole system can be kept at a high level by means of water pumped up from the river. Numerous wide roads have been made all through the garden, so that carriages may be driven through every part of it. Numerous footpaths have also been made. The bamboo and mat erections, which used to do duty as conservatories, have been replaced by three large, handsome and efficient structures of iron, on which a thin thatch of grass is spread; and under shelter of which tropical plants thrive admirably. The valuable collection of dried plants has been suitably housed in a handsome building designed by Mr. E. J. Martin, the Government Architect, the internal arrangements of which are to a considerable extent adapted from those of the then new herbarium building at Kew. New propagating houses, tool and potting-sheds have been erected, and good dwelling houses have been built for the members of the garden establishment. A boundary wall and ditch have been partly built round the garden; and finally, attempts at landscape effects have been made in the garden, and the collections have been increased by considerable accession of plants, both indigenous and exotic. Communication to the garden by road and steamer also improved during the last decade of the 19th century due to King's efforts.



SIR GEORGE KING

King made enormous and remarkable contributions towards Indian botany and initiated the publication of the world-famous Annals of the Royal Botanic Garden, Calcutta, in 1887 and Volume XIV, Part 2, appeared this year. Sir George also moved at this time for the establishment of the Botanical Survey of India which originated in 1890; the first volume of the Record of the Botanical Survey of India appeared in 1893.

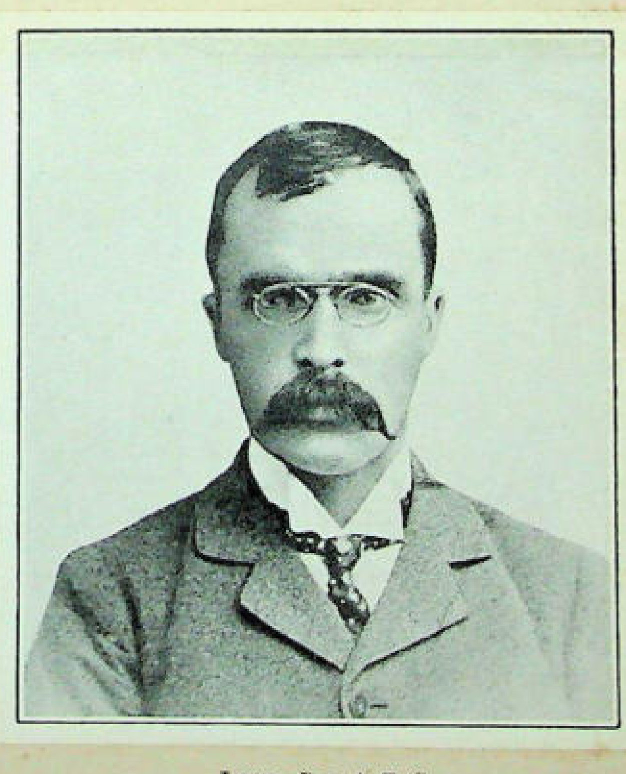
Sir David Prain

In 1878, in succession to the late Mr. W. S. Kurz, the reputed author of the "Forest Flora of Burma," Mr. John Scott was appointed Curator of the Herbarium. On the 9th January of 1879, Mr. Adolph Biermann, the Curator of the garden, met with a fatal attack by a tigress which, unnoticed by him or his companion, was crouching under shrubbery on the opposite side of the road. The tigress escaped from the menagerie of the ex-King of Oudh, swam across the river and landed in the garden. When they were discussing why a number of monkeys were chattering in an excited manner on a neighbouring teak tree, this huge tigress sprang out and with one blow of his paw detached half of Biermann's scalp and ended the discussion. The savage beast after mauling Mr. Biermann returned to the shade under the west African tree *Kigelia pinnata* which can be seen still standing at the junction of Scott Avenue and Banyan Avenue. The animal thus lay down in full view of its victim lying senseless on the ground. Mr. Scott stood by his companion and with remarkable courage, in full view of the tigress approached Mr. Biermann, lifted him up and removed him to his quarters. Mr. Biermann died of cholera after recovering from his wounds. Six weeks later a black panther also escaped from the same menagerie. This animal spent a night in the garden and was shot by Dr. G. King next morning before it had time to do any mischief. No such danger exists at present.

LLOYD BOTANIC GARDEN, DARJEELING

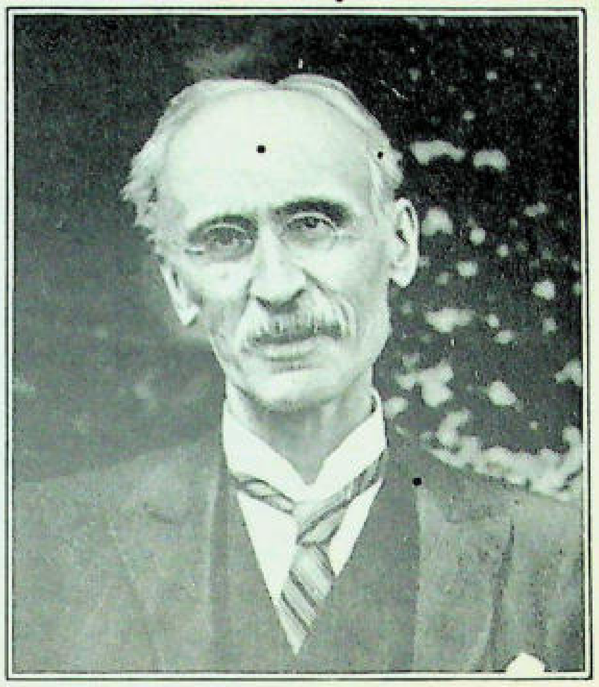
In the year 1878 was founded the Lloyd Botanic Garden, Darjeeling, with the effort of Sir Ashley Eden, the then Lieutenant-Governor of Bengal. The Lloyd Botanic Garden, Darjeeling, is named after Mr. William Lloyd who with the greatest kindness made over to Government 40 acres of land within the Darjeeling station. The garden developed under the guidance of Sir George King.

In this garden, in an area of 40 acres, are represented in miniature the temperate flora of the world with special reference to the indigenous species of the Himalayas. This is the well-known centre for the distribution of Himalayan seeds and plants in India, and with its herbarium serves the purpose of studying the East



Lieut.-Col. A. T. Gage

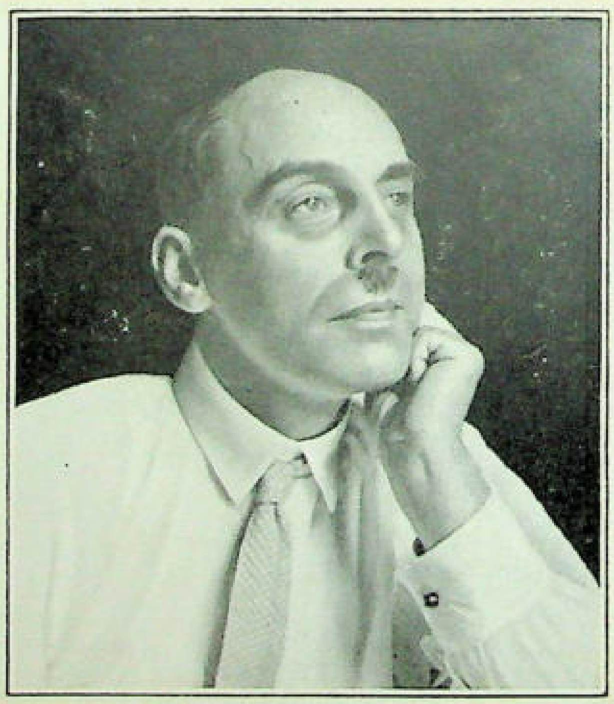
Himalayan plants on the spot. The contributions of the Lloyd Botanic Garden towards acclimatisation and investigation of subtemperate and temperate Himalayan plants and particularly towards improving the town of Darjeeling by way of introduction of many economic plants and foreign species of great horticultural interest are known all over India and abroad.



SIR WILLIAM WRIGHT SMITH

Surgeon-Major, afterwards Lieutenant-Colonel Sir David Prain, C.M.G., C.I.E., M.A., M.B., I.M.S., D.SC., LL.D., F.R.S., F.L.S., who was first appointed as Curator of the Herbarium, succeeded Sir George King, who, after 26 years of meritorious service, retired in 1897. Before Sir David left India in 1904, he sketched out a geographical plan of garden divisions in accordance with which future plantings were to be regulated. Sir David Prain's plan, with slight modifications, continued to be carried on by his successors as opportunity allowed up to the present day. Sir David gained worldwide reputation by his valuable botanical publications and his scientific investigations of considerable value to the State. Sir David Prain, who is now about 85, is still actively engaged in botanical work and has been able to finish his monumental monograph on Dioscoreas in collaboration with Mr. I. H. Burkill, M.A., F.L.S., formerly an officer of the Botanical Survey of India. This work entitled "An Account of the Genus Dioscorea in the East" has just been published in the Annals of the Royal Botanic Garden, Calcutta, Parts I and II, Volume XIV. Sir David retired on the 30th July, 1906, was appointed Director, Royal Botanic Garden, Kew in London.

Lieutenant-Colonel A. T. Gage, C.I.E., I.M.S., F.L.S., was also first appointed as Curator of the Herbarium and succeeded Sir David as Superintendent of the Garden in 1906. A catalogue of non-herbaceous phanerogams cultivated in the Royal Botanic Garden, Calcutta, prepared during Lieutenant-Colonel A. T. Gage's time was published with the object of facilitating the exchange, with other botanical institutions, of plants, seeds, or botanical materials for systematic anatomical, physiological or chemical investigations. Gage was also Professor of Botany, Medical College, Calcutta. Lieutenant-Colonel A. T. Gage retired in 1923. During his absence on leave in 1908, Mr. W. W. Smith (now Sir William Wright Smith, Regius Keeper, Royal Botanic Garden, Edinburgh, and Professor of Botany, University of Edinburgh), who was then the Curator of the Herbarium, officiated as the Superintendent, Royal Botanic Garden. Subsequently Mr. C. C. Calder, B.SC., B.SC. (Agr.), F.L.S., was appointed as Curator of the Herbarium after Smith joined the University of Edinburgh.

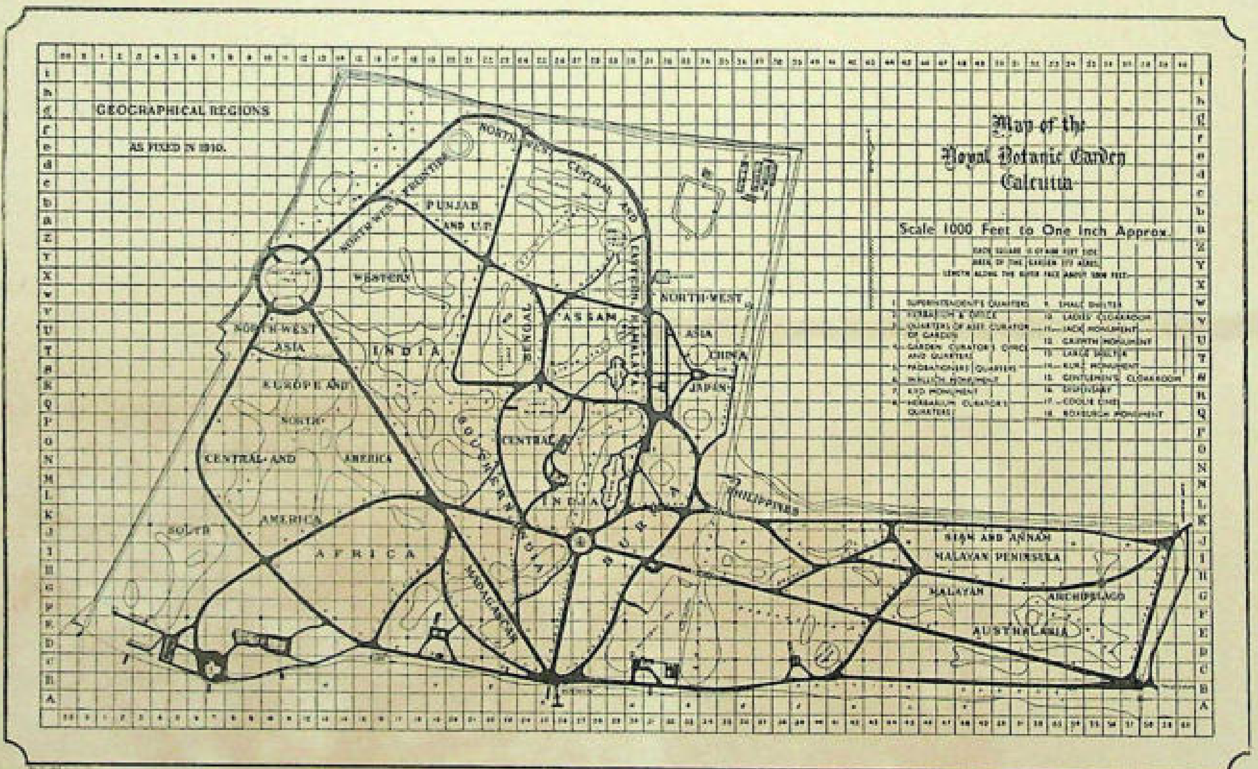


MR. C. C. CALDER

Mr. Calder succeeded Lieutenant-Colonel A. T. Gage in 1923. During Mr. Calder's absence on leave from India Dr. J. M. Cowan, M.A., D.SC., F.L.S., F.R.S.E., now Assistant Keeper, Royal Botanic Garden, Edinburgh, acted as Superintendent, Royal Botanic Garden, Calcutta, from 12th July 1926 to 20th November 1927, and I officiated in 1931 and 1935 when Mr. Calder went home again on leave. Mr. Calder left India preparatory to retirement in October 1937 handing over charge to me.

The scheme adopted 34 years ago was to treat the garden as a map of the world on Mercator's projection representing the tropical floras. The plants of India and Burma are to occupy the central triangular area of the large western part of the garden, this area being again subdivided in accordance with the geographical subdivisions of the Indian Empire. To the west and south-west of the large central Indian area are the divisions for north-west Asia, Europe, the Americas, Africa and Madagascar, and to the east of it the divisions for north-east Asia, China, Japan, the Philippines, Siam and Annam, the Malaya Peninsula and Archipelago and Australasia; the last five being separated from the large central Indian divisions by the special collections of palms, screw-pines and bamboos. Scattered throughout the garden are twenty-six irregular lakes, some of which are of large extent with islands. Altogether the lakes comprise about *one-ninth* of the total area of the garden. Most of them were designed by King with such skilful diversity of outline and surroundings as very greatly to enhance the beauty of the garden. There are at present more than ten miles of roads nearly all of which have now been macadamized.

In the open garden there are about 15,000 trees and shrubs. In addition to these there are several thousands herbaceous species in the Palm-houses, Orchid-houses and



PRESENT MAP OF THE ROYAL BOTANIC GARDEN, CALCUTTA

Ferneries. The garden, however, is by no means so rich in species as it might be, the total number of species in the open probably not exceeding 2,500. For some time the garden fulfilled to a certain extent also the purposes of a zoological garden by having in it birds, deer, swans, monkeys and other animals. Still there is a colony of hill Maina living in the garden. Their favourite spot is the Great Banyan which is situated at the end of the Banyan Avenue which runs from the River Gate leaving the Oreodoxa Avenue on the right.

The Oreodoxa Avenue in Front of River Gate with the Kyd Monument in the background

The Great Banyan in the days of its full juvenile glory looked more like a forest in minature than a single tree. The Great Banyan is now 171 years old. The crown is 1,100 feet in circumference and there are about 666 aerial roots. In 1895, the girth of the main trunk was 51 feet. The tradition current in the neighbouring villages is that when the garden was established the Banyan was already a tree of note under which a holy man used to sit. Lord Vlaentia visited the garden in 1803, and remarked in his account of travels as follows:—

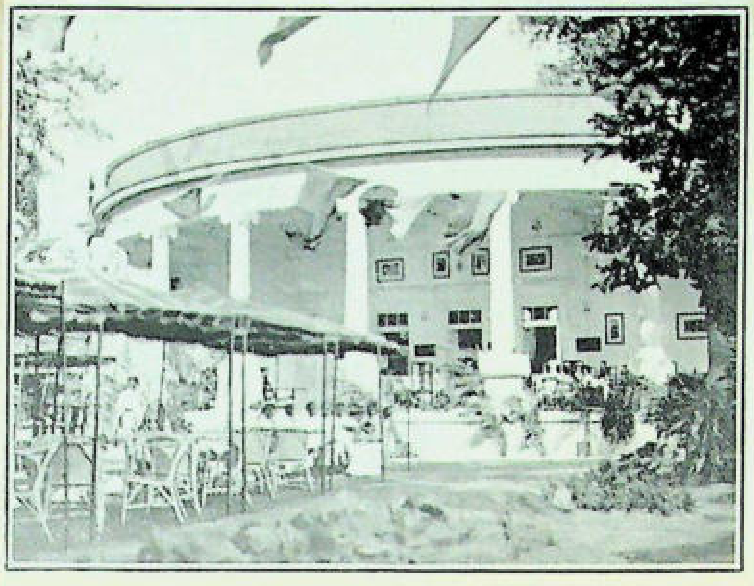
> "*The finest object in the garden is a noble specimen of the* Ficus Bengalensis *on the branches of which are nourished a variety of specimens of parasitical plants and ferns.*"

This Great Banyan must therefore be at least 200 years old. The tree suffered to a certain extent during the cyclones of 1864 and 1867 and some of its main branches were broken and thus exposed the tree to the attack of a hard fungus which was subsequently identified as *Fomes pachyphlaeus* Pat., by Dr. S. R. Bose and was for the first time reported by him from Bengal. This attack finally led to the deterioration of the trunk where the fruit body as large as 60-90 cm. long and 30 cm. broad and 8 cm. thick developed at different heights of the trunk. During the rains when the rays of the sun happened to reach this body of the perennial fungus clouds of spores were discharged from it. Sometimes so dense was this smoke that it was visible from a distance as a cloud overhanging the tree. Slides exposed over the tree revealed that the cloud was mainly composed of spores of the fungus. The trunk was thus decayed by subsequent attack of insects too and had to be removed some time after 1920. Series of major operations were performed and by grafting

The Great Banyan Tree

a daughter tree fresh energy has been infused. The tree has thus been saved. Attempts are being made now to extend the branches across the road round the Banyan Circle as a canopy overhead. The tree is flourishing quite well.

The garden which is open from sunrise to sunset daily is now accessible both by roads and by the river. Communications have been made much easier than what it was about 50 years ago. Motor buses are now frequently running from Calcutta to the Howrah Gate of the garden. Coming by the Port Commissioners' road the College Gate of the garden is reached from the river side. At the River Gate calls the ferry steamer daily both from Calcutta and Garden Reach. By the side of the River Gate is seen the kiosk. Thanks to the liberality of the donor of the Calcutta Electric Supply Company, this building has been provided and handed to Government in 1933 for the use of the public. This removes a long-felt want. Visitors can get from the restaurant drinking water free of charge and refreshments by paying a moderate charge. Attached to this is the room of the Calcutta Electric Supply Company, which leads to the underground tunnel at a depth of 150 feet, below the bed of the river. This tunnel through which runs the high voltage cable across the river, comes out on the other side within the compound of the power house of the Electric Company.



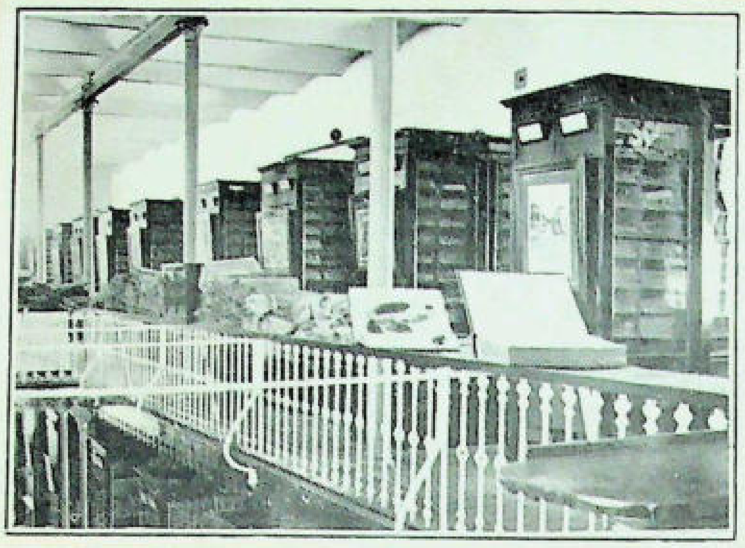
THE KIOSK

No small part of the benefits conferred on the country by the garden in its early days was the demonstration by practical experiment that certain natural products, many of them of a most desirable kind, cannot be grown in Bengal; much money and bootless effort being thus saved to the country. The cultivation of the teak tree, for the sake of its timber, so invaluable for ship-building in early days, was also begun on a large scale and was continued for 35 years, by which time it became clear that, although the tree to all outward appearance grows well on the muddy soil of the Gangetic delta, its stems early become hollow near the base, and are incapable of yielding sound timber of large scantling. The introduction of exotic timber trees also received early attention; and in the garden there still remain a few of the original mahogany trees introduced in these early years. The introduction of tea was one of the items put down in Colonel Kyd's original programme; and in the final establishment of what has now become one of the most important industries in Northern India, the garden bore a most important part. Potato-growing was initiated by the

THE PALMETUM

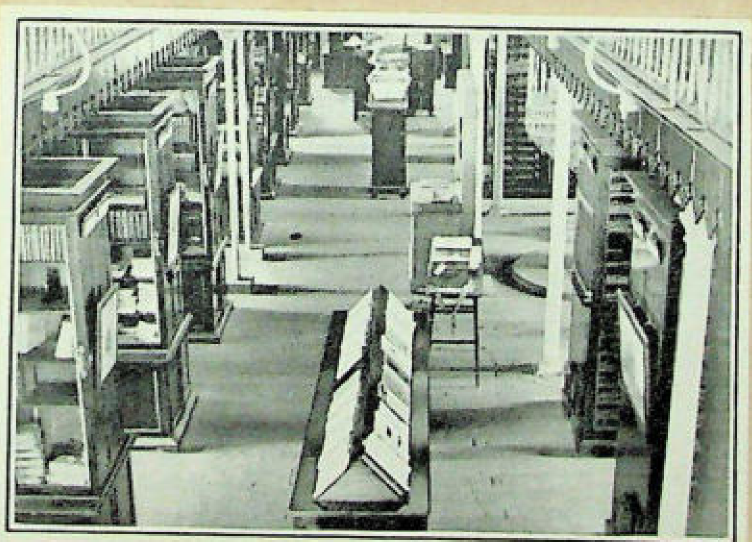
In the foreground on the right is the Talipot palm *(Corypha umrbaculifera)* in full bloom. This palm flowers when mature to its full size once in its life-time and after fruiting profusely, die.

agency of this garden and the cultivation of the quinine cinchonas of the Andes was originated and carried to a successful issue in the plantations in the Darjeeling district. A factory on an up-to-date line was established at Mungpoo. Good quinine has since been manufactured in this factory. Government hospitals and dispensaries have for years been and are still being supplied with quinine from this source. In the improvement of Indian cotton, and in the introduction of jute to the markets of Europe, the garden authorities worked cordially hand in hand with the Agri-Horticultural Society of India, with what success it is unnecessary to point out. By the introduction of some of the best kinds of sugarcane from the West Indies, and the dissemination of these to all parts of the country, a considerable improvement was effected both in the quality and quantity of the sugar crop of the country.



FIRST FLOOR SHOWING THE GENERAL HERBARIUM. THE ROXBURGH'S ICONS AND WALLICH'S CATALOGUE ON THE RIGHT ARE LYING OPEN ON THE RACK

It is unnecessary to discuss in detail the numerous experiments in the cultivation of economic plants which have been and are still being conducted in the garden since its foundation. A few of the products tried may simply be mentioned. Chief among these are flax, hemp, rhoea, or ramie, tobacco, henbane, vanilla, coffee, India-rubber, Japanese mulberry, cardamoms, tapioca and cocoa. As regards horticulture and arboriculture, it would suffice to say that a large proportion of the kinds of exotic plants now found in private gardens and along the roadsides in India have been introduced into the country through the agency of this garden, and that the improved methods of cultivation were to a great extent initiated here. Of recent introduction is the Tung oil tree which is a source of considerable revenue in China. Experiments at this garden indicate possibilities of cultivation of Tung oil, particularly *Aleurites montana*, in suitable areas of Bengal such as in the well drained lower ranges of the Himalayas between 2,000-5,000 feet. Seeds of Tung oil (about half a ton) received from Sir Arthur W. Hill, Director, Royal Botanic Gardens, Kew, were distributed all over India for experimental purposes. Promising reports on successful cultivation of Tung oil from these seeds from Assam and some parts of Bihar and Mysore were received. There is no reason why India should not be made self-supporting with regard to the supply of this oil so useful for the various industrial purposes.



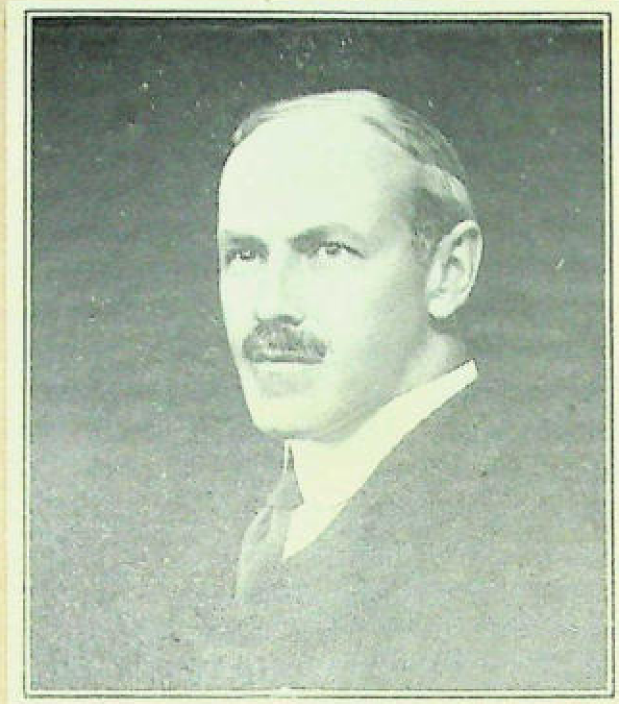
GROUND FLOOR SHOWING THE LIBRARY TO THE LEFT AND LOCAL HERBARIUM TO THE RIGHT

THE HERBARIUM

The collections of the herbarium are incomparably the most valuable scientific collections of their kind in Asia and one of the most valuable in the world. The scientific advancement of India in the study of Botany may be deferred for a century if the material preserved here which is considered as a great trust is sacrificed to the present call for economy. The herbarium with the library is fittingly situated in the garden. The collections of the herbarium dates from Roxburgh's time. The approximate number of sheets in the herbarium is estimated to be about two and a half millions. These are arranged according to Bentham and Hooker's Genera Plantarum. All the precious collections of India, Burma and a fair number of plants of those of Asia outside India, Europe and Australia, also a few of Africa and America are placed upstairs. The provincial floras are stocked downstairs in almirahs situated in the northern wing. The southern wing is mainly occupied by the library. The library contains nearly 25,000 volumes, numerous small papers and pamphlets, and some of the oldest botanical periodicals. The present herbarium building is damp-proof and to a certain extent fire-proof and was erected by expert engineers specially for the purpose under the guidance and advice of the late Sir George King in 1883 for housing securely the irreplaceable collections.

The garden with the herbarium and library offers valuable materials for the critical study of Indian plants in particular and tropical flora in general both in its dried and living state. Thus in the long history of the garden its usefulness has been for the benefit not only of India but also for the other parts of the world. The scientific results embodied in the monumental publications of the Annals of the Royal Botanic Garden, the Records of the Botanical Survey of India and other miscellaneous books and papers written by the Scientific officers of this institution, are of worldwide interest.

*Speech delivered by *Sir Arthur W. Hill, K.C.M.G., M.A., Sc. D. (Camb.), D.Sc. (Adel.), F.R.S., F.L.S., F.N.Z. Inst., V.M.H., Botanical Adviser to the Secretary of State for the Colonies, Director, Royal Botanic Gardens, Kew, on the occasion of the 150th Anniversary Celebration of The Royal Botanic Garden, Calcutta*



SIR ARTHUR W. HILL

HON'BLE NAWAB BAHADUR, LADIES AND GENTLEMEN—

It is singularly appropriate that the 150th Anniversary of the Foundation of the Royal Botanic Garden, Sibpur, should coincide with the Jubilee Meeting of the Indian Science Congress at Calcutta, which is being attended by so many distinguished delegates from Great Britain, many of whom, including the President, we are honoured in having with us this afternoon. We all join offering our good wishes for the continued prosperity of the garden and look back with respectful admiration to its record of valuable work under its distinguished Superintendents during the past 150 years.

I feel particularly fortunate in being present here with you today, as it is the first time a Director of the Royal Botanic Gardens, Kew, has been in India in his official capacity. It is also of special interest to me personally, since my predecessor in office at Kew, Sir David Prain, held with distinction for many years the post of Superintendent of these gardens and the Directorship of the Botanical Survey of India.

Your gardens here offer an interesting and remarkable parallel to those other Royal gardens under my charge at Kew, since Kew is only a few miles from London ; while your Sibpur gardens are within easy distance of the second city of the Empire and are situated on the banks of the Hooghly, which washes the shores of Calcutta. Both our gardens suffer somewhat from being on the flat alluvial soil of the riverside ; the skill of the gardener, however, has transformed both sides into gardens of high scientific interest as well as of great aesthetic beauty, so that they serve as a source of inspiration, education and research for their many visitors. May they find in them both spiritual rest and refreshment and also that tree whose leaves were " for the healing of the nations." Then again you justly treasure in this garden your renowned herbarium, which is in fact the national herbarium of India and is the Mecca for the study of Indian systematic botany by botanists not only in India but from overseas, affording yet another point of similarity with Kew; for our great national herbarium at Kew is the centre for the study of systematic botany both for India and for the Empire.

I earnestly hope that the Govenment of Bengal will continue to realise the importance of these famous Sibpur Gardens and that the necessary funds will be forthcoming both for the maintenance of the scientific staff and for the proper upkeep of the living collections.

These gardens, I would suggest, should, as one of their functions, serve, like Kew, as a training ground for student gardeners, in order that the many good gardens and parks in India may be maintained at a high standard of excellence in the future by Indian gardeners trained at Sibpur. As you know, Sibpur, almost since its inception, has been tended and improved by student gardeners sent out from the Royal Botanic Gardens, Kew, many of whose names are remembered with honour in the roll of Indian horticulture and whose fine work remains as their permanent memorial. This custom, which has resulted in so much benefit to Indian horticulture, I hope may be continued in the future. With one or two men sent out from Kew to Calcutta as Instructors or Curators, there should be no difficulty in establishing at the Royal Botanic Gardens, Sibpur, a "school" for the training of Indian student gardeners for service in various parts of India, so that the great traditions of the past may be adequately continued.

Hon'ble Nawab Bahadur, Ladies and Gentlemen, on behalf of the more youthful Royal Botanic Gardens, Kew, which have not yet reached the 100th year of their existence as a public institution, I beg leave to offer our cordial good wishes for the continued prosperity and enhanced usefulness of the Royal Botanic Garden, Calcutta.

**During the course of the publication of this 150th Anniversary Volume Sir Arthur Hill died in a riding accident on November 3, 1941, at the age of 66 years. Sir Arthur was born on October 11, 1875, and was educated in King's College, Cambridge, where he secured first class Tripos. He was elected Fellow and Dean of King's College, Cambridge, and University Lecturer in Botany in 1907. In 1908 he was elected a Fellow of the Linnean Society, and a Fellow of the Royal Society of London in 1922. Hill received the honour of C. M. G. and that of K. C. M. G. in 1931. In 1907 Hill was appointed Assistant Director, Royal Botanic Gardens, Kew, under Lt.-Col. Sir David Prain who succeeded Sir W. T. Thiselton-Dyer as Director of the Royal Botanic Gardens, Kew, after his retirement from the post of the Superintendent, Royal Botanic Garden, Calcutta, and Director, Botanical Survey of India. Hill was, on the 28th February 1922, appointed Director of the Royal Botanic Gardens, Kew, on Sir David's retirement.*

Hill travelled far and wide and urged improvement of botanical gardens, herbaria, museums and botanical laboratories wherever he went. Hill was particularly interested in the economic plants and during his long tenure of office as Director of Royal Botanic Gardens, Kew, he was actively engaged in the introduction and commercial exploitation of many tropical plants of economic value. Of these mention may be made of a recent introduction to the tropical parts of the British Empire, particularly in India and South Africa, of Tung oil or Chinese wood oil tree which is extremely useful for many industrial purposes as a drying oil of high standard.

Hill's researches in botanical science were not so much in the taxonomical aspect as in other directions. Some of his earlier works are of classical value. But during the latter part of his career he was particularly interested in the origin of Monocotyledons on which he delivered an illuminating address when he visited India in January 1938, during the Silver Jubilee Session of the Indian Science Congress Association as one of the distinguished British delegates. Hill presided over the Botany Section (K) of the British Association in 1930. Hill was connected with almost all the important botanical and horticultural organisations in Great Britain and other parts of the Empire and many of these were benefited by his advice and guidance. Hill was also Editor of the leading botanical and horticultural journals in England.

I had the privilege of coming in close touch with Sir Arthur Hill in Kew and India. My contact with him resulted in the revival of exchange relations between Kew and Calcutta gardens. Hundreds of specimens of rare scientific value recently received from Sir Arthur Hill filled up several gaps in the Calcutta Herbarium. My acquaintance with Sir Arthur ripened into intimacy and his encouragement and guidance in my work while in Kew were of great value to me. Sir Arthur's advice and definite directions towards improvement of the Garden and expansion of the Herbarium and the Botanical Survey of India, if followed, will prove to be of considerable benefit to the progress of botanical science in India.

The botanical world to-day deeply mourns the death of Sir Arthur Hill.

K. BISWAS.

Herbarium, Royal Botanic Garden, Calcutta,
The 5th March, 1942.

Felicitation offered by Sir James H. Jeans, O.M., D.Sc., Sc.D., LL.D., F.R.S., on the 150th Anniversary of The Royal Botanic Garden, Calcutta

We must, I am sure, all feel that it is very fortunate that this Anniversary coincides both with the visit of the British Association to India and with the Jubilee Meeting of the Indian Science Congress Association. I am sure I may take upon myself, in the name of both bodies, to congratulate the Botanic Garden of Calcutta on the completion of its 150th year of public service.

We have heard much, both in Europe and in India, of the fame of this garden. I myself feel particularly at home here because my dear friend, Sir David Prain, one of your late Directors, has so often spoken to me about the garden, and told me of his life here. Like the rest of your visitors, I have only this moment arrived, and so have not had time to appreciate the full beauty of your garden. We all hope to see this more fully later, but in the meantime I am sure we all congratulate you most whole-heartedly both on what we see, and on what we know, about your great service to botanical science.

Presidential Address by The Hon'ble Nawab Khwaja Habibullah Bahadur, of Dacca

Minister, Agriculture and Industries Department, Government of Bengal

"I consider myself to be fortunate in being called upon to preside over the anniversary of the garden Robert Kyd planted at this spot 150 years ago. Coinciding as it does with the Silver Jubilee of the Indian Science Congress, which has attracted to Calcutta shining stars of the first magnitude in the firmament of science from distant lands, it is indeed a pleasure to accord them a warm welcome on behalf of the Government of Bengal and the department which controls the administration of this, perhaps, the most important and oldest botanical garden in the East. As head of that department, I extend a cordial welcome to our guests from abroad and to the other guests who have honoured our invitation. Gentlemen, the history of this garden and the part it has played in the advancement of botanical learning in India and the useful service it has rendered to the country in agricultural matters extended over a period of a century and a half under the fostering care of the galaxy of names read out by Dr. Biswas, are no mean achievements. Many among us must have realized by now that the Royal Botanic Garden was not just a show place with its great banyan tree and beautiful palm avenue, or a place of picnics and weekend outings. On the contrary its long and glorious record clearly established the fact that it is a great centre of learning and has the right to stand abreast with the most up-to-date laboratories and institutes of the theoretical and applied sciences. It was perhaps the beautiful surrounding of this historic garden with the Hooghly, that important and busy daughter of the Ganges, following by which inspired that illustrious son of Bengal, Jagadish Chandra Bose, whose loss we all mourn so deeply to day, to his great discoveries in plant-life and the throbbings of the vegetable kingdom in unison with God's creation as a universe.

The Government of Bengal takes legitimate pride in the fact that it has maintained this garden and added to its beauty and usefulness to the people of the country over an unbroken period of 150 years; and my colleagues in the Cabinet and I will consider it a privilege if we are able to hand over to those who follow us this charge with an enhanced capacity to render still more valuable and lasting service to the scientific and lay world as the finest beauty spot in this city of ours, a veritable Kew Garden of the East. It will be our duty to see that the secrets of nature, still unrevealed to mankind discovered by scholars of botany, horticulture and agriculture in this garden, are applied to the growing needs of Bengal and the country and harnessed for the use of man. I hope that when the time comes for the celebration of the second centenary of this garden, my successor in this chair will be in the happy position to declare that the fulness and bounty of the mighty rivers of Bengal, coupled with the flow of scientific knowledge emanating from the Royal Botanic Garden of Calcutta, have turned it into a veritable paradise.

I am not in a position to-day to indicate the lines along which further progress will be made and improvements carried out, but I can assure my hearers that every scheme submitted by the experts will receive the most careful and sympathetic consideration of the Government.

Before I finish I should like to inform our guests that it is the intention of the authorities in charge to publish the 150th Anniversary Volume of the garden and contributions in the shape of articles will be welcome most gratefully.

I have now the great pleasure to declare the Exhibition of Horticultural Plants of the Royal Botanic Garden open."

Messages

Telegram No. 275, dated London, the 4th January 1938.

From—The Royal Society of London.

Cordial congratulations to the Royal Botanic Garden on its 150th Birthday, and best wishes for the future from the friends of the gardens in the Royal Society of London.

Telegram No. 789, dated London, the 5th January 1938.

From—British Museum (Natural History), London.

Hearty congratulations and all good wishes.

Telegram No. 282, dated London, the 5th January 1938.

From—The Secretary, Royal Horticultural Society, London.

The Royal Horticultural Society, London, sends greetings and congratulations on the 150th Anniversary of the Royal Botanic Garden and prays that its work may ever continue for the benefit of mankind.

Letter, dated Edinburgh, the 22nd December 1937.

From—The General Secretary, Royal Society, Edinburgh.

The President and Council of the Royal Society of Edinburgh are greatly interested to hear of the Celebration, on January 6, 1938, of the 150th Anniversary of the Royal Botanic Garden, Calcutta, with which this Society has been so long in exchange relationship.

I am instructed to convey to you the cordial felicitations of the Royal Society of Edinburgh, and also to send its best wishes for the continued success of the Royal Botanic Garden, Calcutta.

Telegram No. 208, dated London, the 31st December 1937.

From—The President, Linnean Society of London.

Linnean Society of London sends congratulations to Royal Botanic Garden, Calcutta, on completing of its 150th year, and best wishes for its future prosperity.

Letter, dated Edinburgh, the 22nd December 1937.

From—Sir William Wright Smith, Regius Keeper, Royal Botanic Garden, Edinburgh, Professor of Botany, University of Edinburgh, and King's Botanist in Scotland.

I have your letter of 7th December, intimating that the Royal Botanic Garden, Calcutta, celebrates its 150th Anniversary on Thursday, 6th January 1938. As one who *spent some happy years in that Garden and retains many and very pleasant memories of it, I send my congratulations and felicitations for the 6th January with the best of good wishes for its continued success. The staff of the Edinburgh Botanic Garden is in full accord with me in sending this message of congratulation and good will.*

Telegram No. 637, dated Cambridge, the 4th January 1938.

From—Brooks, Professor of Botany, Cambridge.

Congratulations on Anniversary. Best wishes for future.

Letter, dated Glasgow, the 28th December 1937.

From—Dr. John Walton, Regius Professor of Botany, University of Glasgow.

I have the honour to send you greetings and congratulations from the Department of Botany in the University of Glasgow on the occasion of the 150th Anniversary of the Royal Botanic Garden of Calcutta. May I remind you of the close relations which have existed between this Department and India when the Chair of Botany in this University was occupied by Sir William J. Hooker, a relationship of which we shall always be proud.

Letter, dated Aberdeen, the 10th January 1938.

From—Professor J. R. Mathews, Regius Professor of Botany and Keeper of the Cruickshank Botanic Garden, Aberdeen, Scotland.

The Cruickshank Botanic Garden and the University of Aberdeen offer hearty congratulations to the Royal Botanic Garden, Calcutta, on the 150th Anniversary of its foundation. Thi long period of activity has witnessed great progress in the scientific study of botany and horticulture throughout the world, and to this advancement of knowledge the Botanic Garden at Calcutta has made many notable contributions. By the sustained publication of the Garden's handsome "Annals," and in many other ways, invaluable work has been accomplished in the investigation of the Flora of India. The University of Aberdeen recalls with pleasure and gratification its close association with the Botanic Garden, for several of its graduates have been illustrious members of the Garden staff. The University would now extend cordial greetings and continued prosperity to the Garden under the guidance and leadership of Dr. Biswas who has now been appointed in-charge.

Letter, dated Surrey, the 22nd December 1937.

From—Lt.-Col. Sir D. Prain, I.M.S., C.I.E., M.A., M.B., D.SC., LL.D., F.R.S., F.L.S., the late Superintendent, Royal Botanic Garden, Calcutta, Director, Botanical Survey of India and Director, Royal Botanic Garden, Kew, Well Farm, Warlingham, Surrey.

Very many thanks for your letter of 7th December which brings the pleasing information that it is proposed to celebrate the 150th Anniversary of the Royal Botanic Garden, Calcutta, on Thursday, the 6th January 1938.

Nothing would have given me greater pleasure than the acceptance of your invitation to take part in the celebration of that Anniversary had it been possible to do so.

I do not need to assure you that on 6th January, you and the Calcutta Garden will be much in my thoughts and that my hope then will be that the celebration is as successful as I would wish it to be.

Letter, dated Ross-shire, Scotland, the 28th December 1937.

From—Lt.-Col. A. T. Gage, C.I.E., LL.D., I.M.S., F.L.S., Nutwood House, Strathpeffen, Ross-shire, Scotland.

Many thanks for your card of good wishes, with its view of a scene that reminds me of the Hooghly, during a break in the monsoon rains.

You have also sent a letter kindly asking me to send a message on the occasion of the celebration of the 150th Anniversary of the Royal Botanic Garden.

As there is little time left for a message to reach you in due season, I must be brief and not tardy in sending it.

With pleasant memories of the years during which I was privileged to be associated with the Garden and with the kindly folk of India along with whom I worked in the Garden, the herbarium and the office, I send my best wishes for the future prosperity and continuous development of the Garden in the advancement of botanical science and for the welfare of all its staff now and hereafter.

Please also take my best wishes for yourself in particular, and give my kind remembrance to all who were associated with me and who may still survive from those by-gone days.

Letter, dated Leatherhead, England, the 20th December 1937.

From—I. Henry Burkill, Esq., M.A., F.L.S., the late Reporter, Economic Products, Botanical Survey of India, Clova, the Mount, Leatherhead.

Until your letter H/262-37 of 30th November 1937 came—a letter which suffered in the airship mishap at Brindisi and was salved from the sea—it had escaped my memory that the Royal Botanic Garden, Calcutta, was founded in 1787 and that, therefore, you keep your sesqui-centenary. With all the earnestness that is in me I hope for the unbroken continuance of the work of your garden ; and I am proud of the connection which I had with it as well as grateful for the opportunities which that connection gave of grafting my humble researches into the wider researches of the great and zealous men who built up the Garden. It has been twice-born. William Roxburgh, by planting in it with great patience and single-mindedness, made it as nearly as he could a living illustration of his Flora Indica, and a Court of Appeal for his determinations. Francis Buchanan (afterwards Sir Buchanan Hamilton), the man of his time most intimate with the rural economy of India, gave his aid. The eminent scholar Thomas Colebrooke for a short time controlled its destiny. Nathaniel Wallich and William Griffith laboured from it as a centre in the exploration far afield of the vegetation of India ; and it served many others, including Sir Joseph Hooker as a base.

After its plantings had been destroyed by the great cyclones of 1864 and 1867 it was on the cultural side reborn under Sir George King ; and under him on the herbarium side, which those disasters had not impaired, it took immense forward strides. The stream of its growth moves forward still as then. In time Sir George King was given the secondary title of Director *of the Botanical Survey of India. If I mistake not, the future of the Garden lies in strengthening this survey, and it is fitting that the title Director of it becomes the first, not the second, title of the officer called to be Superintendent of the Garden. Surely the spirit of this change has been with the Garden from the very beginning when Roxburgh called his book the Flora Indica ; nor absent at any time in its long history.*

Telegram, No. 170, dated Edinburgh, the 3rd January 1938.

From—Dr. J. M. Cowan, M.A., D.SC., F.L.S., F.R.S.E., the late officiating Superintendent, Royal Botanic Garden, Calcutta, and Director, Botanical Survey of India, and at present Assistant Regius Keeper, Royal Botanic Garden, Edinburgh.

Happiest remembrances. Best wishes.

Telegram No. 216, dated London, 31st December 1937.

From—C. C. Calder, Esq., B.SC. (Aberdeen), B.SC. (Agri.), F.L.S., the late Superintendent, Royal Botanic Garden, Calcutta, and Director, Botanical Survey of India, London.

Congratulations on Anniversary and very best wishes for success of meeting and future of gardens.

Telegram No. 291, dated Wien, the 3rd January 1938.

From—The Botanical Garden, Vienna.

Best wishes.

Telegram No. 680, dated Geneva, the 4th January 1938.

From—Dr. B. P. G. Hochreutiner, Conservatoire et Jardin Botaniques De Genève.

Conservatoire et Jardin Botaniques De Genève congratulates heartily.

Telegram No. 719, dated St. Louis, the 5th January 1938.

From—G. T. Moore, Esq., Director, Missouri Botanical Garden, U. S. A.

Heartiest congratulations.

Telegram No. 627, dated Oslo, the 5th January 1938.

From—J. Holmboe, Esq., Director, Universitetets Botaniske Have und Musuem, Oslo, Norway.

Botanical Garden, Oslo, sends cordial congratulations.

Telegram No. 484, dated Bruxelles, the 5th January 1938.

From—W. Robyns, Esq., Director, Jardin Botanique De L'E'tat, Brussels, Belgium.

Jardin Botanique De L'E'tat, Brussels, joins celebration 150th Anniversary, Royal Botanic Garden, Calcutta, sending good wishes.

Letter, dated Berlin-Dahlem, den 24 Dezember 1937.

From—Dr. L. Diels, General-Direktor des Botanischen Gartens und Museums, Berlin-Dahlem.

Der Botanische Garten in Berlin-Dahlem übersendet dem Royal Botanic Garden in Calcutta die herzlichsten Glückwünsche zur Jubelfeier seines 150-jährigen Bestehens. Wir gedenken gern der hohen Verdienste Ihres Gartens um die botanische Wissenschaft und erinnern uns mit Freude dar glücklichen Beziehungen, die so lange zwischen unseren Anstalten bestehen. Wir bitten, auch künftig uns diese Freundschaft zu erhalten, und wünschen, dass der Royal Botanic Garden, treu seiner ruhmreichen Überlieferung, manches weitere Jahrhundert wirken möge zum Wohle Indiens und zum Fortschritte der Wissenschaft.

[Translation by Consulate-General for Germany.]

From—Dr. L. Diels, General Director, Botanic Garden and Museum, Berlin-Dahlem, Germany.

The Botanic Garden in Berlin-Dahlem sends the Royal Botanic Garden in Calcutta the heartiest good wishes on the jubilee celebration of its 150th Anniversary.

We are glad to recollect the great services of your garden to botanical science and recall with pleasure the happy relationships which have been between our institutions.

We look forward to maintaining this friendship in the future and we hope the Royal Botanic Garden, true to its distinguished record, will be able to work for many more centuries for the good of India and the progress of science.

Letter, dated Groningen, the 5th January 1938.

From—Professor Dr. M. J. Sirks, the Honorary First Secretary, Nederlandsche Botanische Vereeniging, Holland.

Although this letter certainly will not reach you in time for the celebration of the 150th Anniversary of the Royal Botanic Garden the Netherlands Botanical Society esteems it a favour to be one of the many institutions that appreciate the work done by your Garden in so long a period on behalf of our botanical science. I may be permitted on behalf of the Council of our Society to tender your Garden our best thanks for this work and the co-operation you lent to our science and to express our hearty wishes for a flourishing future of your worldwide renowned institution.

Letter, dated Lieden, the 4th January 1938.

From—Dr. H. J. Lam, Director, Rijksherbarium, Holland.

The announcement of the celebration of the 150th Anniversary of the Royal Botanic Garden, Calcutta, only reached us to-day. I am, therefore, afraid our congratulations will arrive after January 6th. This, however, does not prevent me from expressing in the name of the Rijksherbarium our great appreciation for the most valuable work the Royal Botanic Garden at Calcutta has done during its existence for the knowledge of the flora of South-East Asia in particular and for the promotion of botany in general. Allow me to offer you on this occasion our sincere congratulations with the 150th Anniversary of your institution. We are glad to join those who will express the hope that a splendid future lays before you.

Letter, dated Dublin, the 11th January 1938.

From—The Director, Department of Education, National Museum of Ireland.

I beg to acknowledge receipt of your circular, dated the 7th December, which concerns the 150th Anniversary of your institution which was fixed for the 6th January.

Unfortunately, your letter arrived only to-day and it is hence too late to send you our congratulations in time for the celebrations, as we would undoubtedly have done had we got the letter in time. There is nothing left therefore but to convey by this letter that this institution most sincerely wishes all good luck and prosperity for your Botanic Gardens in the future, and I beg to say that your glorious record of the past foreshadows an equally successful development for many years to come.

Letter, dated Roma 4, Gennaio 1938.

From—Professor E. Carano, Il Direttore, Istituto E. Orto Botanico, Roma, Italy.

Rispondo subito alla Vostra lettera d'invito del 7 Dicembre 1937, giuntami soltanto oggi.

Molto volentieri sarei stato presente alla festa per la celebrazione del 150° anno della fondazione di questo glorioso Giardino Botanico, che tanta luce di progresso diffuse nel mondo con le opere e le pubblicazioni periodiche del suo personale scientifico.

Mentre ringrazio del cortese invito, auguro sinceramente che la celebrazione riesca degna di codesta Istituzione, con la quale l' Orto Botanico, che ho l' onore di dirigere, ebbe sempre i migliori raporti.

Voglia, gradire illustre Soprintendente, con i miei auguri i sensi della mia piũ alta stima.

[Translation by Dr. Kalidas Nag, M.A., D.Litt. (Paris).]

From—Professor E. Careno, Director, Institute E. Orto Botanico.

We beg to reply promptly to your letter of invitation, dated the 7th December, 1937, which we received recently.

With great enthusiasm we offer our congratulations on the festive celebrations of the 150th Anniversary of the foundation of the glorious Botanic Garden whose reputation has been diffused all over the world on account of its activities and the periodical publications of its scientific staff.

We offer our best thanks for your courtesy in inviting us, and we sincerely pray for the success of the celebration of your great Institution which I, as Director of the Orto Botanico, have the honour to offer our best collaboration.

Accept, therefore, illustrious Superintendent! our best regards and felicitations.

Letter, dated Paris, le 28 Janvier 1938.

From—Société Botanique de France.

La Société Botanique de France a pris part bien cordialement à la célébration du 150° anniversaire du Jardin Botanique Royal de Calcutta. Malheureusement l'annonce nous est parvenue trop tard pour vous envoyer à temps une adresse de félicitations comme nous l'aurions désiré. C'est pourtant de grand coeur que tous les membres de la Société Botanique se sont associés à cette célébration d'un jardin si utile à la science et dont le rayonnement s'étend sur le monde entier.

Veuillez agréer, Monsieur le Directeur, l'assurance de nos sentiments de haute considération.

[Translation by Dr. Kalidas Nag, M.A., D. Litt. (Paris).]

Letter, dated Paris, the 28th January 1938.

From—The Botanical Society of France.

The Botanical Society of France participate very cordially in the 150th Anniversary Celebration of the Royal Botanic Garden of Calcutta. Unfortunately the announcement came to us rather late so as not to permit us to send you in due time, an address of felicitations as we would have desired to do. However, in fulness of heart, we the members of the Botanical Society of France, associate ourselves with the celebrations regarding a Garden which is so useful to science and whose renown has extended all the world over.

Please accept, Mr. Director, the assurance of our best regards.

Letter, dated Washington, the 31st December 1937.

From—C. G. Abbot, Esq., Secretary, United States National Museum, Smithsonian Institution, Washington, U. S. A.

On behalf of the Smithsonian Institution I take much pleasure in extending to the Royal Botanic Garden our sincere felicitations on the occasion of the celebration of its completion of the 150th year of work in the field of botany.

While it is not practicable for the Institution to be directly represented on this occasion, it is gratifying to note that for upwards of 60 years the most cordial and friendly relations have existed between our two organizations. Through the medium of exchange of specimens and through correspondence the Royal Botanic Garden has contributed to the collections and knowledge here of many interesting examples of Flora of India and elsewhere.

Please accept for yourself and for the Institution under your able direction our sincere hopes for many years of continued service in the field of science.

Letter, dated Brooklyn, the 20th January 1938.

From—Dr. C. S. Gager, Director, Brooklyn Botanic Garden, New York, U. S. A.

The notice of a celebration of the 150th Anniversary of the Royal Botanic Garden, Calcutta, which you addressed to our Librarian, was not received until this morning.

We greatly regret that we did not learn of this celebration in time to have our acknowledgment reach you before the date of the exercises on January 6, 1938.

The Brooklyn Botanic Garden is under very substantial obligations to the Royal Botanic Garden of Calcutta for numerous courtesies extended to us during our brief 28 years of existence, and it affords us a great deal of pleasure to extend to your garden, even though after the date of the exercises, our cordial congratulations on your 150 years of outs anding service to the advancement of botanical science, and our cordial good wishes for the continued prosperity and support of your scientific and educational work. You have made the entire botanical world your debtors.

Letter, dated New York, the 13th January 1938.

From—Dr. H. A. Gleason, Acting Director, The New York Botanical Garden, U. S. A.

I regret exceedingly that we did not receive until January 8 your letter of December 7, announcing the 150th Anniversary of the Royal Botanic Garden at Calcutta. Although my reply will be a month late, nevertheless, permit me to offer my sincere felicitations on this long and useful career, and to express my confidence that your service to botany will be continued long into the future.

Letter, dated Manila, the 17th January 1938.

From—Dr. E. Quisumbing, Curator, Philippine National Herbarium.

Your announcement on the anniversary celebration of the founding of the Royal Botanic Garden, Calcutta, 150 years ago has been received. It is unfortunate that it has been received late, otherwise I could have sent by cablegram a message from this part of the world. Though late I should like to take this opportunity to send you my hearty congratulations for the success of the garden. The herbarium in the Bureau of Science now called Philippine National Herbarium has been one of the beneficiaries of your garden having received very valuable specimens in exchange. The garden has also been a great help to us in the loan of specimens for study and for comparison. We hope that our exchange relation will continue to be happy and fruitful.

Reiterating once more my sincere congratulations on the occasion of the 150th Anniversary of the Royal Botanic Garden of Calcutta and wishing you in the future success.

Letter, dated Berkeley, the 17th January 1938.

From—Dr. W. A. Setchell, Emeritus Professor of Botany, University of California.

In response to your kind invitation of December 7, which unfortunately did not arrive until this morning, I am sending you my congratulations on being able to celebrate the 150th Anniversary of the founding of the Royal Botanic Garden at Calcutta. It has had a long life and a useful one. It has sent forth much material—much more than readily be estimated—both in published form and in the way of specimens, and in the way of helpfulness to other institutions.

May some worthy Superintendent, such as yourself, be present after the next 150 years to receive the congratulations which will be then again due you. A long life and a useful one to the garden and to yourself.

Letter, dated Calcutta, the 4th January 1938.

From—Dr. A. H. R. Buller, Emeritus Professor of Botany at the University of Manitoba, Winnipeg, Canada.

I desire to offer my heartiest congratulations to the Royal Botanic Garden of Calcutta on the completion of 150 years of successful activity. May the garden long continue to flourish.

Telegram No. 156, dated Tokyo, the 28th December 1937.

From—The Director, Nakai Botanic Gardens, Tokyo Imperial University, Japan.

Director, Nakai Botanic Gardens, Tokyo Imperial University, tenders his hearty congratulations upon the auspicious occasion of 150th Anniversary of your institution wishing for everlasting prosperity and success.

Letter, dated SS. *Chicago Maru*, the 7th January 1938.

From—Professor Tyôzaburô Tanaka, Taihoku Imperial University, Taihoku, Taiwan, Japan.

Congratulation for your celebration of 150th Anniversary of the garden! I am now on the way to the Philippines for a short tour, and I sent a cablé from the steamer for congratulating the event.

I am expecting to stay in the Philippines for two months and half, and I wish you best regards and greetings on board the steamer.

Telegram No. 173, dated SS. *Chicago Maru*, the 5th January 1938.

From—Professor T. Tanaka, Director of Agriculture, Formosa, SS. *Chicago Maru*, Hainan.

Congratulation sesqui-centennial celebration.

Telegram No. 17, dated Buitenzorg, the 6th January 1938.

From—The Director, Botanic Garden, Buitenzorg, Java.

Congratulations 150th Anniversary. Best wishes for future growth.

Letter, dated Brisbane, the 11th January 1938.

From—E. W. Bick, Esq., Director, Botanic Gardens, Brisbane, Australia.

With reference to your letter of 7th December last regarding the celebration of the 150th Anniversary of the foundation of your Botanic Garden, I regret that it was impossible for me to be represented by letter at the celebration owing to not having received your communication until to-day. Although now somewhat belated, I wish to congratulate you and your institution on the wonderful work accomplished by you and other officers and staff throughout the long period which has elapsed since its foundation.

We in Queensland are particularly interested in the Indian flora, as owing to the so-called Malayan intrusion, there are in the coastal areas many plants which are also found in India and the Malayan Archipelago. Many Indian trees and shrubs have also been introduced, and thrive well in our State.

Letter, dated Sydney, the 14th January 1938.

From—R. H. Anderson, Esq., Botanist and Curator, Herbarium, Botanic Gardens, Sydney, Australia.

I have noticed with interest that your garden celebrated its 150th Anniversary, and I would like to take this opportunity of expressing our cordial goodwill, and hope for the future prosperity of the institution under your control. Your garden has been responsible for the production of splendid work in the past, and I hope that your future efforts will meet with equal success. By a coincidence it happens that we are celebrating the 150th Anniversary of the foundation of our colony, so that there is an additional amount of mutual interest between your garden and ours.

I hope that your celebrations were completely successful and that the uniformly happy relationship existing with your institution will continue.

Telegram No. 85, dated Southyarraric, the 4th January 1938.

From—F. J. Rae, Esq., Director of Gardens and Government Botanist, Australia, Botanic Gardens, Melbourne, Australia.

Greetings from Botanic Gardens, Melbourne.

Telegram No. 87, dated Hongkong, the 6th January 1938.

From—The Colonial Secretary, Hongkong.

Congratulations and best wishes from Hongkong.

Letter, No. 672/37, dated Singapore, the 20th December 1937.

From—E. J. H. Corner, Esq., Acting Director of Gardens, Straits Settlements.

On behalf of the Gardens Department of the Straits Settlements, I have much pleasure in wishing the Royal Botanic Garden of Calcutta, on the occasion of its 150th Anniversary, the continuous success and eminence which it has enjoyed from its foundation. May the happy relations between our two centres of Botany in Tropical Asia continue to prosper to their mutual good and to the benefit of their science.

Letter, dated Hongkong, the 6th January 1938.

From—Dr. G. A. C. Herklots, Acting Superintendent, Botanical and Forestry Department, Hongkong.

I gladly send sincere good wishes and hearty congratulations from this Department to you on the celebration this day of your 150th Anniversary.

Telegram, dated Peradeniya, the 5th January 1938.

From—The Director of Agriculture, Ceylon, Peradeniya.

Hearty congratulations on 150 years of pioneer work in the east. Peradeniya looks forward to continued co-operation with you in the future.

Telegram, dated Rangoon, the 3rd January 1938.

From—His Excellency Sir Archibald Douglas Cochrane, G.C.M.G., K.C.S.I., D.S.O., Governor of Burma.

Hearty congratulations to the Royal Botanic Garden on having rendered 150 years of valuable service to the public. I hope that the garden will long continue its valuable work in encouraging horticulture and as a centre of botanical interest.

Telegram, dated Camp Lucknow, the 4th January 1938.

From—His Excellency Sir Harry Haig, K.C.S.I., C.I.E., I.C.S., Governor of the United Provinces.

I congratulate the Royal Botanic Garden, Calcutta, on the celebration of its 150th Anniversary and wish this famous institution a future as distinguished as has been its past.

Letter, dated Puri, the 21st December 1937.

From—His Excellency Sir John Austin Hubback, K.C.S.I., I.C.S., Governor of Orissa.

I am very greatly interested to hear that the 150th Anniversary of the Royal Botanic Garden, Calcutta, is shortly to be celebrated. I feel sure that the institution will continue in the future to carry out the admirable work for which it has been distinguished for so many years.

Letter, dated Peshawar, the 23rd December 1937.

From—His Excellency Sir George Cunningham, K.C.S.I., K.C.I.E., O.B.E., I.C.S., Governor of the North-West Frontier Province.

On the 150th Anniversary of the Royal Botanic Garden, Calcutta, I would like to be allowed to congratulate the institution on their achievements in the past and to wish them success in the future.

Letter, dated Calcutta, the 17th December 1937.

From—Dr. Shyama Prosad Mukherjee, M.A., D.Litt., Bar.-at-Law, Vice-Chancellor of the Calcutta University.

Kindly convey to the members of the Royal Botanic Garden the good wishes and congratulations of the Calcutta University on the completion of the 150th year of the existence of the garden, a period associated with noteworthy advances in the progressive development of the biological sciences. The cordial relation between the University and the garden will, I trust, be further strengthened in the years to come and the two institutions will work together in closer co-operation for the advancement of scientific research.

Letter, dated Calcutta, the 16th December 1937.

From—Dr. S. P. Agharkar, M.A., PH.D., F.L.S., F.N.I., Ghose Professor of Botany and Head of the Department, Calcutta University.

On behalf of the members of the staff of the Botany Department of the Calcutta University I have the honour to convey their hearty congratulations to the Royal Botanic Garden, Calcutta, on its achievements during the one hundred and fifty years since its foundation and wish it a brilliant and increasingly useful career in the future.

During the long period of its existence the Sibpur Garden has made important contributions to Indian botany and earned worldwide fame by the excellence of its publications. Its collections have been largely utilised for the preparation of the flora of British India and its provinces. Its herbarium is easily the largest institution of its kind in India. By its pioneer work in the cultivation of cinchona, tea and rubber, the garden has laid the foundations of some of the most important plantation industries of India.

During recent years the garden has suffered a diminution in its scientific staff as a measure of retrenchment. I hope, however, that this will soon be restored and the garden enabled to resume its normal activities and take its proper place as the Central Institute for the study of Indian flora.

Letter, dated Benares, the 5th January 1938.

From—Pandit M. M. Malavya, B.A., L.L.B., Vice-Chancellor of the Benares Hindu University.

The Benares Hindu University offers its congratulations to the Management of the Royal Botanic Garden at Calcutta on the occasion of its 150th Anniversary. Besides having been a source of delightful pleasure to countless visitors to the garden, it has rendered great service to the country in providing facilities for the study of botanical science. The Benares Hindu University sends its best wishes to the Management for even increasing usefulness of the garden in the future in the service of science.

Letter, No. Bt. 1461, dated Rangoon, the 10th January 1938.

From—Professor F. J. Meggitt, "Biology" Department, University College, Rangoon.

I much regret that my absence from Rangoon on a collecting trip resulted in my receiving your letter too late to reply: in fact I only returned yesterday. If it be not too late, I would like you to insert in the report the best wishes of the department for the Royal Botanic Garden, and an appreciation of the work it has already achieved.

Letter No. 161, dated Lahore, the 6th January 1938.

From—Dr. H. P. Chaudhury, D.Sc., Head of the Department of University Teaching in Botany and Director, Kashyap Research Laboratory, and Dr. S. L. Ghose, Ph.D., Director, University Laboratory, Lahore.

The Punjab University Botany Department offers its cordial felicitations to the authorities of the Royal Botanical Garden, Sibpur, Calcutta, on the happy occasion of the garden's 150th Anniversary and conveys its sense of deep appreciation of immense help and co-operation the garden has afforded to botanists in general during the long years of its useful existence. It hopes that the garden will continue to render the same service for many more similar periods.

Letter No. XA13886, dated Chepauk, the 22nd December 1937.

From—The Registrar, University of Madras.

With reference to your demi-official, dated the 7th December 1937, to the Vice-Chancellor of this University, inviting him to participate in the 150th Anniversary Celebration of the Royal Botanic Garden, Calcutta, I am desired by the Vice-Chancellor to communicate to you his congratulations and good wishes on the occasion of the Anniversary Celebrations.

Letter No. 2290, dated Nagpur, the 27th December 1937.

From—Sir Hari Singh Gour, Kt., M.A., D.Litt., D.C.L., LL.D., Vice-Chancellor of the Nagpur University.

The celebration of the 150th day of the Royal Botanic Garden is an event that will arouse a heartfelt welcome in every heart that loves plant-life to develop and popularize which the garden has done such yeoman service during its long and healthy existence.

I most warmly send my congratulations to your great monument of public benevolence and wish it to thrive and grow like its ever-growing banyan tree.

Letter No. 254-VC-37, dated Lucknow, the 24th December 1937.

From—Dr. R. P. Paranjpye, M.A., D.S.C., Vice-Chancellor of the University of Lucknow.

I am in receipt of your letter of the 7th December intimating to me that 150th Anniversary of the Royal Botanic Garden, Calcutta, is to be celebrated on the 6th January. Your gardens have a well-deserved reputation all over the East and the Lucknow University hopes that it will continue to maintain and enhance it.

I am requesting Dr. Birbal Sahni, F.R.S., Professor of Botany in this University to be present at the function, and perhaps I may also be able to attend in person.

Letter No. 2291, dated Bombay, the 27th December 1937.

From—M. Chandarvarkar, Esq., Vice-Chancellor, University of Bombay.

I thank you for your letter of the 7th December 1937. I send you my best good wishes on the historic occasion of the completion of the 150th Anniversary of the Royal Botanic Garden, Calcutta, on the 6th January next. It is your great good fortune to have with you on this occasion the distinguished members of the overseas delegation who have come to this country to attend the Jubilee Session of the Indian Science Congress, and that Sir Arthur Hill, Director, Royal Botanic Garden, Kew, is one of them. I wish every success to the function.

Letter No. 28, dated Indore, the 18th January 1938.

From—Dr. P. Basu, M.A., B.L., Ph.D., Vice-Chancellor of the Agra University.

On the occasion of the completion of the 150th year of the existence of the Royal Botanic Garden, Calcutta, I, on behalf of Agra University, send you my hearty congratulation. During this long period of its existence the Royal Botanic Garden has done very good scientific work which has been of great value both to technical science and to the spread of general knowledge about plants. I wish it success in future and hope that it will continue to do the very useful work even better in future.

Letter No. 8114, dated Calcutta, the 14th December 1937.

From—Dr. C. S. Fox, D.SC. (Birm.), M.I.M.E., F.G.S., F.N.I., F.R.A.S.B., Director, Geological Survey of India.

The Geological Survey of India sends cordial congratulations to the Royal Botanic Garden on its 150th Anniversary, with best wishes for the successful continuation of its distinguished scientific activities and the restful amenities provided for the public.

Letter, dated Calcutta, the 3rd January 1938.

From—Dr. B. Prashad, D.SC., F.Z.S., F.R.S.E., F.N.I., F.R.A.S.B., Director, Zoological Survey of India.

On behalf of the Zoological Survey of India, Indian Museum, Calcutta, I have great pleasure in conveying sincere felicitations to the authorities of the Royal Botanic Garden, Calcutta, on the occasion of the 150th Anniversary of this venerable institution. The Zoological Survey and its predecessors, the Natural History Sections of the Indian Museum, and of the Museum of the Asiatic Society of Bengal, had very close and cordial connections with the Royal Botanic Garden since the days of its earlier Superintendents Nathaniel Wallich and Hamilton Buchanan, and these have been fully maintained by the long series of their distinguished successors.

The Herbarium of the Royal Botanic Garden, which is a store house of very valuable collection of plants, has rendered very valuable services to the country ever since its foundation. It is but proper that the authorities of the institution should celebrate the 150th Anniversary of this institution in a befitting manner. The Zoological Survey of India wishes the Royal Botanic Garden a bright future and long era of useful service in the cause of science.

D.-O. letter No. 11009, dated New Delhi, the 22nd December 1937.

From—Rao Bahadur B. Viswanath, F.I.C., Director, Imperial Agricultural Research Institute, New Delhi.

While assuring you that I shall make earnest endeavour to participate personally in the function, I take this opportunity of conveying the appreciation of myself and my colleagues at this institute of the most valuable and brilliant record of work and achievements of the Royal Botanic Garden during a century and a half of its existence. May the garden achieve yet greater distinction in the domain of Indian botany.

I offer my heartiest good wishes for the success of the function.

Letter No. 6250/113-2, dated Dehra Dun, the 29th December 1937.

From—L. Mason, Esq., I.F.S., Inspector-General of Forests, Dehra Dun.

The good wishes and congratulations of all scientists, and more particularly botanists, will go out to the staff of the Royal Botanic Garden, Calcutta, and to all concerned on the occasion of the celebration of the 150th Anniversary of the garden.

The Indian Forest Service takes a more than academic interest in this celebration since many of the sheets in the herbarium bear the names of members of the Indian Forest Service. Sir Dietrich Brandis, Gustav Mann, J. S. Gamble, H. H. Haines, C. E. C. Fischer are names that spring to the mind, but very many forest officers have sent collections to the herbarium of the Royal Botanic Garden, Calcutta, or have carried out scientific work there.

In the preparation of local floras compiled by members of the Indian Forest Service the collections at Calcutta have been of very great and, in fact, indispensable assistance.

As far as the Forest Research Institute is concerned, the happiest exchange relations have existed between it and successive Superintendents of the Royal Botanic Garden.

It is a peculiar pleasure for me to voice the goodwill of all members of the Forest Department in India on the occasion of the celebration of this milestone in a long and honourable career.

Letter No. 7-14-29, dated Dehra Dun, the 5th January 1938.

From—Dr. N. L. Bor, I.F.S., M.A., D.SC., F.L.S., F.R.S.E., Forest Botanist, Forest Research Institute.

It is a matter of great regret that I am unable to take part in the celebrations attending the attainment of the 150th Anniversary of the Royal Botanic Gardens, Calcutta.

I and all my predecessors owe a very great deal to the herbarium and to the treasures housed therein. The happiest relations between the Botanical Branch of this institute and the Botanical Garden have always existed and it is with the greatest pleasure that I send a message of goodwill and congratulations on the attainment of this anniversary.

D.-O. letter No. E.B.-3, dated Poona, the 3rd January 1938.

From—L. S. S. Kumar, Esq., Economic Botanist to Government, Bombay.

I thank you for the invitation to attend the 150th Anniversary of the Royal Botanic Garden, Calcutta. Much as I would like to be present on this occasion I regret my inability to do so. Your garden and the herbarium has been of considerable help to us in obtaining information in the past and I wish your institution a long life of useful activity.

Telegram, dated Maymyo, the 5th January 1938.

From—The Chief Conservator of Forests, Burma.

The Forest Department, Burma, congratulate the Royal Botanical Garden, Calcutta, on completion of 150 years' successful and valuable work.

Telegram, dated Riyang, the 4th January 1938.

From—P. V. Osborne, Esq., Manager, Cinchona Cultivation, Government of Bengal, Mungpoo, Darjeeling district.

Members of Mungpoo Cinchona Plantation send you heartiest congratulations on your 150th Anniversary and every good wishes for the future.

Letter No. 3, dated Calcutta, the 6th January 1938.

From—Johan Van Manen, Esq., C.I.E., General Secretary, Royal Asiatic Society of Bengal.

The Royal Asiatic Society of Bengal, remembering its long and intimate relations with the Royal Botanic Garden and its distinguished staff, a matter of pride and happiness at all periods, offers to the sister institution across the Hooghly on the occasion of its 150th Anniversary the warmest felicitations, wishes it a long and prosperous future, and anticipates for it a continuance of achievement and valuable results, fully commensurate with those of the past.

D.-O. letter No. 381, dated Bombay, the 17th December 1937.

From—Dr. T. S. Wheeler, D.SC., Principal, Royal Institute of Science, Bombay.

On behalf of the Royal Institute of Science, Bombay, I heartily congratulate the Royal Botanic Garden, Calcutta, on the attainment of its 150th Anniversary and I express the hope that it will flourish in the future as it has flourished in the past.

Letter No. 302/T., dated Calcutta, the 5th January 1938.

From—A. F. M. Abdul Ali, Esq., M.A., Honorary Secretary to the Trustees of the Indian Museum.

On the occasion of the celebration of the 150th Anniversary of the Royal Botanic Garden, Calcutta, the Trustees of the Indian Museum which has invariably for a long period entertained cordial relations with the garden, have much pleasure in conveying their warmest and sincerest felicitations. The herbarium of the Royal Botanic Garden is the store house of a unique and very valuable collection; and not only has it elicited encomiums from many a distinguished botanist and scientist but has also been a national glory. It is but meet and proper that the authorities of the institution should celebrate the historic occasion in a befitting manner and the Trustees wish them all success and a long era of unflagging and further useful service to the cause of science and research.

D.-O. letter No. 5773, dated Calcutta, the 23rd December 1937.

From—Sanat Kumar Roy Chaudhury, Esq., M.A., B.L., Mayor of Calcutta.

On the occasion of the 150th Anniversary of the Royal Botanic Garden, Calcutta, I, on behalf of the citizens of Calcutta, convey to you my heartiest good wishes. The Botanic Garden has provided a haven of rest to the tired and jaded city dweller.

So far as the city administration is concerned, the officers in the Botanic Garden have been immensely helpful with their suggestions in various matters. I refer particularly to your help during an investigation on the problems of water filtration.

As a centre of diffusion of knowledge in Botany and allied subjects, your garden occupies a unique place.

I hope that the Botanic Garden will have many more years of its very useful life.

Letter, dated Howrah, the 4th January 1938.

From—Mr. B. C. Datta, Bar.-at-Law, Chairman, Howrah Municipality.

The Royal Botanic Garden has always been a pride of Howrah. It has attracted to this town many distinguished visitors from India and abroad and has served as a place of recreation, amusement and enjoyment to everybody in and about Calcutta.

On this occasion of the celebration of the 150th Anniversary of this very useful institution, I congratulate the authorities of the garden for the public service they have rendered during the last century and a half and wish that it may continue to serve the people in the same way as it has so long done.

Letter, dated Bombay, the 1st January 1938.

From—The Superintendent, Municipal Garden, Bombay.

Please accept my hearty congratulations at the celebration of the 150th Anniversary of the Royal Botanic Garden, Calcutta, to be held on the 6th January 1938. I very much regret that due to unforeseen circumstances, I am not able to attend the function on such an unique occasion. But all the same I offer my felicitations on the happy event and wish you all success.

Letter, dated Bombay, the 3rd January 1938.

From—Mr. P. M. D. Sanderson, F.Z.S., Honorary Secretary, Bombay Natural History Society.

Please accept on behalf of the Council and Members of the Society our sincere congratulations on the 150th Anniversary of the Royal Botanic Garden, Calcutta.

Your garden has made a great contribution to the advancement of botany in India both from the scientific and popular standpoints, and it is our hope that it will continue to maintain its position as one of the premier institutions of its kind in the East.

Letter, dated Bangalore, the 26th December 1937.

From—The Secretary, " Current Science."

The Editorial Board of "Current Science" desire to convey their warmest greetings to the Royal Botanic Garden, Calcutta, on the historic occasion of the celebration of the 150th Anniversary of the garden. This institution has made numerous significant contributions, *both in the scientific and economic fields, and "Current Science" has had the distinction of publishing, in its columns, a few of the results of its activities. It is hoped that in the years to come, the Royal Botanic Garden will widen, still further, its sphere of usefulness to the country, and become a recognised centre of reference for all enquiries on tropical plants.*

Letter, dated Calcutta, the 6th January 1937.

From—S. P. Lancaster, Esq., F.L.S., F.R.H.S., M.R.A.S., Secretary, Royal Agri-Horticultural Society of India, Alipore.

There has always been active co-operation between the Royal Botanic Garden and the Society since the early days when Carey collected material from the Terai, Bhutan and wherever the padre was stationed till the present time. We are indebted to the assistance of the Herbarium for the identification of specimens that reach us from members all over India and for the gift of seeds and plants from foreign countries, which we reciprocate whenever possible.

The close association between our institutions is shown by the names of several Superintendents who have been elected Presidents and Vice-Presidents of the Council.

I have been asked by the Council of the Society to add its good wishes to the congratulatory messages that have been received today.

Letter, dated Calcutta, the 27th December 1937.

From—Professor S. C. Mahalanobis, F.R.S.E., President, Botanical Society of Bengal.

On behalf of the Botanical Society of Bengal I have great pleasure in congratulating the Royal Botanic Garden, Sibpur, Calcutta, on the occasion of the 150th Anniversary of its foundation. We hold in great admiration the efforts and achievements of the founders and past organizers of the Royal Botanic Garden—among whom are included the names of many illustrious makers of Botany. It would be difficult to overstate the value of the services rendered by the Royal Botanic Garden, during the hundred and fifty years of its existence, towards the furtherance of the interests of the science of Botany and particularly for the promotion of botanical studies in India. We rejoice with the present authorities of the Royal Botanic Garden on this impressive occasion commemorating the great event of a century-and-a-half ago and send them our best wishes for a continued career of increasing usefulness of the garden.

Telegram, dated Cooch Behar, the 5th January 1938.

From—His Highness the Maharaja Gaekwar of Baroda.

Wish the celebration of the 150th Anniversary of the Royal Botanic Garden, Calcutta, the oldest and the most famous botanical institution every success.

Telegram, dated Trivandrum, the 6th January 1938.

From—The Private Secretary to His Highness the Maharaja of Travancore.

His Highness the Maharaja of Travancore has heard with great pleasure of the celebration today of the 150th Anniversary of the Royal Botanic Garden, Calcutta This event in the history of an institution of such standing representing this branch of science is one for real congratulations. Please accept His Highness' best wishes.

Telegram, dated Cooch Behar, the 6th January 1938.

From—The Vice-President, State Council, Cooch Behar.

His Highness desires me to convey his most cordial congratulations to the Royal Botanic Garden on the occasion of its 150th Anniversary.

Letter, dated New Delhi, the 31st December 1937.

From—Sir Abdur Rahim, KT., President, Indian Legislative Assembly.

I wish to convey my cordial congratulations to the Royal Botanic Garden, Calcutta, on the celebration of its 150th Anniversary. I believe it is the finest botanical garden in India and is of the greatest usefulness to the students of Botany and to the members of the general public interested in the flora of the country. I wish it were possible for me to be present at the function, as I have always been an admirer of its layout and its rare and beautiful specimen of trees and shrubs. I hope the authorities in charge will always bestow on it their best care and attention.

Letter, dated Comilla, the 2nd January 1938.

From—A. C. Dutt, Esq., M.A., B.L., Deputy President of the Indian Legislative Assembly.

I regret I shall not be able to be present at the 150th Anniversary function of the Royal Botanic Garden, Calcutta. I wish the function success and I hope that the garden will have a very useful and glorious future under the very able management of the present Superintendent, Dr. K. P. Biswas, who is an well-known botanist today.

Letter No. D. 8435/37-G., dated New Delhi, the 22nd/23rd December 1937.

From—The Imperial Council of Agricultural Research, New Delhi.

I much regret that it is not possible for me to be present at the 150th Anniversary celebrations of the Royal Botanic Garden on the 6th January 1938, owing to official engagements from which I cannot escape but I wish your celebrations every possible success and have no doubt that the Royal Botanic Garden will continue to maintain its position which is unique in India.

Letter, dated New Delhi, the 30th December 1937.

From—Sir Girija Shankar Bajpai, KT., K.B.E., C.I.E., I.C.S., Member, Governor-General's Executive Council, Department of Education, Health and Lands.

I am much obliged to you for your letter of the 20th December. Unfortunately I see no prospect of being in Calcutta on the 6th proximo in order to attend the celebration of 150th Anniversary of the Royal Botanic Garden. I send you, however, my warmest wishes for the success of the anniversary functions and for as proud a record of service to science by you and your colleagues as that of your distinguished predecessors.

Letter No. 7586, dated Calcutta, the 20th December 1937.

From—Sir Ramnath Chopra, KT., Bt.-Col., I.M.S., C.I.E., LL.D., F.N.I., F.R.A.S.B., Director, School of Tropical Medicine, Calcutta.

Kindly allow me to convey my congratulations and good wishes to you on the occasion of the completion of the 150th year of the Royal Botanic Garden, Calcutta. May the garden continue to be a mighty source of knowledge and benefit to the scientists!

I wish you all success.

Letter, dated Tagore Castle, the 6th January 1938.

From—The Maharaja Bahadur Sir Prodyut Coomar Tagore, KT., K.C.I.E.

To-day, the 6th January 1938, happens to see the 150th Anniversary of the foundation of the Royal Botanic Garden at Sibpur. A century and a half ago it was not foreseen by the founders that this department of the British Administration would be so useful to India. It is, therefore, fitly and worthily resolved to celebrate the hundred and fiftieth birthday of the "Garden of Eden," as it may be called, in Bengal by recalling its history and furnishing a summary of this garden's life.

It is with feelings of admiration rather than of terror that we see this sand bank of Hooghly, once a safe place for tigers and leopards, now transformed into a thing of beauty. Nature has been trained to submit to a highly developed and scientific civilization. It is possible, however, to welcome here to-day the wilderness as much as the beauties of rural nature.

The celebration of the garden has been very happily conceived by the present learned Superintendent Dr. K. P. Biswas who possesses uncommon merit in botany. His exposition of its history and gradual development will be read with considerable interest by the public, as it has been squeezed into unsavoury and unreliable dryness, as such reports unfortunately are in Bengal like other places.

The progress of the garden has steadily increased with successive eminent botanists like Drs. King and my esteemed friend C. C. Calder whose departure no one regrets more than myself as Chairman of Board of Trustees of the Indian Museum.

The present Superintendent's constant attention and organising power cannot but tend to lend, freshness, vigour and variety to the work as well as sustain and enhance its reputation and at the same time perpetuate and enlarge its usefulness.

D.-O. letter No. 1461C., dated the 23rd December 1937.

From—N. V. H. Symons, Esq., C.I.E., M.C., I.C.S., District Magistrate of Howrah.

I am writing to wish the Royal Botanic Garden success in its 150th Anniversary celebrations as well as for the future. Howrah district is fortunate and proud to have such a magnificent Botanic Garden within its boundaries. To me personally the garden has provided many hours of delight.

Letter, dated Dacca, the 4th January 1938.

From—Srish Kumar Sen, Esq., Dacca.

This auspicious occasion is one of joy not only to those who are the worthy successors to the great and noble band of workers commencing from Roxburgh but also to outsiders like myself who have had the good fortune of residing in the immediate neighbourhood of the garden nearly 40 years ago and of imbibing some of the spirit pervading its atmosphere.

Additional significance will be lent to the function by the fact that it coincides with the joint sitting of the British Association and the Indian Science Congress and will be attended by Sir Arthur Hill and other eminent botanists and takes place almost simultaneously with the taking over of charge by the first Indian botanist destined to be the permanent Superintendent of the garden.

Although circumstances will not permit of my personal attendance at the celebration my fervent prayers go out for its unqualified success. I shall be glad to receive a copy of any book or pamphlet that may have been prepared in connection with the celebration.

The 150th

ANNIVERSARY VOLUME

OF THE

ROYAL BOTANIC GARDEN, CALCUTTA

Part II

Some Impressions of a Botanist in India

by

PROFESSOR R. RUGGLES GATES, D.Sc., LL.D., F.R.S.

Professor of Botany, King's College, London

During the Indian tour of the British Association one's time was so taken up with sights of the fleeing landscape and visits to laboratories and institutions, that it was impossible to make more than occasional very rough notes. The result is that many impressions of the vegetation which were vivid enough at the time failed to be recorded on paper and are now overlooked.

Travelling through Hyderabad, one was perhaps most struck by the red laterite soil in some places and the extensive areas of thin black soil often with curiously angular fragments of black basalt (Deccan trap) projecting through it. This black soil appeared to be most serviceable for cotton. One also saw crops of Cicer, Maize and Ricinus. Around Aurangabad, Mimosa was common by the roadsides, and Artocarpus characteristic as a large tree with smooth outline and dark green leaves. Near Ajanta I first saw teak. The trees near the roadside were small, but the huge leaves which give it its name, *Tectona grandis* L., were still adhering, although brown and dead. These trees were in fruit on the ends of the branches, which gave the appearance of a sort of halo around the tree. Later I saw much more of it in the elephant jungle between Mysore and Ootacamund, where it is abundant. In one of the teak trees here, at Bandipur, when cut, as many as 1,500 annual rings of wood are said to have been counted, and the rings are stated to be very clear.

The wild sterile date-palm (*Phoenix sylvestris* Roxb.) was common not only in parts of Hyderabad, but I afterwards saw a grove of it near Dacca. A species of Cassia, a bush with yellow flowers, was common here. I first became familiar with this genus on the Amazon, where there were many species; some herbaceous, some large shrubs with very heavy woody pods, and some trees. In Hyderabad and various parts of Northern India leguminous trees with varied types of pods were characteristic. Ascending the hill to the Fort of Aurangabad were several wood apple trees (*Feronia elephantum* Correa). Other plants noted in this region were a Euphorbia with candelabra-like branches, which was common, a large Rhipsalis-like form, and *Argemone mexicana* L., one of a number of Mexican introductions which was afterwards seen in many places from Mussoorie to Cape Comorin. Lantana, another native of Central America, one of the best known of Indian weed pests, was common here as in many other parts of India. I afterwards saw it in various parts of the Nilgiri Hills.

At Sanchi, in Bhopal, one saw banyans and various other tree genera. A large Ficus with small fruits was also seen here. The celebrated banyan (*Ficus bengalensis* L.) in the Sibpur gardens, now surviving by its radiating rooted branches after the central trunk has disappeared, is in a class by itself. I afterwards photographed at Madura what is claimed to be the second largest banyan in India. It was said to be nearly 300 years old and 500 yards in circumference. A striking feature of many Indian roads is that they have been planted with avenues of banyan trees stretching for many miles and forming a grateful archway of shade from the hot sun for pedestrians or bullock-cart drivers. I was particularly struck with these avenues near Madras and Mysore. In these trees the propensity to form roots from the branches is only permitted close to the trunk. Other roots are frequently cut off some distance from the ground, with the result that they break out into branches near the tip, forming a bushy mass of roots hanging from above. One was again reminded of the habits of the strangling figs of the Brazilian jungles, taking their origin in an abundance of adventitious roots which ultimately stifle the growth of the tree on which they germinate as epiphytes, but without branches radiating like arms, as in the banyans.

In the gardens at Bangalore I saw the var. *Krishna* of the banyan, which is grown in different parts of India and which probably arose as a mutation. It differs from the species in that (1) the leaves are practically all ascidia, (2) no aerial adventitious roots are formed. At Allepey in Travancore a tree of *F. glomerata* Roxb. in a garden showed cauliflory very strongly, the trunk and main branches being covered with bunches of the fruits. The peepul tree (*Ficus religiosa* L.), first seen at Bombay, with the very long, projecting tip to the leaf, was a familiar object in many places. At " The Towers," Cossipore, in the garden of my kind hosts, Mr. and Mrs. H. P. V. Townend, I saw another fig with banyan-like habits, *Ficus comosa* Roxb. Here, too, I made the acquaintance of a large tree, *Thespesia populnea* Corr. (Malvaceae), covered with beautiful flowers like those of cotton and with a similar red spot at the base of the petals.

At Sanchi I first made the acquaintance of *Grevillea robusta* A. Cunn., the tall and slender Proteaceous tree from Australia which I afterwards saw cultivated in many places, especially in South India. As it is not mentioned in Hooker's *Flora of British India* (1890), it is presumably a recent introduction. They are sometimes planted in avenues, the finely divided leaves are often used in bouquets, and the rapidly growing wood is useful for firewood. They are also used as a shade tree for the tea plantations.

At the Imperial Agricultural Research Institute, New Delhi, I was interested, among many other things, in seeing the root nodules of gram (Cicer), as well as another plant in which the bacteria do not form nodules but adhere to the surface of the roots, being chemotactically attracted from the soil. Also a *Diplococcus* which, when added to a solution of virus, causes the virus to disappear.

The great display of Indian timbers at the Forest Research Institute, Dehra Dun, was most instructive. It was evident that many of these woods had qualities which have never yet been properly utilized. The method of impregnating a large log with ascu (containing copper sulphate, chromic acid and an arsenious compound) in ten minutes under high pressure in an iron pipe seemed advantageous over creosoting, and the use of the abundant bamboo as a source of paper was very successful. In the grounds of the institute were large and brilliant Poinsettias (which I afterwards saw, equally flourishing, at Ranchi in Bihar), Bougainvillea which is everywhere, and *Cassia fistula* L. in full pod.

Ascending the second range of foothills north of Dehra Dun by hairpin turns to over 6,000 feet we saw the dusty plains below and the snowy line of the Himalayas to the northwards. The mountain sides we ascended were terraced in many places and bearing a crop of young, light green wheat. The near hillsides were covered with forest which appeared to be mainly Pasania. Familiar reminders here of the European flora were a Violet, a Salvia and a Berberis ; also a very large, bright red, bushy Rumex.

East of Lucknow, a shrub with leaves suggesting Sciadopitys, but single and thinner, with large yellow flowers, milky juice and small rounded green fruits probably belonged to the Apocynaceae. The crops in this part of Northern India included extensive fields of various Brassicas and indigo.

On the boat journey down the Lower Ganges and Brahmaputra from Goalundo to Narayanganj one was struck with the floating islets of Eichhornia, frequently with a heron standing on them, and afterwards one saw the complete choking of small channels and lagoons with this South American introduced water weed. I recalled seeing acres of it in bloom in lagoons on its native Amazon, and saw it again afterwards on the Malabar coast, as considerable floating islets. As Eichhornia is not mentioned in Hooker's *Flora* it must be a later introduction.

While the palms are so numerous and characteristic of many parts of India, I was struck by the paucity of *species* in comparison with the Amazon region. Apparently no single genus is common to both India and Amazonia; but Cocos, a South American genus, is cultivated in India, and *C. nucifera* L., must have been introduced very early from farther east. Such Eastern genera as Livistona have been introduced into Brazil.

In addition to *Phoenix sylvestris* Roxb., already mentioned, the fan-palm (*Borassus flabellifer* L.) is very abundant on the Coromandel coast between Calcutta and Madras. At the lower levels in the Western Nilgiri Hills are large groves of betel-nut palm (*Areca catechu* L.), tall, slender stems with rings looking like bamboo, growing very close together under irrigation. In Mysore one can drive for many miles through open country with large groves of coconuts. But it is on the Malabar coast, in Cochin and Travancore, that one finds them at their best. Here great areas of them line the lagoons and canals, dominating all other vegetation and forming a major element in the economy of the State and the activities of the people. The talipot fan-palm, *Corypha umbraculifera* L., was fairly common near Kottayam, with enormous dark green fan-leaves and stout stems, generally short. *Caryota urens* L., the Kitul-palm, was seen near Lake Periyar. It is not common, but some were large trees. The species is monocarpic and a tree dies soon after producing an enormous mass of fruits. A tree in process of fruiting was afterwards seen in Ceylon. The Borassus fan-palm is very common on the south-east coast near Mandapam.

North of Madras a thorny Acacia is common, apparently planted in groves and used for making hedges. I drove with Professor Ekambaram and Mr. Abraham to Vandaloor, 18 miles south of Madras, to study a type of vegetation which I was surprised to find here. It is a typical spiny scrub, resembling in general facies the Mediterranean maqui or the Californian chapparal, although more spiny and less sclerophyllous than the latter and forming quite impenetrable thickets of considerable extent. Intermingled were a certain number of succulents, including Euphorbia sp. and *Vitis quadrangularis* Wall. Nearby were pools and damp ground containing various water and bog plants. The list of identifications, from several of which I was able to obtain specimens, was as follows: *Zizyphus Oenoplia* Mill., *Z. jujuba* Lamk., *Acacia arabica* Willd., *Tamarindus indica* L., *Cassia auriculata* L., the Rubiaceous genera Pavetta, Morinda, Ixora, Randia, and Mussaenda, *Drosera Burmanni* Vahl. and *D. indica* L., *Jatropha glandulifera* Roxb., Carissa sp., Barleria sp., *Lepidagathis cristata* Willd., Cuscuta sp., *Allophylus Cobbe* Blume, Isoetes sp. and Selaginella.

In the gardens at Bangalore I was interested to see the large African tree *Spathodea campanulata* Beauv., with dull yellow curved buds and large orange scarlet flowers in great clusters. Also tree of the African *Kigelia* with its very heavy, oblong, grey fruits hanging down from stalks two or three feet long. *Araucaria Cooki* R. Br., as well as many other introductions, was also growing here. In the zoological gardens at Mysore, I was much interested to see huge trees of *Parkia biglandulosa* W. & A., a Malayan legume which aggregates its flowers into a large ball of Composite-like compactness. Of the innumerable florets in this ball or head, only six or seven finally develop legumes attached to the swollen central receptacle. This genus appears to have added the inflorescence of the Compositae to the flower of the Leguminosae—and interesting case of parallel evolution. Several stages were collected.

In visiting the Kurubas at Bandipur, half-way between Mysore and Ootacamund, in the bamboo jungles, I obtained one of the musical pipes of these primitive jungle people. It was said to be made of the wood of one of the Verbenaceae. This jungle is rich in bamboos, large and small, some reaching 100 feet in height. Sandal wood is also abundant.

At higher levels in the Nilgiri Hills on the road to Ootacamund the scenery is fine and essentially temperate in aspect. The higher slopes of these rolling hills and some of the hill-tops are covered with dense grassy vegetation, the wooded areas being confined to lower levels. The same condition was seen on the hills around Lake Periyar. This reminds one of the conditions on some of the Coast Range mountains of California. A fine deep red Rhododendron (probably *R. arboreum* Sm.) was here, and a large shrubby Hypericum (probably *H. mysorense* Heyne) with large flowers. Eucalyptus is so common as to appear almost like a native tree, and they grow very tall. Araucaria also reaches an exceptionally large size.

In the Nilgiris I was also interested in an introduced phyllodic Acacia from Australia. It was a large tree with narrow dark green " leaves " and so common that I at first mistook it for a native species. At Ootacamund it was interesting to observe some seedlings which showed clearly the recaptitulation in leaf-form. A natural seedling, three to four feet high, bore on its stem twenty or more compound Acacia leaves. In the axil of each leaf arose a short branch bearing several phyllodic leaves. The transition was thus a sharp one. Suckers from the roots of older trees also showed many compound leaves as well as phyllodes, but they were less regularly disposed than in the seedlings.

On the road to Coimbatore the hillsides in many places are covered with dense jungle. Other hillsides and valleys are terraced with great potato and vegetable gardens. Here also are extensive tea and some coffee plantations, and lower still rice, which one saw growing in nearly all parts of India visited. In some places in South India were rubber plantations, not now being actively tapped.

At Coimbatore the breeding experiments are much too numerous to mention. A point which caught my attention, because so little is yet known of the inheritance of anatomical structure in plants, was the demonstration that different types of anatomy at the base of the cotton flower are inherited as simple Mendelian differences, giving in one case a 9 : 3 : 4 ratio. These were independent of the Mendelian differences in leaf morphology.

On the road from Kottayam in Travancore to Permade in the Nilgiris, I first photographed the jack fruit (*Artocarpus integrifolia* L.) with its great fruits hanging on long stalks down the trunk—a typical example of cauliflory. At Permade (3,500 feet) there is a fine outlook over rows of hills covered with not very dense jungle. Near the travellers' bungalow I saw the large tree, *Vernonia travancorica* Hook. (Compositae), my previous acquaintance with this large genus being an herbaceous species in East North America.

A day was spent in being paddled along Lake Periyar in a large dugout canoe. They are made from a trunk of *Artocarpus hirsuta* Lamk. Four men will make one over 20 feet long and three to four feet wide in about 20 days. They have strengthening ribs and cross-pieces for seats and will hold many men. The Mannans also make numerous rafts for fishing, from six large bamboos (*Bambusa arundinacea* Willd.) tied together. Lake Periyar was flooded forty-eight years ago, but the gaunt skeletons of dead tree trunks still stand partially submerged in many parts of the lake. Eriodendron (*Ceiba pentandra* Gaertn.) is common in the surrounding forests. It was leafless and in flower, with large, red flowers and spike-like projections on the younger stems. It has the same features on the Amazon, where it is perhaps the largest of the jungle trees. *Terminalia tomentosa* Bedd. was another large tree pointed out to me. Other trees recognized were Pterocarpus, Alpinia (Zingiberacae), the handsome *Asclepias curassavica* L., (introduced from the West Indies) and *Allamanda cathartica* L., with large yellow flowers, another American species.

The Uralis by Lake Periyar cut off one or more large tree trunks some 20 feet from the ground and build on this foundation a thatched hut to escape the elephants. It is reached by a bamboo ladder and is often covered with climbing vegetation. The Uralis grow primitive gardens of sweet potatoes, plantains, cucurbita, capsicum, colocasia (yams), brinjal, and a few cabbages, all of which the elephants may come and destroy by night.

Travelling by motor-boat from Kottayam to Allepey and Quilon on the Malabar coast was a scene of tropical luxuriance long to be remembered. It is a beautiful region of lagoons and canals, paddy fields and coconut groves as far as the eye can reach. *Pandanus tectorius* Soland. fringes the water, as well as *Cerbera Odollam* Gaertn., the small apocynaceous tree whose poisonous green globular fruits are very buoyant in the water. Colocasia grows here and *Hibiscus tiliaceus* L. was in flower. In narrow channels, the tall coconut palms almost meet overhead. The square sails of the boats are made from mats of interwoven strands of Pandanus leaves, the mats being sewn together.

In a lagoon near Trivandrum I had the opportunity of seeing with Professor Koshy all the typical genera of mangrove vegetation in brackish water near the sea. Two species of Rhizophora, *R. mucronata* Lam. and *R. Candelaria* DC., were in all stages of buds, flowers and fruits, the viviparous, torpedo-shaped seedlings falling upright in the mud and continuing their development. A quantity of material was collected. Barringtonia was also in flower, with square fruit and seedlings. Sonneratia showed its large pneumatophores and Avicennia its smaller ones. In a lagoon nearby floated Limnanthemum and *Nymphaea stellata* Willd.

At the Cape Comorin we collected Algae in the strong surf, especially Caulerpa spp., Ulva, Chaetomorpha, Sargassum, Dictyota, Delesseria, Gracilaria, Ceramium, Polysiphonia and others. Men of the fishing villages go out in catamarans made from three or four trunks of *Bombax malabaricum* DC. tied together. *Euphorbia antiquorum* L. is commonly used as a hedge in Travancore, *Cycas revoluta* Thunb., is abundant in some places on the road from Cape Comorin to Trivandrum, frequently producing cones. *Gnetum scandens* Roxb., is a common liana scrambling over the vegetation within two miles of Trivandrum, and is frequently found around Hindu shrines. The fruits were in all stages of development, from very small up to mature fruits nearly as large as olives, which they somewhat resemble. The large, bright red follicles of *Sterculia nobilis* R. Br. with lead-coloured seeds are very striking. In at least one of the Amazon species of this genus of huge trees, the follicles were lined with irritating brown hairs.

I was able to make a few final observations of Indian vegetation in the area of sand dunes between Mandapam and Adam Strait. The umbrella tree, *Acacia umbraculata*, is very common here, ranging from a small shrubby growth to a good sized tree. Its white thorns two inches long give the tree a greyish appearance at a little distance. The leaves are very small and divided into extremely fine leaflets. Many creepers grow over the loose sand and low dunes, but less commonly on the wind-swept sands at Cape Comorin. The xerophytic grass, *Spinifex squarrosus* L. was common as a sand-binder in both places. *Vitis quadrangularis* Wall., with its square, succulent stems and tendrils, was common near Mandapam; also a Convolvulus with tiny pink flowers only 10 mm. in diameter, a mint, a papilionate, a clover and a cucurbit. A small species of Pandanus also bound the sand in some places. There were few other plants, but an unidentified polster plant grew in some areas and a Juncus in moist locations. Nowhere was there an approach to a closed formation. The Convolvulus sends out runners for probably 100 feet and more in a perfectly straight line over the loose sand. The runners cross each other in various directions to form a very open network.

In these hurried glimpses of the vegetation of India one found most striking (1) the great diversity of species and ecological types in different parts of the country, (2) the extraordinary number of introduced plants, especially from tropical America but more recently the temperate introductions, particularly from Australia.

It was only possible to see so much of Indian vegetation through the kind assistance and co-operation of Government officials in various States, as well as many botanical colleagues and former students, to all of whom my hearty thanks are due for the help so generously given.

Distribution Areas of the Indian Floras

by

H. N. RIDLEY, C.M.G., M.A., F.R.S., F.L.S.,

Late Director of Gardens and Forests, Straits Settlements

If we examine the flora of India from the Himalayan region to Ceylon and Burma, we notice that it is composed of a series of elements common to other regions of the surrounding areas; of these we may eliminate for study purposes the weeds or plants intentionally or accidentally introduced by man and confine our attention to those which are indigenous, and we must make a distinction also between plants which have migrated overland and the seaborne or maritime species which have arrived by quite a different path. Hooker (Flora Indica, 1855) gave a division of the flora as then known into sections according to geographical affinity. More recent investigations have much modified his sections, and in this short paper I propose to give an outline of the divisions as known at the present day.

(1) NORTH TEMPERATE ZONE

This zone contains a very extensive flora which occupied the whole area from the arctic regions southwards to about 30°N. and all Europe, Northern Asia, Siberia, China and Japan and North America. Much of it is of very early date such being the *Magnoliaceae Lauraceae, Hamamelideae, Cupuliferae, Salix, Derris* (or *Dalbergia*) which are known to have flourished in the cretaceous period in this area. Other groups belonging to this northern region are *Ranunculaceae, Berberideae, Hypericineae, Ternstroemiaceae, Rosaceae, Umbelliferae, Cornaceae, Nyssaceae, Celastrineae, Rhamnaceae, Aceraceae, Vacciniaceae, Primulaceae, Styraceae, Gentianaceae, Boragineae, Chenopodiaceae, Engelhardtia, Carex* and many more.

In India this flora is practically limited to the Himalyan mountains, but not rarely representatives of these orders and genera have spread, usually along mountain ranges far southwards, thus we find such north temperate plants as *Gentiana, Swertia, Anemone, Agrimonia, Sanicula, Ranunculus* as far south as the mountains of Java and Sumatra.

(2) CENTRAL EQUATORIAL ZONE

A considerable flora in the tropical parts of India consisting of plants, chiefly trees and shrubs of the rainforest type, extends from the Malay islands through India to North-East Africa and reappears in Eastern South America, and this flora seems to have originated or at least been in existence in the Oligocene period as far north as Southern Europe.

As these plants belonged to an area with a heavy persistent rainfall, they have largely disappeared in the heavily-populated and long-cultivated regions of India and Central Africa, which now bear a desert or sub-xerophytic flora, for wherever man has settled in large numbers over a long period the destruction of the rain-forest flora is complete, and owing to the drying of the climate, the old flora is replaced by xerophytic herbs and shrubs.

Relics of the old flora, however, persist occasionally in localities, chiefly mountainous, unaffected by man and often at considerable distances apart, and these have been called "Discontinuous distributions."

In India we have additional proofs of the lost forest flora of the central portion in the presence of the Peacock and the Ape, *Semnopithecus*, both formerly forest-lovers and only preserved for religious motives. The Malay peacock in a truly wild state in the Malay peninsula lives habitually in forest regions though mainly on the edges where the country is more open. The *Semnopithecus*, of which there are several species living further East, is entirely confined in Malaya to the dense forests, living in the loftiest trees and rarely if ever descending to the ground.

In Africa probably the disappearance of most of the equatorial forest was due to natural climatic changes, but much of the open treeless area was heavily populated for a very long period, and the forest thus destroyed.

The number of genera common to Malaya, India, Africa and Eastern South America is very large, and there are some indigenous species quite identical over the whole area. Among these genera may be noticed *Tetracera* (*Dilleniaceae*), *Bombax* and *Eriodendron* (*Bombacaceae*), *Sterculia Buttneria*, *Erythroxylum*, *Ouratea*, *Bauhinia*, *Cynometra*, *Crudia*, *Parkia*, *Dialium*, *Zizyphus*, *Berchemia*, *Rhamnus*, *Casearia*, *Homalium*, *Ixora*, *Psychotria*, *Ardisia*, *Rauwolfia*, *Buddleia*, *Strychnos*, *Lepidagathis*, *Ebermaiera* and other *Acanthaceae*, *Callicarpa*, *Vitex*, *Clerodendron*, *Piper peltatum*, *Croton*, *Acalypha*, *Alchornea*, *Cleidion*, *Plukenetia*, *Tragia*, *Trema*, *Laportea*, *Elatostemma*, *Gymnosiphon*, *Burmannia*, *Bulbophyllum*, *Eulophia*, *Calanthe*, *Polystachya*, *Corymbis*, *Vanilla*, *Costus*, *Xyris*, *Sciaphila* and very many others. *Rhipsalis* is interesting as being the only representative of the large order *Cactaceae* in the Old World. It occurs in West Africa, Seychelles, Mauritius, Madagascar and Ceylon. The fruits are small berries with viscous pulp and small seeds and may have been carried from Mauritius to Ceylon by birds, *Engleranthus* (*Labiatae*) is a small genus, of which there are several species in Africa, one endemic one is found on one mountain in Ceylon. This seems to have been derived from Africa by a land connection.

SOME DISCONTINUOUS DISTRIBUTIONS

Anaxagorea (Anonaceae), a small genus of low trees and shrubs, probably a rather primitive form of the order. It is found in the Malay forests and in Ceylon, and again in the West Indies, but not in Peninsular India not in Africa. As this plant possesses only capsular fruit with a very limited form of dispersal, it must have been formerly very much more abundant and has disappeared in the intermediate area.

Baphia (*Leguminosae*), a small genus of trees and shrubs, occurs in Borneo (two species) and also in Africa (ten species). It is quite absent so far as it is known from the intervening area.

Klugia (Gesneraceae) is a small genus of one or two succulent jungle herbs, allied closely to *Rhynchoglossum* of Malaya. One or two species are found in Bombay, Madras and Mishmee, and in Ceylon, and two or three in Mexico, Costa Rica and Columbia in South America. It has not been found in the African region. *Klugia* is especially remarkable as it is the only genus of that section of the *Gesneraceae* which occurs at all in South America. The Asiatic and American species very closely resemble each other.

The plants common to Africa and Eastern South America could only have reached both countries by an overland bridge between. On reference to Arldt's maps of the early distribution between West Africa and Eastern South America which he calls Sudaclantis, it existed from the Neocomian period to the Oligocene after which the two countries were separated. This gives the date for the first appearance of these plants at this period, and from what we know of the fossil flora it is most probable that it was in the Oligocene age that they were flourishing. The absence of the Old World mammals of Pliocene Age in America confirms the early date of the transition. The connection of the Indo-Malayan region with Africa is less clear, but Arldt's maps show a peninsula extending from Southern Africa northwards to India and including Ceylon but apparently not touching the Malay peninsula. This peninsula is shown in the map of Neocomian age and has disappeared in the Oligocene. From the plant distribution, however, it seems clear that there was a land connection between South America, Africa and Indo-Malaya at a later date than the Neocomian.

(3) THE ARABIAN INVASION

After the closing of the east end of the Mediterranean probably considerably later than the Miocene Age and the desert formation of Arabia and Beluchistan, much of the west coast of India became xerophytic and sub-desert, and a desert flora invaded Scinde, Rajputana and Bombay as far south as Travancore—very characteristic are the *Salvadoraceae, Azima* and *Salvadora, Dodonea, Acacia, Heliotropium, Indigofera, Crassulaceae, Zygophyllaceae, Capparidaceae* and many desert, *Cruciferae, Farsetia, Malcolmia*, etc., many grasses, *Zoysiae, Andropogoneae* and others. Many of the weeds of cultivation common in waste ground all over India are probably due to this invasion from this region.

(4) CEYLON—PLANTS FROM MALAYA AND AUSTRALIA

A number of plants are found in Ceylon which have come along the south of Asia, but have not reached India proper, and show a former land connection between the Malay islands—probably Sumatra and Ceylon. Of these, the most interesting are *Acrotrema* (*Dilleniaceae*) Ceylon and Malaya *Anaxagorea* (*Anonaceae*) one species, two in Malaya (most of the Ceylon Anonaceae and Menispermaceae have affinities with Malaya and not India), *Cullenia* (*Durioneae*), the only genus of this group found outside Malaya; *Kurrimia* (*Celastrineae*) one Ceylon, the rest Malaya, *Pometia pinnata, Campnosperma* (Anacardiaceae); Semecarpus strongly represented in Malaya and Ceylon, one species in India; *Timonius jambosella* (*Rubiaceae*); very closely allied to *T. peduncularis* of the Malay peninsula and Nicobars, genus absent from India; *Lagenophora Billardeiri.* This little daisy seems to have been evolved in the Antarctic continent and spread northward from Australia *via* Hongkong, Philippines. Yunnan to Khasiya, and westwards *via* Java and Sumatra to Ceylon. *Horsfieldia Irya* (*Myristicaceae*), Malay region to Ceylon, *Notothixos* (Loranthaceae) Australian, and Philippine islands to Penang, one species, and Ceylon species *Burmannia Championi.* This seems identical with *B. tuberosa* Becc., of Malaya; *Trichopus* (*Dioscoreaceae*) one species on the east coast of the Malay peninsula and one in Ceylon; *Susum anthelminticum* (*Juncaceae*) and *Scirpodendron Malayanum* (Cyperaceae) are found also in Malaya and Ceylon only.

Piper (Heckeria) *subpeltatum* is an interesting plant from its wide distribution though it appears to be absent from North India. It is a large forest herb usually growing on wet rocks. Probably evolved in South America where it is plentiful from the West Indies to Paraguay, it seems to have travelled through Hawaii, Norfolk island and North Australia to New Guinea and the Philippines and thence north to Bonin and Formosa islands, and west through the Malay islands and peninsula to Ceylon and then north to Madras and Canara. It is abundant in tropical Africa, Madagascar and the Seychelles and Comoro, which it probably reached from America

THE MARITIME PLANTS

As I have said the invasion of the seashore or maritime plants of the Indian coast was by a very different route or routes than the terrestrial ones. A large proportion of these plants were evolved in the coral islands of Polynesia and Malaya, and their seeds drifted along the south coast of Asia settling on the shores of Ceylon and Madras, sometimes, more rarely, travelling up the west coasts to the Bay of Bengal. Some passed on past Southern India to East Africa and its islands, but never to Western Africa. Such are *Calophyllum inophyllum, Ochrocarpus, Samadera, Xylocarpus granatum, Colubrina asiatica, Desmodium umbellatum* and *Derris uliginosa, Afzelia bijuga, Rhizophora conjugata, Bruguiera eriopetala, Pemphis, Scyphiphora, Guettarda, Wedelia biflora, Ochrosia, Tournefortia argentea, Avicennia officinalis, Cassytha, Hernandia, Flagellaria, Remirea maritima* and *Spinifex squarrosus*, and some others. Evolutions of maritime sea-travellers in India are few. *Heritiera* is an Indo-Malayan genus, some species of which are inland forest trees. *H. fomes* peculiar to the Sundribuns is adapted for sea dispersal, but has travelled but a short way; *H. littoralis*, more successful, has wandered as far as Australia and Fiji, *Dolichandrone Rheedii* (*Bignoniaceae*) evolved from Indian inland and river-bank species has spread as far as to the Philippines and New Caledonia by sea.

The genus *Scaevola*, evolved in Australia, has spread but a short way into Malaya and Polynesia except in the case of two species of which the fruit has been adapted for sea-dispersal, *Sc. Koenigii* has spread *via* the Malaya coasts as far as to Madras and Bombay and on to East Africa, *S. Plumieri* travelled to America thence to West Africa and Madagascar, and to Bombay, Scinde and Ceylon but no further, so that the two species travelling round the world in opposite directions meet in Southern India.

A very interesting story is that of the palm *Nipa* fruticans which is now found in the Bay of Bengal and along the Malay region as far as the Solomon islands, but is quite absent from Africa and America. In Eocene time a nearly identical species was abundant in Southern England and along the Mediterranean as far as Cairo. In Arldt's maps from the Neocomian period to the Oligocene the Mediterranean sea was connected with the Indian Ocean to Nepal and along the Malaya coast, so there was no difficulty in its spreading from the Thames estuary to the Bay of Bengal. It probably was evolved somewhere in the American-European region, as fruits have been found fossil in North America and its only ally is the *Phytelephas* of South America. Much the same story belongs to the tidal mud *Acanthus, A. ilicifolius* and *A. volubilis* of the Sundribuns, for very closely allied to these is *Acanthus rugatus* of the Bembridge beds (Oligocene) in the Isle of Wight. The two living species grow with the *Nipa* at the present day over the same area.

In this paper I have only been able to give a short outline of the distribution and origin of the vast flora of India and Ceylon. No story of plant distribution is complete without a considerable knowledge of tertiary palaeo-botany 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 largely what remains of the Oligocene flora as represented in Europe and which probably occupied all tropical regions then above water. Many of the early genera and perhaps orders have disappeared owing to changes in land-surfaces and climate, but some species of that date seem to have persisted with little or no alteration to the present day. Further researches will enable us to correlate the extinct and living genera and probably to fix the date at which, and the locality where, they were evolved.

Razumovia Sprengel versus Centranthera R. Brown again

by

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In 1937, I followed Britten and Alston in accepting *Razumovia* Sprengel (1807) in place of *Centranthera* R. Brown (1810). This action was taken on the basis of clear priority as between these two names. It now develops that the syngenesious genus *Razumovia* Sprengel, assumed by all botanists to have been first published in 1826, and thus to be later homonym, was first published in 1805. It thus actually invalidates the scrophulariaceous generic name *Razumovia* Sprengel of 1807. In my treatment of the genus in 1937* I adjusted the synonymy for the nine recognised species and two varieties under *Razumovia*. It now becomes necessary to reinstate *Centranthera* R. Brown as the correct name for the scrophulariaceous genus under consideration. Otherwise it would ne necessary to include *Razumovia* Sprengel (1807) in some future list of *nomina generica conservanda*, which action scarcely seems to be justifiable.

Shortly after my paper was published, Dr. S. F. Blake of the United States Department of Agriculture called my attention to the fact that the syngenesious genus *Razumovia* Sprengel "1826" = *Humea* Smith (1804) was actually published in 1805. The current references to this genus in botanical literature are to *Razumovia* Sprengel ex Juss. in Dict. Sci. Nat. 44: 526 (1826). It develops that the hitherto overlooked publication of the syngenesious *Razumovia* Sprengel 1805, although short, is valid, and thus automatically invalidates Sprengel's use of the same generic name in 1807 for the scrophulariaceous genus with which we are concerned. The first publication of *Razumovia paniculata* Sprengel appears in the Allgemeine Literatur-Zeitung (Halle Leipzig), Intelligenzblatt 136. January 30, 1805. The original description is as follows:—

"Dem Grafen *Alexis Razumofsky* in Moskau zu Ehren Hat Hr. Prof. *Sprengel* in Halle eine neue Pflanzengattung *Razumovia* genannt, deren Abbildung und Beschreibung nachstens erscheinen wird. Sie gehort zur Syngenesia, Polygamia aequalis, flosculos, und steht zunachst bey Eupatorium und Piqueria. Ihr Gattungscharakter ist:

Cal. imbricatus, biflorus, squamis scariosis laxis.

Rec. nudum.

Papp. o.

Sem. teretia, glandulosa.

Euopatorium unterscheidet sich durch *Papp.* pilosum und *Stylum* longum.

Piqueria durch *Cal.* 4 phyllum aequalem und *Sem.* pentagona. Die art ist *Razumovia paniculata*.

Hr. Sprengel erhielt sie durch einen Freund aus des beruhmten Banks Herbarium."

The description is short, and by itself is perhaps scarcely sufficient for accurate identification of the plant intended, yet it is certainly enough to establish the generic and

*Merrill, E. D. Razumovia Sprengel *versus* Centranthera R. Brown. Bull. Torr. Bot. Club 64: 589-593. 1937.

specific names. As Dr. Blake notes, since it is a monotype, both the generic and the specific names are effectively published. It is clearly the genus later described by Jussieu as *Razumovia* Sprengel in 1826, and the binomial published by DeCandolle as *Razumovia paniculata* Spreng. ex DC Prodr. 6: 158. 1837, *in syn. Razumovia paniculata* Sprengel (1805, 1837) is a synonym of *Humea elegans* Smith (1804).

The genus *Centranthera* R. Brown (*Razumovia* Spreng. 1807, non Spreng. 1805) is a small one of no economic or horticultural importance. As it has currently been known under the generic name *Centranthera* R. Brown since that genus was characterized in 1810 up to the time that Britten (1901), Alston (1931) and myself (1937) substituted *Razumovia* Sprengel (1807), (non-Razumovia Sprengel 1805) for it, the logical course seems to be to accept *Centranthera* R. Brown. There would seem to be little or no justification in proprosing to conserve *Razumovia* Sprengel (1807) over *Centranthera* R. Brown (1810), for conservation would be necessary to validate the former because of the earlier publication of *Razumovia* Sprengel (1805) for the syngenesious genus-*Humea* Smith (1804). The type of *Razumovia* Sprengel (1807) is *R. tranquebarica* Sprengel which is identical with *Centranthera humifusa* Wall. The type of *Centranthera* R. Brown is *C. hispida* R. Br., the original description based on an Australian specimen. The two species are clearly congeneric.

With this preliminary reconsideration of the case I reproduce below the key to the species and varieties that I recognised under *Razumovia* Sprengel in 1937, and summarize the synonymy and geographic distribution of the several species and varieties under *Centranthera* R. Brown.

KEY TO THE RECOGNIZED SPECIES

1. Leaves broad, longitudinally 3-nerved, sparingly toothed; flowers large, about 5 cm. long, bracts broad.................................1. *C. grandiflora.*

1. Leaves narrow, entire, not longitudinally nerved.

  2. Vegetative parts more or less hispid, hirsute, or lepidote.

    3. Calyx inflated, 2 cm. long........................2. *C. Hookeri.*

    3. Calyx much smaller, rarely 1·3 cm. long.

      4. Coarse, erect, simple or branched, hispid or hirsute plants, the flowers 1·5 to 4 cm. long.

        5. Calyx 3-toothed, 3-winged.............3. *C. Chevalieri.*

        5. Calyx not toothed or winged.

          6. Calyx with few to many elongated, stiff, spreading hairs, the indumentum on the vegetative parts similar in type.

            7. Corolla 3 to 3·5 cm. long..................4. *C. Brunoniana.*

            7. Corolla 2 to 2·5 cm. long..................5. *C. indica.*

6. Calyx rather densely appressed-hirsute, the vegetative parts hispid.

7. Corolla 3 to 4 cm. long.................... 6. *C. longiflora.*

7. Corolla 1·5 to 2·5 cm. long.

8. Corolla mostly yellow, 1·5 to 2 cm. long. .... 7. *C. cochinchinensis.*

8. Corolla mostly pink-purple, 1·5 cm. long .... 7a. var. *nepalensis.*

8. Corolla yellow or yellow inside and pink-purple outside, sometimes pink or purple, 2·5 cm. long................ .... 7b. var. *hispida.*

4. Small prostrate plants, the flowers less than 1 cm. long, leaves linear, more or less lepidote, the upper ones alternate.. 8. *C. tranquebarica.*

2. Vegetative parts glabrous or nearly so, flowers 1 to 1·2 cm. long, all leaves opposite.. 9. *C. tonkinensis.*

1. **Centranthera grandiflora** Benth. in Wall. List no. 3880. 1830, *nomen nudum*, Scroph. Ind. 50. 1835, DC. Prodr. 10: 525, 1846; Hook. f. Fl. Brit. Ind. 4: 301. 1884; Prain, Jour. As. Soc. Bengal 72 (2): 21. 1903; Bonati in Lecomte Fl. Gén. Indo-Chine 4: 449. 1927.

Centranthera maxima Bonati, Bull. Soc. Bot. Genéve II 5: 140. 1913.

Razumovia grandiflora Merr. Bull. Torr. Bot. Club 64: 590. 1937.

A characteristic species extending from Assam, Khasia, and the Sikkim Himalayan region to Burma, Indo-China, and to Yunnan, Kwangsi and Kwangsi Provinces in China.

2. **Centranthera Hookeri** (Merr.) comb. nov.

Razumovia Hookeri Merr. Bull. Torr. Bot. Club 64: 591. 1937.

India (Sikkim).

3. **Centranthera Chevalieri** Bonati, Bull.. Soc. Bot. France 71: 1099. 1924, et in Lecomte Fl. Gén. Indo-Chine 4 : 448. *f. 46, 15, 47, 7-8.* 1927.

Razumovia Chevalieri Merr. Bull. Torr. Bot. Club 64 : 591. 1937. Indo-China.

4. **Centranthera Brunoniana** Wall. List no. 3882. 1830, *nomen nudum* : Benth. Scroph. Ind. 50. 1835, DC. Prodr. 10 : 525. 1846; Hook f. Fl. Brit. Ind. 4 : 301. 1884; ? Bonati in Lecomte, Fl. Gén. Indo-Chine 4: 449. 1927.

Razumovia Brunoniana Merr. Bull. Torr. Bot. Club 64: 591. 1937.

Centranthera procumbens Benth. var. latifolia O. Ktz. Rev. Gen. Pl. 459. 1891.

Burma and? Indo-China.

5. **Centranthera indica** (Linn.) Gamble, Fl. Madras 971. 1924.

Rhinanthus indica Linn. Sp. Pl. 603. 1753; Trimen, Jour. Linn. Soc. Bot. 24: 145. 1887.

Purshia ciliata Dennst. Schluss. Hort. Malabar. 35. 1818.

Centranthera procumbens Benth. in DC. Prodr. 10: 525. 1846: Hook. f. Fl. Brit. Ind. 4: 301. 1884; Trimen, Fl. Ceyl. 3: 258. *t. 68.* 1895; Petch. Ann. Bot. Gard. Peradeniya 6: 69. 1915.

Centranthera Brunoniana sensu Thwaites, Enum. Pl. Zeyl. 220. 1864, non Benth.

Razumovia indica Alston in Trimen, Fl. Ceyl. 6: (Suppl.) 217. 1931; Merr. Bull. Torr. Bot. Club 64: 592. 1937.

Corosinam Rheede, Hort. Malabar. 9: 133. *t. 68.* 1689.

India and Ceylon.

6. **Centranthera longiflora** (Merr.) comb. nov.

Razumovia longiflora Merr. Bull. Torr. Bot. Club. 64: 593. 1937.

Indo-China and Southern China (Kwangtung Province).

7. **Centranthera cochinchinensis** (Lour.) Merr. Trans. Am. Philos. Soc. II 24 (2): 353. 1935.

Digitalis cochinchinensis Lour. Fl. Cochinch. 378. 1790, ed. 2, 459. 1793.

Centranthera hispida sensu Benth. in Hook. Jour. Bot. 5: 131. 1853, Fl. Hongk. 254. 1861; Miq. Fl. Ind. Bat. 2: 707. 1858: Hemsl. Jour. Linn. Soc. Bot. 26: 202. 1890; Merr. Fl. Manila 421. 1912, Enum. Philip. Fl. Pl. 3: 442. 1893; Koord. Ekkursionsfl. Java 3: 181. 1912; Bonati in Lecomte Fl. Gén. Indo-Chine 4: 448. 1827, vix R. Brown.

Centranthera Brunoniana sensu Hemsl. Jour. Linn. Soc. Bot. 26: 201. 1890; Makino, Phan. Pterid. Jap. Ic. 1: *t. 3.* 1899, non Wall.

Razumovia cochinchinensis Merr. Bull. Torr. Bot. Club 64: 594. 1937.

Siam and Indo-China to Yunnan, Kangsi, Kweichow, Kwangtung, Hainan, Hupeh, Anhewi and Japan southward to the Philippines, Sumatra and Java.

7a. var. **nepalensis** (D. Don) comb. nov.

Centranthera nepalensis D. Don, Prodr. Fl. Nepal. 88. 1825.

Capraria rigida Ham. in Wall. List no. 3881. 1830, in syn.

Digitalis stricta Roxb. Hort. Beng. 45. 1814, *nomen nudum*, Fl. Ind. ed, 2. 3: 99. 1832.

Centranthera hispida sensu Wall. Pl. As. Rar. 1 : 39. *t. 45.* 1830; Benth. Scroph. Ind. 50. 1835; Wight, Illus. Ind. Bot. 2: 194. *t. 165b.* 1850; Griff. Notul. Pl. As. 4; 128. 1854; Dalz. and Gibs. Bombay Fl. 182. 1861; Hook. f. Fl. Brit. Ind. 4: 301. 1884, *pro majore parte*; Trimen, Fl. Ceyl. 3: 259. 1895: Nairne, Fl. Pl. West. India 220. 1894; Woodr. Jour. Bombay Nat. Hist. Soc. 12 : 175. 1898 ; Collet, Fl. Siml. 359. 1902; Prain, Bengal Pl. 776. 1903; Cooke, Fl. Presid. Bombay 2 : 308. 1905; Duthie, Fl. Upper Ganget. Plain 2: 158. 1911; Haines Bot. Bihar Orissa 637. 1922; Gamble, Fl. Presid. Madras 2: 971. 1924, vix R. Brown.

Razumovia cochinchinensis Merr. var. *nepalensis* Merr. Bull. Torr. Bot. Club 64: 595. 1937.

Western Himalayan region to the Khasia Hills and Ceylon to eastern Tibet, Yunnan and Hunan.

This is the yellow-flowered Indian form currently referred to *Centranthera hispida* R. Br. The actual type of Robert Brown's species was an Australian plant considered below to represent a distinct variety.

7b. var. **hispida** (R. Br.) comb. nov.

Centranthera hispida R. Br. Prodr. 438. 1810; Benth. in DC. Prodr. 10: 525. 1846 quoad pl. Austr., Fl. Austral. 4: 513. 1869; F. M. Bailey, Syn. Queensl. Fl. 360. 1883, Queensl. Fl. 4: 1122. 1901; Moore and Betche, Handb. Fl. N. S. W. 342. 1893; Ewart and Davies, Fl. Northern Terr. 247. 1917, vix aliorum.

Razumovia hispida Briten, Jour. Bot. 39: 69. 1901.

Razumovia cochinchinensis Merr. var. hispida Merr. Bull. Torr. Bot. Club 64: 596. 1937.

Australia and New Guinea.

Robert Brown's type was a specimen collected by Banks in eastern tropical Australia. This Australian form usually has pink or purplish flowers, sometimes yellow inside.

8. **Centranthera tranquebarica** (Spreng.) comb. nov.

Razumovia tranquebarica Spreng. Fl. Hal. Mant. 45. 1807; Britten, Jour. Bot. 39: 69. 1901; Merr. Bull. Torr. Bot. Club 64: 597. 1937.

Torenia lepidota Roth, Nov. Pl. Sp. 281. 1821.

Centranthera humifusa Wall. List no. 3883. 1830, *nomen nudum*; Benth. Scroph. Ind. 50. 1835, DC. Prodr. 10: 525. 1846; Hook. f. Fl. Britt. Ind. 4: 301. 1884; Trimen, Fl. Ceyl. 3: 259. 1895; Prain, Bengal Pl. 776. 1903, Jour. As. Soc. Bengal 74 (2): 364. 1905 (King, Mater. Fl. Malay. Penin. 4: 574); Haines, Bot. Bihar Orissa 4: 638. 1922; Ridl. Fl. Malay Penin. 2: 487. 1923; Gamble, Fl. Presid. Madras 2: 972. 1924; Bonati in Lecomte, Fl. Gén. Indo-Chine 4: 447. 1927.

Cararia humifusa Ham. in Wall. 1 c. in syn.

Razumovia lepidota Alston in Trimen, Fl. Ceyl. 6: (Supl.) 217. 1931.

This is the type of the genus *Razumovia* Sprengel. The species extends from India and Ceylon to Hainan, Kwangtung and Fukien southward to Sumatra, Java, Borneo and Celebes.

9. **Centranthera tonkinensis** Bonati, Not. Syst. 1: 337. 1911, Lecomte, Fl. Gén. Indo-Chine 4: 447. 1927.

Razumovia tonkinensis Merr. Bull. Torr. Bot. Club 64: 598 1937.

Indo-China.

Centranthera tonkinensis Bonati var. *fastigiata* Bonati, l. c. may not be distinct from the species. *Centranthera scoparia* Bonati, Not. Syst. 1: 338. 1911, Lecomte. Fl. Gén. Indo-Chine 4: 447. 1927, is only very briefly described in comparison with *C. tonkinensis* Bonati and may well prove to be but a habitat form of the latter species.

Critical Research Concerning the Indian Arrowhead

(Sagittaria sinensis Sims=S. sagittifolia Aut.)

by

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I—Historical Section

The Indian or Asiatic Arrowhead is a plant widely distributed through the whole of Asia, but it's taxonomic definition has been up to the present a much discussed question. There are three different views about it :—

(1) The first view considers this plant to be identical with Sagittaria sagittifolia L.

(2) The second view regards this plant as a variety of S. sagittifolia L.

(3) The third view regards this plant as separate species.

I.—Authors who consider the Indian Arrowhead to be identical with S. sagittifolia L.

J. Loureiro, Flora Cochinchinensis, 1790, p. 698. His description concerns the Asiatic plant (" flos albus.").

W. Roxburgh, Flora Indica, 1832 et 1874, p. 675. His definition concerns the Asiatic plant as is evident in the descriptions of flowers and of germination of tubers.

Ledebour, Flora Rossica, 1853, Vol. IV, p. 41. His description refers at the same time to the European and Asiatic plant. Any differences between the European and the Asiatic plant are quite unknown to Ledebour.

Maximowicz, Primit. Fl. Amurensis, 1859, p. 267.

E. Regel, Tentamen Fl. Ussuriensis, 1861, p. 140.

Franchet et Savatier, Enumer. Plant. Japan, etc., 1874-1879, II, p. 16.

Ed. Boissier; Flora Orientalis, Vol. V, p. 11. His description refers at the same time to the European and Asiatic Arrowhead as we conclude from the territories of geographical distribution.

T. Aitchison, Fl. Kurram Valley, Afghanistan, 1880, p. 99.

J. D. Hooker, Fl. Brit. India, 1890, VI, p. 561. His description refers at the same time to the European and Asiatic plant.

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*It is regrettable that Professor Hugo Glück, the author of the " Critical Research Concerning the Indian Arrowhead," died during the course of printing of the 150th Anniversary Volume of the Royal Botanic Garden, Calcutta. Dr. Glück was a. o. Professor of Botany and Pharmakognosie i. R., of the University of Heidelberg, Germany. His death occurred at the age of 71 in Heidelberg on the 28th September 1940. Professor Glück made a life-long study of the life-history, morphology, systematic and biology of water and marsh plants. In the bibliography added to his paper he has mentioned some of his publications. His works on Alismaceae, Trapa and other genera are valuable additions to our knowledge of the aquatic plants. Glück's " Süsswasser-flora von Mittel Europa," Vol. 15, Pteridophyten und Phanerogamen, Jena, 1936, is a comprehensive volume on water-plants. It is an indispensable book for all botanists interested in water and swamp plants. Glück's departure is a loss to the botanical world. I offer on behalf of the staff of the Royal Botanic Garden, Calcutta, and Lloyd Botanic Garden, Darjeeling, and on my own behalf our deep sympathy and condolence to the bereaved family.

The death of Professor Glück and the devastating world war prevented me from sending out the proof and the manuscript to Germany for correction. The revision and correction of his work consequently devolves on me. His original manuscript was written in German, but it was subsequently translated by one of his friends. The language required to be modified here and there and necessary addition, alteration and emendation were made by me without making drastic change in the text. In some places the language might have been made more explicit, happy and terse, but as such modification is likely to affect the subject matter, I preferred to leave it undisturbed. It is no mean gratification for me to get an opportunity to publish the last and one of the best posthumous contributions of Professor Glück in this memorable volume of the 150th Anniversary of the Royal Botanic Garden, Calcutta, along with other reputed overseas and Indian botanists.

K. BISWAS,

Superintendent,

Royal Botanic Garden, Calcutta.

V. L. Kamaraw. Flora Manschuriæ, 1901. Vol. I, s. 232.

Forbes and Hemsley, Enumerat. Plant. China, etc., 1903-05, p. 190.

Matsamura and Hayata, Enumerat. Plant. Formosa, 1906, p. 464.

T. Cooke, Fl. Pres. Bombay, 1908. II, V, p. 834.

T. Nakai, Fl. Coreana, 1911, p. 274.

H. Koorders, Exk. Fl. Java 1911, p. 92-93.

Makino, Tinuma Somoku-Zsusetsu. 3. Edit. 20, 1912, Plate XXXVIII.

W. G. Craib, Contrib. Fl. Siam; 1913, p. 24.

Ridley, Fl. Malayan peninsula; 1924. Vol. IV, p. 363.

J. C. Liu, Syst. Bot. N. China; 1931, p. 161. His text drawing refers only to the Sagittaria only.

Biswas, K., and Calder, C. C.: Handbook of Common Water and Marsh Plants of India and Burma, 1936, pp. 77-78, Plate XVII, Fig. 4. The authors record S. sagittifolia L. and S. guayanensis H. B. K. as occurring throughout India extending to Assam and Burma.

II.—Authors who consider the Indian Plant to be identical with a variety of S. sagittifolia L.

W. Miquel, in 1871, in his Illustration Archip. Ind. p. 49. designates the plant first S. sagittifolia var. leucopetala Miquel.

Marco Micheli, who published in 1881 the first monograph of the Alismaceae, and created S. sag. var, diversifolia Micheli as a new variety (p. 67). His definition embraces not only the Asiatic Sagittaria, but also S. natans P. (Arctic regions), S. latifolia Pursh and S. pubescens Mühlb. (both in North America).

F. Buchenau who published in 1903 the second monograph of the Alismaceae, the Asiatic plant according to W. Miquel as S. sag. var. leucopetala Miq. which is clearly recognized by its white petals (" petala tota alba ").

C. A. Backer did the same in 1925 in his Flora of Java (Vol. I, p. 55).

Makino in Tinuma Somoku-Dzusetsu 1912. 20. (Plate XXVII.) Describes the plant as " S. sagittifolia L. var. sinensis Makino." This figure refers to the form with edible tubers, as the Japanese name " Kuwai " is added; but it shows nearly no difference in comparision with S. sagittifolia L." in the same volume (Plate XXXVIII.)

III.—Authors who consider the Indian Arrowhead to be a separate species

It is described under the following names :—

(*1*) *S. trifolia* L. C. a Linne, Species Plantarum. Edition I. Tom. II, 1753, p. 933. Doubtful name !

V. L. Komarow, Flora of U. S. S. R. I, 1934, p. 288.

Makino and Nemoto, Nippon Shoknbatsu Sovan (Flora of Japan), 1931; p. 1289 (*see* below.)

Gorodkov in Travaux Mus. Bot. St. Petersbourg, 1913, p. 156.

Genkei Masamune, Island of Yakusima, 1933, p. 466.

Handel-Mazzetti, Symbolae Sinicae, VII. 5 p. 1187.

(*2*) *S. sagittata* **Thunberg,** in his Flora Japonica, 1784, p. 242.

(*3*) *S. obtusa* **Thunberg,** in his Flora Japonica, 1784, p. 242.

(4) *S. sinensis* **Sims,** in Botanical Magazine, 1814, Vol. 39 (Plate 1631).

R. Sweet, 1826, in his Hortus Britannicus, p. 375. (nomen nudum !).

(5) *S. hastata* Don, in his Flora Nepalensis, 1825.

(6) *S. hirundinacea* **Blume,** in his Enumer. Plant. Jav. 1830, p. 34.

This name is accepted from Hasskarl 1842, l. c. p. 133 and from the same 1848, l.c. p. 103 Nr. 46, and in addition to this from Miquel, 1855, Fl. Ind. Batav. Vol. III, p. 241.

Hasskarl's diagnosis (1842, p. 133) of the Indian Arrowhead is to be especially considered. The polygonal stem of the scapes, the reflexed sepals, the different length of outer and inner stamens and also the yellow coloured anthers are here marked out.

(7) *S. macrophylla* **Bunge**[1], in Mémoires Académy St. Pétersbourg II, 1834, p. 137.

(8) *S. leucopetala* **Bergmans,** Vaste Planten, etc., 1924, p. 479. **Bergmans.**

And now the following questions arise :—

(1) Is it correct to identify the Indian Arrowhead with the European Arrowhead ? (= S. sagittifolia L.) ?

(2) Is it better to take it for a variety of the European S. sagittifolia ?

(3) Is it necessary to consider the Asiatic plant as an individual species ?

According to the law of priority *S. trifolia* L. should occupy the first place. This denomination however is not free from objection. Linné's species is based on a figure in J. Petiver's Gazophylacium (London, 1702; Plate XIX, Fig. 5,) and is described with the following words "Sagittaria falus ternalis." This figure, of which I have a good copy, is about 9 cm. long, has in its lower part two leaves and terminates with two open flowers like ♀ flowers of Sagittaria and some flowering buds. Both leaves are petiolate and arise directly from the scape; although the scape of each Sagittaria is leafless. The limb is composed of three lanceolate and acute segments (3·5 cm. long and 5—6 mm. broad) which are very little connected at the base. On one of the leaves two segments are horizontally opposite, but this position I have never seen among many herbaceous specimens of *S. sinensis.* Finally the nervation of segments is curious and has nothing to do with that of Sagittaria. The median-nerve of these segments bears many side-nerves, and so we have the impression of a clover-leaf. I am therefore compelled to give up this doubtful name in favour of *Sagittaria sinensis* Sims. Although John Sims has not marked the most important systematic differences between the Indian and European Arrowhead, the coloured plate added to his diagnosis demonstrates that his new species must have a right to exist.

John Sims, however, found no recognition, and M. Micheli and F. Buchenau who are two monographers of the Alismaceae did not accept this name.

We need not concern ourselves with the American *Sagittaria latifolia* Willd., although it was formerly identified with *S. sinensis*; an error which was corrected by J. G. Smith[2]

II.—Systematic and biological differences between S. sinensis Sims and S. sagittifolia L.

After having seen that among many names *Sagittaria sinensis* Sims must be the most correct name for the Indian Arrowhead, I am obliged to confirm this plant as a good species, being different in many points from the European Arrowhead. I cultivated[3] many Indian

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[1]S. macrophylla Bunge must not be confused with S. macrophylla Zuccarini which is identical with S. mexicana Steudel.

[2]J. G. Smith, l.c. p. 9—14 (34—40).

[3]I recieved tubers of this plant from the garden of Mr. Zweeifel in Gelnhausen (in Hassiae, Germany); but I cannot indicate the original home of this material.

Arrowheads, in the open as well as in the hothouse; and I drew the following conclusion from the results of my experimental cultivation. All descriptions of *S. sinensis* by modern botanists are quite insufficient. B. N. Gorodkov (l. c. 1913) gives a relatively good description which was accepted from the Flora of the U.S.S.R. (Vol. I, p. 288) although only a few striking differences are marked. (Difference of medium-lobe and basal-lobes of sagittate leaves, pure white petals, yellow coloured filaments.) But we shall learn in the following lines that many other differences between the Asiatic and the European Arrowheads have been neglected up to the present.

(*A*) *Vegetative organs*

I. Stem.—The rhizome of *S. sinensis* is scarcely different from that of *S. sagittifolia.* Both have a short, compact rhizome which is not perennial. The rhizome of *S. sinesis* is, if well developed under water, 2·2—2·7 cm. long and 1·7—2·6 cm. thick. Every rhizome of *S. sinensis* produces usually 3—6 stolons under the earth ; vigorous specimens produce 6—10 stolons and feeble ones 1—2 only. The stolons are (7) 10—50 (95) cm. long and consist of several internodes which are (1·8) 3—20 cm. long and (2) 3—8·5 (10—12) mm. thick. The cataphylls of the rhizome are colourless scales which are 0·9—20 (30) mm. long and open.

All stolons carry at the tip either leafy shoots or tubers. The formation of both seems to be dependent on various factors mainly pressure and temperature. Stolons running near the top of the mud produce as a rule leafy shoots (Fig. 1.), but such stolons as penetrate deeper into the mud usually produce tubers. And finally it is important to note in this connection that all stolons during the warm season carry terminal leafy shoots, but during the cooler season they bear tubers (Fig. 2) instead of leafy shoots.

fig. 1. End of a stolon, terminating with a leafy shoot, which produced two little stolons. ×½.

II. Tubers.—The tubers of *S. sinensis* are oval or oval globular and composed of three swollen internodes and show on the surface some annular cicatrices (Fig. 2)[1]. The tubers are 8—33 mm. long and 7—30 mm. thick ; they are white or yellow-white or faintly purple-violet-blue.

Development of tubers is by far the best in half submerged specimens in the hothouse ; they are 8—33 mm. long and 7—30 mm. broad. They are somewhat smaller, if cultivated under the same conditions in an open-air tank, namely, 9—30 mm. long and 7—25 mm. thick. Smaller tubers, however, were produced from land-forms (in the hothouse) ; namely, 5—20 mm. long and 3·5—20 mm. thick. In contrast to the type *S. s. var. edulis* which is sometimes cultivated in China and Japan, produces the largest tubers which are 3·5—5 cm. high and 5—6·6 cm. thick (Fig. 3.).

[1] Gorodkov's designation in his diagnosis of *S. sinensis* and *S. sagittifolia* (pp. 156 and 163) is absolutely mistaken. Tubers of all species of Sagittaria in the whole world are metamorphosed parts of an axis and not of a root.

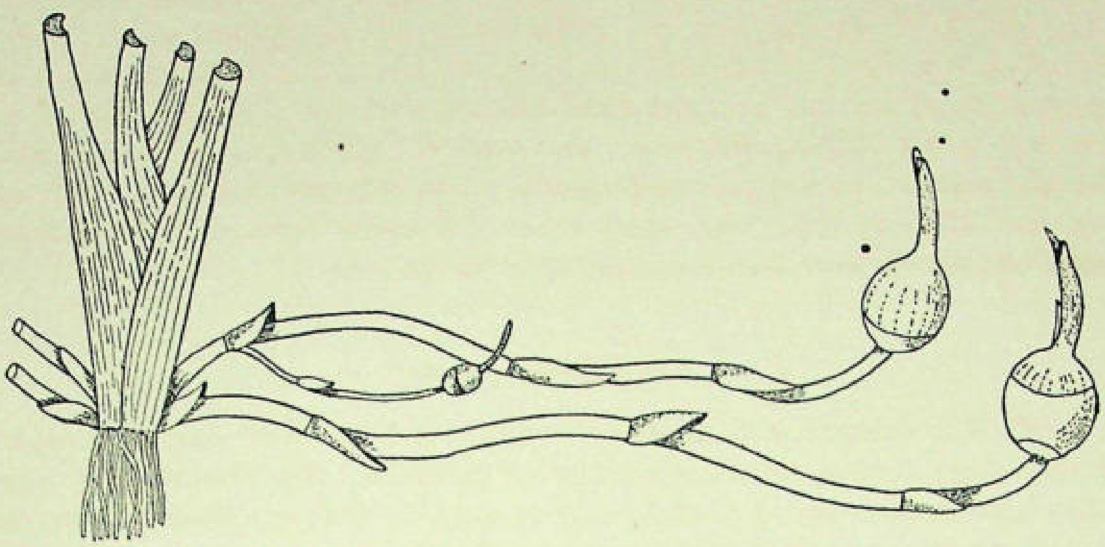

fig. 2. Base of a half submerged plant with two large tuber bearing stolons. ×½.

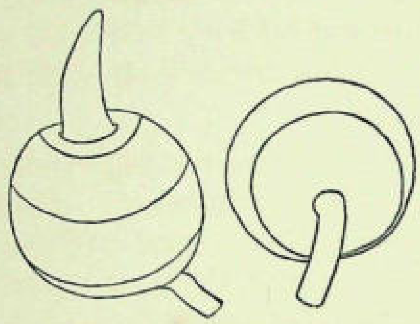

fig. 3. Two tubers of *S. s. var. edulis.* ×½.

Stolons and tubers of the European *S. sagittifolia* are scarcely different from those of *S. sinensis* ; they are (2) 10·5—121 cm. long and (2) 3—5 (14) mm. thick, but the cataphylls become about twice as long as before (0·8)2—4·3 cm. Tubers, however, do not vary so much in size : 6-28 mm. long and 4-20 mm. thick. The most important difference consists in the growth of the apical leafy shoots which are never produced from the European Arrowhead, whereas they are regularly formed from the Asiatic Arrowhead.

Development of the various leaves.

S. sinensis may produce different forms of leaves during different stages of development.

I. Awl-shaped Phyllodes.—The germinating tuber bears (Fig. 4) first a short stalk-like stem which is (under water) 7—11 cm. long and 2—3·5 mm. thick, with one little cataphyll near the middle. This stem terminates in a shoot, consisting of awl-shaped phyllodes which are produced in a similar form at the apex of the stolons. These phyllodes were developed best at a depth of 10—60 cm. in the hothouse. One specimen bore first 1—2 scale-like cataphylls and later 3—4 phyllodes which are awl-like and narrowed to the end and (6) 9—49 (72) cm. long and (1) 2—5 (10) mm. thick. Their upper side is slightly flattened and the cross-section is also flattened either of an elliptical or triangular shape ; towards the base however they are elongated to a large sheath. Usually 1 or 2 transitional leaves follow after the phyllodes, or at least the erect sagittate leaves. In the open-air tank phyllodes are developed in water 80 cm. deep, but smaller—10—34 cm. long and 2·6 mm. thick ; and in water 40 cm. deep of the same tank they were 4—8·5 cm. long and 1—2 mm. thick (Fig. 4.)

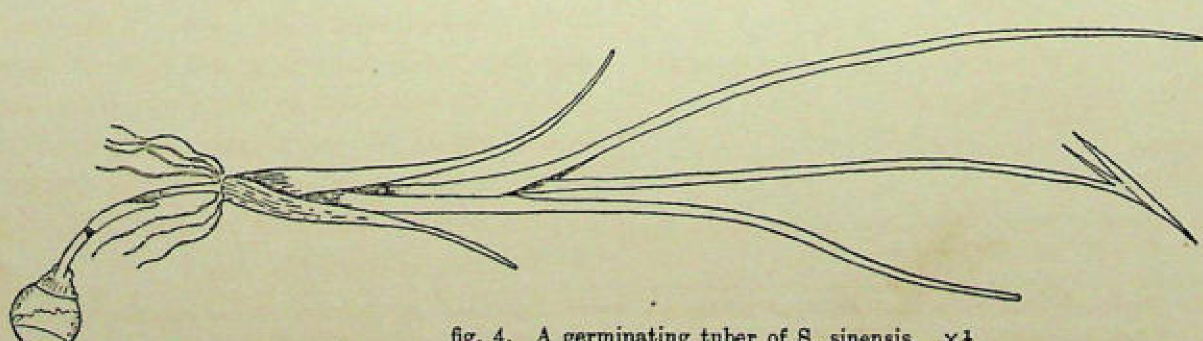

fig. 4. A germinating tuber of S. sinensis. ×½.

Even out of water (in the hothouse) the germinating tubers bear 3—4 phyllodes, but much shorter than the above : (1·7) 2—6·5 (10) cm. long and (1) 2—3·5 mm. thick; after these, there follow sagittate leaves.

The same phyllodes are also produced in all stolons which terminate with a young shoot (*see* Fig. 1).

II. Strap-like leaves.—In contrast to the awl-shaped leaves, strap-like leaves were produced under certain conditions and are the result of insufficient nourishment. Little and feeble tubers, germinating in 40—80 cm. deep water of the open-air tank, bore first awl-shaped phyllodes (4—22 cm. long and (1) 2—2·6 mm. thick) and later some strap-like tapering leaves which were very tender and transparent, 7·5—33 cm. long and 2—6 mm. wide (Fig. 5) at the end of May. All vigorous tubers on the contrary bore in 40—80 cm.

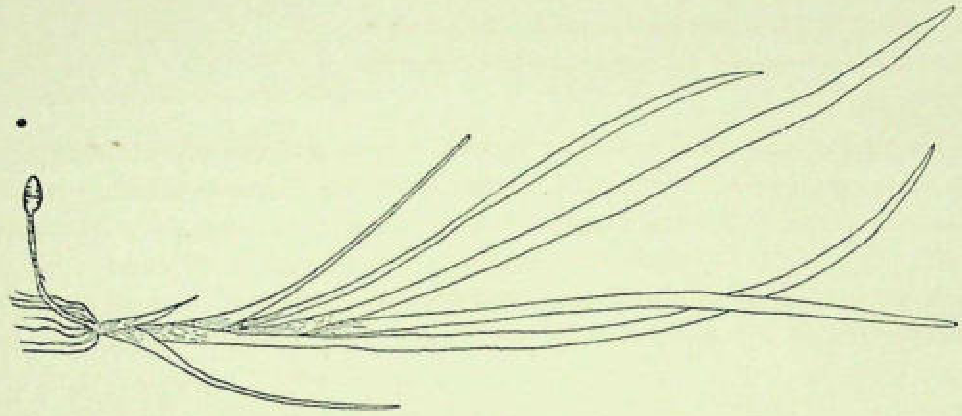

fig. 5. A feeble germinating tuber of S. sinensis with straplike leaves. ×½.

deep water awl-like phyllodes only and later swimming leaves. But in terrestrial forms strap-like leaves may occur ; little and feeble tubers produce (in the hothouse) 3—4 little strap-like leaves (1·7—5·5 cm. long) and after these 1—2 transitional leaves and finally erect sagittate leaves. Between awl-shaped and strap-like leaves many transitional leaves are to be found, the limb of which is flattened and shows a narrow elliptical cross-section.

Finally we have to compare the primary leaves of S. sinensis with those of S. sagittifolia:—

(1) Awl-shaped phyllodes are never developed in germinating tubers of S. sagittifolia.

(2) Strap-like leaves however are produced regularly in germinating tubers and appear as well under water as out of water and are regular fore-runners of the sagittate leaves. In deep water or in running water strap-like leaves are the only leaves and saggittate leaves are suppressed. One specimen bears 8—17 enormous strap-like leaves, 40—250 cm. long and 4—32 mm. broad ; most of these forms are sterile. Flowering scapes are 116—204 cm. long[1]. Thus it is evident that the strap-like primary leaves of *S. sagittifolia* are different not only in their size but also in their continual vegetation.

III. Swimming leaves.—Up to the present time it was not possible for me to discover any record in the literature of the swimming leaves of *S. sinensis*; this kind of leaf did not exist also in the rich herbarium materials which I examined. Nevertheless, I have succeeded in cultivating these (Fig. 6); and they have developed very well in water 40—80 cm. deep in the open-air tank. In water 40—60 cm. deep of the hothouse swimming leaves have appeared only seldom and isolated ; and in 10—15 cm. deep water swimming leaves appeared neither in the open-air tank nor in the hothouse. From these experiments I draw the following conclusions :

Deep water and low temperature are favourable for the development of swimming leaves. Swimming leaves of *S. sinensis* become 50—90 cm. long ; their petiole is weak, flexible and

[1]*See* H. G l ü c k, Süsswasserflora, l.c., p. 103, with Fig. 57.

1—2·5 mm. thick. The limb is in its outline lanceolate, 6—12·5 cm. long and (9) 12—20 (26) mm. broad (base of median-lobe). The latter is sometimes longer, sometimes shorter than the basal lobes ; these are elongated to a very fine tip and are mostly convergent (Fig. 6, I and II).

The form with floating leaves represents, as a rule, a transitory stage ; but may last the whole summer in water which is 80 cm. deep and cool. *S. sagittifolia* bears also a natant form under certain conditions, these floating leaves are 30—125 cm. long, but their limb is larger and broader (3·5—10·5 cm. long and 2·5—7·5 cm. broad), the basal lobes are never convergent, and in addition to this the limb is thick, leathery and darkgreen. Finally the natant form of *S. sagittifolia* bears from time to time flowering scapes which are 110—130 cm. long.[1]

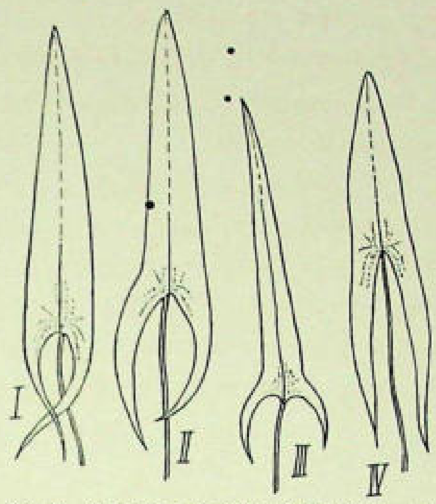

fig. 6. 4 blades of swimming leaves. ×½.

IV. Secondary leaves.—Secondary leaves represent the well-known leaves which are erect, sagittate and resemble those of sagittifolia. One individual may produce 3—9(12) leaves which are erect, but very polymorphous. They become 11—150 cm. long. The corresponding form of leaves of *S. sagittifolia* varies from 8—217 cm.[2] The petiole of the leaves of *S. sinensis* is in the middle pentagonal or hexagonal flattened and becomes at its base half cyclindrical. It is in the middle (4) 5—10 (16) mm. thick and at the base 1—4 c.m.

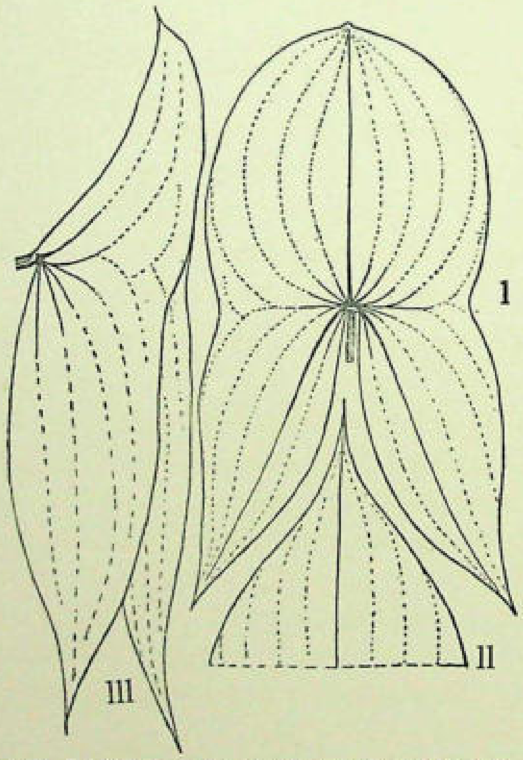

fig. 7. Different blades of erect sagittate leaves. I. represents the ovalis-forma, III. represents the sagittata-forma, II. is a transition between I. and III. ×½.

The blade of the erect leaves is very variable. I like to reduce all forms to four types, which represent extreme forms, and which show a great many intermediate forms.

I. Ovalis-forma.—This is the most common form. It is arrow-shaped, triangular in outline (Fig. 7I and 8I). The blade is (4·5) 7·5—20(35) cm. long and (1) 1·8—15 cm. broad (base of terminal lobe). The terminal lobe is large oval and suddenly acute; in var. *plena* however sometimes gradually acute (Fig. 8 II).

The two basal lobes are oval or oblong-oval, usually divergent about 1½—2 times as long as the terminal lobe and gradually acute[3].

This ovalis-forma corresponds in general with S. s. (=trifolia) f. *typica* Gorodkov. Forms with enormous basal lobes as in Fig 8-I are identical with S. s. (=trifolia) var. *suitensis* Makino.

The ovalis-forma comprises not only S. s. (trifolia) var. *typica* forma *subhastata* Makino, but also forma *suitensis* which forms are not easily separated. Fig. 7-II shows a slight transition to the following ; the basal lobes of this are exceedingly divergent.

[1]See H. G l ü c k, Wasser und Sumpfgewächse, Vol. I. 199ff. and Süsswasserflora, p. 103.

[2]The maximal length of sagittate leaves is erroneously indicated as 210 cm. in the "Süsswasserflora," 1936, p. 102, in stead of 217 cm. Such gigantic specimens were collected by me near Konigsberg (Northern Bohemia).

[3]Following herbarium sheets represent this form: *Asiatic Russia*: mountains of Tian-schan near Taschkent leg. Gravitovet Vvedensky VI, 1928. *China* : Hongkong ; leg. E. Taber, 1885-1886 prov. Hupeh, Dr. Henry's Collection No. 7383. *Japan* : without locality. Herbar Rein. *Java* : Batavia leg. Blume. Indian: East Bengal, Herbar Griffith, R. B. G., Kew and Calcutta, 1862-1864, Chitral Relief Exped., 1895, No. 1673 and 17598 (Swat valley, 3,000 feet). Philippinos : leg. M. Ramos No. 75642, etc.

II. Sagittata-forma.—This form is less common. It is also marked by a triangular outline. The blade is 4·5—40 cm. long; 1·0—14 cm. broad (median-lobe); and the basal lobes are 0·5—8·0 cm. broad (base). This form represents the largest blades in *S. sinensis.* The terminal lobe is, in contrast to the preceding form, pyramidal and gradually tapering. The two basal lobes are a little longer than the terminal lobe as in Fig 7-III and 9-VI[1] but sometimes twice as long as the terminal lobe (Fig. 9-VI). The basal lobes vary from large lanceolate to narrow lanceolate and taper gradually to the end. All blades with linear-lanceolate basal lobes, as in Fig. 9-V and VI are designated as *S. sinensis* (or "*sagittifolia*") var. *longiloba* or forma *longiloba* Turcz. This so-called longiloba blade is 13—29·5 (40) cm. long; the median-lobe is 20—59 mm. broad; and basal lobes are 10—25 mm. broad[2]. The sagittata-forma was produced in my cultivation in water 80 cm. deep in the outside tank (Fig. 7-III) and also in a smaller landform occurring in natural habitat. Makino's and Nemeto's Flora of Japan, 1931 (p. 7990) S. trifolia "var. typica Makino forma subhastata Makino" (in the herbarium of Geneva) represents habitat form with sagittate leaf like in Fig. 9-V.

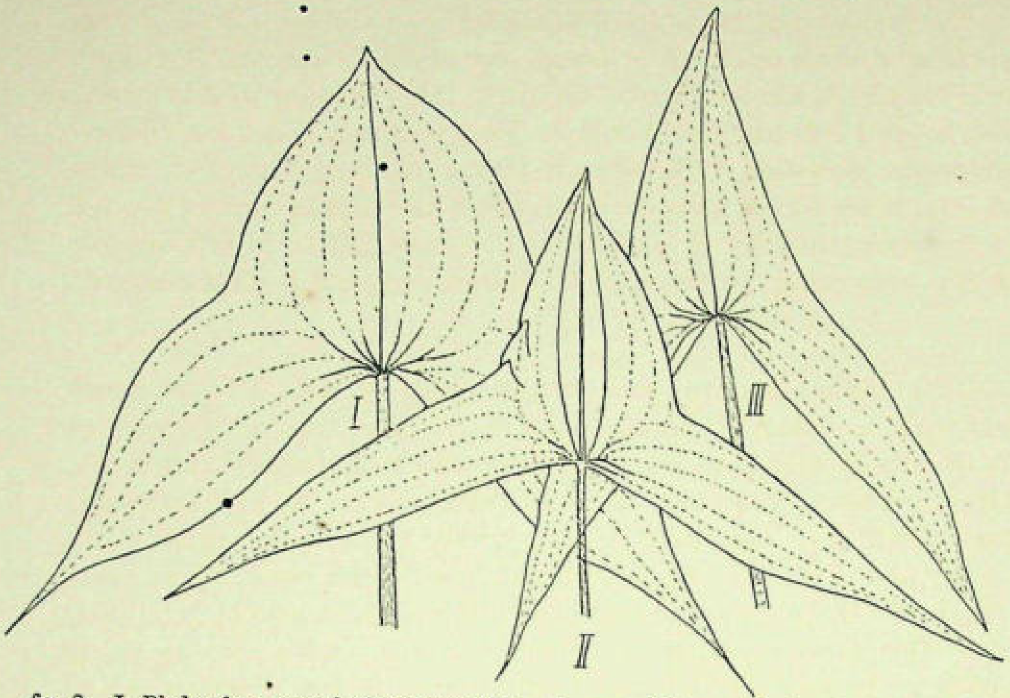

fig. 8. I. Blade of an erect leaf, representing a large ovalis-forma (=S. suitensis Mak.). II. leaf tip of *S. s. var. plena* (ovalis-forma). III. blade of an erect leaf, representing the obtusa-forma. ×⅓.

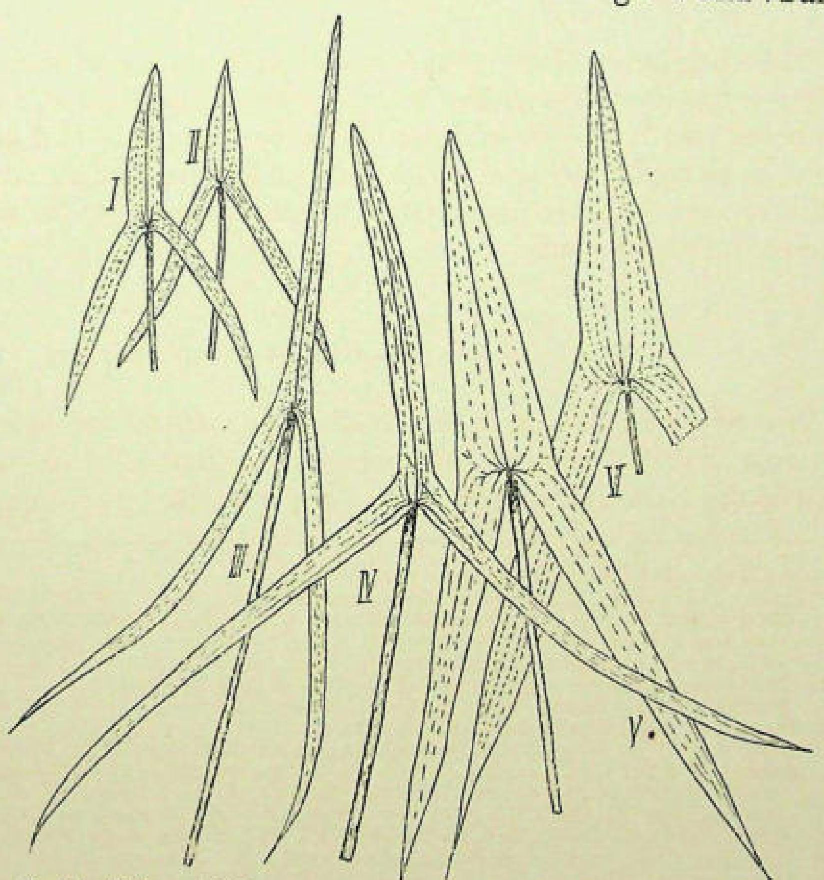

fig. 9. Different blades of erect leaves. I. and II. two narrow-leafed blades of a cultivated landform. III. and IV. two blades, representing the small-leafed sagittata-forma (=*var. longiloba*). III. originates from West-Celebes (Sombasang). IV. and V. originate from Khasia (India); both from the same specimen. VI. originates from the Phillippines (Calumpit, Luzon). ×⅓.

III. Lineata-form.—This form is derivable from the preceding form by narrowing

[1]The typical sagittata-forma, as in F. III is for instance represented in following herbarium sheets :—
Japan : Isle of Schikoku (Tokushima) leg. B. Krug.
Japan : S. S. var. edulis, from different localities, blade up to 40 cm. long; terminal lobe up to 8 cm. broad.
China : Yunan. G. Bonati No. 3024.
China : Prov. Schensi sept. Herbar Biondi No. 1836.
Philippines : a., Luzon. leg. E. Elmer. X. 1915.
Philippines : b., E. Merrill, Species Blancoanae No. 982.
India : Upper Burma, Shan Hills leg. A. Huk, 1892, and W. Himalaya, Hazara, leg, Iynayan, Herb. Calcutta. 1893.

of the lobes ; as we can find this form mixed with the sagittata-forma in one and the same individual (*see* Fig. 9-IV and 5-V). The shape of the blade is triangular, but the lobes are very narrow and linear (Fig. 9-III and IV). The blade is 10—18 cm. long; the medium-lobe is 4—9(16) mm. broad and the basal lobes are 3—5·5(9·5) mm. broad. Such forms are described as var. *longiloba* in general or as var. or forma *angustifolia* (Siebold) Gorodkov. S. s. (trifolia) f. *tenuissima* Handel-Mazzetti (Symb. sin. VII. 1188) belongs to this group. and has extremely reduced lobes 1—2 mm. broad only.[1] Very probably this *lineata-forma* is the product of unfavourable nutrition. The outer leaves of one terrestrial form showed the hastata-forma, the inner leaves however approached the lineata-forma (Fig. 9-I and II)[2]. Such plants were designated by M a k i n o as S. s. var. *typica* f. *heterophylla* Makino. This heterophylly appearing in the end of August suggests a diminution of nutrition.

IV. Obtusa-forma.—This blade has an oval shape (Fig. 8-III). The terminal lobe is largely rounded with a point of minimum size at the top or sometimes moderately acute ; and is usually shorter than the basal lobes which are parallel and acute. This form appeared only transitionally among the cultivated plants in my hothouse. Moreover this form occurs also in S. s. var. *edulis* and may have considerable dimension ; *i.e.*, blade 11—38 cm. long and 5·5—19 cm. broad (median-lobe) ; basal lobes oval-triangular, acute, 2·412 cm. broad (base).[3] According to the different botanist (M. M i c h e l i, G o r o d k o v, and others) this form seems to be limited to var. *edulis* ; but as it has appeared in my cultivation next to leaves with ovalis-forma, I assume that it occurs also in natural localities. The obtusa-forma is also not sharply limited. There are certain forms which approach more or less the ovalis-forma.

The whole series of different forms of sagittate leaves of *S. sinensis* which we have now studied is repeated in a similar manner by the European *S. sagittifolia*[4]) with the following differences : (1) The blade of *S sagittifolia* becomes only half as long (up to 15, rarely up to 27 cm.) as that of *S sinensis* ; (2) blades with lobes spreading nearly horizontally are missing ; (3) the obtusa-forma is not present in erect leaves ; (4) the tip of terminal and basal lobes are never needle-like aute.

(*B*) *Organs of reproduction*

The flowering-season of *S. sinensis* in natural localities is very variable when the large area of distribution of this species is considered. It flowers in July and August in the region of the Ussuri (R e g e l , M a x i m o w i c z). In June in the environs of Peking,

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[1]This form is represented in the following herbarium sheets :—

I. **Japan :** Yokohama. Maximowicz. Iter secundum 1862.
II. **China :** Prov. Schansi, ad templüm Chin-ssü. leg. H. Smith. Pl. sinenses No. 6838. One of these specimens represents the longest blade which I have seen in S. s. var. longiloba. Blade 40 cm. long. teriminal lobe 22 cm. long and 33 mm. broad ; basal lobes 24·5 cm. long and 24 mm. broad.
III. Indo-China: Tonkin (environ de Chapon) leg. S. Polelos. VIII. 1931.
IV. **Celebes:** Palapag, Samar. Merill. Spec. Blancoanae Nr. 982.

I reckon here the following herbarium sheets :—

I. **Amur Prov.** (Gouv. Tomsk, near Blagowjestschensk) Coll. F. Karo 1898. Plantee Amurenses Nr. 73.
II. **China :** (1) Pl. of Kweichow; leg. S t e w a r d, Chiao and Cheo., prov. Fokien, Dunn's Exped, 1305, Hong-Kong Herb. No. 3722 (2) Prov. Hupeh. leg. Henry No. 2664. (3) Prov. Kwangsi (Yao-shan) leg. S.S. Sin. No. 8271. (4) Prov. Kiangsi. leg. H. Hu. 1921. (5) Prov. Yun-nan prope Hoching, ca. 2,400m. Cam. Schneider No. 2698.
III. **Japan :** (1) Nippon media. Coll. T s c h o h o s k i, (2) Isle of Schukoku (Magurame) leg. E. Krug No. 389, (3) Hokkaido: Jubut-su (Prov. I buri). Herb. S a p p r o. 1892.
IV. **India orient :** Khasia. Reg. subtrop. 4000-6000 ft. Hooker and Thomson. Chitral Relief Exped, 16730, by Harris, 1895 ; Birma : Herb. Griffith E. India Comp. No. 5400 ; Southern Shan States : Taungyi, leg. A. Khalil, 1894. Royal Botanical Garden, Calcutta.
V. **W. Celebes :** Lombasang. leg. Bunnemeyer. ca. 950 mm.

[2] The blade of the outer leaves is 8, 9·5 cm. long ; terminal lobe 15—21 mm. broad; basal lobes 8—9·5 mm. broad. The blade of the inner leaves is 7·5—9 cm. long ; terminal lobe 9—10 mm. broad ; basal lobes 5·5—6·5 mm. broad.

[3] I reckon the following herbarium sheets here : China : Peking leg. Dr. Bretschneider, Shanghai, Exo. Herb. Maingay No. 421. Japan : without locality, leg. Hilgard.
Flora of the Philippine Islands : Plants of Leyte, No. 1521. bell.
C. A. Wensel VII. 1915. "Sagittaria obtusifolia" ex Herb. Burmani (probably originating from Japan).

[4] *See* H. G l ü c k, Wasser und Sumpfgewachse, Vol. I, Plate VI (Fig. 37 a-e).

it is evient that here the development of the flowers is connected with the warm season. In the low land of all the tropical localities the plant is certainly in flower during the whole year excepting, however, all the localities situated in the higher mountains which have a cool temperatüre during the winter season and do not differ much from the northern places in the climatic condition. It was collected in India ; 1,000 feet, 4,500 feet, 4—6,000 feet and 7,800 feet above the sea-level.[1] In addition to this it has been collected from Southern China, namely, in the province of Yunnan at 2,400m., 2,500m. and 2,900m. above the sea-level, in the localities which belong more or less to the sub-tropical region.[2] All specimens cultivated by me in the hothouse in warm and damp-atmosphere bore during the summer months regular scapes, but on the contrary all those specimens, cultivated in an open-air tank were sterile. Therefore I assume that the optimum development of scapes is dependent on moist and warm climate like the subtropical and tropical climate.

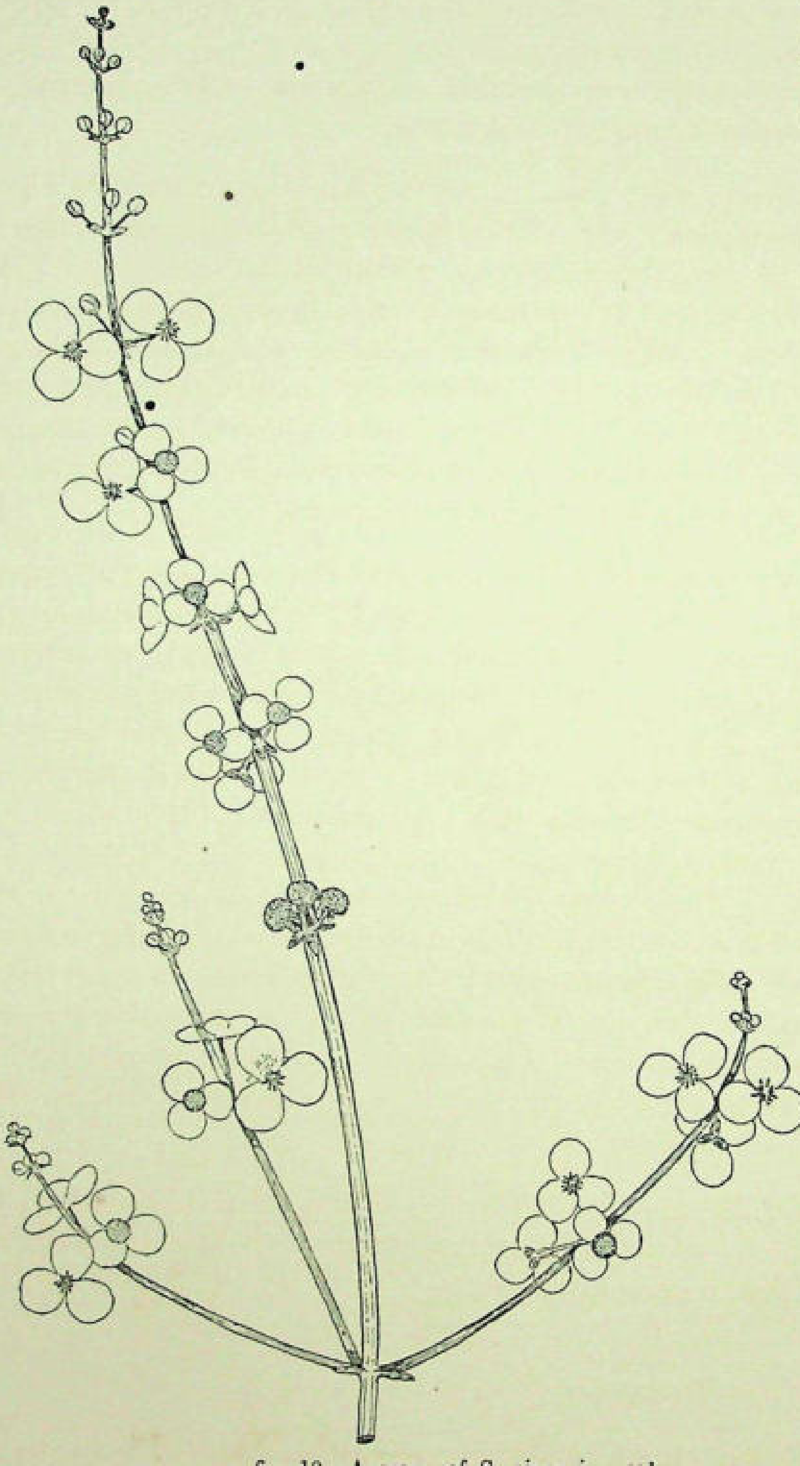

fig. 10. A scape of S. sinensis. ×½.

Scapes

Usually the scapes are only produced if the sagittate leaves are present. In exceptional cases however one shoot with the lanceolate leaves (as in Fig. 1) bears one scape. One Indian specimen (Jaintia Hills, Maodumai, leg. Burkill and Banerjee. No. 224, Royal Botanic Garden, Calcutta Herbarium), has four lanceolate leaves, 25—32 cm. long, and a limb 5—9 cm. long and 8—15 mm. broad ; and one scape 38 cm. in length.

In a hothouse-tank, in 10—50 cm. deep water, I produced the most luxurious specimens, with scapes which were 45—150 cm. high.[3]

[1]The highest locality in India is in the Nilgiris District, Prov. Madras at 7,800 ft. Coll. G a m b l e.

[2]The highest locality in China is at 2,900 m. in Yunnan : " in stagno prope Ngulelsch in reg. Sichiang." Coll. C. S c h n e ü d e r. VIII, 1914 Iter Chin. No. 3583.

[3]Scapes of terrestrial forms, 11-27 cm. long, originating from a natural loality are excepted.

Only rarely this length is exceeded. In the Herbarium of the Royal Botanic Garden, Calcutta, the scape of one specimen (growing in Assam: Cachar Hills, leg. Craib, 1908) is 160 cm. long, furnished with 2♀ and 5♂ whorls.

Fig. 10 shows the inflorescence of such a scape. Scapes of the European *S. sagittifolia* become 20—190 cm. high (but 11—27 cm. in terrestrial forms). The stalk of the scapes below the inflorescence is hexagonal or polygonal (Fig. 11) and only at its base it is cylindrical and slightly triangular and 8—18 mm. thick in the middle. The scape in the corresponding section of S. *sagittifolia* however is triangular (Fig. 12).

Nearly all flowers of *S. sinensis*. both ♀ and ♂ are in tri-merous whorls (Fig. 10); four or five-merous whorls are exceedingly rare.[1] The proper main-axis of the inflorescence is (18·7) 26·5—56·5 (64·5) cm. long (but usually up to 40 cm.) and bears 5—13 whorls. 3—5 whorls of the lower part are usually ♀. Instead of single flowers there are in the lowest whorl or in 2—3 of the lowest whorls 1—9 branches which are 4—30 cm. long and are accompanied by 5—9 whorls (*see* Fig. 10)[2]. 1—4 of which are ♀, and the rest are ♂; but sometimes all whorls of one branch are ♂. Between ♀ and ♂ whorls hermaphrodite flowers are often present with little pistils in the centre surrounded by stamens and in normal ♂ flowers a few reduced ovaries also are sometimes present.

Scapes of *S. sagittifolia* in half submerged specimens are 20—190 cm. long. The cross-section of the stalk is triangular below the inflorescence (Fig. 12). The main-axis of the inflorescence itself is 6—16 (21) cm. long (in terrestrial forms: 5—9 cm. only). It is therefore much shorter than that of *S. sinensis.* Consequently the number of the whorls on the scape is smaller 3—5 (6—8). Finally I must point out that the inflorescence of *S. sagittifolia* is mostly unbranched, but sometimes one branch in the lowest whorl is present which is 3—10 (20) cm. long and bear 1—3 whorls with a terminal-flower. The occurrence of two branches in the lowest whorl is uncommon[3]. In this connection I would like to mention the gigantic inflorescences of *S. sagittifolia* forma *vallisnerifolia*; a form which usually does not flower and which has no analogous form to *S. sinenses.* This form is only produced in deep and moving water and was discovered by me with scapes in one locality only[4]. The scapes are 116—204 cm. long, and the real axis of the inflorescence was 23—53 cm. long. One side branch, 23—53 cm. long, was present in the lowest whorl of each inflorescence. Each rhizome of these specimens had 8—17 enormous strap like leaves, 40—250 cm. long and 4—32mm. broad[5].

♂ and ♀ flowers of *S. sinensis* like many other flowers of this genus are trimerous in calyx and corolla. L o u r e i r o ' s report of dimerous flowers[6] in *S. sinensis* is a variation observed by me in different species of the genus.

Bracts

The bracts of *S. sinensis* in the axil of which all flowers arise are disposed normally in tri-merous whorls (sometimes di-merous, four or five-merous). Bracts are broadly oval

[1] In a few scapes, originating from my hothouse, the lowest ♀ whorl of an inflorescence was four-merous; and a five merous ♀ whorl was found by me only once in a Chinese herbarium specimen.

[2] Many specimens of natural localities, originating from warmer parts of Asia have the same ramification of scapes as my cultivated specimens.

[3] Among many specimens of Europe, examined by me, I found only two scapes, accompanied by two branches in the lowest whorl, 7—8·5 cm. long and bearing 2—3 whorls (*see* H. G l ü c k , Biol. und Morphol. Unters, I, p. 201).

[4] The only locality, I know myself, is near the little village Diersheim in Baden (Southern Germany), namely, in an old branch of the Rhine ("Rhine-Altwasser" in German).

[5] Further details of this form are to be found in H. G l ü c k , "Wasser und Supfgewächse," Vol. I, p. 210 f. and 216 f. with Plate VII, Fig. 42; "Lebensgeschichte der Blütenpflanzen, etc," p. 103 and "Subwasserflora," p. 623, with Fig. 57.

[6] L o u r e i r o , l. c. p. 698.

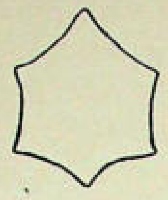

fig. 11. Cross-sections of the stalk of the inflorescence of S. sinensis below the inflorescence. ×½.

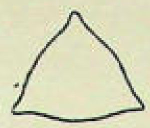

fig. 12. Cross-sections of the stalk of the inflorescence of S. sagittifolia. below the inflorescence. ×½.

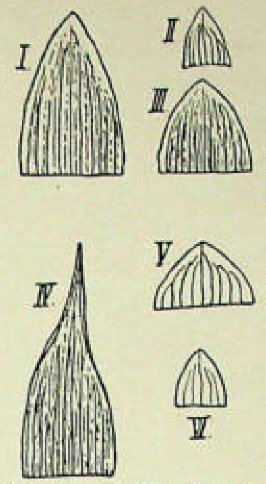

fig. 13. I.-III. bracts of typical S. sinensis. I. and II. from the lowest whorl of two different specimens, III. from a higher whorl. I. and II. belong to my cultivated plant, III. to a plant from East-Bengal. IV. bract from the lowest whorl of *S. s. var. edulis.* V. and VI. two bracts of S. sagittifolia, V. from the lowest whorl, VI. from a higher one. ×½.

or nearly triangular (Fig. 13I-III), sessile with a broad base, obtuse at the end, with parallel nerves, transparent, perishable, (4) 7—13mm. long and (2·2) 5—7 mm. broad (base). Different from these, however, are the bracts of var. *edulis* (*see* below); they are larger in size (Fig. 13-IV), oblong-lanceolate at the end and more or less acute; 5—20 (28) mm. long and 2—6·5 mm. broad (base.)

Leaf-shaped Bracts

Such bracts are not very rare in scapes of var. *edulis*. I observed these in five different scapes (from Japanese herbarium-material). They are isolated beside two normal bracts in the lowest whorl of scapes. The leafy bract varies from narrow or broad-lanceolate to elliptical form, acute at the end and narrowed petiole-like at the base. Four leaf-shaped bracts were 2·5—8 cm. long and 4—14 mm. broad; and the last was 16 cm. long and 40 mm. broad (Fig. 14.)

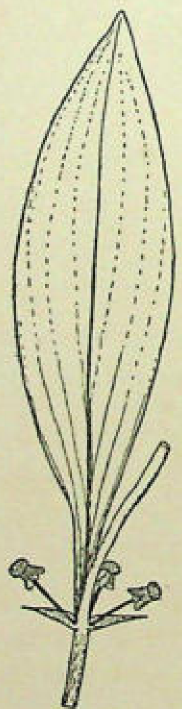

fig. 14. Whorl with 3 female flowers after flowering and with one large leafy branch. ×½.

Another remarkable scape I saw among Indian specimens. This is 78 cm. high, has 8 whorls and within the two lowest whorls one leafy bract, 16—20 cm. long with a long petioled limb which is 8—12 cm. long and 22—26 mm. broad (Upper Burma: Shan Hills, leg. A. Huk. 1892. Herbarium, Calcutta).

Bracts of *S. sagittifolia* are similar to those of the type, but are half as long as the latter, 3—5·5 mm. long and number of nerves is smaller (Fig. 13-V and VI).

Flowers

♀ *flowers.* ♀ pedicels of *S. sinensis* are 7—20 mm. long; and ♀ flowers themselves are 18—24 (28) mm. broad.

Sepals are boat-shaped, oval, slightly acute, distinctly parallel nerved, membranaceous at the periphery, 4—7 mm. long and yellowish-green.

Petals are roundish, somewhat broader than long, very short unguiculate, 10—15 mm. long, 11—16 mm. broad and pure white. The petals of *S. s.* var. *edulis* are, as a rule, also white; but according to two herbarium-sheets red-blue coloured flowers occur sometimes.[1]

[1] These two herbarium-sheets belong to the University-Herbarium in Geneva: (1) China: Ta Han. "Flowers pink." Alt. 760 m. Coll. J. Lindseley Gressitt. (2) China "Fleuve bleu, rhizieres et plaine de Kioo-Kia." Alt. 400 m. VII. 1918. Leg. E. E. Maire. The petals of these specimens are so clay white or nearly colourless that it is impossible to decide, if these plants which have the size of a terrestrial sinensis form, belong to S. sinensis or not.

♂ flowers of *S. sagittifolia* are similar to those of *S. sinensis*, but their pedicels become twice as long as before, and flowers themselves are of the same diameter, namely, 18—23 mm. Pedicels are 14—30 (40) mm. long.[1] Sepals are 4—5·5 mm. long and 3—4 mm. broad, and for the rest of the same structure. Also petals of *S. sagittifolia* are on the average somewhat smaller, 9—13 mm. long and 11—5 mm. broad ; their base is tinged with a little brown-violet blue spot.

The number of stamens of *S. sinensis* is 22—25, which are 2—3·5 mm. long. Outer stamens are shorter than inner ones (Fig. 15). The filaments of outer stamens are about ¾—1 times as long as the appertaining anther ; but those of inner stamens are 1¼—1½ times as long as the anther. Anthers are rectangular, 1½—2 times as long as broad, and are bright yellow coloured ; but according to Handel-Massetti (l.c.p. 1788) the anthers are rarely red coloured which indication must be proved.

Stamens of S. sagittifolia.—These are in many respects similar to those of *S. sinensis* ; their number is 18—24 ; the length is 2·8—3·5 mm.; and the filaments are about 1—1¾ times as long as the appertaining anthers (Fig. 16). The latter, however, is on the average somewhat smaller, rectangular or quadrangular and 1—1½ times as long as broad ; and the two pollencells are, in contrast to those of *S. sinensis*, distinctly divergent downwards.

Finally it must be pointed out, that the anthers of *S. sagittifolia* are red-brown coloured in contrast to those of *S. sinensis*.

The *pollen* of both plants is globular. This of *S. sinensis* is 17—20μ. in diameter and its surface is slightly tuberculated ; but that of *S. sagittifolia* is somewhat bigger, 19—26μ. in diameter and the tubercles at its surface are more distinct and irregular.

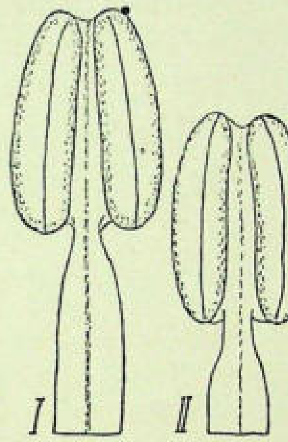

fig. 15. Two stamens of S. sinensis. ×⅓.

♀ Flowers

The ♀ pedicels of *S. sinensis* are 4—18 mm. long ; and the ♀ flower itself is (11) 13—22 mm. in diameter (Fig. 17). The calyx is similar to that described above and its sepals are distinctly reflexed after flowering (*see* Fig. 14); ♀ petals are slightly smaller than before, 6·5—11 mm. long and nearly of the same width. The head of carpels is globular and 3—5 mm. in diameter.

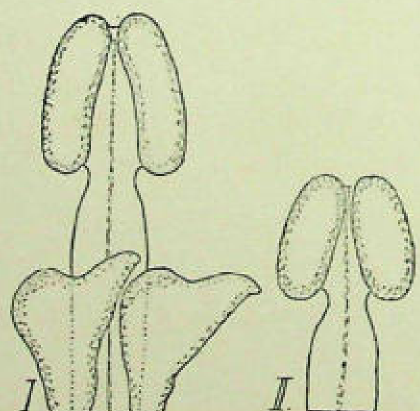

fig. 16. Two stamens of S. sagittifolia; in I. also two withered ovaries at the base of the filament. ×⅓.

♀ pedicels of *S. sagittifolia* are about of the same length ; 1—15 (18) mm. ; but the higher at the axis are sometimes sessile. The ♀ flower itself is 16—27 mm. in diameter (Fig. 18) ; and the carpel-head is 4—7 mm. thick. The sepals are, in contrast to those of S. sinensis, expanded or clasping the fruit after flowering. ♀ petals have either at the base a little spot like the ♂ petals or are accompanied near the base by a relatively large brown-violet-blue and roundish spot (Fig. 18). All these spots, however, are not much visible in dried herbarium plants. Between ♀ and ♂ flowers hermaphrodite flowers are also sometimes present in sagittifolia[1]. These coincide with the ♂ flowers, but there is a little head of carpels in the centre of the stamens. Isolated and withered ovaries are sometimes also found in ♂ flowers (*see* Fig. 16-I).

[1]The longest pedicels of 40 mm. were produced by forma vallisneriifolia.

Pistils of *S. sinensis* are numerous and are placed on a globular and soft receptacle. The pistils are little triangular and flattened organs with winglike and obscurely waved

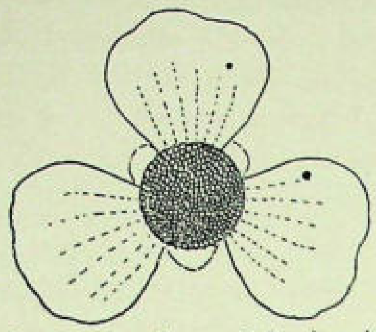

fig. 17. flower of S. sinensis. ×½.

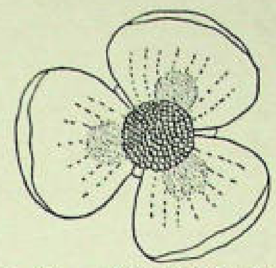

fig. 18. flower of S. Sagittifolia, petals white with a roundish spot at their base. ×½.

appendages at the dorsal side (Fig. 19I-III). The applanate form of the pistils is clearly represented from the cross-section in Fig. 19-IV. The real style is tapering and horizontal, while its tip is occupied by a group of short cylindrical papillae. Pistils of *S. sagittifolia* are very similar to those of sinensis, but dorsal winglike appendages are not prominent and never waved at the dorsal edges (Fig. 20).

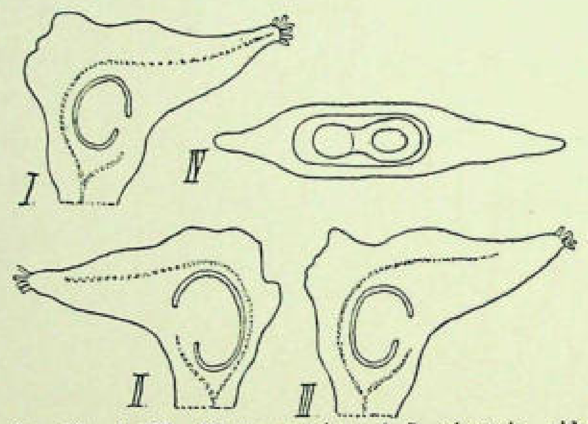

fig. 19. I.-III. Three ovaries of S. sinensis, side view. ×½.
fig. 19. IV. Cross-section of another ovary of S. sinensis. ×½.

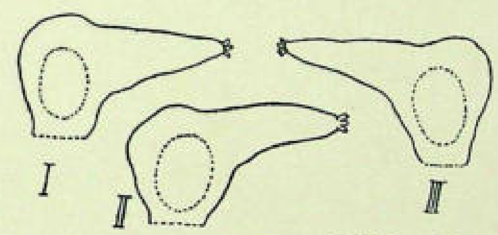

fig. 20. Three ovaries of S. sagittifolia, side view. ×½.

Fruits

Fruit heads of *S. sinensis* have often been produced in my cultivation. These are globular, slightly depressed, 11—22 mm. high and 14—20 mm. in diameter. Those of *sagittifolia* have the same shape, are however on the average somewhat smaller: 11—17 (22) mm. high, and 14—20 (22) mm. in diameter. The ripe fruits of both plants are little nuts, strongly complanate, surrounded by a colourless wing and beaked ; but the differences are as follows : Those of *S. sinensis* are (3·5)4—5 mm. long and (2·5)3—3·8 mm. broad; the outline of the fruits is triangular or oval-triangular (Fig. 21-I-III) ; and the wings are on one side often more or less irregularly waved or toothed ; and the ventral side terminated with a short and erect beak. The fruits of *S. s. var. edulis* are in contrast to the typical fruit oval-triangular only and somewhat smaller: 3·3—4 mm. long and 2—2·6 mm. broad (Fig. 21-IV and V) ; and in addition, the wings are on one side scarcely waved only. These fruits are sometimes more or less reduced and become oblong or lanceolate and are 0·8—1·2 mm. broad[2]). In all these specimens the bracts of the scapes are distinctly acute (*see* above

[1]*See* H. G l ü c k, Süsswasserflora, l.c. 1936, p. 102.
[2]The following herbarium sheets belong here : (*a*) "S. sagittifolia var. edulis" from Japan ; but without locality.
(*b*) "S. sagittifolia var. leucopetala" from Batavia in Java. Introduced from Chinese people ; according to Dr. C. A. B a c k e r.
(*c*) Cultivated specimens ; ex. Horto Bogoriensi, 1869. Hortulanus T e y s m a n n.

p 71). I am, however, not absolutely sure, if these smaller fruit-form is limited to cultivated specimens or not. In all cases I have seen such fruit-forms in different other specimens which may originate from natural localities[1]. The fruits of *S. sagittifolia* are nearly of the same magnitude as before : 4—5(6) mm. long and 3·5—4·5 mm.broad ; but oval in outline and never triangular (Fig. 22), and in addition the wings are not toothed and not waved, although I must confess that one find here and there wings which are very scarcely waved (Fig. 22-II). And finally the beak of the fruits is not so sharply marked as in *S. sinensis* ; it is sometimes oblique and sometimes erect.

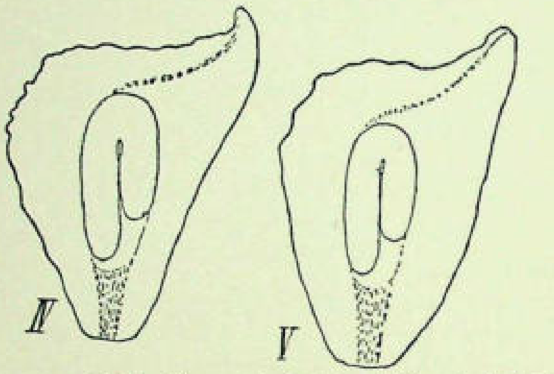

fig. 21. I.-III. Three ripe fruits of the typical S. sinensis. ×½.
IV.-V. two ripe fruits, belonging to var. edulis; originating from Batavia. ×½.

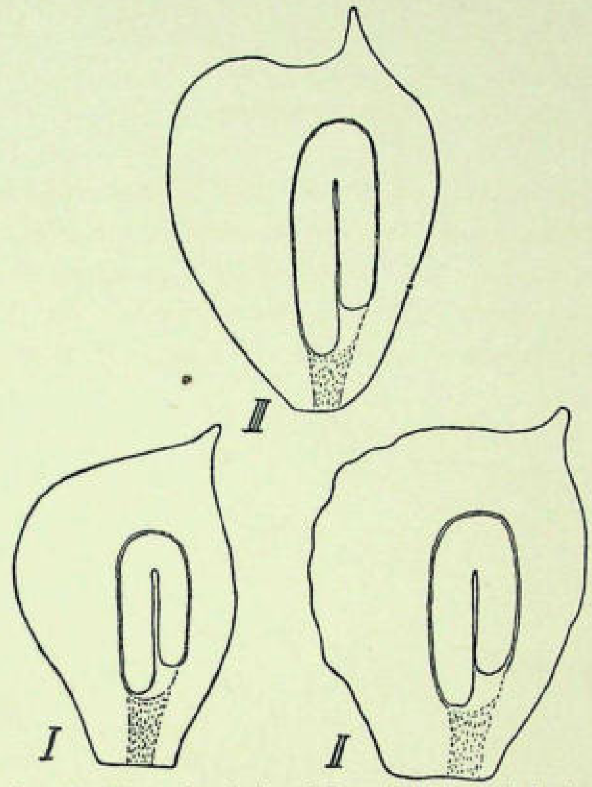

fig. 22. Three ripe fruits of S. sagittifolia; originating from different localities in Germany. ×½.

III—Varieties of S. sinensis

S. sinensis var. edulis and *S. s. var. plena* are two varieties which are often recorded in our literature but not sufficiently explored.

I. Sagittaria sinensis var. edulis (Siebold).

=S. edulis Siebold[2].

=S. macrophylla Bunge.

=S. sinensis Sims s. st.

=S. sagittifolia var. sinensis (Sims) Makino in Iinuma Somoku-Dzusetsu 20. Plate XX-VII, 1912.

=S. trifolia L. forma edulis (Siebold herb.) Gorodkov.

=S. trifolia L. var. sinensis Makino (in Makino and Nemoto, Fl. Japan, p. 1290).

Popular name in Japan : " Kuwai " (according to Somoku-Dzusetsu 1912).

[1]For instance the following herbarium sheets belong here : (A) Plants from *India* : (*a*) Herb. East India Comp. R. Bot. Garden, Kew and Calcutta, 1864-1866. (*b*) Plain. Ganget. Sup. 1,000 pd. Hooker & Thomson. (*c*) Khasia, 4,000-6,000 ft. Hooker fil. and Thomson. North Canara : leg Talbot No. 1170. (B) Plants from *China* : (*a*) Isle of Liu-Kiu (East China). Warburg. 6. X. 1887. (*b*) Isle of Hainan, Coll. Dr. A. Henry. XI. 1889.

[2]In Schlechtendal, Plantae Leiboldianae in Linnaea 1844. p. 432.

Popular name in China : *Chee-koo* " (*T'sz-ku*), according to Hawaii Agric. Exp. Sta. Bulletin, 1929, p. 45.

or *Tz'u Ku*, according to I. C. Lin, Syst. Botany, l c. p. 207.

According to the records of different botanists the tubers of S. s. var. edulis are used as food. It is also stated in all the descriptions that the blades are larger than in normal forms[1]; which quality may be produced by cultivation; other characteristic features, however, are not noted. But I have the impression that some other differences are present.

I. As to the shape of the blades I must point out that we do not have a characteristic feature, as some botanists indicate[2]. There are on the one hand blades of the obtusa-forma (*see* p. 67). Blade 11—38 cm. long; terminal lobe 5·5—19 cm. broad (base); basal lobes 2·4—12 cm. broad (base). The basal lobes are usually longer than the terminal lobe, but sometimes of the same length or a little shorter[3]. On the other hand there are blades of the ovalis-forma or sagittata-forma (*see* p. 65, 66). To the ovalis-forma belongs the plant, originating from Batavia (Java): blade (8)15·5—27 cm. long. Terminal lobe 1·8—10·5 cm. broad (base). Basal lobes 1·1—5·4 cm. broad (base) and $1\frac{1}{3}$—2 times as long than the medium lobe. To this form belongs " S. sagittifolia var. sinensis Makino " in Somoku-Dzusetsu (l.c. Plate XXVII).

To the *sagittata-forma* in general belong different Japanese specimens: blade 20—40 cm. long. Terminal lobe 6—15·3 cm. broad (base). Basal lobes 2·9—8 cm. broad (base) and longer than the terminal lobe (up to $1\frac{1}{2}$). These blades are by far the largest blades which I have seen in S. sinensis[4].

II. The bracts of the scapes in var. edulis are longer and more acute than in the type (*see* p. 70 and Fig. 13-IV).

III. The fruits of S. sinensis are smaller than those of the type and sometimes reduced (*see* p. 72).

IV. The tubers of *S. sinensis* are in contrast to those of the type not only larger, but also globular or depressed-globular with reference to a sketch in the herbarium of Kew Gardens. These tubers become 3·5—5 cm. high and 5—6·6 cm. thick. But according to M a k i n o and N e m o t o (Fl. Japan p. 1289) tubers with a large oval form are in Japan sometimes to be found. The colour of the tubers is variable according to M a k i n o and N e m o t o (p. 1289); it is sometimes white (=forma albida Makino) and sometimes blue or light-blue (=forma coerulea Makino).

The plant, however, which originates from the Hawaiian Islands has different tubers ; these are cylindrical or slightly tapering at both ends, or flattened and terminated by an elongated sprout, 1—$1\frac{1}{2}$ inches long, $\frac{3}{4}$—$1\frac{1}{2}$ inches wide, the colour is gray, bluish-gray or yellowish and when cut it is yellow or buff[5].

Use of the tubers

According to the records of different botanists S.s. var. edulis is cultivated in different parts of Asia for its tubers, as for instance in China (near Canton and Peking), in Japan, in Java (but to-day it is no more cultivated except perhaps along fish ponds), in the Malayan

[1]If we compare the picture of the cultivated form in Somoku-Dzusetsu (Plate XXXVIII) with the wild growing form (= "S. sagittifolia"), we can find only a slight difference in the magnitude.

[2]According to M. M i c h e l i (l. c. p. 67) and to G o r o d k o v (l. c. p. 157) such blades have an oval outline and are largely rounded.

[3]*See* the picture in Botanical Magazine, Vol. 39. Plate 1631.

[4]The material concerned with these is in the "Rijksherbarium" of the University Leiden (Holland)

[5]Hawaii Agric. Experim. Station Bulletin 1929 ; p. 45-46.

Peninsula (in Province Wellesley, Perak, Penang and Selangor), in the Hawaiian Islands (near Honolulu) where the plant has escaped cultivation and may be often seen in swamps, associated with the bulrushes.

The " Kyov or Kev plant of Kashmir " refers also to Sagittaria sinensis and is also used as food by the Kashmeres[1].

The tubers of S. edulis are harvested three times in the year in the Malayan Peninsula[2], but probable only once in all cooler parts of Asia, as in China and Japan.

According to Watt's record the tubers are edible if cooked and after the bitter element has been extracted by boiling. As to the preparation for the table a detailed instruction is to be found in the Bulletin of the Hawaii Agricultural Station No. 60, 1929, page 45-46.

As to the records of Ridley (l. c. IV, p. 363) and of Burkill (l. c. p. 1941-2) the tubers are also used to feed pigs in the Malayan Peninsula.[2]

According to Crevast and Lemaric (l. c. p. 150) the Annamese regard the tubers also as tonic and laxative medicament.

According to the communications of Heyne and Filet the young leaves and petioles are also eaten.[3]

All this information, given by me about S.s. var. edulis, may be corrected or supplemented in different lines, as I have not yet studied living material of this form.

II.—Sagittaria sinensis var. plena (Makino)

=S. sagittifolia var. plena Makino.

=S. trifolia var. typica forma plena Makino.

=S. japonica flore plena Hortorum.

=S. sagittifolia flore plena Hortorum.

S. sinensis is the only one among all species of the Alismaceae which produces a form with full flowers. It is recorded in different places in literature.[4] We do not know how this form first originated. I assume, however, that it might have originated from the Japanese horticulture, as we know that the Japanese people have for a long time been interested in every kind of horticulture. The material which I cultivated, originated from the so-called " Palmgarden " in Frankfurt (Main). Specimens cultivated by me in water 5—10 cm. deep in the hothouse were as follows: The erect sagittata leaves were (35) 50—105 cm. long. Their limb is (9) 17—33 cm. long and 3·5—15·5 cm. broad (medium lobe); basal lobes are 1·8—6·5 cm. broad. It coincides either with the ovalis-forma or here and there with a sagittata-forma. The former had a very broad-oval and sharply acute terminal lobe (up to 15·5 cm. broad); the latter had a lanceolate gradually tapering terminal lobe (up to 3·8 cm. broad) and narrowed basal lobes (1.3—1·8 cm. broad) (Fig. 8-II). The sagittata-forma is also here produced in consequence of small supply of nourishment. The scapes are shorter than the leaves, (29)35—65 cm. high; the stem is 3·5—9 mm. thick, cylindrical or compressed and polygonal. The bracts of the scape are not different from those of the type. Like many other artificial forms of garden flowers this form shows

[1]Kew Bulletin, 1918, p. 373-374.

[2]*See* The Gardens Bulletin, Vol. I, 1914, p. 228.

[3]K. Heyne, Nutt. Plant. Necl. Tud. 1927, p. 139.

Files, Plansk. Woordenb. 2nd ed. 1888, p. 48.

[4]Hamburger Garten-und Blümenzeitung, 1877, p. 10. E. Andre, "Illustr. hort." 1877, VIII. p. 16. Journal of Hort. XLIII. 1901, p. 218, Fig. 219. The Garden, LXXIV. 1910, p. 6. (Illustration ordinary.)

different abnormalities. The number of flower-whorls is in one scape 3—5 only which is caused by withering of the higher part of the scape. Development of a short side-branch in the lower inflorescence is not rare. The whorls are three-four or five-merous ; and the pedicelsof the flowers are 1·5—3·5 cm. long. The flowers themselves are all ♂ .

One flower is 2·5—3 cm. broad ; has 3—4 sepals and many petals, most of which however are abnormal. The outer petals only are large-oval, and a little narrowed towards their base ; the remaining petals, however, are spathulate and petiole-like in the lower half. The petals are 15—20 mm. long and 6—8 mm. broad. The form of these petals as well as the missing filaments may demonstrate that all petals are petaloid stamens.; all petals are here also pure white. This full form is of course propagated by tubers only.

IV—Geographical distribution of Sagittaria sinensis

Sagittaria sinensis grows in ponds, morasses, ditches and often in ricefields, localities which are periodically inundated ; and we may assume that Sagittaria s. is in different localities introduced or propagated by the rice-cultivation.

In the following lines I shall make an attempt to characterize the distribution of *S. sinensis* with the help of herbarium material [1]) and records available in literature. [2]

I wish to distinguish : (I) Regions in which *S. sinensis* is indigenous; and (II) Regions in which *S. sinensis* has only been introduced.

I—Regions in which S. sinensis is indigenous

(1) European Russia

Literature : B. V. Gorodkov, Taxonomy of European and Asiatic species of Sagittaria, p. 157. One locality only is here noted on the northern shore of the Black Sea : New Odessa, where the plant grows on the banks of the river Bug. This point is of particular interest, as it is the most eastern locality in the Old World.

(2) Asiatic Russia

The Flora of Mandschutikuo and Corea include, as both belong to the continental Asia.

Literature : C. J. Maximowicz records in 1859 in his Primitiae Fl. Amurensis (p. 267) as well the typical form (="S. sagittifolia") as var. longiloba Turcz. On the banks of the Amur and Ussuri rivers. E. Regel, Tentamen Fl. Ussuriensis, 1861 (p. 140), records different forms of "S. sagittifolia" on the bank of Sungatschi and Usuri rivers, as also on the shore of the lake of Kenkga.

Edmond Boissier. Fl. Orientalis, Vol. V, p. 11. Among the different regions, recorded for "S. sagittifolia" two Transcaucasian localities : Redutkale at the shore of the Black Sea and Lenkoran at the shore of the Caspian Sea belong according to Russian botanist to *S. sinensis Sims.* V. L. Komarov. Flora Manschuriae, Vol. I, p. 232, 1901. Recorded regions in which S. sinensis occurs belong here, but partially only as I assume (=S. sagittifolia.)

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[1]This material originates from the Museum in Berlin, Leiden (Holland) and Kew Gardens (England).
[2]All the records of literature are abbreviations, full titles are cited in the bibliography.

S. Korshinsky, Pl. Amurensis, p. 394. 1892 (="S. sagittifolia" f. normalis Korsh. and f. longiloba Turcz.). Both in the middle course of the Amur river.

T. Nakai, Fl. Coreana, 1911, p. 274, records one locality only for "S. sagittifolia" f. longiloba Turcz.

B. V. Gorodkov made in 1913 in the taxonomy of European and Asiatic species of Sagittaria the best indications of S. *sinensis* in Russia. The following countries are cited: Transcaukasia, Lenkoran, Turkestan, region of the Japanese Sea (Flora of Ussuri), environs of the Amur river, Manschuria, Corea, Mongolia. Further details and sheets of herbarium material are recorded in Gorodkov's treatise.

Flora of U. S. S. R. (edited by Komarow), Vol. I, p. 288, 1934 (="S. trifolia"). Here are cited: Western Siberia, Irtisch, Central Asia, environs of the lake of Baikal, the lake of Aral, Eastern Siberia, Dawuria, environs of Ussuri, etc., land of the Far East.

Herbarium materials

Turkistan: Taschkent, in the mountains of Tian-shan, leg. Granitov A Vvdensky. VI, 1928.

Amur-region: Blagowjestschensk (Gouv. Tomsk). Coll. F. Karo, VII, 1889. Pl. Amurensis No. 73. (="S. Sagittifolia" f. longiloba Turcz.).

Manschuria: no locality recorded. Coll. Hugo Bonhof 1898-1899 ("S. sagittifolia" var. longiloba Turcz.).

Corea septentrionalis: no locality recorded. Coll. Komarow.

(*3*) *Iran* (*Persia*)

Literature: E. Boissier. Fl. Orientalis (V, p. 11.): "Babylonia ad Korna."

Gorodkov; l. c. p. 157 (Gilan in Persia).

Fl. U. S. S. R., Vol. I, p. 288.

(*4*) *Afghanistan*

Literature: E. Boissier: Fl. Orientalis (V, p. 11.): Afghanistan, but no locality is given.

T. Aitchison: Fl. Afghanistan, p. 99: Ricefields, common, Shalizan. M. Micheli, Alismaceae, p. 68.

Herbarium material

Afghanistan: no locality is given. Ex. herb. Griffith.

Afghanistan: Kurram Valley. Coll. Aitchison.

(*5*) *China*

Literature: J. Sims in Curtis Botan. Magaz., Vol. 39, Plate 1631, mentioned China and Cochin China as home.

A. Bunge records in Enum. Pl. China Boreal., 1835, p. 137, Peking as a locality (="S. Macrophylla Bunge.").

S. Kurz; New Pl. from Yunnan, 1873, p. 193, records Yunnan only as a locality (nomen nudum !).

L. Diels; Fl. von Central-China, 1901, p. 220 (="S. sagittifolia") records Ichang only.

Forbes and Hemsley, Enum., etc., 1903-1905, p. 190 : "China from Chihli and Corea to Yunnan, Formosa, Hainan"; and mention especially ten different provinces; so one may conclude that "S. sagittifolia" is widley distributed.

J. C. Liu, System. Bot., etc., 1931, p. 161, gives no localities.

Herbarium material

1a. *China interior* : Prov. Shensi sept. Coll. J. Giraldi: X, 1892. Herb. Biondi. 1836.

1b. *China interior* : Prov. Schensi, ad templum Chin-ssü leg. H. Smith. Plantae sinenses No. 6838.

2. *Central China* : Prov. Hupeh. A. Henry's Collection, 1885-1888, No. 2664.

3. *Prov. Schantung* : Perlgebirge, südl. der Kiautschauschlucht. Coll. B. Krug, 1906, No. 334.

4. *Flora Pecinensis* : Coll. Dr. Bretschneider.

5. *Ning-po Mountains* : Coll. E. Faber, 1888.

6. *Canton* : Herb. Hance, No. 5344.

7. *Yunnan* : Regio Lichiang. Coll. C. Schneider.

8. *Yunnan*, in campis oryeae propes Hoching. Alt. ca 2400 m. Sept. 1926. C. Schneider, No. 2698.

9. *Yunnan*, in stagnoprape Ngulehlsch in reg. Sichiang Alt. ca. 2900 m.

10. Plaine de Tong-tchonan. rizieres. Alt. ca 2500 m. leg E. E. Maire.

11. *Isle of Hainan.* Coll. Dr. A. Henry, XI, 1889.

12. *East China* : Kiu Liu Inseln. leg. Warburg. Okt. 1887.

13. *Yche-Ly* : Ting Foa. leg. Chanet, 1906.

14. *Kweichow province* : Coll. Steward, Chiao and Cheo.

25. IX, 1931. Alt. 600m. No. 558.

(*6*) *Japan*

The state of Mandschukuo and the peninsula Corea are mentioned above (*see* p. 76—Asiatic Russia).

Literature: C. P. Thunberg; Fl. Japonica, p. 242 (='S. sagittata Thunb.) Franchet et Savatier; Enum. Pl. Jap. II: Hab. ad ripas, aquam in stagnis et fossis, Kiousiou, circ. Nagasaki (Thunberg, Mahnike). Nippon media ad Yakoska (Savatier Nos. 1213, 1214).

Matsamura and Hayata; Pl. Formosa, 1906, p. 464.

Linuma Somoku-Dzusetsu. 3 Ed., Vol. 20, 1912, Plate XXXVIII.

Makino and Nemoto: Nippon Shokubutsu Soran (Flora of Japan), 1931, p. 1289.

Genkei Masamune; Isle of Yasumina, 1934, p. 466. (="S. trifolia L." var. typica Nakano).

Herbarium material

1. *Flora of Hokaido*: Jubutsu. Prov. Uburi. Herb. Sapporo VIII, 1892.

2. *Japan*: no locality is given. leg. Rein.

3. *Nippon media*: no locality is given. Coll. Tschanoski, 1866. Maximowicz. Iter Secundum 1866.

4. *Japan*: no locality is given. Coll. Hilgendorf. 12, IX. 1874.

5. *Yokohama*: no locality is given. Maximowicz. Iter sec. 1862. (="S. sagittifolia" f. minor.)

6. *Yokohama*: in orycetis. Coll. Wichura. Per. Exped. Ost-Asien, 1860. No. 1250.

7. *Formosa*: Coll. R. Oldham. 1866, No. 750.

8. *Isle of Schikoku*: Marugame, leg. B. Krug. No. 389.

9. *Japan*: no locality is given; leg. Hilgard.

(7) *India*

Literature: W. Roxburgh, Fl. Indica, 1874, p. 175, records the vicinity of Calcutta only.

J. D. Hooker, 1890. Fl. Brit. India, p. 561: and Biswas, K., and Calder, C. C., Handbook of common water and Marsh plants of India and Burma, p. 77-78, 1937. In tanks, etc., throughout the plains of India from the Punjab to Bengal and eastward to Assam, Munipore and Burma.

Cooke, T., Fl., Pres. Bombay, 1908, Vol. II, 5, p. 834.

S. sinensis does not occur in the flora of Ceylon. At least it is not cited in Trimen and Hooker's large work on Ceylon.

Herbarium material

1. *India orientalis*: Khasia. Regio subtrop. 4,000-6,000 feet. Coll. Hooker and Thomson.

2. *India orientalis*: Plan. Ganget. Sup. Regio trop. Alt. 1,000 ped. Coll. J. Thomson.

3. *Upper Gangetic plain*: Kheri. leg. Inayat.

4. *Valley of Kashmir*: Ramu. 5,500 feet. Coll. J. E. Winterbottom.

5. *Kashmir*: Ramu. 5,500 ft. Coll. G. A. Gammie.

6. *Kashmir*: no locality is given. Coll. R. R. Stewart.

7. *Burma*: Katha district, Coll. J. H. Lace.

8. *Burma*: Southern Shan States. Coll. W. A. Robertson, 4,500 ft.

9. *Manipur*: Coll. G. Watt.

10. *Madras*: Nilgiris Distr. 7,800 ft. Herb. Gamble.

11. *East Bengal*: no locality is given. Griffith Herb. East India Company, No. 5400.

12. *Chittagong*: leg. Hooker and Thomson.

13. *Planta culta*:: Hortus Botanicus, Calcuttensis.

(8) *Siam, Annam and Cochin China*

Literature: Loureiro, Flora, 1 c. p. 698 (="S. sagittifolia."). W. Craib records in 1913 in his Fl. of Siam (p. 24) one station: Chiengmai, in moat, 300m. (leg. Kerr No. 1223).

Herbarium material

1. *Siam*: no locality is given. leg J. G. Kerr, VI, 1910.

2. *Indo-China*: Tonkin "environsde Chapon", leg. A. Petclot, VIII, 1931.

(9) *Philippines*

Literature: Blanco, Flora de Filipinas. Ed. III. Vol. IV"[1]), 1880, p. 51 ("S. sagittifolia Willd"). Merrill)[1] notes on one label of the "Species Blancoanae" No. 982: "S. sagittifolia L. is widely distributed in the Philippines, but is of very local occurrence."

Herbarium material

1. *Isle of Luzon*: Palapag, Samar 10. III, 1916. Merill, Spec. Blancoanae No. 982.

2. *Island of Luzon*: Irosin (Mt. Bulusan). Prov. of Sorsogon. Phil. Pl. Elmer No. 14339, Oct. 1915.

3. *Isle of Legte*: leg. C. A. Wenzel, VII, 1915, No. 1521.

4. *Isle of Bohol*. Coll. M. Ramos VIII-X, 1923, No. 4259.

Sagittaria sinensis is up to the present not recorded among the Flora of Australia and is not cited in Bentham and Mueller's big work (1878, Vol. VII). And also the whole continent of Africa contains not one species of Sagittaria, although we should assume that the European *S. sagittifolia* L. is present in the northern parts surrounding the Mediterranean Sea.

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[1]I wish to mention that no species of Sagittaria is cited in E. D. Merill's Flora of Manila.

II.—REGIONS IN WHICH S. SINENSIS HAS ONLY BEEN INTRODUCED

(1) *Malayan Archipelago*

Literature: B l u m e . Enumer. P. Jav. I. 1830. p. 34.

H a s s k a r l , Plant, Jav. 1848. p. 103.

M i q u e l , Flora Ind. Bat. Vol. III, p. 241. According to this flora *Sagittaria sinensis* (=S. hirundinacea Bl.) is in Sumatra and Java "common in the morasses and in the ricefields"; which report, however, is not yet warranted with certainty according to Dr. C. A. B a c k e r ' s information.

K o o r d e r s , Exkursions flora Java, 1911. p. 92-93.

B a c k e r , Handbook Fl. Java, 1925, I., p. 55.

R u t t n e r , Trop. Binnengewässer, 1932. p. 240.

In addition to these *Sagittaria sinensis* is recorded from the following localities according to Dr. Backer's [1]information.

Sumatra : region of Atjeh.

West of Borneo : region of Pontianak.

Celebes : in several localities, in pools and ricefields ; 900-1200 m.

K o o r d e r ' s report of the occurrence of "S. sagittifolia" in ricefields in the whole of Java and there also in mountains is wrong and misleading[2].

Dr. C. A. Backer in Holland, the best botanist of Java has written the following to me :—

"Sagittaria hirundinacea Blume=S. sagittifolia L. var. leucopetala Miquel is certainly very closely allied to S. sagittifolia L. from which it mainly differs by the entirely white petals. In my opinion it is not Malayan plant at all. Nowhere in the Archipelago it occurs in an undoubtedly wild state. It was collected only near Batavia (for the last time in 1905) and, about 70 years ago near Buitenzorg, not in ricefields as has often been wrongly stated but, always near Chinese habitations, in pools, where it may have been cultivated or at least have been an escape from cultivation. Teysmann in Jaarverslag's Lands Plantentuin (Ann. Rep. of Buitenzorg Bot. Gardens), 1871, came across it in the island of Bangka, where it was cultivated by the Chinese (for its tubers). B l u m e, J u n g h u h n and myself found it only near Batavia. Z o l l i n g e r never collected it, neither did K o o r d e r s. R u t t n e r (Trop. Binnengewasser III, p. 240) who in 1928-29 visited in Sumatra, Java and Bali, quite a lot of localities apparently fit for it, expressly states never to have seen it there."

Herbarium material

1. Java: no locality is given. Herbarium D. B l u m e. No 897, 288, 150(=S. hirundinacea Bl.) three sheets)[3].

2. Java: Batavia; leg. J u n g h u h n (=S. sagittifolia var. leucopetala) three sheets.

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[1]Letter, dated Jan. 23rd, 1939.

[2]*See* C. A. B a c k e r ' s "Kritiek op de Exkursionsflora of Java", p. 58-59. Any botanist, interested in the Flora of Java, must study Backer's important treatise, which demonstrates that in Kooder's Flora of Java there are many wrong and misleading indications.

[3]This material originates probably from Batavia.

3. *Java*: Ex horto Bogoriensi Javae, 1869. Misit E. Teysmann.

4. *Celebes*: Tjempaga. leg. Rachmat 10, VII, 1913. (=S. sagittifolia var. leucopetala).

5. *West-Celebes*: Lombasang. leg. Bünnemeyer 21, IV, 1921. (= S. sagittifolia var. leucopetala Miq.).

(2) *Malayan Peninsula*

We must also have some doubt if *S. sinensis* is indigenous in the Malayan Peninsula. Ridley's Flora (1924, IV, p. 363) of this peninsula says with regard to "S. sagittifolia" the following: "A Chinese form is sometimes cultivated to feed pigs. I have never seen it in flower." And besides "S. sagittifolia" is not cited as indigenous in the peninsula.

(3) *Hawaian Islands*

S. sinensis is to be found in these islands in one locality only as a cultivated plant. F. Hillebrand[1] says in Flora: "In 'taro' ponds near of Kapalama near Honolulu."

Finally I wish to refer to the sketch in Fig. 23 in which the area of S. sinensis and sagittifolia is marked out. This sketch is partially adapted to the sketch, given in Gorodkov's treatise (l. c. p. 155), but it is corrected by me in different points. On one side the southern part of India, the Malayan Peninsula and the Malayan Archiplago is excluded from the area of *S. sinensis*; and on the other side the western half of Scandinavia, Scotland, Corsica, the lower half of Italia and Greece is excluded, as we miss any record of *S. sinensis* and *sagittifolia* in these regions. We can recognize from this sketch that *S. sinensis* is limited to Asia (except one little point in Southern Europe), and that it ranges southwards from the 52 degree of northern latitude to the equatorial region. If we compare this area with that of *S. sagittifolia* we recognize that this area comprises the middle and the north Europe, but rare and isolated in the warmer regions of Europe. In Ireland there is only one locality in the centre, in Westmeath Ca.[2] In the Iberian Peninsula is one locality north of Barcelona (Ampurdàn) and in addition two localities on the coast in North Portugal[3]. In Italy there are the two most southern localities in the vicinity of Rome (laghetto di Ricti) and between Rome and Naples (Palnudi Pontine)[4]; but it is not recorded from Greece and all the Mediterranean islands.

V.—Resumé

(*A*) *Brief survey of the differences of S. sinensis and S. sagittifolia*

1. The sagittate blades of *S. sinensis* have two basal lobes which are 1—2 times as long as the terminal lobe; while in *S. sagittifolia* the terminal lobe is as long or slightly longer than the basal lobes. The basal lobes of sinensis taper always in a very fine needle-like tip; but those of sagittifolia are obtuse. The so-called *obtusa-forma* is limited to *S. sinensis* only.

2. In *S. sinensis* awl-shaped phyllodes, which precede (in all young shoots) the sagittate leaves, never occur in sagittifolia.

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[1]F. Hillebrand, l. c. p. 457.
[2]According to Dr. L. Praegor's information in Dublin.
[3] *See* William and Lange, Fl. Hisp. 1 and Supplement Contintro—Fl. Portugal, p. 122.
[4] According to Prof. Pampanini's information in Cagliari (Italy).

3. In *S. sinensis* slight strap-like primary leaves are produced in a small number from feeble tubers only. In sagittifolia well developed strap-like and sagittate leaves alternate regularly.

4. The stolons of *S. sinensis* bear at the tip either leafy shoots or tubers, but those of sagittifolia bear tubers only.

5. Swimming leaves of *S. sinensis* are lanceolate and have convergent basal lobes in contrast to the swimming leaves of *S. sagittifolia* which are larger, obtuse, and the basal lobes are never convergent.

6. Scapes of *S. sinensis* are relatively large, have 1—9 branches and are rarely unbranched. Those of *S. sagittifolia* are usually unbranched, or have one little branch only. The stalk of the scape of *S. sinensis* has, below the inflorescence, a hexagonal or polygonal cross-section; but the corresponding cross-section of sagittifolia is always triangular.

7. The bracts of *S. sinensis* are 2—3 times as long as those of sagittifolia, are sharply acute in var. *edulis* and are sometimes elongated in a lanceolate blade.

8. The ♀ calyx of *S. sinensis* is reflected after flowering, but that of *S. sagittifolia* is expanded or clasps the fruit.

9. The petals of *S. sinensis* are pure white (or, as it is told, sometimes red-blue), in contrast to those of sagittifolia which are white and towards the base tinged with brown-violet-blue or have a little spot of the same colour.

10. The ♂ pedicels of *S. sinensis* are on the average only half as long as those of *S. sagittifolia.*

11. The anthers of *S. sinensis* are rectangular and the two pollencells are nearly parallel or slightly divergent; while those of *S. sagittifolia* on the average smaller, rectangular or quadrangular and the two pollencells are distinctly divergent. The pollen of *S. sinensis* is globular and slightly tuberculated; that of *S. sagittifolia* is similar, but becomes larger and is more distinctly tuberculated.

12. *S. sinensis* exists in two cultivated races (*S.* s. var. *edulis* and *S.* s. var. *plena*), while *S. sagittifolia* has no race.

13. The fruits of both plants are nearly of the same magnitude; but those of *S. sinensis* vary from a triangular to an oval shape and are on one side irregularly waved or toothed; while those of *S. sagittifolia* are oval only and very scarcely or not waved; and in addition the beak of *S. sagittifolia* is not so distinct as the other.

14. *S. sinensis* needs for its optimum growth not only a higher temperature but also more moist atmosphere than those *S. sagittifolia,* and therefore *S. sinensis* endures not only a moderate but also a tropical climate. The area of *S. sinensis* is limited to the continent of Asia, that of *S. sagittifolia,* however, islimited to central and northern Europe and a small part of the moderate Asia. In all warmer parts of Europe (South and West Europe) it is either missing or rare.

The Indian or Asiatic arrowhead and the European arrowhead are two separate species, and as to the designation of the Indian arrowhead *S. sinensis* Sims is the only correct name.

(*B*) *Taxonomic value of the varieties and forms of S. sinensis.*

Gorodkov's arrangement is as follows :—

S. trifolia (=*S. sinensis*).

forma angustifolia (Sieb.) Gorod.

forma edulis (Sieb. herb.) Gorod.

forma typica Gorod.

forma longiloba (Turcz.) Gorod.

Makino's and Nemoto's arrangement is as follows :—

S. trifolia (=*S. sinensis*).

var. alismaefolia Makino.

var. sinensis (Sims) Makino (=S. sagittifolia f. sinensis Makino).

forma albida Makino

forma coerulea Makino

var. typica Makino (=S. sagittifolia var. leucopetala Miquel)

forma heterophylla Makino

forma longiloba (Turcz) Makino (=S. sagittifolia var. longiloba Makino,

forma plena Makino (=S. sagittifolia var. plena Makino)

forma subhastata Makino.

forma sinensis Makino.

S. s. var. alismaefolia and var. *typica* forma heterophylla must be struck out. Var. *alismaefolia* has linear or oblong-oval and sharply acute leaves. The linear leaves which I got myself from tubers of *S. sinensis* (p. 64) are at the end never sharply acute ; and so I reckon this form with *S. pygmaea,* the leaves of which are also sharply acute.

Forma heterophylla Makino has in its periphery broad-shaped leaves and in the middle narrow-sharped leaves. We have seen (p. 67) that this heterophylly is caused by poor nutrition, and so we can leave this form. *Forma subhastata Makino* and *forma sinensis Makino* are related to the erect sagittate leaves. Forma subhastata comprises apparently different forms with a rounded or sharply acute terminal lobe and often divergent basal lobes. Forma suitensis belongs to the ovalis-forma which I have mentioned above (p. 65).

As to my own investigations the varieties and forms of *S. sinensis Sims* (synonyms in the historical section) may be arranged as follows :—

I. var. typica (*Gorodkov*) s. 1[1].

=S. trifolia L. forma typica Gorodkov.

The blade of the erect sagittate leaves shows the ovalis-forma or sagitata-forma ; but rarely the obtusa-forma. Terminal lobe broad-oval and suddenly acute or triangular and slowly tapering. Basal lobes oval, oblong-oval and acute or broad-lanceolate and slowly tapering to a very fine tip.

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[1]Gorodkov describes under this name plants with a little ovalis-forma only.

Forma semimersa mihi [1].

Plant half submerged in water, 10—60 cm. deep ; with 5—7(12) erect and 60—150 c.m. long leaves. Petiole 4—10(16) mm. thick (at the middle) ; 2—4 cm. at the base. Blade 10—20 (35) cm. long and 4—0-15(20) cm. broad (base of mediuim-lobe). One rhizome with (1)2—6 (8—10) stolons, terminating in leafy shoots or tubers. Stolons (12)25—60(95) cm. long ; internodes (1·8) 4—22·5 cm. long and (2)3—8(12) mm. thick. Tubers (8) 15—33mm. long and (7)12—30 mm. thick. Scape 80—150. cm. high ; axis below the inflorescence 5—7(18) mm. thick. Main-axis of the inflorescence unbranched, with 7—13 whorls, or with 1—9 side branches, 15—30 cm. long and with 5—9 whorls.

Forma natans mihi [2].

One rhizome with 4—6 floating leaves, 50—90 cm. long ; petiole 1—2·5 mm. thick. Blade narrow, relatively delicate, floating, 6—12·5 cm. long and 9—26 mm. broad ; sagittate at the base. Lobes convergent and often crossing one another. Sterile form ; is usually a transitory stage. Up to the present this form is known in a cultivated form only.

Forma terrestris mihi [3].

In one rhizome 3—9 erect leaves (18)30—50(63) cm. long. Blade (4·5) 6—10(16·5) cm. long, and (9)13—32 mm. broad (medium-lobe) ; petiole (2)3—6 mm. thick. Stolons (1)2—8 in one rhizome ; 10—23 cm. long ; internodes 4—8 cm. long and 2—4 mm. thick. Tubers (5)10—21 mm. long and (3·5)7—20 mm. thick.

Cultivated sterile form.

Landforms, originating from natural localities[4], produce sometimes scapes : erect leaves 18—28 cm. long ; blade 7—11 cm. long and 13—21 mm. broad (medium-lobe) ; basal lobes 5—10 mm. broad. Scapes 13·5—26 cm. high, with 3—7 whorls, unbranched or with a short branch. Inflorescence with 1—3 ♀ in addition to ♂ flowers.

S. sinensis var. longiloba (Turcz.)
=S. sagittifolia F. longiloba Turcz.
=S. trifolia L. f. longiloba (Turcz) Gorodkov.
=S. trifolia L. f. angustifolia (Sieb.) Gorodkov.

The blade of the erect leaves is triangular. The terminal lobe varies from a lanceolate to a linear-lanceolate or linear form ; leaves 50—64 cm. long. Blade 18—30 cm. long. Terminal lobe 20—50 mm. broad ; basal lobes 10—25 mm. broad. Scapes 50—64 cm. high ; with 1—3 branches or unbranched [5]. This broad-leaved form is not common (China : Prov. Schansi, p. 11, note 1, II ; Japan : Yokahama, p. 11, note 1, III, Isles of Philippines : Bohol, p. 30, No. 4, East India : Khasia, p. 29, No. 1. Celebs ; Palapag, p. 11, note 1, III.)

Var. longiloba forma angustifolia (Sieb.) Gorodkov.
=S. Sagittifolia forma minor Regel.
=S. trifolia L. forma tenuissima Handel-Mazzetti.

Leaves 25—50 cm. long ; blade 7—18 cm. long ; terminal lobe 4—9(16) mm. broad, basal lobes 3—5·5(9·5) mm. broad [6]. Scapes 25—45 cm. high, with one little branch or

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[1] This form is cultivated from the ovalis-forma (*See* p. 65).
[2] This form was cultivated by me from the ovalis-forma (*see* p. 65).
[3] This form was cultivated by me from the ovalis-forma (*see* p. 65).
[4] Plants of Kweichow Prov. China. Coll. Steward, Chiao and Cheo Nr. 558. Japan : Sendai leg. S, Tisiba IV. 1919 (=S. sagittifolia subsp. sagittata Makino var. hastata Makino.
[5] Compare Gorodkov, l.c. p. 157 (with Fig. III).
[6] According to Handel-Mazzetti the lobes of f. tenuissima are 1-2mm. broad only.

unbranched. This narrow-leaved form is to be found within the area of the type (Amur Prov., China, Japan, East-India).

S. sinensis var. edulis (Siebold).

Blade on the average larger than in the plants growing wild ; very variable, its shape corresponds with that of the ovalis-forma or the hastata-forma or the obtusa-forma. Scapes apparently not different from those of the type. Bracts longer and distinctly acute. Fruits smaller than in the type. Tubers larger than in the type, and usually globular or depressed globular. In cultivation in China and Japan for its tubers.

S. sinensis var. plena (Makino).

A garden form with full flowers. The blade corresponds with the ovalis-forma and in some leaves with the sagittata-forma. Many petals, stamens and ♀ flowers are missing. It is a garden plant only.

S. Aginashi Makino in Somaku-Dzuschsu, l.c. Plate XXIX and Botan. Magazine Tokyo XV, p. 104.

=S. sagittifolia var. Aginashi Makino in Notes on Jap-plants. Botan. Magazine Tokyo VI, p. 49.

This plant has narrow-leaved blades and is according to the definition of Gorodkov (l. c. p. 157) identical with *S.* s. var. *longiloba.* But according to Makino's full description in Bot. Mag. Tokyo XV, p. 104, this plant is distinguished by missing stolons, having small tubercules at the base within the vagina of petioles, staminodes in the ♀ flower and fruits which are more or less striate on both faces.

The above treatise concerning the Indian Arrowhead was carried out by me at the suggestion of Dr. K. Biswas, Superintendent, Royal Botanic Garden and Herbarium in (Sibpur) Calcutta, as a contribution to the hundred and fiftieth anniversary volume. Dr. K. Biswas as well as some other botanists, namely, Professor L. Diels, Director of the Botanic Garden in Berlin, Dr. C. A. Backer in Heemstede (Holland), Sir Arthur Hill, Director, Royal Botanic Gardens, Kew in England, Mr. William T. Stearn, Secretary, Lindley's Library in London, Professor H. T. Lam, Director of the Botanic Museum (Rijksherbarium), Leiden in Holland, Professor Hochreutiner in Geneva, Switzerland and Professor R. Pampanini in Cagliari, Italy have helped my work in different ways. I am highly indebted to these botanists.

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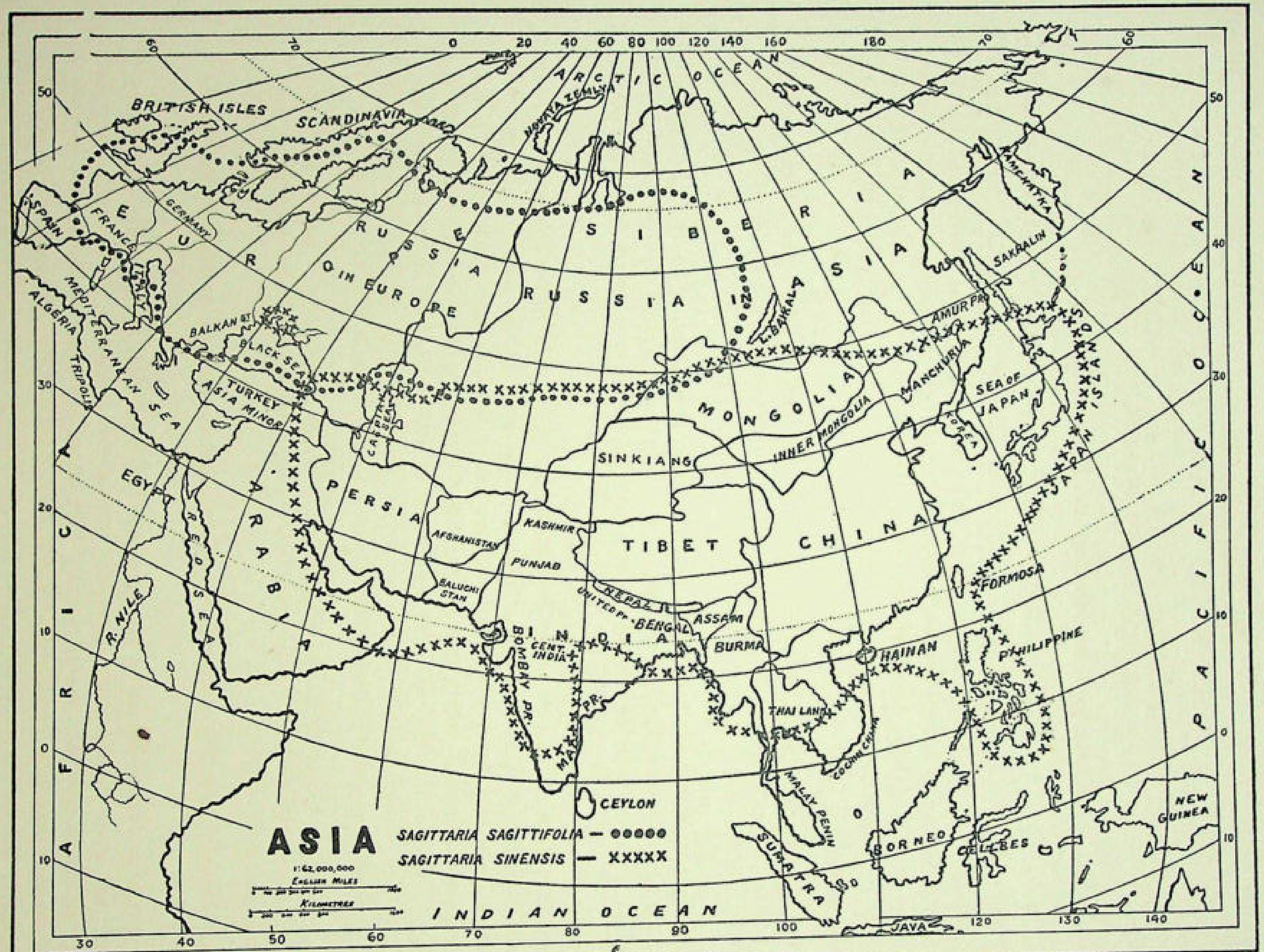

fig. 23. Map showing the distribution of the Indian and European plant. The area of the Indian Arrowhead S. sinensis is shown with little crosses, and that of S. sagittifolia is shown with little points. (*Redrawn from the original sketch.—K. Biswas.*)

Gregarious Flowering of Strobilanthes (Acanthaceae) in Malaysia

by

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INTRODUCTION

On this festival occasion it seems appropriate to choose for treatment a subject with which Indian botanists are well acquainted. The peculiar gregarious flowering of *Strobilanthes* is well known to Indian botanists and much information is hidden in various communications scattered throughout the literature. The phenomenon as such is much less well known in Malaysia. The ecological explanation is equally obscure in both countries and I can only point to the need for further research.

Before discussing *Strobilanthes* in Malaysia, it seems worth while to give a short survey of gregarious flowering in general supplementary to the extensive treatment by VON FABER.

Gregarious flowering is often related to leaf fall, as is the case in many leaf shedding trees. This occurs mostly during the changing of monsoons or during the dry season. It is of course necessary that developed flowerbuds must be present before flowering takes place.

Gregarious flowering which occurs only in special years is known in Malaysia, *e.g.*, in *Bambusae, Conifers* and *Dipterocarps.* This flowering and fruiting can take place over rather large areas simultaneously. The decisive factor is not always known. It seems that for *Dipterocarpaceae,*—which prefer mainly the evergreen, moist rain forests of Sumatra, the Malay Peninsula and Borneo,—the occurrence of dry years, that is, years which are characterised by a more definite or slightly longer dry season, is the main cause. Such dry years, called "seed years," occur normally once in 5-6 years in Western Malaysia.

The gregarious flowering in these cases is obviously due to the climate. It is not known with certainty whether in other years flower buds are absent, but I can hardly accept that such is the case.

Pinus Merkusii, Agathis and probably other Conifers also produce seed in abundance in special years.

The occurrence of seed-years is of course not limited to the tropics. The periodicity of certain fruit trees in producing abundant fruit is well known in Europe; the crop is produced usually in alternate years, possibly because of a smaller production of organic matter in the year following a seed year. Production of fruit in Europe is also influenced to a high degree by the occurrence of night frost during critical periods of floral development.

Bambusae also often flower gregariously (*cf.* VON FABER). In this case the flowering culms often die after having produced the fruit. I do not know what change of climate over large areas affects the flowering of *Bambusae.* I have never observed the phenomenon myself ; the only thing I know is that it is very difficult to get bamboos flower in the field.

It is certain that a change in climate whether towards dryness or moistness can cause gregarious flowering.

All the cases above refer to flowering once or twice a year.

Another class of gregarious flowering is that of several orchids, among which the pigeon orchid is the best known, but to which may be referred also *Coffea*, *Murraya* and several other plants.

These plants flower gregariously within a limited area. The flowering takes place more than once per year.

The gregarious flowering of these plants is due to sudden climatic change, viz., a lowering of the temperature (mostly accompanying heavy showers) by a certain number of degrees. The flowering occurs, of course, only if small but essentially fullgrown (" mature ") buds are present. The lowering of temperature is a stimulant for development. The opening of the flowers takes place a certain number of days after the lowering of temperature. This number of days is rather constant for each species (7, 8, 9, 10, 11, 14 days). The lowering of temperature must be abrupt and reach a certain amount (ca 4-5°C.) The growth of the resting buds is caused essentially by the elongation of the cells and not by cell-divisions.

The first to suggest a relation between the flowering and the lowering of temperature was I. H. BURKILL, in 1917. A fine series of experiments was made by Ch. COSTER who was able to give an entire and satisfactory explanation of the phenomenon (1925).

Not all individuals behave exactly in the same way. There sometimes occur specimens which have their own constant flowering cycle which may differ from the common stock by 1 or 2 days. The same individuality is observed in leaf-shedding trees, in which even twigs may behave individually.

An aberrant case is that of *Zephyranthes rosea* LINDL. Miss KERLING has made numerous experiments with this plant at Medan (East Coast of Sumatra). The flowering takes place several times a year and consists essentially of cell-elongation of " ripe " buds. She has found, that an abrupt lowering of temperature is not necessary as is the case in *Dendrobium* c.s.; the periodicity is due to a temperature lower than ca 26°C. acting for some hours on buds of at least 28mm. long, during which period the earth and air must be moist.

Though the circumstances of flowering are ecologically slightly different from those of *Dendrobium* c.s. I include *Zephyranthes* in the group with *Dendrobium*.

Another type of gregarious flowering closely allied to that of the leaf-shedding trees is apparently represented by the Fungi ; it is based on observations by E. J. H. CORNER.

CORNER says : " The fruiting of *Hygrophorus firmus* in Malaya is seasonal. It takes place during a week or two in each wet season after a dry spell, which must be of 2 or 3 weeks' duration and pronounced enough to dry off the surface layer of humus in the forest. In Singapore such a spell generally occurs twice a year, in February and in July or August, and it is followed by a period of 3 to 4 months' intermittent rain during which the humus is always moist. The fruit bodies of *H. firmus* then begin to develop some 6 weeks after the break in the dry weather. Over a small area of forest where the rainfall is uniform, one may therefore find the troops of fruit bodies twice a year during 1 or 2 weeks, and only very sporadically, if at all, in the intervals. Each mycelium fruits only once in each season. The fruiting of *H. hypohaemactus* also appears to be seasonal. During four years 1929-1932 it has fruited twice a year in the Singapore Botanic Gardens at intervals of 2 to 4 months after the break of the dry spell."

Another category of gregarious flowering is that in *Strobilanthes*. This is a most obscure phenomenon ; hitherto no explanation has been offered for its appearance. Flowering takes place only once, after which the plants, which have the morphology and behaviour of annuals, though the stems can attain large dimensions and grow woody, perish. Flowering as the final stage of a plant's life is of course most common. All annuals die after flowering and live only one year, all biennials flower and die after two years.

Some palms, *e.g.*, *Corypha* and *Metroxylon* also flower only once, caused by the fact that the inflorescence is terminal and the palm has no further buds at its disposal for further growth. In annuals and biennials the dying off after flowering is caused also partly by absence of further buds and, moreover, by the correlation between the developing ovaries which suppress the development of still existing buds, which can be proved by the removing of the developing flowers, which causes a development of the resting, suppressed buds.

Before an explanation of the gregarious flowering of *Strobilanthes* can be offered the existing facts must be ascertained and put into order. There is much information already existing in Indian literature which I cannot attempt to exhaust. WALKER, BEDDOME, CLARKE, TRIMEN and others have remarked on the flowering rhythm and given data on the length of the life-cycle. (For some peculiar reason KURZ does not mention anything in his Forest Flora.) Different species show different intervals, some being 7, 8, others 11 or 12 years. *Str. sexennis* NEES of Ceylon is named after the observation of WALKER that the plant flowers in its sixth year but Mr. FARR told Dr. TRIMEN that the flowering occurs not sooner than the 11th or 12th year. There are some species which inhabit open meadows, such as *Str. Kunthianus* on which Mrs. M. E. ROBINSON gave remarks : that there is a full gregarious flowering once every 12 years in the Neilgherries (1826, 1838, 1850, 1862, 1874, 1886, 1898, 1910, 1922, 1934), the plants producing abundant honey ; and that there are lesser outbursts of flowering in scattered areas at other times. TRIMEN gave valuable characteristics for Ceylon : the species form together or separately unbroken sheets of undergrowth in the forests. Some species are quite woody and up to 10 feet tall, with stems up to 10 cm. diameter. A few flowers may be found here and there every year, but it is not until the plants reach a certain age, usually from 10-13 years, that the whole patch bursts into simultaneous blossoming ; these patches are often of great extent, and the boundaries between those of different ages are very conspicuous, being as distinct as if artificially sown.

HUGH MURRAY and A. S. mention (1896) that after the profuse flowering of *Str.* there is a chance for oak and fir seedlings to make a start and send their roots into the soil. *Str.* can be successfully got rid of by pulling it up by the roots and throwing it away, as no new seedlings at all come up.

J. H. L. WILLIAMS mentions that the south-east monsoon of 1935 was very much more open and sunny than usual and very much below normal rainfall. Possibly this has something to do with the gregrarious flowering of *Str.* between August 1936 and April 1937, when in fact almost every *Str.* plant under the heavy evergreen forests seems to have flowered and died during this period.

Observations in Java and Sumatra

On the mountain slopes above ca. 1000 m. alt., *Strobilanthes* spp. often cover large surfaces as a pure dense undergrowth. LÖRZING found in Preanger Res. (W. Java) one species covering ca. 40 ha: pure patches of 1-20 ha are common on Mts. Salak, Gedeh, Patoeha, Papandajan, Goentoer, Malabar, Diëng, etc. I observed the same in South Sumatra on Mt. Pakiwang (Bull. Jard. Bot. Btzg. 13, p. 16). The period of flowering is mostly in the months of May to August during or after the start of the dry season. The following year thousands of germinated plants come up. The young plants often bear variegated leaves, and those white blotched juvenile plantlets were described by the late Dr. KOORDERS as *Str. pictus* n. sp., a juvenile stage of *Str. cernuus*. The gregarious phenomenon is rarely 100 per cent; of the most common species *Str. cernuus*, every year some flowering individuals can be observed, often in different months of the year. Occasionally a new shoot can be formed on an old stem, as I have already pointed out concerning the violet-flowered *Str. alata* from Mt. Papandajan (De Trop. Natuur 24,1935,145). Large individuals of several species of *Str.* form stiltroots at the base of the stems, both on dry and moist soil; moreover, I observed in several species aerial roots protruding from the lower twigs on the nodes.

We do not possess the knowledge of Malaysian species given by long period of observation. Nobody has ever tried to cultivate the plants to obtain exact measurements of the growth, the formation of buds and establishing of the period. The field observations are not absolutely trustworthy as this depends on general impressions, and it is possible that the patches compared have not been always the same stock of plants. Formerly it was understood that the white-flowered *Str. cernuus* has a flowering period of 7 years which was accepted by the Sudanese (who call all *Str.* species boeboekoean, boekoe, pronounced boku, meaning articulation). The late Mr. BARTELS Sr., our well-known ornithologist, who was highly interested in this species, as a special kind of finch (*Serinus estherae*) feeds on the seeds, and the late Dr. KOORDERS noted gregarious flowering on Mt. Gedeh in the years 1902, 1911 and 1920, to which I can add from own observation the years 1929 and 1938. The period of *Str. cernuus* is, as DOCTERS VAN LEEUWEN (1933) stated, 9 years. *Str. cernuus* is pollinated by Bombycidae. The altitude may give differentiation of flowering; DOCTERS VAN LEEUWEN mentions that in June 1920 the species was entirely past flowering at Tjibodas below 1,800 m. alt., but was still in full flower at higher altitudes. This year (1938) *Str. cernuus* has not only flowered above Tjibodas on the northern slope of Mt. Gedeh, but also on the southern slope, further on the neighbouring Mts. Salak, Megamendoeng and Boerangrang. This is the only case in which the average period seems to be rather well known. And even here there are gaps in our exact knowledge of the phenomenon.

Mr. M. L. A. BRUGGEMAN, formerly curator of the mountain garden at Tjibodas, told me that he had also observed gregarious flowering in spring 1922 and spring 1926 above the mountain garden. However, it is not known whether there may be several "sets" of flowering plants of the same species and whether BRUGGEMAN'S observations refer to the same plots examined by the other naturalists.

JUNGHUHN was the first to mention gregarious flowering of *Str. speciosa* from Mt. Tjikoerai (W. Java). I do not know which species is meant.

C. A. BACKER mentions that *Str. diclipteroides* MIQ. flowered gregariously on Mt. Patoeha (West Java) in spring 1914. According to the natives the period was 7 years.

I observed gregarious flowering of *Str. alata* on Mt. Papandajan in 1934.

For the other species I have gone through all the herbarium material which we possess of the genus. This has not led to many new arguments, as, firstly, the 10-15 species known to occur in Java are not yet well delimited, secondly the field notes on the labels are often too fragmentary for conclusions, and thirdly the plants have been collected in various remote places.

Gregarious flowering is noted on herbarium labels of *Str. bibracteatus* near Tjianten (south of Buitenzorg) in 1918, and Mt. Jang (East Java) in 1934 ; of *Str. involucrata* on Mt. Gedeh in 1911 and on Mt. Patoeha in 1935 ; *Str. hirta*, probably a form of *Str. cernuus*, on Mt. Patoeha in 1914 ; of *Str. cernuus* on Mt. Salak in 1929 (same year as Mt. Gedeh), and at Telagabodas in 1915 (which does not agree with the Gedeh period). *Str. filiformis* does not grow over large areas gregariously and possibly shows no cyclic flowering. Of *Str. cernuus* Mr. F. H. HILDEBRAND found gregarious young plants 10-15 cm. tall in 1935 on Mt. Patoeha ; other plots in the neighbourhood were, however, of much taller growth, viz., 3-4 m. Moreover, Mr. HILDEBRAND observed sometimes two sheets of different species above each other ; the lowest being the germination stage of one species, the taller the advanced stage of the other species. The remarkably sharp demarcation of the plots against each other and the existence of sets of different age make it very difficult to arrive at an explanation based on the argument of the influence of climate. There is another genus, by several authors included in *Strobilanthes*, viz., *Lamiacanthus viscosus* O. K., of which gregarious flowering was observed on the west slope of Mt. Lawoe (East Java) between 2,000 and 2,400 m. alt. in July 1936. Further it must be said, that not all species flower periodically ; as far as I can judge, *e.g.*, *Str. crispus* does not show any cyclic flowering.

Dr. Ch. COSTER, of the Forest Experiment Station at Buitenzorg, gave me some interesting results of his observations on Mt. Patoeha (West Java), in the forest reserve Tjipadaroeoem, situated between 1,700 and 2,200 m. alt. He observed gregarious flowering in 1932 and 1936. The flowering plots were very sharply demarcated. The set of 1936 covers some 12 sq. km., that of 1932 covers only ca. 4 sq. km. The border between the plots is very irregularly shaped. There were 3 flowering species in both sets, viz., *Str. alata, cernuus* and *involucratus*. The length of the plants and their habitat had no influence, as flowering was observed both on ridges and in ravines and both in tall plants and in those measuring only 10-20 cm. Ca 6-12 months after flowering the number of seedlings was counted ; COSTER found in several localities ca 500 specimens pro sq.m. measuring 1-2 cm. in length. The plots of flowering are mapped and it is planned to continue the observations in future. With that our detailed knowledge concerning Malaysia is exhausted.

Numerous questions arise, which cannot be answered at present. For instance : Is *Strobilanthes* essentially annual or perennial ? It has certainly the habit of an annual, but on the other hand it approaches the *Corypha*-type in the long period before buds are formed. Further research is necessary to see whether the buds are formed only in the year of flowering, or whether flower buds are present at a much earlier date in a latent phase.

The cause of the simultaneous bud development is still obscure. The fact that not only on one mountain but also on several neighbouring slopes flowering can be remarkably synchronised points undoubtedly to some exterior cause, whether this may be moistness, dryness or cold stimulating flowering in a certain stage of bud development, which would agree with flowering periods in the pigeon orchid, etc. On the other hand, the seemingly definite period for each species points to a internal periodicity, as no climatic cycle is constant for so long a period as that which is observed for example in *Str. Kunthianus*. Moreover, the different species show very different cycles varying between 7 and 12 years : this can hardly be brought into agreement with meteorology. Lastly I may point to the fact that the habitat is very different, *Str. Kunthianus* being a meadow plant getting every year full sunshine and heat, whereas most other species are hygrophytes of rather dark mountain forests.

Concluding it must be said, that though the phenomenon as such is well known, no satisfactory explanation can yet be given. This essay is only compiled to summarise facts on a subject which has interested numerous Indian and Malaysian botanists both in old and recent times. I hope that in the near future some clever botanist will succeed in getting to the bottom of this mystery.

Summary

The flowering of plants can be divided into several categories :—

(1) Annuals live normally 1 year, flower gregariously or not and perish.

(2) Biennials live normally 2 years, flower in the second year gregariously or not and die.

(3) Perennials flowering irregularly throughout the year.

(4) Perennials flowering normally throughout the year but gregariously at regular periods, caused by the climate, *i.e.*, cold (*Dendrobium crumenatum, Coffea, Murraya, Zephyranthes*).

(5) Perennials flowering twice a year gregariously, caused by the climate, *i.e.*, moistness *versus* drought (*Hygrophorus*).

(6) Perennials flowering once a year, often gregariously mostly at the changing of seasons (most leaf shedding trees).

(7) Perennials flowering only once in 2 or more years often gregariously, probably on account of the climate, *i.e.*, extremely (?) dry years (*Bambusae, Dipterocarpaceæ, Conifers*).

(8) Perennials flowering only once but not simultaneously, after which they die on account of the absence of further lateral buds (several palms, *e.g.*, *Corypha, Metroxylon*).

(9) Perennials flowering only once and then gregariously, after a definite period which is constant for each species ; die after fruiting (*Strobilanthes* sspp., *Lamiacanthus viscosus*).

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An outline of the Vegetation and Flora of Tibet

by

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Founder's Medal, Royal Geographical Society; Livingstone Medal, Royal Scottish Geographical Society; Victoria Medal of Honour and Veitch Memorial Gold Medal, Royal Horticultural Society.

To us in India the flora of Tibet is of particular interest, both by reason of its intimate connection with the Himalayan flora and because India has contributed largely to the restocking of Tibet after the Pleistocene glaciation. It can rarely happen that the vegetation of a political state conforms so closely to the topographical divisions as it does in Tibet; nor are those divisions always so well marked and relatively simple. Briefly Tibet is a high plateau; and is of course being degraded by all the forces of destruction—wind, rivers, glaciers, snow, rain, frost, and so on. Owing to causes which will be explained later, this degradation increases progressively from west to east, and it is convenient to regard the plateau as divisible into three parts, each part representing a further stage in the process of degradation. It is almost as though over three great areas, after a certain stage had been reached, the process had been stopped.

These three areas are from west to east—

(*i*) The Tibet lake basin, or interior plateau.

(*ii*) The outer plateau.

(*iii*) The river gorge region.

(*i*) The lake basin occupies the whole of West Central and North-Western Tibet. It is all that remains of the original plateau with internal drainage, and salt or brackish lakes. The climate is continental and very severe, and the entire flora comprises only some fifty species of flowering plants, none of them woody. They are widely scattered, and can rarely be said to form lesser plant communities. The whole is an alpine tundra climax.

(*ii*) The outer plateau comprises most of South-Western, Eastern, and North-Eastern Tibet. The rivers flow outwards, away from the plateau, and eventually reach the sea ; the lakes are fresh water, having an outlet. The climate, though still very severe in the interior, becomes milder to the south and east in the valleys of the great rivers, and almost genial, at least in the summer, as the river gorge region is approached.

The outer plateau is the principal grazing and also the chief residential area of the country. Its flora, as restricted as that of the lake basin in the interior, increases rapidly to the south and east, until it numbers several hundred species, including a few small trees and shrubs.

The valleys of the outer plateau are water worn. There is no trace of ice action over the plateau as a whole, though the mountain valleys contained small glaciers during the glacial age. The rivers appear to have been larger formerly then than they are to-day.

(*iii*) Still further east however the valleys become different in kind; the change marks the transition from outer plateau to river gorge country. Here the valleys are ice ploughed; at a later date, after the retreat of the glaciers, rivers cut narrow V-shaped gorges in the wider glacier worn valleys. Enormous ranges of mountains, some of which are over 25,000 feet high, surround and enclose the river gorges, where these break through the edge of the plateau to reach the alluvial plains. This river gorge region* comprises part of Southern and the whole of South-Eastern Tibet.

The climate is anything from moist warm-temperate to sub-artic; but its keynote is comparative humidity, and abundant summer rain. On the whole it is a forest climate.

The flora of the river gorge region is by far the richest in Tibet and includes well over a thousand species. Almost every type of vegetation is represented, but mainly it is mesophytic. As already remarked, the climate differs widely in the three great divisions of Tibet, and climate alone is enough to account for many differences of vegetation and flora. The interior plateau, or lake basin has a cold desert climate; the outer plateau, mainly a grassland climate, the river gorge region a forest climate. But it is important to recognize that the flora of Tibet, of Western China, and of the Great Himalaya and associated ranges is one indivisible whole. A fairly constant type of flora runs right through this region, and praticularly through Tibet itself, becoming rapidly poorer in species and in life from east to west, and from south to north. Nevertheless it can always be recognised as *Sino-Himalayan*. The constant association of certain species and groups of species as well as the occurrence of endemics should be sufficient to establish a geographical region or sub-region; the higher the denomination of the endemics—family, genus or species—the more natural, that is to say, the longer isolated the area. Sino-Himalaya has few endemic genera but the constant association of certain genera and species entitles it to rank with other great natural floristic regions. It is on a basis of vegetation or life form that the tripartite division of Tibet is made. From the phyto-geographical point of view, the plateau cannot be detached from the mountain region which girdles it to the north-west, south and east. It has little in common, except poverty of species, with the low-lying Central Asian region, which comprises Turkestan and Mongolia.

The present flora of Tibet is not an indigenous flora; it has been almost entirely derived from the surrounding regions. The arrangement of the mountain ranges which completely encircle the plateau, and the former great extension of the Himalayan, Chinese and Eastern Tibetan glaciers prove that during the Pleistocene glaciation the plateau was surrounded by a belt of ice which must have almost completely sterilized any pre-glacial flora it possessed. Whatever that pre-glacial flora may have been, little, if any, of it survived the ice age. Since the restocking of Tibet the flora has probably undergone little modification.

If, as some geologists believe, the Himalaya are still rising, and have been rising since long before the ice age, it is probable that the climate of Tibet was formerly very different from what it is to-day. Moreover, bones of rhinoceros and other large mammals have been found in Western Tibet, indicating that this part of the plateau, now a desert, was probably forested in middle or late Tertiary times. The gradual shrinking of the Tibetan lakes which were once far more extensive, also points to a moister climate. A moister climate combined with a general lowering of temperature over the northern hemisphere would help to account for the glaciation which was probably contemporary with that of Europe and North America, though this has not been conclusively proved.

*Here the country no longer has the appearance of a plateau, it has, however, been carved from the original plateau, and the underlying plateau structure is still recognisable.

South-Eastern Tibet probably always had had a moister climate than Western Tibet; but there can be little doubt that the dessication of Tibet is a comparatively modern affair. Continuous uplift of the boundary ranges gradually cut off the rain bearing circulation leading to drought conditions. But the glaciation of Eastern Tibet did good as well as harm, for it led to the breaching of the Himalaya and the gradual admittance once more of rain bearing winds, this time from the south-east.

The floristic elements which are combined in the Tibetan flora are as follows: (*i*) an Indo-Malayan element; (*ii*) a Chinese or Eastern Asiatic element; (*iii*) a northern element; (*iv*) a Mediterranean element.

Previous to the cutting of the river gorges, notably that of the Tsangpo, first by ice and then by water that is to say, previous to, and even during the earlier stages of the glacial epoch, there must have been considerable interchange of flora across South-Eastern Asia, along a general north-west to south-east line. Not only have Eastern Tibet and Western China a common alpine flora, but Japanese, Formosan and Eastern Chinese species reappear in Tibet. This element is most conspicuous in the extreme south-east on the confines of Burma and Assam.

One effect of cutting the river gorges through this continuous belt of high land including of course the Himalaya, was to emphasize the difference between the eastern and western portions (due to climatic causes) and to let in an Indo-Malayan element from the south. This southern element entered Tibet *via* the newly cut river gorges. In general the flora of the North-West Himalayan region is more closely related to that of Europe and the Mediterranean region, than of the Eastern Himalaya to the Indo-Malayan and Eastern Asiatic flora.

The Eastern Asiatic element is represented by numerous trees, such as *Taiwania cryptomerioides*, various Mangnoliaceae, Hamamelidaceae, etc., as well as by herbaceous Berberidaceae, Saxifragaceae, Primulaceae, and others. This is one of the oldest elements in the Tibetan flora. It may have reached Tibet long previous to the Ice Age and survived that disaster in the Ice Age in secluded valleys; particularly on the southern slopes of the Himalaya and in South-West China and Burma.

The alpine flora of Tibet, which makes up a large proportion of the whole, is almost entirely of northern origin. It is not confined to any one region but is spread over the whole plateau, although towards the north and west the number of species is greatly reduced. The similarity between the alpine flora of the Eastern Himalaya and the mountains of Western China is gradually being established, and it is this alpine flora derived from the north temperate region which is so conspicuous in Tibet. It includes many species of Primula and Rhododendron, Gentiana, Meconopsis, Saussurea, Pedicularis, Androsace, Anemone, Polygonum, Aconitum, Delphinium, Ranunculus, Aster, Dracocephalum, Gaultheria, Vaccinium, Corydalis, Salvia, Potentilla, Parnassia, Lactuca, etc., etc., besides such endemic genera as Cremanthodium, Nomocharis, Notholirion, Berneuxia, Chionocharis, Bryocarpum, Eriophyton, Cyananthus, Wardaster, Oreosolen, etc. It is in fact the element which is most typically Tibetan, occurring in all three divisions of the country. By what route it entered Tibet during the glaciation of the northern hemisphere is not yet clear; but probably from the north-east.

Since with the exception of the Indus, all the great rivers of Tibet, such as the Tsangpo, Salween, Mekong, Yangtze, and Hwang Ho flow eastwards and (except the Hwang

Ho) eventually southwards, the general slope of the plateau is necessarily from west to east. This slope, very gradual to begin with of course never approaches uniformity; but in general it is true that the highest regions of the plateau lie in the north-west, the lowest to the south-east. Further, south-eastern Tibet was since preglacial times at least moister than the west, and was therefore more heavily glaciated. It will now be fairly obvious why I stated at the beginning that the plateau has been degraded progressively from west to east, owing to the gradually increasing size of the rivers, to the increasing rainfall, and to the introduction of glacier ice as a denuding agent. The outer plateau and the river gorge region are only more highly modified portions of the same continuous plateau.

In the deep moist gorges of south-eastern Tibet, such as the gorges of the Tsangpo and Subansiri headwaters, occur many Lauraceae, Acanthaceae, Begoniaceae, Euphorbiaceae, Rubiaceae, Verbenaceae, Gesneriaceae, Orchidaceae, Melastomaceae, Bignoniaceae, etc., which have close Indo-Malayan affinities. The shelter afforded by the deep gorges, and the moisture ensured by the lowering snow peaks above, have enabled an almost sub-tropical flora to creep round the eastern end of the Himalayan range into Tibet.

One element of the new Tibetan flora however has reached the plateau from the west or south-west. Species found in the north-west Himalaya and in the desert regions of western peninsular India, reappear in the warm dry valleys of the outer plateau, north of the Himalaya. *Morina Coulteriana* (Dipsaceae), a plant of the Simla Hills occurs near Lhasa. In the valley of the Tsangpo is found a species of Pteropyrum (Polygonaceae), the only Indian species of which *P. Olivieri* occurs in Sind. In South-Western Tibet there is a species of Acantholimon, a typical Mediterranean genus. How this Mediterranean element reached Tibet can only be surmised at present. It may be a pre-glacial relic. If the North-West Himalaya were lower by several thousand feet in Pleiocene times, there may have been a direct route into Tibet. Or if, as Sir Sidney Burrard has suggested, the Tsangpo-Brahmaputra formerly flowed from east to west and crossed the Himalaya in the north-west, there may have been a route comparable to that of the Tsangpo gorge of to-day. It is not improbable that up to the late Pleistocene a more uniform climate and flora spread from N. W. Europe to the Himalaya. Whatever the route, there is a small but unmistakable Mediterranean element in the Tibetan flora to-day. Whether or not there is also an East African element is unknown; but it seems quite possible. The northern flora has already been referred to, and it may be added here, that it includes a number of British species, widely spread in the northern hemisphere, e.g., *Plantago major*, *Agrimonia Eupatoria*, *Potentilla anserina*, *Geranium Robertianum*, *Pinguicula alpina*, *Pyrola uniflora*, *Taraxacum dens-leonis*, *Hyoscyamus niger*, *Pedicularis sylvatica*, *Brunella vulgaris* and many more.

These various contributions to the flora have spread gradually over Tibet, so far as this was possible. Naturally, one does not find species of Indo-Malayan affinity on the interior plateau, nor high-alpines in the deep forested gorges. Nevertheless one does find, e.g., Gesneriaceae (Incarvillea spp.) and Bignoniaceae (*Amphicome arguta*), on the outer plateau; similarly one finds alpines on the high ranges which traverse the gorge region, descending indeed to remarkably low levels. The various diverse elements have fused and spread to establish a remarkably uniform flora. This helps to emphasize the solidarity of the flora, just as does the widespread occurrence of one or two species in almost every endemic genus which is not monotypic, e.g., *Nomocharis nana*, *Meconopsis horridula* * and species of *Cremanthodium*.

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*Endemic genus in Sino-Himalaya except for M. cambrica in W. Europe.

It was stated at the beginning that the vegetation of Tibet, i.e., the plant associations conform closely to the topographical divisions. The flora of the interior plateau comprises a single climax association, the Tundra Climax. It is a xerophytic perennial herbaceous association, distinct from the alpine association of the mountain ranges.

On the outer plateau occur several alpine climax formations, one of the commonest being :—

Scrub Climax with thickets of low thorny shrubs often (perhaps usually) gregarious, as *Sophora Moorcroftiana, Hippophäe rhamnoides, Rosa sericea, Caragana jubata* and *C. crassispina*, (occasionally *C. tibetica*) and Berberis sp. together with non-thorny shrubs such as Lonicera, Cotoneaster, Leptodermis, Wikstroemia, *Ceratostigma Griffithii*, etc., and a few woody climbing plants like Clematis. Another life form which is found chiefly in stony ground has a large woody underground rootstock, much longer than the part above ground, e.g., *Dicranostigma lactucoides* and *Ephedra Gerardiana*. Mixed with these woody plants are certain herbaceous perennials, e.g., Iris sp. *Dracocephalum tanguticum*, Allium, Sedum, etc.

In the valleys of big rivers like the Tsangpo there is a sand dune community (*Oxytropis sericopatala, Onosma Waddellii*) and along irrigation channels a bog-land community (*Primula tibetica* and *P. sikkimensis*, Iris sp., Pedicularis, etc.). There is no forest; but there are groves of trees in the villages and along the banks of streams. Often the streams are dry, though water occurs a short distance below the surface. The commonest trees here are *Hippophae rhamnoides* and *Buddleia tsetangensis, Populus alba, Salix amygdalina* and *S. opaca, Ulmus pumula* and *Juniperus recurva.*

Several climax associations may be distinguished in the river gorge region, including the following (*i*) Coniferous forest (*Abies Webbiana-Tsuga Brunoniana*), (*ii*) temperate broad leafed forest, and (*iii*) alpine; there may be other forest associations not yet distinguished.

The vegetation of Tibet has probably been less interfered with by man than that of any other region of equal size in the world. Nevertheless even here, and particularly in South-Eastern and Southern Tibet where most of the population is located, man has had a certain destructive and modifying influence. Pastures are grazed, and in places perhaps over-grazed, by enormous herds of cattle, sheep, ponies, goats and even donkeys; smaller areas are cultivated; and trees are cut down. But the comparatively limited forests as a whole have been less interfered with than the immense grazing plateaux. As a result of this, and of natural destructive agents such as rivers, landslips, avalanches, etc., climax vegetation is destroyed or put back, and seres are initiated. But no work of any sort has been done on *Succession* in Tibet, and scarcely any observations have been recorded. Here is an enormous field for research, but the subject is outside the scope of this paper. I have given a brief account of the elements which are combined to make up the flora of Tibet (a part of the Sino-Himalayan floral region) and whence they came; together with an outline of the climax associations into which those combined elements have sorted themselves. This is enough to serve as an introduction to a fascinating subject, the Botany of Tibet.

RHODODENDRON COUNTRY
NEAR TONGLU
With R. Arborium and R. Thomsonii

RHODODENDRON WIGHTII

(Commemorating Robert Wight, once Superintendent of Madras Botanic Garden)

RHODODENDRON CAMPANULATUM

In Sikkim

The Rhododendrons of India

by

J. M. COWAN,

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Some account of the Garden having been given it is no work of supererogation, in celebrating the one hundred and fiftieth anniversary of its foundation to discuss some of the plants which have adorned its history; and no more appropriate subject can be chosen than the Rhododendrons of India. The fascination of the Rhododendron seizes the mind; to me they form, as it were, a bond between different spheres of work and interest—the Forests of Bengal (recalling happy memories of Kalimpong, Sikkim and Tonglu), the Garden and Herbarium at Sibpur, and the Royal Botanic Garden, Edinburgh, where so many Himalayan Rhododendrons flourish in a climate not unlike their own. But the reason for my choice

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of subject is more than a personal one. The Royal Botanic Garden, Calcutta, has been concerned with Rhododendrons almost from the beginning of its story, and different species bear the names of many of the illustrious men who during the past century held office as Superintendent of the Garden. First among these is Doctor Nathaniel Wallich (1815-1846) who is commemorated by *Rh. Wallichii* Hook. f. of which Hooker wrote, "a handsome species worthy to bear the name of one who may justly be called 'Botanicorum Indicorum facile princeps'; then come Griffith and Falconer each with his own species; and later Dr. Thomas Thomson (1854-1860), to whom Hooker dedicated *Rh. Thomsonii* Hook. f. with the inscription "to this species I give the name of Dr. Thomas Thomson, surgeon H.E.T.C.S., late of the Thibetan Mission, son of the learned Professor of Chemistry of Glasgow University, my earliest friend and companion during my college life and now my valued travelling companion in the Eastern Himalaya"; and following the succession we come to *Rh. Kingianum* Watt MS., descript. Hook. f., "named for Dr. George King (since Sir), Superintendent of the Royal Botanic Garden, Calcutta"; and finally *Rh. Prainianum* Koorders, a New Guinea plant named in honour of Sir David Prain.

Besides these, many other Rhododendrons have been named after men and women who have devoted their lives to India. Governor-Generals and their wives, members of the Civil Service and Political officers, Forest officers, Medical and Army officers:

Rh. Aucklandii Hook. f., in honour of Lord Auckland, Governor-General of India from 1835 to 1841; *Rh. Dalhousiae* Hook. f., for Lady Dalhousie whose name is familiar in India; and other species chosen by Hooker to commemorate men whose names are well-known to botanists all over the world—Robert Wight, M.D. (1796-1872), Superintendent of Madras Botanic Garden; John Royle (1799-1858) of the Medical Service, Bengal; Michael P. Edgeworth (1812-1821) of the Bengal Civil Service and Commissioner of Mooltan; Lieutenant-Colonel Edward Madden, also of the Bengal Civil Service and Mr. B. H. Hodgson at one time the East India Company's resident in Nepal.

Sir George Watt who collected many Rhododendrons in Assam dedicated new species which he discovered to his friends; to Mr. Elliott (afterwards Sir Charles), Chief Commissioner of Assam and Lieutenant-Governor of Bengal; to McCabe, Deputy Commissioner of Manipur, who had a romantic career; and to Mrs. Johnstone, wife of the Political Agent of Manipur in 1882.

Sir Henry Collett (1836-1901), at one time Colonel in the Bengal Army and author of "Flora Simlensis", discovered in Afghanistan the rhododendron which bears his name, and lastly Lieutenant-Colonel Bailey recently resident in Nepal who in the course of his journey in 1913 when investigating the course of the Tsangpo river gathered several species of Rhododendron, gave his mame to one, *Rh. Baileyi* Balff. f., as also did his companion on that journey, the late Major H. T. Morshead of Mount Everest fame.

The genus Rhododendron was founded by Linnaeus in his Species Plantarum (1753) and in 1796 the first rhododendron known to be in India, *Rh. arboreum* **sm.**, was discovered on the Siwaliks by Captain Hardwicke in the course of a journey to Srinagar. Both Hamilton and Wallich found it again in Nepal at the beginning of the nineteenth century, and Wallich, convinced that it would grow in Britain, sent seed. A little later the editor of the Botanical Magazine (1834) wrote: "We regret to find that experience does not confirm the expectations of our learned friend; for all the Indian Rhododendrons appear to be incapable of enduring the climate of Britain." But Wallich has been proved abundantly to be right, for nearly all the known Indian Rhododendrons are now in cultivation in Britain and except for a few (mostly in the Maddenii Series) they can all be grown out of doors. Concerning even *Rh. arboreum* sm. Wallich was right, and it may be of interest to add that amongst the archives of the Edinburgh Garden I came across a letter from a correspondent, written about 1820, asking for a few seedlings raised from Wallich's seed, and a reply to say that six young plants had been sent. There stands a tree in the Rhododendron House in the Garden today which may well be one of these original plants. No one knows its age, all that can be said is that 50 or 60 years ago it was apparently no smaller than it is now. Wallich in his Catalogue records a number of other species from Nepal—*Rh. anthopogon* D. Don, *Rh. barbatum* Wall., *Rh. campanulatum* D. Don and *Rh. lepidotum* Wall.

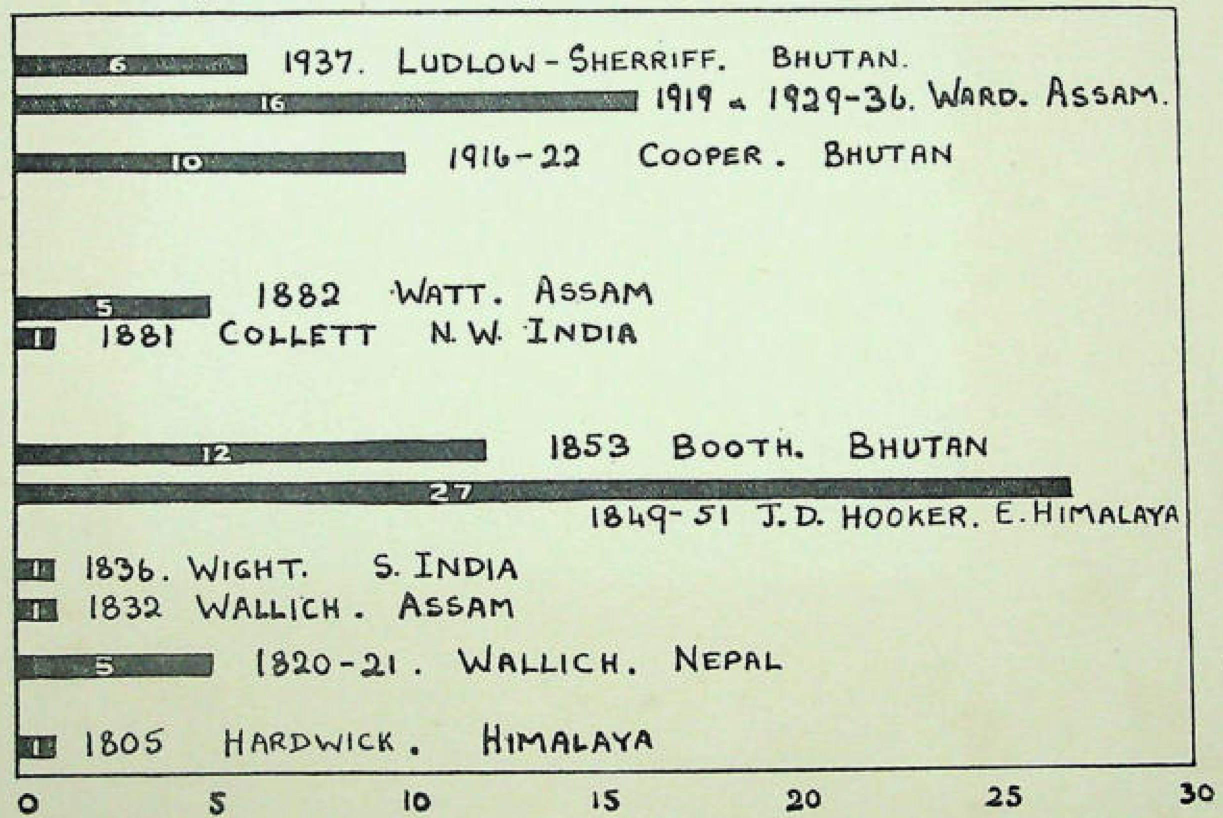
[Next (1838), Griffith in Bhutan discovered *Rh. grande* and *Rh. Griffithianum* which were later described and figured in Wight's Icones, and meanwhile *Rh. nilagiricum* Zenk., the only Rhododendron in Southern India, had been described in 1836. Like *Rh. arboreum* sm. it has usually scarlet or blood-red flowers, unless, as Mr. C. E. C. Fischer told me, the plants were attacked by a fungus, when the flowers are often pink. In spite of the fact that Hooker said that *Rh. nilagiricum* Zenk. is "a species assuredly quite, and permanently distinct from *Rh. arboreum*" for long it was confounded not only with true *Rh. arboreum* but also with *Rh. zeylanicum* Booth descript. Cowan of Ceylon; but there is no doubt that Hooker's view is the correct one (*see* Notes R. B. G. Edin. vol. XIX (1936) 162].

The whole Himalayan chain from Kashmir to Assam is of course the part of India in which Rhododendrons abound, especially the Eastern Himalayas and the accession of new species to the list of Indian Rhododendrons is summarised in the diagram given below which shows, from 1805 to the present time, the progress of our knowledge. This it will be observed by following the heavy line from left to right has risen, not by slow and even tread but by erratic leaps and bounds, as from time to time collectors and botanists explored new territories.

No one has done more than Sir J. D. Hooker, the famous botanist, later Director of Kew, who travelled in the Darjeeling district and in Sikkim from about 1847-1851 and first revealed the great wealth of the Rhododendron flora of this region. The entrancing record of his journeys is to be found in the well-known " Himalayan Journals " and for descriptions of the Rhododendrons which he discovered we turn to his beautifully illustrated book " The Rhododendrons of Sikkim Himalaya " (1849). In the introduction to this large volume—at the time of its publication the most comprehensive one on the genus and still a classic—the editor, Sir W. J. Hooker, says " perhaps with the exception of the Rose, the Queen of flowers, no plants have excited a more lively interest throughout Europe than the several species of the genus Rhododendron, whether the fine evergreen foliage be considered or the beauty and profusion of the blossoms. " In this work which contains thirty-one magnificent plates, we find, besides species already mentioned and others, *Rh. aeruginosum, Rh. argenteum, Rh. camelliaeflorum, Rh. campylocarpum, Rh. ciliatum, Rh. cinnabarinum, Rh. elaeagnoides, R. fulgens, Rh. glaucum, Rh. lanatum, Rh. nivale,*

Indian Rhododendrons

Progress of their Discovery—Total to date of known species 85



Rh. pendulum, Rh. pumilum, Rh. setosum and Rh. triflorum. " The author in a very limited sojourn in Sikkim and with little means of prosecuting extensive researches yet collected and described eleven species of which nine were new. " But this was only a beginning. Sir. J. D. Hooker collected altogether some forty-three species and he sent seed of many of them to Britain, and plants raised from his seed still grace the gardens of Lochinch in Wigetownshire, Stonefield in Argyll and Penjerrick in Cornwall, among others, while their progeny and hybrids adorn a wider sphere. The profusion of blossom which some of these Rhododendrons provide will surprise even those who know them in their Himalayan home. In a fascinating work on " Flowers " Sir Herbert Maxwell wrote, " It is recorded of him (Sir Joseph Hooker) that, when he revisited the Cornish *riviera* many years after the planting which he had recommended to be done, he exclaimed—' why, rhododendrons flourish better here than in Sikkim.' "

Soon after Hooker had explored Sikkim, Booth visited Bhutan (1853) and added ten more new species including the magnificent *Rh. Nuttallii*, which Sir Wm. Hooker designated the "Prince of Rhododendrons," and others described by Nuttall *Rh. Hookeri*, *Rh. Kendrickii*, *Rh. Shepherdii*, *Rh. Windsori*, *Rh. lucidum*, *Rh. calophyllum*, *Rh. eximeum*, *Rh. Keysii* and *Rh. Boothii*.

For the next thirty years scarcely another species was added, until about 1882 when Sir George Watt, touring in Assam, collected and named *Rh. manipurense* and three other species to which reference has already been made. Unfortunately the name *Rh. Kingianum* Watt M. S. can no longer stand [*see* Notes R. B. G. Edin. Vol. xix (1936) 157], but I have called the plant which should have borne King's name, *Rh. Wattii*.

Now follows another barren period as far as new species are concerned, but the interest in the genus was maintained through the Lloyd Garden, Darjeeling, and gardens in Britain—public and private alike—have gained inestimably from a steady annual supply of seed, gathered mostly by the two well-known Lepcha collectors Ribu and Rhomo, and forwarded through Calcutta. Nor should I omit to mention the name of Mr. G. E. Cave, for many years the energetic curator in Lloyd Botanic Garden, Darjeeling, and of Sir William Wright Smith with whom he toured in Sikkim.

But it was not until 1914 that there was again a considerable influx of new species, when R. E. Cooper, collecting for Mr. Bulley in Bhutan, had the good fortune to discover *Rh. rhabdotum*, one of the most handsome and curious of Rhododendrons, with very large, cream coloured, funnelshaped flowers, marked lengthwise with broad bands of purple. This species and his others, *Rh. argipeplum*, *Rh. brachysiphon*, *Rh. polyandrum* and *Rh. Cooperi*, *Rh. papillatum*, *Rh. epapillatum*, *Rh. haemonium* and *Rh. thyodocum* were named and described at Edinburgh by the late Sir Isaac Bailey Balfour who by his unrivalled knowledge of the genus and enthusiasm displayed in his writings has raised for himself an enduring memorial.

Then in more recent times from 1919 onwards came Kingdon Ward's journeys in Assam, productive of some fourteen new species of which the more important are *Rh. cerasinum*—"Coals of Fire" or "Cherry Brandy," *Rh. crebreflorum* with small dark flowers, *Rh. deleiense*, *Rh. lanigerum*, *Rh. notatum*, *Rh. pemakoense*, *Rh. Ramsdenianum* and *Rh. riparium*. A point of special interest arising from Ward's exploration is the cropping up in this territory of species collected at earlier dates by himself and by Forrest in Burma and in Western China, thus bridging the gap in our knowledge of distribution and binding closer the ties between the Rhododendrons of India and those of Tibet and China.

Last of all we must record the work of Ludlow and Sherriff now in the field. The four expeditions in 1933, 1934, 1936 and 1937 have yielded six new species from within the confine of Bhutan. *Rh. tsariense*, *Rh. igneum*, *Rh. dignabile*, *Rh. amandum*, *Rh. miniatum* and *Rh. Ludlowi*. Their work continues and may it prosper; collections made in 1938 have still to be examined.

Thus there are some eighty-six species of Rhododendron in India, of which most but not all have been mentioned; and there is no fairer country in the world than the slopes of the Himalaya where forests of Rhododendron abound. "I held my breath in awe and admiration. Six or seven successive ranges of forest-clad mountains, as high as that whereon I stood"—wrote Sir Joseph Hooker from Darjeeling—"intervened between me and a dazzling white pile of snow-clad mountains, among which the giant peak of Kinchinjunga rose 20,000 feet above the lofty point from which I gazed! Owing to the clearness of the atmosphere, the snow appeared, to my fancy, but a few miles off, and the loftiest mountain at only a day's journey. The heavenward outline was projected against a pale blue sky. Such is the region of the Indian Rhododendrons. It may not be my lot again to live amongst them but from afar in quiet contemplation, 'I will lift up mine eyes unto the hills.'"

RHODODENDRON
CINNABARINUM HOOK

In its profusion of blossom

RHODODENDRON NUTTALLI

"Prince of Rhododendrons"

RHODODENDRON CAMPYLOCARPUM

In the Royal Botanic Garden, Edinburgh

The Terrestrial Vegetative Buds of Dioscorea Alata *Linn.*

by

I. H. BURKILL,

Late Director of Gardens, Straits Settlements, previously officiating Reporter of Economic Products to the Government of India and Superintendent of the Indian Museum, Industrial Section, Calcutta, Botanical Survey of India

The section of the genus Dioscorea to which *D. alata* belongs has received the name " Enantiophyllum ", *i.e.*, the opposite-leaved one. The name is descriptive of such parts of the appropriate species as are commonly preserved in herbaria, but it is not as appropriate as a name ought to be, because the parts of the species of Enantiophyllum which herbarium collectors neglect commonly present alternate leaves. Thus is one of the limitations of herbarium-study exposed. In these pages I deal with the base of the stem of the species named where alternation of leaves is the rule. What I have to put on record makes part of a series of studies on which I am engaged as material comes to hand ; and here I have to tender my best thanks to Dr. K. Biswas for sending to me bulbils in liberal quantities, wherefrom I was able to obtain the buds I required.

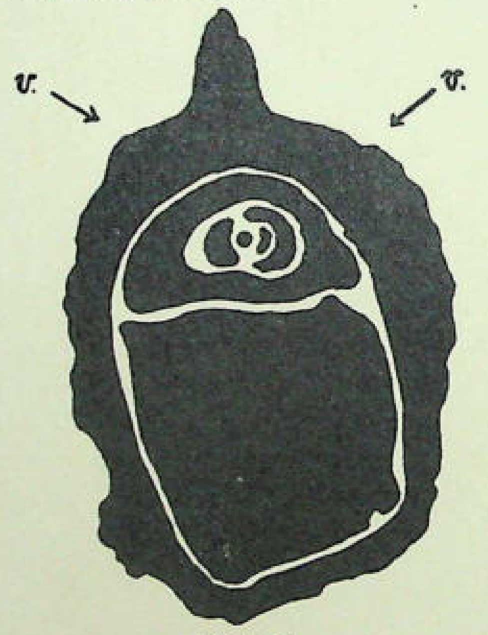


FIGURE 1.
A transverse section through the bud just above the base of the calyptriform scale, showing the axis and the secondary bud in the axil of the scale, v.-v. the lateral vascular bundles, x 30.

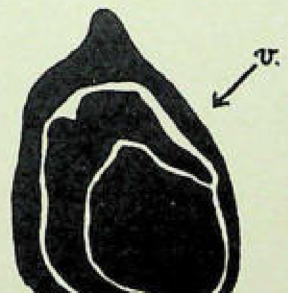


FIGURE 2.
A transverse section at a higher level than in figure 1, showing the origin of leaf No. 2, x 30.

When a bulbil is encouraged to germinate by a sufficiently high temperature and appropriate moisture, buds form under its corky coat and in time extrude through the coat as small rounded white objects. They elongate, become bluntly pointed and show themselves very sensitive to gravity by turning the point upwards. If at this stage transverse sections be cut through the object, the lower part will be found solid, and the upper part

1. The phyllotaxy of *Dioscorea glauca* Muhl. Journ. Bot. 1936, p. 89.
2. The phyllotaxy of *Tamus communis* Linn. Journ. Bot. 1936, p. 153.
3. The life cycle of *Tamus communis* L. Journ. Bot. 1937, p. 42.
4. The development of the tuber of *Dioscorea sansibarensis* Pax. Blumea, suppl. no. 1, 1937, p. 232.
5. The growth and tension between the nerves in the leaf blade of *Tamus communis* Linn. Journ. Bot. 1939, p. 325.

will be found to be an organized stem. Figures 1 and 2× show such× transverse sections cut at different levels, the first just above the solid part, the second about midway between the solid part and the tip. Both figures show that the outermost organ of the bud encloses a chamber wherein are all the other organs, *e.g.*, in figure 1 a stem and a secondary bud. In figure 2 the secondary bud is not seen, for the section is on a level above its tip ; but the stem is seen at the place where a leaf arises on it. The outermost organ of both figures is the first foliar organ of the bud. It appears as an emergence in the usual way of foliar emergencies but spreads round the whole axis, acquiring the broadest possible base ; and after that it grows upwards forming a sleeve or rather a case shaped like a candle-extinguisher, with a lateral opening by the top so small that it is very difficult to detect. On one side it is ridged and on that side is in general rather thicker than on the opposite side. The ridge and the greater thickness give more rigidity to this side than to the opposite side and when the elongating stem within pushes against the tip a curvature results : the calyptriform organ has then its tip pointing back slightly over the ridge. The chamber it encloses is an incubation chamber for the rest of the bud.

This chamber-forming leaf-scale—the calyptriform scale—may have three, two, one or no vascular bundles. Its largest and most constant bundle runs under the ridge and is unmistakably the midrib of the scale. The position of the other two is marked in figures 1 and 2 (*v*) : one of them extended further than the other and passed towards the side of the calyptriform scale.

Goebel on one occasion was at some trouble to show that the absence of a vascular bundle does not prove an organ to be a mere emergence. This was by a study of the bracts in the inflorescence of *Utricularia*. So in Dioscorea also, when the calyptriform scale is not vasculated, it nevertheless is still a foliar organ.

The tissues of the calyptriform scale are parenchymatous and entirely without intercellular spaces ; and there are no stomata in the epidermis. There are no hairs on it ; but club-shaped 2-6-celled hairs are plentiful on the stems within it. Scattered cells in the tissue are filled with mucilage. Raphides may be sparingly present.

In figure 1 the sub-quadrangular structure seen within the calyptriform scale is the axis which bore the scale : but it is a bud in the axil of the scale. The axis of this secondary bud begins its organization by forming a calyptriform scale, and has produced, as shown, its second, third and fourth leaves : its apex is seen between them. The section which served for the figure showed the secondary calyptriform scale to have two vascular bundles, one under each of the ridges. That on the left was clearly the midrib, because (*i*) by examining the sections below a minute bud was found within it, and (*ii*) by examining the sections above the opening into the chamber was found to be on the opposite side : moreover it was slightly larger than the other.

Where the wall was broken the free leaf-margins overlapped, maintaining the chamber closed.

The attractive mathematical precision of the rules of phyllotaxy is for theory only. But measurements of angles are useful for descriptive purposes and so I would point out that the divergence of the second calyptriform scale from the first is (as seen at this stage) rather over 90° or $\frac{1}{4}$. I shall show later that deformations due to growth may increase it. At its initiation the tertiary bud arises laterally on the secondary bud in one of the two positions where the pressure of the primary calyptriform scale on the primary axis is least : and it is more than probable that the secondary axis takes up its rhythm of emergence-production at this point as being the most nearly a void.

The tertiary axis will repeat the behaviour of the secondary, and so on. It will produce as its first foliar organ a calyptriform scale making an incubation chamber for the organs which follow.

I have used buds on bulbils for my work but buds on tubers give the same results. There is a reserve bud with its incubation chamber at the base of each aerial vine. In *Dioscorea glauca* there are numerous buds in reserve, as I have pointed out: but *D. alata* makes no further provision than one at a time. If the stem be destroyed, that one takes its place and in doing so lays down a reserve bud against mishap. Obviously there is in the process hormonic control with a time-lag. The control becomes tightened as the first internode of the stem elongates, *i.e.*, at the stage in which the bud supplying figures 1 and 2 was cut. The reserve bud grows to that point, and then is arrested.

The accommodation in the incubation chamber is brought about by the elongation of a single internode whereby the leaves of the main axis are carried above the secondary bud. They, with the hairs among them (these hairs have not been inserted in the figures), fill the upper part of the chamber of the calyptriform scale. In figure 4 I have drawn the leaves at the point where the greatest number are cut, which is where the tenth or last of those present is in process of parting from the axis. The calyptriform scale being the first, they are numbered 2 to 10. The angles of the successive divergencies are more or less 38°, 165°, 150°, 130°, 122°, 150°, 150° and 125° or a theoretical divergence of $\frac{3}{8}$ departed from in varying degree.

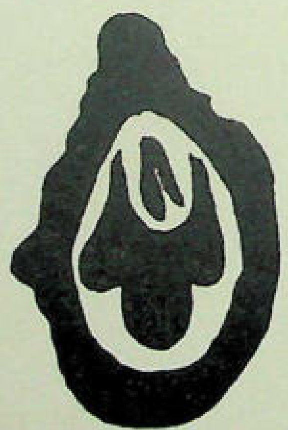


FIGURE 3.
A transverse section of a bud in which a weak axis had produced but two foliar organs after the calyptriform scale, x 30.

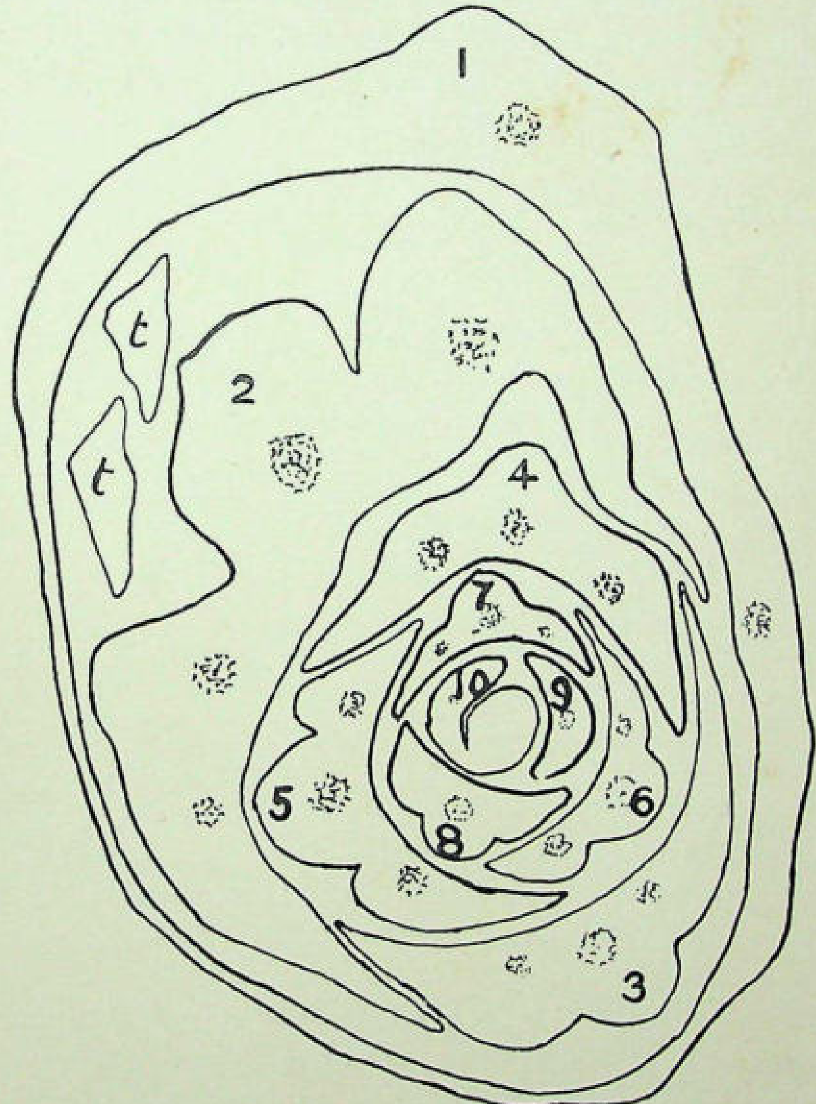


FIGURE 4.
A transverse section at a still higher level than in figure 2, showing all the leaves produced by the axis: leaf No. 2 impinges on the top of the chamber and is crumpled,-t-t., x 200.

I have given figure 3 here to show that for this divergence a divergence of $\frac{1}{2}$ may be substituted in a weaker bud, as indeed a divergence of $\frac{1}{2}$ occurs in the secondary bud of figure 1, and I must add that undoubtedly there is much variation in leaf-arrangement in the basal part of the stem, where six ridges are usual instead of the four wings of the stem higher up. Buchanan-Hamilton's *D. octangularis* seems to have been founded on a departure in leaf-arrangement from what is usual at the base of the stem.

Lateral axes in other members of the family Dioscoreaceae start the rhythm of emergence-production by an organ at about 90° from the scale subtending it and continue with an organ on the opposite side, *i.e.*, in the only other position which approaches being a void, and from that gradually reduce the angle from something near 180°. *Tamus communis,* for instance, does this.

One of the minor differences between Monocotyledons and Dicotyledons is that the leaf-base is usually broader in the former than in the latter. Within *D. alata* it passes from one condition to the other, for the calyptriform scale, as already stated, has a base which extends all round the axis : leaf No. 2, as shown in figure 2, has a base which extends round almost three-quarters of the axis : but above as figure 3 shows, the leaf-bases are narrower.

In those parts of the quadrangular stem of *D. alata* where it carries its large paired leaves there are 16 vascular bundles, eight being cauline and eight common, alternating ; of these four of the common bundles are under the four corners and four halfway between. Whereas in *Tamus communis* one can connect a ridge on the stem with the passing of a common bundle into the first leaf which blocks the way, the same is not true of the base of the stem of *D. alata.* An examination of serial sections, from that drawn as figure I upwards, shows that although there is a common bundle under each of the four angles of the main axis, the angles do not pass, as they do in the part of the stem above, on to the back of the leaf but the base of leaf No. 2 is so broad that whereas the upper left-hand angle actually extends on to the back of the midst of that leaf, the upper right-hand angle and the lower left-hand angle sink into a part of the surface which is cut off as part of the leaf. It is not obvious why the axis here is quadrangular. Then one comments—how could leaf No. 3 be opposite to leaf No. 2, when No. 2 has so large a base ? And continues—Decussate foliage is impossible where leaf-bases are typically Monocotyledonous, *i.e.*, broad ; and that is why decussation is rare in Monocotyledons, the Dioscoreas which have it providing conspicuous exceptions. It is apparent that where, as in the plant under consideration, the arrangement of the leaves passes from alternate to decussate conditions deserving study occur.

Vascular bundles are servants to the tissues they thread : they are formed in obedience to demand and the vascular cylinder of the stem where the leaves are alternate is unlike that where they are opposite. Towards the base of the stem instead of sixteen bundles (eight cauline and eight common), we find twelve (six cauline and six common) or ten (five cauline and five common) ; and we find transitions. The axis is usually of smaller diameter near the base than above. And indeed, the rule in Dioscorea is that an axis not yet at full vigour produces a thinner length of stem, with alternation of leaves and vascular bundles proportionately reduced in number. It happens very rarely, and entirely as an abnormality, that alternation of leaves is continued up an axis even to the top. An individual plant of a race from British Guiana which I had in my garden for a short time, produced several such stems. Combined with alternate leaves they had cylinders of 10-14 vascular bundles, in no internodes increased to 16, but varying much. The wings of the stem were in some internodes three and in other internodes five ; but never four. Since invaribly a foliar organ of a Dioscorea receives no more than three common bundles, even if with as broad a base as the calyptriform scale, the number of common bundles in the vascular cylinder depends on the number of leaf-bases nearby to call them out and not on the actual breadth of those leaf-bases. But the breadth of those leaf-bases in relation to the circumference of the growing apex of the axis determines the divergence of the foliar organs and so determines the number of common bundles. Thus it is that the dimensions of the growing point indirectly determine the number of vascular bundles in the cylinder. And since the growing point of the stem of *D. alata* increases in circumference for a short distance above the base there comes a dimension when it is possible for a pair of rhythms of emergence formation to move forward side by side: then decussation supervenes and sixteen vascular bundles are called forth.

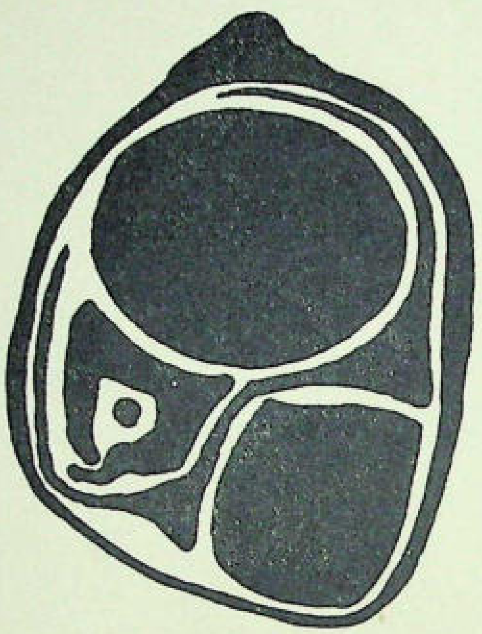


FIGURE 5.
A bud in transverse section, in which the main axis had been decapitated, showing the distortion due to the growth of the secondary axis, x 30.

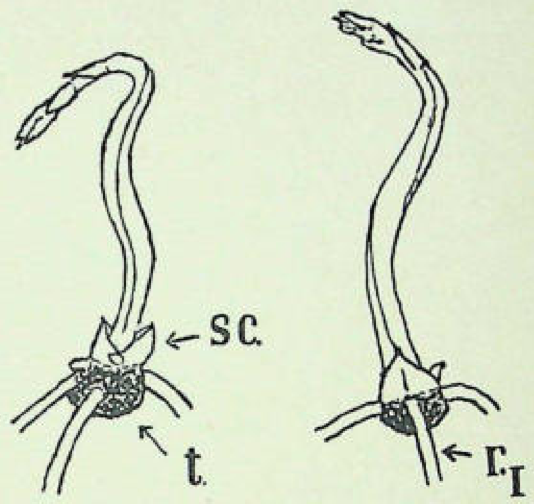


FIGURE 6.
DIOSCOREA ALATA.
The formation of new plants. At the base of the stem the calyptrate scale *(sc.)*, split in the figure on the left; below the scale, the new tuber (t): from the tuber and under the calyptrate scale the first root (r_1). Two roots follow arising simultaneously. The fourth and sixth roots, also, are seen in the figure on the left, x ½.

Taking advantage of the ready way in which lost parts of a bud are replaced, I have experimented with many bulbils, allowing germination to proceed until I could see and remove the first axis; then allowing the bed to thurst out the second, which was removed in turn; the third and even the fourth after that. By this means I can call into evidence several axes and their calyptriform scales and produce on the top of the forming tuber a crowd of densely packed organs pushed against each other. Figure 5 is from one experiment. In it the main axis was cut but the second was allowed to grow until it had unfolded in the air seven foliar organs. By this time its own first bud had been pushed out of position and to the side of the stump of the main axis. If the secondary axis had been cut at this stage, the tertiary axis, as weaker than the well-established second axis, could only have found room for itself laterally. From other experimental beheadings done when the secondary axis was small and weak I have reason to believe that the main and the secondary axes may be forced apart. But the exact course of growth is made difficult to foresee for slight differences in induration make great differences in the direction of yielding. I would stress the point that the top of the young tuber is very plastic and very liable to be deformed in growth. Indeed I observe that the top of a tuber may grow and engulf considerable parts of the bases of the stems it bears.

Summary

The first foliar organ on a stem of *Dioscorea alata* is a calyptriform scale-leaf which makes an incubation chamber for the rest of the axis.

The organs push each other out of position and shape within this chamber and may be made to continue to do so even more by decapitating the axes as they free themselves.

The foliar organs are arranged in an irregular spiral manner on the lower part of the stem, but the divergence varies from axis to axis and on different parts of the same axis.

The vascular bundles in the axis are as the foliar emergencies variable in distribution, and according to the need.

Pressure produces two-keeled scale-leaves; and one of the keels is to be recognized as the midrib.

The features of a narrow leaf-base and of decussate foliage, which characterize the mature stem of *D. alata* but are more developed in Dicotyledons than in Monocotyledons, come into existence upwards on the stem being absent from the very base.

Larix Griffithii or Larix Griffithiana?

by

WILLIAM T. STEARN

(Lindley Library, Royal Horticultural Society, Westminster, England.)

About 150 Indian species of plants bear the name of *William Griffith* (1810-1845), who from 1842 to 1844 acted as Superintendent of the Calcutta Botanic Garden, and it is fitting that they do, for no one could have devoted himself more whole-heartedly to the botanical exploration of India than this keen observer and diligent collector did during his tragically brief career.[1] Among his discoveries in 1838 was the Himalayan larch later named in his honour *Larix Griffithii* Hook. f. et Thomson and *Larix Griffithiana* Carrière. Both names were first validly published in 1855. Both have been adopted in works of authority. To decide which has prior publication it is necessary to ascertain as exactly as possible the dates of publication of Elie Abel Carrière's *Traité géneral des Coniféres* (8vo, Paris) and Sir Joseph Dalton Hooker's *Illustrations of Himalayan Plants* (folio, London).

The introduction (p. xv) to Carrière's *Traité* is dated "12 mai 1855." The Lindley Library possesses a copy received by John Lindley, editor of the *Gardeners' Chronicle* (London), from Carrière on 25 June 1855. With it is a letter from Carrière dated "8 Juin 1855" in which he says: "J'ai l'honneur de vous informer que je mets aujourdhui à la librairie Dusacq pour vous être envoyé un exemplaire du Traité des Conifères que je viens de publier. Daignez, je vous prie, d'accepter." It was offered for sale in the Paris book-trade Journal *Bibliographie de la France* **44.** 421, on 16 June 1855; the previous number of the *Bibliographie* appeared on 9 June 1855 and probably went to press a day or two before that. Carrière presented a copy of his work to the Société Impériale et Centrale d'Horticulture at Paris on 21 June 1855 (*cf. Journ. Soc. Imp. Hort. Paris* **1.** 272: 1855). Lindley's review appeared in the *Gardeners' Chronicle* **1855.** 455, on 7 July 1855. From this it is clear that Carrière's *Traité* was published in June 1855.

The dedication of Hooker's *Illustrations* is dated "June 30, 1855." A review in the *Gardeners' Chronicle* **1855** 515, on 4 August 1855, describes it as having "just appeared," evidently in late July. The *Revue Horticole* (4) **4** 324 reviewed it on 1 September 1855.

Since Carrière's *Traité* had been offered for sale in Paris and had reached England while Hooker's *Illustrations* was still in the printer's hands, *Larix Griffithiana* Carrière has clear priority over *L. Griffithii* Hook. f. et Thomson. Its synonymy is as follows :—

[1]Griffith (at one time Gruffydd or Gruffud) is a Welsh surname, but *William Griffith*, though possibly of Welsh parentage, his father being a London merchant, was born at Ham Common, near Richmond, Surrey, England on 4th March 1810. His father and mother died while he was a boy, which may have contributed to his enterprise and independence of character, but wise guardians saw to his education. He studied under Lindley at University College, London, and then went out to India as Assistant-Surgeon to the Madras Establishment of the East India Company, arriving at Madras in September 1832. In the next few years he went on botanical missions to Assam, Burma, Bhutan and Afghanistan, penetrating alone into troubled country never visited by a European before and collecting observations and specimens which he hoped to use later in the preparation of a vast flora of India. Fever contracted in both Burma and Afghanistan, the hardships of these journeys and continual overwork undermined even his strong constitution and he died at the age of thirty-five with his project unrealised. In 1841 he was appointed as Civil Assistant-Surgeon at Malacca, Straits Settlements. Wallich left Calcutta in 1842 to recuperate at the Cape and did not return until 1844. His place as Superintendent of the Botanic Garden and Botanical Professor at the Medical College was taken by Griffith. After Wallich's return, Griffith went back to Malacca, arriving there in December 1844. His death on 9th February 1845 was a public calamity. He had already published 22 scientific papers, but such was his industry that there remained unpublished manuscripts which when printed later by order of the Government of Bengal occupied over of 2,760 octavo pages and sketches which occupied over 660 plates. These were published as his *Posthumous Papers* under the editorship of John McClelland:—*Notulae ad Plantas of Asiaticas* part **1** (1847), **2** (1849), **3** (1851) but not received by Lindley in London till 7 August 1852, **4** (1854); *Journal of Travels*(1847) ; *Itinerary Notes* (1848); *Icones Plantarum Asiaticarum*, part **1** (1847), **2** (1849), **3** (1851), **4** (1854).

W. H. Land gives an interesting appreciation of his contribution to botany as a morphologist in F.W. Oliver, *Makers of British Botany*, 178-191 (1913); for an obituary, *see Proc. Linn. Soc.* **1.** 239-244 (1845).

Larix Griffithiana Carriere

Laris sp., Griffith, Itinerary Notes, 189 n. 1010 (1848).

Abies Griffithiana Hook. f. ex Lindley et Gordon in Journ. Hort. Soc. London **5.** 214 (1850), *nomen subnudum.*[2]

Larix Griffithii Hook. f., Himal. Journ. **2.** 44 (1854), *nomen nudum.*

Larix Griffithiana Hort. ex Carr., Traité gén. Conif. 278 (June 1855); Gordon, Pinetum, 126 (1858); Ostenfeld et Larsen, Species of the Genus Larix (Kgl. Danske Videnskab. Selskab, Biol. Meddel. IX. **2**) 8-14 (1930).

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The Gregarious Habit in North Indian Trees and Shrubs

by

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Conception.—The phenomenon to be considered in this paper is not that of geographical distribution nor yet that of absolute frequency of occurrence, but is that of relative frequency in any small part of the natural range of a species. A species may be very widely distributed but nowhere make more than a small contribution to the total vegetation so that its removal would make no difference to the general aspect, *e.g.*, *Mitragyne parviflora* from the deciduous forests of the Indo-Gangetic tract. On the other hand, a species may have a restricted range, or occur only in a few localities, and yet where it does occur may be prevalent enough to be an influential constituent of the plant community which would be fundamentally altered by its removal; *Quercus lanugenosa* provides a good example of this type of occurrence. When a species occurs in such quantity in the plant community under consideration, it is said to be gregarious. No more precise definition is at present possible, and it remains a matter of opinion as to which, if any, among the 8 or 10 species predominating intimately commingled in our very characteristic deciduous monsoon forest should be termed gregarious.

Previous literature.—It is necessary to preface any discussion of this subject by noting that in a general way, the gregarious habit is much more conspicuous and prevalent in the simpler vegetation of temperate climates than in the more complex and varied vegetation of the tropics and subtropics. In the former (including Europe and North America which form the background of most writers to date) a wood is nearly always an oak wood, a pine wood, etc., *i.e.*, one with a gregarious dominant species, whilst in tropical India, we usually have to say a " deciduous forest ", " thorn forest ", or " rain forest," and when we do say a " teak forest " we only mean a forest which contains some proportion, perhaps quite small, of that economically important species.

E. Warming (1) towards the end of his classical work on the Ecology of plants devotes a short chapter (CXCVIII) to " The weapons of species " in which, among other points concerned with the computation between species for occupation of a site, he makes brief reference to conditions which may determine the extent to which a single species may come to predominate a plant community. In a general way, he considered that the prevalence of a species to the exclusion of other competitors depended on the simultaneous occurrence of the maximum number of site factors favourable to it. He noted, however, that instances are not uncommon where the individuals of a species grow better in mixed communities than in those in which they strongly predominate, *e.g.*, older trees are better developed on a moist rich loam where thay occur singly among other trees, than in a tropical pure older wood on a swampy site. This is actually an example of another generalisation, for the majority of species which are prevalent on poor sites, are capable of better growth on better sites from which they are normally excluded by other species which cannot or can hardly exist or spread on the poorer site. Warming also mentions the influence of burning on species proportions, favouring the fire-hardy (pine) against the fire-tender (spruce).

Schimper (2) in his classical work does not specifically discuss the subject of gregarious habit, though naturally making many reference to types of vegetation with a single dominant.

Clements (3) (4) (5) and his co-workers similarly do not, as far as I am aware, deal with it separately, though it inevitably comes up time and again in connection with the classification of vegetation and the various aspects of plant competition. The phenomenon of "aggregation" as the antithesis of migration is described, and the definition of a consociation, the major subdivision of an association, is a "community characterised by a single dominant species," societies being similar dominated communities within the association or consociation, and clans and colonies being similar but smaller and less influential units. In England, Tansley (6) and other writers also similarly deal with the matter incidentally rather than specifically.

Braun Blanquet (7) in his "Plant Sociology" devotes a short section to "Sociability, gregariousness and dispersion" and suggests a scale for recording it, though this appears to be more applicable to the lower layers of an association. This scale is as follows :—

(1) Occurring singly.
(2) Grouped or tufted.
(3) In patches or cushions.
(4) Small colonies to extensive patches.
(5) Populations (pure).

He points out that the degree of sociability is rarely determined by growth habit, but is much influenced by the habitat and factors of competition between species, so that one can deduce from it how near locality conditions are to the optimum for a given species, whilst the stage reached in a succession may be marked by the degree attained.

The value of gregarious habit in competition with other species has been noted on by various writers. It has also been pointed out that pioneer species tend to be highly sociable and that factors which enable such species to become established on a site before competitors arrive, are of great survival value ; thus Clements (5) quotes the case of lodge pole pine which seeds abundantly at an early age and is thus able to occupy a much larger area than it otherwise could on sites where other species would displace them but for frequent fires which kill out regrowth of competitors before they have begun seed production.

Writers on forestry also frequently refer to gregarious occurrence of forest trees, much controversy having waged round the relative merits and demerits of pure crops (exclusive gregariousness) and mixed crops as an aim in systematic forest management.

Only Heinrich Mayr (8) and after him Rubner (9), consider the matter at all from the general viewpoint. Points brought out are (1) the greater prevalence of pure crops in cooler localities, (2) the tendency of all trees to form pure crops at the optimum portion of their natural range, and to occur more dispersed the further conditions are from the optimum, (3) the greater prevalence of pure crops on the poorer soils or soils with some pronounced physical or chemical factor, (4) the tendency of shade-tolerant species as compared with light demanders to form pure crops, especially if heavy seeded, and (5) the greater tendency of heavy-seeded than light-seeded light-demanding species to form pure crops, the latter if occurring gregariously coming under (3) above.

Examples of gregariousness in N. India.—In the tropical and sub-tropical plains areas, *Shorea robusta* (*sal*) provides the really outstanding example of markedly gregarious habit. It is relatively uncommon to find it occurring as single tree ; if it occurs at all, it predominates and may form 80 or 90 per cent. of the top canopy over extensive areas. *Anogeissus latifolia* is another gregarious species characteristic of drier localities than the *Shorea*, *e.g.*, the hill slopes on the Siwalik formation. Sites presenting pronounced soil characteristics in the *sal* tract frequently carry nearly pure crops of other species which otherwise only occur sparsely ; thus dry stiff clay will carry *Aegle*, damp clayey loam, *Terminalia tomentosa*, wet clayey soil *Eugenia Jambolana* and so on. Examples of gregarious poineer species are the well-known *Acacia catechu* and *Dalbergia sissoo,* sometimes followed in the primary succession by *Holoptelea integrifolia* almost equally gregariously.

Gregariousness to a lesser degree is met with in many other species, and is frequently ascribable to the existence of exceptionally suitable sites, to the limited spread by regeneration, vegetative or by seed, from one or two mother trees, or most usually to the action of influences preventing the natural development of the vegetation such as burning, heavy grazing, etc., and will be discussed later. *Trewia nudiflora, Diospyros spp.* and *Bombax* provide examples of these phenomena.

In the lower subtropical hills, *Pinus longifolia* provides the conspicuous example of a gregarious species, surpassing *sal* in that it forms normally 100 per cent. of the canopy over most of its area of distribution. In the higher temperate hills, the forests generally tend to be pure crops of *Quercus incana, Q. semecarpifolia, Cedrus deodara, Pica morinda,* etc., or very simple mixtures such as *Quercus semecarpifolia* with *Abies Webbiana,* or *Picea* with *Cedrus.* The only types here which are typically mixed, are the richer broad-leaved evergreen including *Q. dilatata,* and the broad-leaved deciduous forest, though the component species, including the oak itself, are often found as pure crops of varying extent, e.g., *Aesculus* and *Carpinus. Alnus nepalensis* and *Pinus excelsa* are the outstanding examples of gregarious dominants on new sites.

Below the dominant canopy, the lower vegetation shows a similar range of variation in the complexity of its composition, and " societies " form a varying proportion of the underwood. Bamboos are good examples in the monsoon deciduous and temperate forest, *Phoenix humilis* in some *sal* forests and *Nyctanthes* in the dry types. Gregarious shrubs are numerous, and examples are *Flemingia fruticulosa* and *Clerodendron infortunatum* in *sal, Carissa* in dry forests, *Woodfordia* in the chir pine, and *Indigofera gerardiana* and *Strobilanthus Wallichii* in the higher fir forests. *Adhatoda vasica* occurring extensively under *Acacia catechu* illustrates the same feature in a seral community and is accordingly termed a " socies."

(1) *Inherent factors influencing gregarious occurrence.*—Vegetative reproduction might be expected to favour the steady spread of a species from any individual which had managed to reach maturity in a mixed crop, the new shoots being nourished as long as necessary by the parent tree. Actually this character seems to be of little value and the few trees with pronounced rootsuckering ability such as *Stereospermum* and *Ehretia acuminata* are not gregarious. At best a small group results, not a consociation.

(2) *Copious seed production.*—It is a noteworthy fact that many conspicuously gregarious species produce heavy crops of seed at intervals of a few years and little or none in the meantime. This is true of *sal, chir* pine, deodar and the oaks. It is probably also significant that the seed are relatively large, with enough food reserves to give the seedlings a a good start before they must depend on their own assimilative activities. Generally the seed of gregarious trees is relatively heavy with rather limited dispersal. As is well known, pioneer species like *Dalbergia sissoo, Acacia catechu, Betula* and *Alnus* typically produce frequent and abundant crops of light seed adapted for quickly reaching appropriate new sites.

(3) *Gregarious flowering.*—The same feature is carried to a further stage in the gregarious flowering of several of the gregarious species of the lower storey. These plants are characterised by a purely vegetative phase from 2 years to perhaps 40, culminating in copious flowering usually followed by death and a new start from seed; all the plants of the species over a wide tract of country may flower out in one year in this way and flowering be rare or entirely absent till the next cycle is complete. The genus *Strobilanthus* (10) is

the stock example of this behaviour with flowering cycles of 2 to 12 years varying with species. Most bamboos (11) behave similarly with longer cycles of 20 to perhaps 60 years. After such gregarious flowering, the death of the flowered-out plants removes their competition and gives great opportunities for seedlings which have held out under their shade to gain possession of the ground, and this is undoubtedly how many of the top storey trees get up. The bamboo, however, produces enormous quantities of seed, so that even after meeting the needs of birds and rodents, a carpet of seedlings occupies every vacant spot. This profusion of seedlings is important, especially with the very palatable bamboos, to meet the usual heavy seedling mortality, and ensures survival in quantity enough to shade out competitors and so to restore the original gregarious thickets.

(4) *Persistence of regeneration under shade.*—In the last paragraph we have seen how some gregarious underwood species regenerate without the seedlings having to get up in the shade of the parent plants. The gregarious pioneer species avoid the same difficulty by regenerating always in new sites. Large climax trees have to face this regeneration problem and we are not yet clear as to how they encompass it. Tolerance of shade is a great asset and normal successions usually involve the displacement of the more light-demanding by more shade tolerant species: thus *Pinus excelsa* is regularly ousted by the shade-bearing *Abies*, and *Dalbergia sissoo* by *Holoptelea*, and sometimes *Shorea* by *Eugenia jambolana*, and *Pinus longifolia* by *Quercus incana*. When the climax stage is reached, the struggle is for the retention of chance gaps resulting from the death of top canopy trees from old age, climbers, insects, fungi, lightning, etc. Any seedlings that can persist in the shade a few years without losing their power of response to improved conditions of light and moisture are obviously at a great advantage in relation to new arrivals as seed. To be effective, at least periodic renewal of the stock of seedlings is necessary to replace losses from all causes, including age beyond retention of responding power. Now the seedlings of many gregarious species, *e.g.*, *Shorea* and *Picea* are notoriously intolerant of the shade of their own species: this may not be due to lack of light, in fact is more often due to toxic effects of the mat of fallen leaves, to root competition or to drip, but the end result is the same. In such cases, as the gregarious dominant apparently cannot reproduce in the same site, it cannot form a stable climax community, but our knowledge is still too inadequate to dogmatise. It is thus quite possible that regeneration is not direct, *i.e.*, that the chance gaps are first occupied by other species under which in turn the gregarious dominant regenerates and ultimately regains possession.

(5) *Shade cast by foliage.*—The greater the shade cast by the foliage of a tree, the less chance there is of other species getting established beneath it, pushing up through it and ultimately overtopping it. Such shade is particularly dense and effective in early life (*e.g.*, *sal*) though it may only be cast during part of the year (*e.g.*, teak during the monsoon). It is noteworthy that gregarious dominants usually cast a relatively dense shade, whilst the forester's " light-demanders," which are rarely gregarious except as early stages of a succession or in naturally open associations, are usually, light crowned.

(6) *Longivity.*—This is undoubtedly an important factor in many cases of gregarious dominants, deodar offering the best example. Persistence beyond the natural term of life of the surrounding competitors inevitably leads to more or less exclusive occupation of the ground by any fairly numerous species. It may be noted that *sal* is also longer-lived than most or all of its associates, though owing to human interference, really old trees are rarely to be seen now-a-days.

(7) *Susceptibility to disease, etc.*—All plants are liable in varying degrees to mortality from fungoid, bacterial and virus diseases as well as to insect epidemics. The spread of both insects and diseases is facilitated by concentration of their hosts, so that gregarious species

are particularly exposed to this class or risks, and do in fact frequently suffer seriously from them. Gregariousness can thus only succeed in a species which is hardy enough to survive such epidemics when they occur. This would appear to be one reason for the many recorded instances of failure after a promising start of many plantations, *e.g.*, of *Gmelina arborea*, though unsuitability of site has undoubtedly also frequently been influential.

Biotic factors influencing gregariousness.—It is an easily observed fact that human influences acting directly or indirectly on the vegetation tend to emphasise strongly any pre-existing tendencies to gregarious occurrence and to the dominance of a few species.

Fire may first be considered and it may be safely said that only in the last decade or two have we come to realise how great an influence this factor has had on the present composition of our forests. Not so long ago, we only anticipated that with a period of effective protection an open canopy would close up and the stems would be saved from fire scars, etc., now we realise that this is only one of the results and not the most significant. We have learnt that continued fire protection of formerly burnt tracts may result in complete failure to regenerate on the part of the present dominant species and hence ultimately in a complete change in consociation (or "type" as foresters prefer to call it), and by deduction it follows that the present crop would probably not be there now but for a continued history of burning. This is the position with many of our moister *Shorea* forests where *sal* must have taken possession more or less as a pioneer species in fire swept grassland itself following climax forest destroyed in one way or another. Burning then tends to kill out all but the fire hardiest species and these tend to come into sole possession of space they formerly had to dispute with many competitors. Factors bestowing fire resistance thus assist gregariousness but do not explain why the fire resistant associates of *sal* such as *Sterculia villosa* and *Lagerstroemia parviflora* are not equally gregarious. A notable feature with *sal* is the extraordinary vitality of the seedling rootstock after the first year or so ; it may survive the death of the above ground shoots however caused, for even 30 or 40 years during which period the number of stocks may accumulate so far that a chance succession of years with little or no burning, will permit of the development of enough shoots to thin out the inflammable grass to such an extent that some of them will survive the later fires, shade out the grass, and develop as a pure patch of *sal.* Kamrup in Assam provides examples now classical in forest literature.

Pinus longifolia is similarly so much more resistant to fire than any possible competitor that it obtains undisputed possession of the ground except where the fires are too fierce even for it and scrub, which can send up new shoots annually, is spared all competition from trees. In the higher hills, fires followed by protection may lead to the gregarious occurrence of *Pinus excelsa* though this is a very fire tender species, the reasons being its relative hardiness on hot dry exposures and the regularity and abundance of its seed crop produced from a very early age. It is in fact one of the pioneer species already mentioned on all types of potential tree bearing sites however denuded of tree growth.

Grazing exerts a similar selective effect and emphasises any tendency to gregariousness among inedible or well protected species, especially species which can regenerate under the very unfavourable conditions of soil and exposure prevalent in heavily grazed areas. The fact that sal and chir pine are very little eaten by cattle is yet another help to their predominance, and the same applies to *Adhatoda* and *Carissa* already mentioned as gregarious in undergrowth. A palatable species stands no chance of gregarious occurrence in a heavily grazed area, as only widely scattered individuals, overlooked by chance, or usually protected by a thorny bush, escape to carry on the species. This is the reason for the absence or shortage of young trees of the economically most important timber species in the mixed deciduous monsoon forests *Bombax*, *Adina*, etc. A very pronouncedly gregarious species may survive through its very abundance, as most grazing animals tend to vary their diet and there is often a relatively short period when exposure is at its maximum, when the foliage is new and palatable, or when feed is most scarce. These factors probably also come into play with *sal*.

Heavy grazing is usually associated in India with heavy continuous lopping of the branches of trees of palatable species, leading to their gradual destruction and so favouring the spread of their inedible competitors. Thus *Rhododendron arboreum* which is useless as fodder (and a bad fuel) normally occurs singly among *Quercus incana* and rarely appears at all gregarious, but areas can be seen where under the conditions just described the oak has been practically exterminated and the *Rhododendron* has spread and formed an open but pure crop (*e.g.*, near Dharamsala).

Forest Management.—During the last 50 years or more, a new factor has been at work, viz., systematic forest management aiming at increasing the proportion of economically more valuable species. Sometimes, as with *sal*, this has merely hastened natural tendencies, locally pushing them beyond the limit attainable by undirected processes ; but sometimes, as with teak, it has led to the predominance of a species in which the tendency to gregarious occurrence is absent or at best very feebly developed. All other species hampering the favoured ones such as the two mentioned, are removed and in this way the great mortality between the seedling stage and the tree with its place assured in the top canopy, is largely eliminated. Similarly in the hill forests, the pines have been favoured against broad-leaved species and deodar against *Picea* and *Abies*.

Conclusion.—Gregariousness in plants is a phenomenon not easily separable from high frequency, but which nonetheless plays an important part in determining the balance between the several species composing the vegetation, under the complex of influences affecting it. A natural tendency to gregariousness in a species of economic value is a valuable factor, in that it greatly facilitates operations aiming at increasing its abundance in mixed crops, or even devoting the whole surface and fertility of the soil to raising it in pure crops. Experience so far indicates that there is less risk from diseases, etc., in pure crops of naturally gregarious species than in similar cultures of non-gregarious species, but no agreement has yet been reached as to whether a pure crop can utilise available soil and space as efficiently as a mixed crop.

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Photo: E. C. Mobbs, October 1933.

PURE PINE FOREST (PINUS LONGIFOLIA)

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The Ecological Status of the Himalayan Fir Forests

by

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It has been suggested several times recently that the fir forest of the Western Himalaya is not a climax type of vegetation, because in many places it is failing to reproduce. No one who has made this suggestion has indicated what the climax is in the zone at present occupied by fir forest and the matter might be dismissed as not worth consideration except that it has been referred to by H. G. Champion in the presidential address of the Botany Section of the Indian Science Congress at Hyderabad in 1937.

Many persons who have written about the fir forests refer to them as if they were composed of two species only—*Abies pindrow* Spach. and *Picea Smithiana* Boiss—and overlook the very important though less conspicuous broad-leaved species associated with the conifers. In considering the question as to whether the fir forest is a climax type or not it is essential to understand the composition of the fir forests as nature intended them to be.

Forest Officers who have worked in the West Himalaya have noted the occurrence of scattered deodar trees usually of large size in fir forest. In such cases the fir is usually not more than about 100 years old. The deodar almost invariably show fire damage at the base. Forests of this nature are common in the Sutlej basin and are frequently found elsewhere. Both spruce and silver fir attain a girth of 20 feet and over and a girth of 12 to 15 feet is normal in forests of mature trees, whereas in 100 years a girth of 6 feet or less is to be expected. Forests that have suffered from fire within the last 100 or 200 years cannot be taken to represent the climax for fir forests. Both spruce and silver fir are very sensitive to fire and a prolonged period of immunity from fire lasting hundreds of years is necessary before the climax can be established.

Another type of fir forest is very commonly seen in the Himalaya. This is a degraded type of forest which is dying out. It contains large numbers of mature spruce and fir but little else, and no trees less than 30, 50 or 100 years old. This type of fir forest is rapidly increasing in area and is the result of overgrazing. All stages of the process can be seen from forests in which the younger age classes become progressively older and older accompanied by the opening out of the canopy owing to the steady disappearance of the old stock. The final stage is short grass and other herbs with or without a few scattered old trees which are awaiting their time to disappear leaving no descendants.

It is probably this type of forest that has led superficial observers to suggest that the fir forest is not a stable climax. Obviously no climax is stable if exposed to excessive grazing any more than it is if periodically burnt.

In order to see the fir forests as nature intended them to be, it is necessary to go far afield as such forests do not now exist anywhere on the main routes whether roads or long valleys. They may be seen in Pangi on the Upper Chenab and occasionally elsewhere in short side valleys especially if the forest happens to be protected by precipitous ground between it and the nearest villages and has no alpine pastures above. For the climax to survive protection from local village cattle as well as from the buffaloes of migrant *gujars* and the sheep and goats of migrant *gaddis* is required. Such conditions are occasionally met with in places that are not so inaccessible as Pangi, to reach which by the direct route involves crossing a pass of over 14,000 feet. Fairly accessible areas of forest far from villages may not as yet have been attacked by the *Gujar* and may be neglected by the *gaddis* hastening to reach and stake out a claim for the season in some more distant and desirable pasture area.

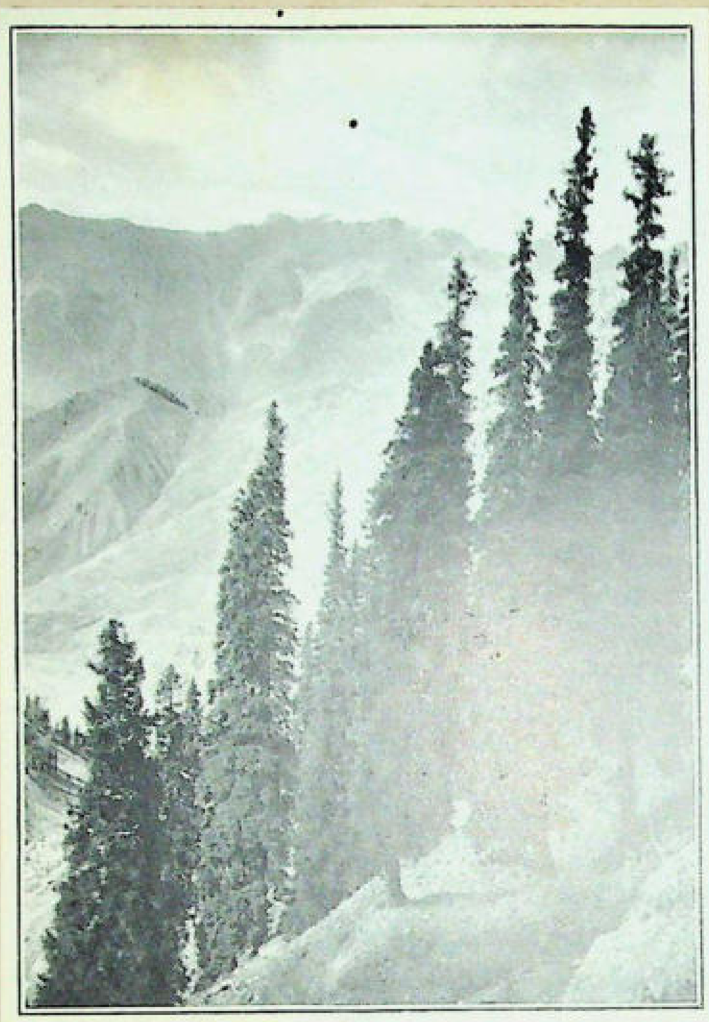

FIGURE 1.
Fir forest in the Kagan Valley, Hazara, 9,500 feet.

A marked feature of the fir forests where they have not been exposed to heavy grazing or fire is the very considerable admixture of broad-leaved trees and the presence of the younger age-classes of the firs. In my opinion this admixture is not merely normal but essential to the existence of this climax. The fact that young fir may be seen apparently in the process of replacing broad-leaved trees does not mean that the general type of the vegetation is changing over large areas, since the opposite process where broad-leaved trees are regenerating under old firs is also found. Both the spruce and the silver fir are longer lived than the broad-leaved trees associated with them as well as being much taller and hence there is a tendency for the firs to outgrow and outlive their associates and form pure crops. In such cases the humus becomes very deep and young firs fail to establish themselves as the roots of seedlings cannot reach the mineral soil. Many of the broad-leaved trees such as *Quercus semecarpifolia* Sm.; *Aesculus indica* Colebr. and *Juglans regia* Linn. have large seeds and proportionately vigorous seedlings and are able to regenerate in humus too deep for the fir seedlings. Others such as *Elm, Maples* and *Prunus cornuta* Wall. also manage to do so, in spite of their seeds being much smaller. What advantages they possess which enables them to succeed where fir fails remains to be ascertained. Drought, if it occurs, is experienced in November and possibly the deciduous tree seedlings can endure drought at this season better than the evergreen fir. Whatever the precise explanation may be, the pure fir forest is unstable, but this is quite another matter from sayihg that the fir forest is not a climax type.

As the fir forests, as usually seen, are in process of destruction by overgrazing, I may add a few remarks on the vegetation found in such forests. Firstly I should like to say that it is difficult to define overgrazing. A single flock of sheep and goats passing through a fir forest on their way to their summer pastures may be sufficient to prevent all regeneration of fir, if as is often the case, the flock goes through the forest so early in the season that only evergreen plants are available for food. The same flock spending a month in the forest later in the season may do little harm. As the fir forests are usually visited by forest officers and others much later in the season when there may be a dense mass of herbaceous vegetation knee-high or waist high, a highly erroneous impression of the effects of grazing may be obtained. A dense mass of herbaceous vegetation throughout the forest and not merely in moist ravines, combined with the absence of young trees is a sure sign of overgrazing at some season of the year. Another sign is a great abundance of any one plant such as *Strobilanthes Wallichii* Nees. east of the Sutlej in areas of heavy monsoon rainfall or of *S. atropurpureus* Nees. elsewhere. These plants are not conspicuous in ungrazed forest, but in overgrazed areas they may occupy an acre or more with scarcely anything else in the undergrowth.

Grazing especially by buffaloes has a most injurious affect on the broad-leaved trees as there are hardly any these animals will not eat. Anything they can reach is broken down and destroyed and trees too high to be reached are lopped by the *Gujar* and killed in a few years. Young fir frequently come up freely in forests that have been exposed to buffalo grazing and even forest officers have supposed that buffaloes are sometimes beneficial. The regeneration of the firs is usually at the expense of the broad-leaved trees and however good it may be, the forests tend to become pure fir forests which is not to their ultimate advantage.

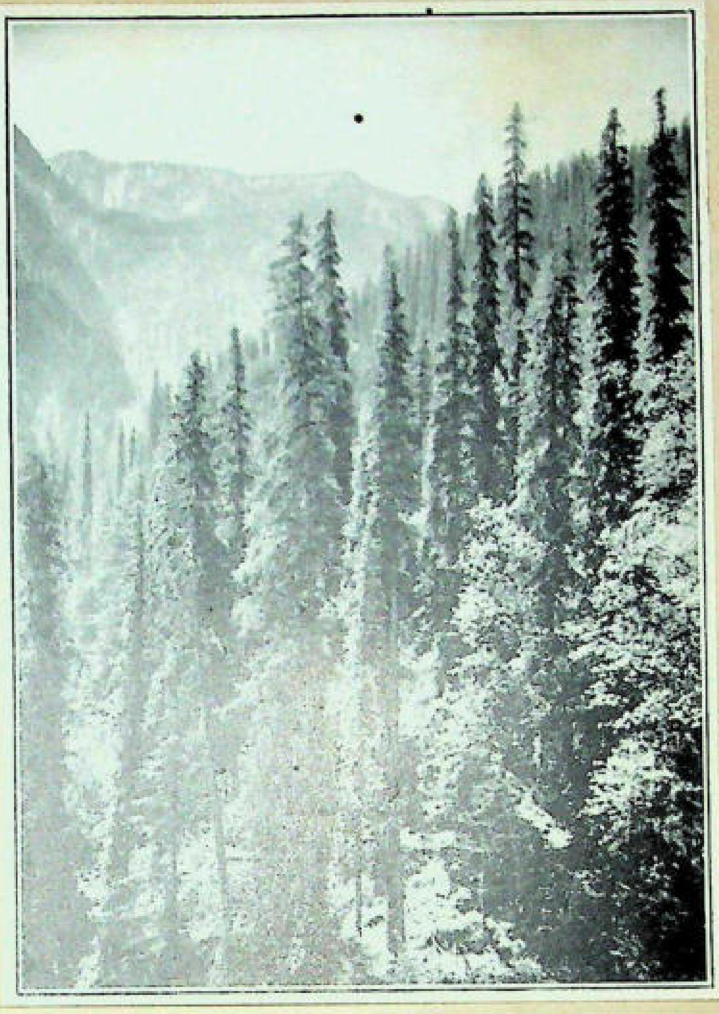

FIGURE 2.
Sutlej Valley, 9,000 feet.

Another sign of overgrazing is the confining of the young growth, especially young broad-leaved trees, to rocky precipitous ground. Normally the ravines and easier slopes are occupied by broad-leaved trees with only scattered fir, but such places are particularly heavily grazed so that no young broad-leaved trees can come up and as such places are often too damp for fir there is no fir regeneration either.

Most of the fir forests in the Western Himalaya are subject to grazing throughout the growing season by various kinds of animals. Early in the spring flocks of sheep and goats pass through finding nothing except young spruce and fir to eat. They are followed by cattle which eat all young broad-leaved trees and are frequently fed on loppings from trees too high to be reached. By the time the monsoon arrives and there is ample fodder the damage has been done. The process of destruction proceeds in one or two stages according to the amount of sheep and goat grazing. If this is not too heavy, there may be good regeneration of the firs at the expense of the broad-leaved trees until the forest become pure fir forests when regeneration stops. If goat and sheep grazing is also heavy no regeneration of any sort takes place and the forest slowly dies out as the old stock disappears. Figure 1 shows a fir forest which unhappily is typical of most of the fir forest in the Kagan Valley of Hazara district. It will be seen that there has been no regeneration for 100 years or more and under peresent condition this forest is doomed to extinction as soon as the present trees die.

Figure 2 shows a fir forest high above the Sutlej in a side valley. Figure 3 shows a fir forest on a stream flowing into the Pabar river, a tributary ultimately of the Jumna.

Both these photographs were taken in Bashahr State and represent what I consider natural fir forest not appreciably altered by man or his domestic animals. The considerable admixture of broad-leaved trees will be noticed especially in Figure 3, whereas the slopes are easy the forest in places consists largely of *Acer Caesium* Wall with very little fir.

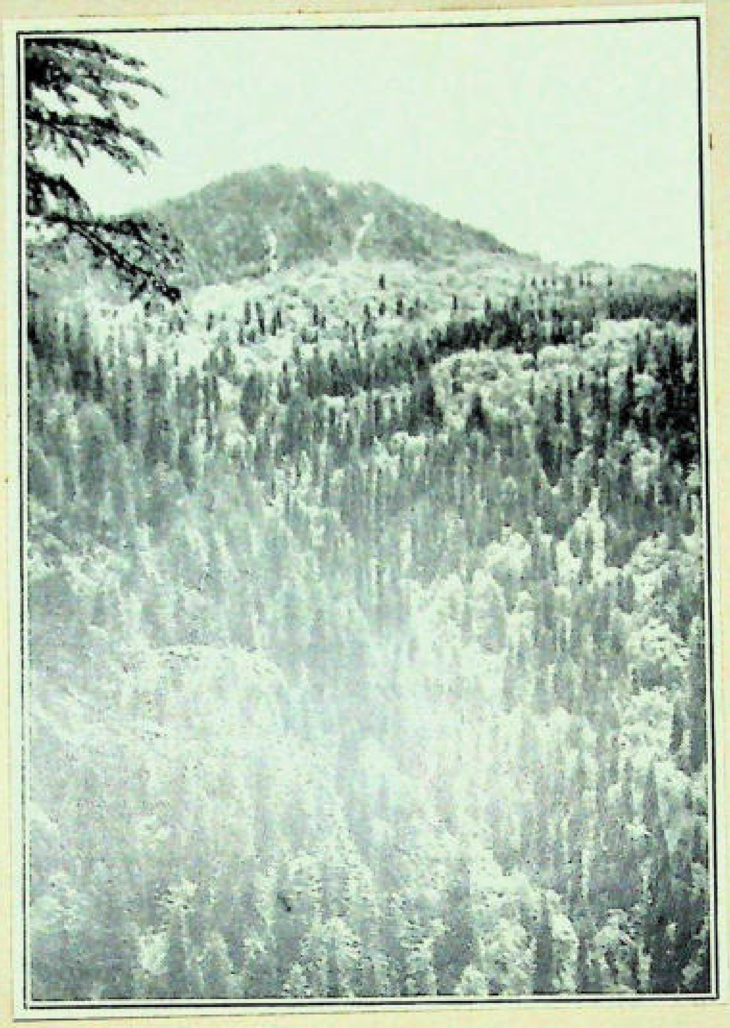

FIGURE 3.
Pabar Valley, Bashahr State.

It has been found that pure fir forest similar to that shown in Figure 1 can be regenerated by fencing to exclude all grazing animals and scraping off the humus in strips 10 feet wide so as to expose the mineral soil alternating with strips of the same width on which the surplus humus is thrown. This method will merely result in one crop of fir being replaced by another which in its turn will need artificial aid in order to maintain it. This is not regenerating the natural fir forest but merely maintaining an abnormal type of forest. To replace the original forest, it will be necessary to reintroduce the broad-leaved species which formerly occurred and also to devise some means of preventing them from again being destroyed. Until this is done, a stable climax will not be established.

In conclusion, I should like to explain that I have avoided using the special vocabulary of the Ecologist. Many of the terms with which the subject has been burdened seem unnecessary and the remainder have been used with different meanings so that they have lost much of any value they might have had (*vide* Burtt Davy, *The Classification of Tropical Woody Vegetation—Types, Imperial Forestry Institute Paper No. 13).*

Some remarks upon the Geology and the Flora of the Naga and Khasi Hills

by

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Over half a century ago, in 1878, the Naga Hills was formally taken over and the first Deputy Commissioner established his residence at Kohima, which has ever since been the headquarters of the district. A few years later, in 1885, two botanists, Dr. (later Sir George) Watt and Mr. C. B. Clarke botanised along the same route between Manipur and the plains of Assam. The collections of these two gentlemen were the result of the first serious botanical exploration of the Naga Hills and for many years formed our only source of information regarding the flora. C. B. Clarke collected about 1,000 plants and gave an account of them in the Journal of the Linnean Society, Vol. XXV (1889). I have not been able to discover if Sir George Watt ever published a list of his Naga Hills plants, but C. B. Clarke mentions (loc. cit.) that Watt and he himself had collected mainly the same plants. More than thirty years elapsed before further investigations were made. Since 1921 Captain Kingdon-Ward and the writer and subsequently Dr. K. Biswas have made large collections and the flora is now fairly well known.

Burkill (1925) and Bor (1938) have published accounts of the flora of the Abor Hills and the Aka Hills, respectively, so that the vegetation of the hills surrounding the Assam Valley is not now the mystery it used to be up to comparatively recent years.

In a letter written to Sir J. Hooker in 1887, and published in the Journal of the Linnean Society (Botany), Vol. XXII, p. 128 et seq., Mr. C. B. Clarke remarks he was struck by the difference which the flora of the Naga Hills at comparable altitudes exhibited from that of the Khasi Hills which is only 100 miles away as the crow flies. He found that there was a far greater resemblance to the flora of Sikkim and in particular to that of Darjeeling. He was puzzled to account for this seeing that Darjeeling lies 500 miles away to the north-west with the whole width of the Brahmaputra valley between.

It is the purpose of this paper to examine that statement in the light of the results of exploration of the eastern Himalayas and of the flora of the Naga Hills in particular, and to indicate some of the salient features of the Naga Hills flora without giving the elaborate analysis which is one of the most valuable features of Burkill's book.

It is accepted by geologists that the Shillong plateau is by far the oldest part of the chain of hills forming the southern boundary of the Assam Valley.

According to Evans (1934) the main mass of the Shillong plateau, which at the present time is little over 2,000 m. at its highest point, is composed of metamorphic rocks of very great age. These metamorphic rocks are for the most part gneisses, schists and quartzites into which have been intruded granites, dolerites and peridotites. Thus it seems that the core of the Khasi Hills has affinites with the Gondwana continent and is distinct from the Himalaya to the north and from the chain of high hills which lie to the east and north-east. The entire area was flattened before a deposit of sandstones of Huronian age occurred. Long afterwards, in the mesozoic period, the plateau was submerged beneath a cretaceous sea which has left its traces in the beds of sandstones of cretaceous age. In certain places these cretaceous beds are overlain by the lowest tertiaries (which are calcareous) and point to a futher subsidence having taken place.

Long after the Shillong plateau had been formed the area to the east and south-east was under water and was most probably a river estuary. It is believed that, during the Oligocene period, part of this sea or estuary was silted up and raised. At that time climatic conditions were such that a coal forming flora covered very large areas. Subsidence again took place and the plant remains were covered with many thousands of feet of sandstones.

Towards the end of the Miocene period extensive earth movements on a vast scale began. The tertiary beds were elevated, corrugated, sheared, torn and twisted to an extraordinary extent. In the Naga Hills especially, the forces of nature were so great that the strata were torn apart along immense faults and vast stretches of Tipam sandstones were pushed unconformably over the Disang shales. Thus it happens that the Barail range of the Naga Hills, with its highest point Japvo, 3,300 m., is composed of these rocks.

All the subsequent thousands of years of denudation have given the Naga Hills their present appearance, but it is scarcely open to doubt that in remote times they reached heights comparable to those of the Himalaya, and far greater than those ever attained by the Khasi Hills. Denudation would have a far greater effect upon the Naga Hills, composed of sandstones and shales, than upon the relatively harder archæan rocks of the Khasi Hills and the rocks of the Himalaya.

It must be borne in mind that, during all this period of upheaval, of stress and strain, the ancient Khasi Hills stood firm.

The Eastern Himalaya was elevated about the same time, though these are composed of rocks which are very different from those of the Naga Hills.

The next great event in the history of the Himalaya was the coming of the glacial age which occurred in Pleistocene times.

The discovery by Hooker of terminal moraines in Sikkim at an altitude of 2,300 m., where at the present day no glaciers are found below 4,600 m., suggests that during the glacial epoch the mountains of the Himalaya which are now forest clad, must have been covered with snow. The Naga Hills may very well have been in the same condition. The Bhabar tract in Goalpara and Darrang consists of enormous boulder deposits of Pleistocene age which indicate that even the plains may have been too cold to support such a flora as is now found in the Eastern Himalaya at high altitudes.

The immediate result of the glacial epoch would have been to eject the pre-glacial flora of the Himalaya to the south where there was sufficient warmth for it to exist. The retreat of the ice would see the return of an Indo-Malayan flora, the advance of which was facilitated by the mountainous country which lay to the south and south-east. If this theory be correct one would expect to find a general resemblance in the floras of the Eastern Himalaya, Naga Hills and Khasi Hills.

When comparing the flora of any two regions it is all-important to remember that it is the climax flora which is the one that really matters when one is searching for true affinities.

The activities of man and his domestic animals are confined to the destruction of the climax formations and it is well known that many of the herbs and shrubs of climatic zone have only been enabled to enter those zone simply because man has created bare areas. This does not exclude natural bare areas caused by the slipping of steep hillsides, by earthquakes, erosion and the like, as lines of migration. These, however, are small compared with the areas which man clears for his staple crops and those which are kept in a permanent state of inferior rank by burning and grazing.

It is fairly safe to say, in fact the state of the flora bears the assumption out, that there is very little land below 4,500 feet in the Khasi and Naga Hills which has not been *" jhumed" at one time or another.

The Nagas, the Khasis, the Cacharis, and the Mikirs have all had a hand in the destruction of forest and so have opened up an easy path for the migration of plants which can tolerate the conditions at such levels.

The fact that the geological formations of the Naga Hills and of the Khasi Hills are different does not necessarily mean that their floras should be different. The rainfall of the two areas is high enough and the climates so similar as to preclude any possibility of edaphic influences of that nature being strong enough to control the vegetation.

Now with regard to the flora of the Khasi Hills it must be emphasised that there is very little climax vegetation left. What strikes the visitor is that the vegetation consists for the most part of pine forests and rolling grasslands. Man, his domestic animals, and fire have played their destructive roles in their own respective ways in these hills and the result is that large areas have been reduced to grass. The pine, *Pinus insularis* forms pure woods and the fires which occasionally kill these associes of pine, regenerate them by removing the layer of raw humus and thus providing a bed upon which the seeds germinate in thousands. If, on the other hand, a pine forest is protected from fire, as the reserves constituted by Government are, then the pine seed is prevented from germinating, or if it succeeds in germinating, is prevented from growing into a tree by the evergreen undergrowth which is so noticeable a feature in these forests.

Fortunately there still remain the sacred woods of the Khasis which are rigidly protected from outside interference. Unhappily, the spread of Christianity and other religions has removed, or is in the process of removing, the superstitious awe with which these forests are regarded by the present-day Khasi. Trees are now cut and grazing permitted in sacred woods which have existed untouched for hundreds, possibly thousands, of years.

Fortunately there are, however, sufficient of these woods to give an adequate description of the climax forest on the Shillong plateau at an altitude which can be compared with similar areas in the Naga Hills.

The trees consist of the following species: *Michelia doltsopa, Quercus fenestrata, Quercus dealbata, Quercus lanceaefolia, Daphniphyllum himalayense, Cinnamomum impressinervium, Machilus odoratissima, Elaeocarpus braceanus, Elaeocarpus lanceaefolius, Engelhardtia spicata, Schima khasiana, Ficus nemoralis, Bucklandia populnea* and a few others. *Pinus insularis* is not found in these forests.

*" jhum " is the term applied to shifting cultivation in Assam.

Among the smaller trees are to be found species of *Ilex, Rhododendron, Symplocos, Pyrus, Lindera, Prunus, Ligustrum, Ehretia, Myrica, Olea, Pentapanax, Euonymus, Illicium, Camellia* and many others.

In the shrubby layer are to be found species of the following genera: *Gaultheria, Myrsine, Skimmia, Lasianthus, Leptodermis, Euonymus, Spiraea, Rubus, Phyllanthus, Vaccinium, Colquehounia, Desmodium, Polygala, Hypericum* and a number of others.

Ferns and herbs are numerous, among the former being species of *Osmunda, Diplazium, Diacalpe, Microlepis, Drynaria, Pteris* and *Polypodium*.

So far as the Naga Hills is concerned the one place which Clarke had for comparison with the Khasi Hills was the slopes of Pulebadze.

The point to which this name is given (which Clarke called Polly Badgeley) dominates Kohima at an altitude of 2,000m. and from it the forests, with a northern aspect, slope comparatively steeply to Kohima. On the slopes the climax forest is composed of the following species: *Quercus lamellosa, Quercus xylocarpa, Quercus pachyphylla, Phoebe paniculata, Michelia cathcartii, Michelia doltsopa, Bucklandia populnea, Schima khasiana, Alsiodaphne dumicola, Castanopsis tribuloides, Ficus nemoralis, Evodia fraxinifolia, Acer campbellii, Magnolia campbellii.*

The trees comprising this climax are about 25m. tall and form a close canopy, hence smaller trees are rare. Those that are found include species of *Machilus, Brassaiopsis, Acanthopanax, Symplocos, Styrax, Ligustrum, Litsaea, Lindera, Myrica, Cephalotaxus* and *Euonymus*, and *Dendrocalamus patellaris.*

Species of the following genera form a shrubby growth: *Mahonia, Viburnum, Dobinea, Myrsine, Maesa, Viburnum, Polygala, Ardisia* and *Strobilanthes.*

The forest on the slopes of Pulebadze develops its full luxuriance at a higher level, viz., 2,000—2,750m. and the area described is really an ecotone between the upper and lower temperate zones, in which the trees of the upper climax predominate as the area is upon the cooler, more humid, northern aspect.

The tall trees comprising any climax unit are those which give it its facies and, therefore, it will now be considered how these two areas differ from one another.

If the tall trees of the Khasi and Jaintia Hills between 1,500 and 2,000m. are taken to represent the climax of that area one observes that all of them, except *Elaeocarpus braceanus* and *Schima khasiana*, are trees of the Eastern Himalaya. *Elaeocarpus braceanus* and *Schima khasiana* which are not found in the Eastern Himalaya are common to both Naga Hills and Khasi Hills.

Now with regard to the Naga Hills climax we find that *Quercus lamellosa, Quercus pachyphylla, Quercus polystachya, Michelia cathcartii, Michelia doltsopa, Bucklandia populnea, Castanopsis tribuloides, Ficus nemoralis, Evodia fraxinifolia* and *Acer campbellii* are common trees of the climax forest of the Eastern Himalaya. *Schima khasiana* and *Elaeocarpus braceanus* are common to the Naga and the Khasi Hills, while of the remainder *Alseodaphne dumicola* is a Chinese species and *Quercus xylocarpa* is Burmese.

Thus it will be seen at once that the very great majority of the species which comprise both these lists are Eastern Himalayan and a good many are common to both the Khasi and the Naga Hills. Clarke, however, was correct when he said the forests were very different. Oak is very abundant on the slopes of Pulebadze and give the forest a Himalayan rather than a Khasia appearance.

Although the Khasi Hills possesses in Cherrapunji one of the rainiest spots in the whole world, the precipitations fall off very rapidly towards the north and in fact the climates of, in so far as rainfall is concerned, Shillong in the Khasi Hills, Kohima in the Naga Hills and Kurseong in the hills of north Bengal are very similar, certainly not different enough to make any great divergence in so far as the vegetation is concerned. These stations have been cited because they are at comparable altitudes.

We have already compared the climax forests between 1,600 and 2,000 m. simply because the highest point in the Khasi Hills is in the neighbourhood of 2,000 m. Although the very great majority of species in both units are Eastern Himalayan and Burmese, it has been found that the facies of both climax units are different. The tables below show range of the species which give each unit its physiognomy :—

KHASI HILLS CLIMAX

Species.	Lower limit.	Upper limit.
Quercus fenestrata	1,700 m.	2,000 m.
Quercus dealbata	1,800 m.	2,000 m.
Quercus lanceaefolia	1,000 m.	1,700 m.
Daphniphyllum himalayense	1,000 m.	3,300 m.
Michelia doltsopa	1,000 m.	2,000 m.
Ficus nemoralis	2,000 m.	2,800 m.
Bucklandia populnea	1,000 m.	2,800 m.
Cinnamomum impressinervium	1,300 m.	2,300 m.
Machilus odoratissima	1,000 m.	2,300 m.
Engelhardtia spicata	500 m.	2,000 m.
Elaeocarpus braceanus	1,500 m.	2,000 m.
Elaeocarpus lanceaefolius	2,000 m.	2,800 m.

NAGA HILLS CLIMAX

Species.	Lower limit.	Upper limit.
Quercus lamellosa	2,800 m.	3,000 m.
Quercus xylocarpa	1,800 m.	3,000 m.
Quercus pachyphylla	1,800 m.	3,000 m.
Michelia cathcartii	1,800 m.	2,000 m.
Michelia doltsopa	1,000 m.	2,800 m.
Bucklandia populnea	Plains.	2,800 m.
Castanopsis tribuloides	Do.	2,800 m.
Ficus nemoralis	1,900 m.	2,800 m.
Evodia fraxinifolia	1,300 m.	2,800 m.
Acer campbellii	1,800 m.	3,300 m.
Magnolia campbellii	2,000 m.	3,500 m.
Cinnamomum impressinervium	1,300 m.	2,300 m.

It will be clear from these tables that the trees of the Khasi Hills climax forest are near the upper limit of their range while those of the Naga Hills are near the lower limit within the altitudes we have chosen for comparison.

The explanation of the difference in facies is to be found in the fact that the Naga Hills ascend to much higher altitudes than do the Khasi and Jaintia Hills. The effects of the higher altitude on the vegetation are well known in that they enable high altitude plants to descend lower on northern aspects and in places where cold air drainage is to be expected.

It must also be remembered that when Clarke says that the trees are all Oak about Kohima he was referring doubtless to the Pulebadze slopes which have a northern aspect. This again would account for the predominance of the Oak species which have already been enumerated.

There is a further factor to be considered and that is the low country which is found at the junction of the Khasi Hills and the Naga Hills. This would form an effective barrier to the migration of high altitude species which might succeed at the altitudes reached in the Khasi Hills.

The foregoing paragraphs have sought to show that the flora of the Khasi Hills and that of the Naga Hills are not so dissimilar when comparable altitudes are studied, and any dissimilarity can be rationally explained as being due to ecological factors.

Taken as a whole the flora of the Eastern Himalaya, the Naga Hills and the Khasi Hills is essentially Indo-Malayan with a strong admixture of Chinese elements. Recent collections by Captain Kingdon-Ward and the writer have added the following records to these hills (Fischer).

Of Yunnan and Chinese plants the following have been added to the flora of the Naga Hills:—*Uraria hispida, Jasminum dumicola, Trachelospermum auritum, Ehretia macrophylla, Pogostemom nigrescens, Alseodaphne dumicola, Primula obconica, Edgeworthia chrysantha, Passiflora leschenaultii.*

Burmese plants :—*Vernonia blanda, Diospyros glandulosa, Swertia lacei, Lindenbergia philippinensis, Eranthemum ciliatum, Congea tomentosa, Pottingeria acuminata, Kalanchoe spathulata.*

Sikkim plants which are first records for Assam (Naga Hills) and which do not penetrate into the Khasi Hills are :—*Swertia bimaculata* (also Aka Hills), *Pedicularis curvipes, Plectranthus scrophularioides, Hedychium venustum, Cirrhopetalum elatum, Cirrohopetalum, wallichii, Calanthe biloba, Gastrochilus pseudodistichus, Corydalis leptocarpa* and *Viburnum atrocyaneum.*

From the Western Himalaya come *Lycopsis arvensis* and *Euphorbia maddeni.*

A "find" of uncommon interest was *Petrocosmea parryorum,* previously only known from the Lushai Hills to the south.

That interesting parasitic plant, *Sapria himalayana,* was discovered by Griffith in the Mishmi Hills in 1836. Nearly one hundred years later it was collected by the writer in the Aka Hills and at the same time by A. Das, I. F. S., in the Khasi Hills. It will doubtless be discovered also in the Naga Hills where its principal host, *Vitis elongata,* is to be found.

Wightia gigantea, one of the few scrophulariaceous trees, is common in Sikkim, Aka Hills, Naga Hills and Khasi Hills. This tree is also found in Burma.

Areas above 3,000 m., which are represented by Japvo (3,300 m.) near Kohima, and Sarameti (4,000 m.) on the Burmese border to the east are surprisingly alike in flora. The forest between 3,000 and 3,300 m. can be called a *Rhododendron-Betula* forest from the prevalence of these two species. The *Rhododendrons* common to the two areas are *Rhododendron macabeanum, R. dendricola. R. johnstoneaum. R. iteophyllum, R. falconeri, R. ellioti, R. maddeni, R. vaccinioides, R. barbatum, R. dalhousiae.* These are all East Himalaya species except the endemic *Rhododendron macabeanum, R. johnstoneanum* and *R. ellioti. Betula cylindrostachys* forms pure woods.

Even the ground flora at these altitudes is very similar. *Lomaria glauca* cover large stretches and *Campylandra wattii* (previously only known from Japvo) is also found. *Aconitum nagarum* is common.

The distribution of *Pinus insularis* is interesting. This is a tree of north Burma, Khasi and Naga Hills. It flourishes between altitudes of 1,500-2,000m. It avoids areas of very high rainfall as is evidenced by its absence from the neighbourhood of Cherapunji. As this tree is a light demander it is not able to compete with the evergreen climax forests in the areas in which it is now found. It is extremely probable, therefore, that its return to Assam has been comparatively recent, that is, at the time when man began to cultivate and destroy climax forest for his fields, and so opened barren areas for the dispersal of the pine. One occasionally finds isolated small trees of this species in abandoned jhums in the Kacha Naga country to the south of Kohima. To the east near the Tizu river where annual fires keep the vegetation in a degraded state, the tree flourishes. The fact that it is not found in many places of the Naga Hills which are suited to its ecological requirements, suggests that it is a straggler and is still migrating to the north.

Another plant of great interest is *Nepenthes khasiana* the pitcher plant, which was found by Hooker in the Jaintia Hills and also by R. N. De, I.F.S., in the valley of the Someswari river in the Garo Hills. The nearest cogeners of this plant are to be found in Ceylon and the Malayan Peninsula over 1,000 miles to the south. As the latter are all climbers, and since climbers are considered to be more recent than shurbs or trees, it may very well be that the original home of the genus *Nepenthes* was in Assam and when in Pleistocene times, the representatives of the species were driven south, they failed to return and have reached their present luxuriance in the steamy atmosphere of Malaysia, leaving a solitary representative in the Khasi Hills.

This account of the flora has sought to show, in the space at my disposal, how close is the connection between the vegetation of the mountainous regions of Assam, both north and south of the Brahmaputra, and that of Burma and, to a lesser degree, that of China. The reason for this similarity is the geological history of the area.

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Floristics of Assam—A Preliminary Sketch

by

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INTRODUCTION

Assam Flora is not by any means an untrodden ground. Exploration of parts of Assam was undertaken by Wallich and Griffith. Sir J. D. Hooker himself paid a visit to the Province, specially to the Khasi Hills. Klicau of Cachar, De Silva of Sylhet, Peal of Sibsagar and Commissioner Jenkins—all enthusiastic botanists, contributed largely to the collection at the Royal Botanic Garden, Sibpur.

Mr. C. B. Clarke was the most enthusiastic worker in this field and traversed the whole province several times on foot and made a very extensive collection. Mr. Mann (the first Conservator of Forests, Assam) has also left a large collection for his successors. Mr. I. H. Burkill of the Botanical Survey of India visited Khasi Hills and North-Eastern Frontier Tract. His contributions were of far-reaching importance. Exploration of Dr. G. Watt also was very remarkable and interesting. Contributions of the Botanical Survey of India and many other workers in this field were quite large.

Rai Bahadur U. N. Kanjilal, F.L.S., at the initiative of Sir Archdale Earle, the then Chief Commissioner of Assam, commenced a comprehensive and systematic collection over the whole province and compiled elaborate and extensive field-notes on individual species for the preparation of a Flora for Assam.

In subsequent years the collections of Mrs. N. E. Parry in Garo and Lushai Hills, Dr. N. L. Bor, D.SC., I.F.S., F.L.S., in Naga Hills and Aka Hills, Mr. P. C. Kanjilal, B.SC., I.F.S., (throughout Assam), Mr. A. Das, I.F.S., F.L.S. (throughout Assam), and Dr. K. P. Biswas, M.A., D.SC., F.R.S.E., Superintendent, Royal Botanic Garden, Sibpur, in Manipur and Khasi Hills, and Mr. R. N. De, B.SC., I.F.S., have been a great asset to the Province.

A proper herbarium for Assam has now been inaugurated at Shillong out of all the materials available which will serve as a venue for future economic development of the forest products of the province as well as for Botanical Research. Thanks to the combined efforts and ungrudging devotion of many workers, as mentioned above, the Assam Flora is now very satisfactorily represented in the herbarium of the Royal Botanic Garden, Sibpur, through which Kew and many other herbarium have received contribution. The herbarium at the Royal Botanic Garden, Sibpur, is now the chief centre in India for working on the Flora of Assam.

Several species examined in recent years at the herbarium of Royal Botanic Garden, Sibpur, have now been described as new to Science (Assam Forest Records Botany Series, Vols. I and II, and Indian Forester, May 1938) ; some of them are enumerated below :—

(1) Pachylarnax pleiocarpa *Dandy*.

(2) Sterculia khasiana *Debbarman ex Biswas.*

(3) Gymnocladus assamicus *Kanjilal ex P. C. Kanjilal.*

(4) Lagerstroemia minuticarpa *Debbarman ex Kanjilal.*

(5) Agapetes Kanjilali *Das.*

(6) Maba cacharensis *Das et Kanjilal.*

(7) Symplocos Pealii *King ex Das.*

(8) Chirita mishmiensis *Debbarman ex Biswas.*

(9) Strobilanthes furcatus *Biswas.*

(10) Phœbe Cooperiana *Kanjilal ex Das.*

(11) Machilus globosa *Das.*

(12) Eugenia cyanophylla *Kanjilal et Das.*

(13) Pasania Milroyii *Purkayastha ex Das.*

(14) Salacia khasiana *Purkayastha.*

(15) Purkayasthaca pseudomicropora *Purkayastha ex Narayanaswami.*

(16) Ilex khasiana *Purkayastha.*

There are many more Assam species which are now being investigated into, at the herbarium of the Royal Botanic Garden, Sibpur, which will prove to be new to Science.

It is not the intention to discuss here in details the plant ecology of the Province but to depict a general floristic picture of the region on more popular lines.

The Flora of Assam is perhaps the richest in India, most varied (giants of the evergreen forests to the microscopic species of cryptogamic flora) and immensely interesting.

There is preponderance of Malayan species occurring specially in Khasi Hills, Lushai Hills and Manipur. Several Chinese species have also been recorded from the Assam Frontier.

Species such as Pachylarnax pleiocarpa *Dandy* (P. praecalva *Dandy* from Penang and Annam), Gymnocladus assamicus *Kanjilal* ex P. C. Kanjilal, G. burmanicus *Parkinson* from Burma, and G. chinensis *Baill.* from China) are exclusively recorded from Assam and even these genera are remarkably absent from the other parts of India. There are many other species whose distribution is confined to this Province only.

Floristics of the Province consist of a bewildering number of species and only the Phanerogamic flora will be dealt with in these pages.

Forest Types

The ecological factors such as (*a*) Climatic and physiographic, (*b*) Edaphic, and (*c*) Biotic which determine the distribution of species and their classification into main types of Forest Associations need not be discussed here in details. It is, however, necessary to give a general outline of the climatic conditions and altitude of the region.

In Assam the annual revolution of the seasons is not marked by the strongest contrast of temperature; the average relative humidity varies from 73° in Shillong to 90° in Sibsagar and the normal rainfall (annual) from 68 in Nowgong to 220 inches in Khasi and Jaintia Hills (Cherrapunjee about 500 inches). The altitude varies from the sea level to about 15,000 feet in Aka Hills in the Northern Frontier of the Province.

Mr. H. G. Champion in his paper entitled " A preliminary survey of the Forest Types of India and Burmah " classifies the vegetation of Assam into as many as 24 types and sub-types based on the preliminary study of the plant ecology of the Province. It will fulfil the purpose of describing the general floristics of the Region, if the following main types based on zonation are adopted. It must, however, be noted that a considerable tract of vegetation is obviously occupied by transitional forms.

I. TROPICAL—

(i) Evergreen—

(a) Assam Valley.
(b) Surma Valley.

(ii) Deciduous.
(iii) Grassland.
(iv) Riparian.
(v) Swamp.

II. TEMPERATE (including lower and upper temperate zones).

III. ALPINE (including sub-alpine zones).

I. TROPICAL—

(i) *Evergreen.*—

(a) *Assam Valley.*—This type occupies the major parts of N. E. F. Tracts, Lakhimpur, Sibsagar, the S. E. portion of Nowgong district, northern portion of North-Lakhimpur subdivision and Darrang district up to Panch Nandi, foot-hills of the Eastern Himalayas, a portion of Garo Hills, a portion of the lower elevation of Khasi and Jaintia Hills, parts of Naga Hills and Manipur.

(b) *Surma Valley.*—This type is met with in the major part of Sylhet, Cachar, portion of N. Cachar Hills and Lushai Hills.

The species occurring in the two valleys (evergreen type) are enumerated below in a comparative statement :—

Assam Valley.	Surma Valley.
Dilleniaceae	
Delima sarmentosa *Linn.*	D. sarmentosa *Linn.*
Magnoliaceae	
Magnolia pterocarpa *Roxb.*	absent.
M. Griffithii *Hk. f. & Th.*	absent.
M. Pealiana King	absent.
Pachylarnax pleiocarpa *Dandy*	absent.
Manglieta insignis *Bl.*	absent.
M. Hookeri Cubitt & Smith	absent.
M. Caveana *Hk. f. & Th.*	absent.
Talauma Hodgsoni *Hk. f. & Th.*	T. Rabaniana *Hk. f. & Th.*
T. phelocarpa *King*	T. phelocarpa *King.*
Michelia Champaca *Linn.*	Michelia Champaca *Linn.*
M. montana *Bl.*	M. montana *Bl.*
Kadsura Roxburghiana *Arn.*	absent.

Assam Valley.	Surma Valley.
Anonaceae	
Polyalthia simiarum *Benth.* & *Hk. f.*	absent.
P. Jenkinsii *Benth.* & *Hk. f.*	P. Jenkinsii *Benth.* & *Hk. f.*
Unona discolor *Vahl.*	U. discolor *Vahl.*
Mitrephora tomentosa *Hk. f.* & *Th.*	M. tomentosa *Hk. f.* & *Th.*
absent	Cathocalyx malabaricus *Hk. f.* & *Th.*
Bixaceae	
Bixa orellana *Linn.*	B. orellana *Linn.*
Flacourtiaceae	
Hydnocarpus Kurzii *Warb.*	absent.
Gynocardia odorata *R. Br.*	G. odorata *R. Br.*
Guttiferae	
Garcinia xanthochymus *Hk. f.*	G. xanthochymus *Hk. f.*
Garcinia Cowa *Roxb.*	G. Cowa *Roxb.*
G. pedunculata *Roxb.*	absent.
absent	Ochrocarpus longifolius. *Benth* & *Hk. f.*
Mesua ferrea *Linn.*	absent (only cultivated).
Kayea assamica *King* & *Prain*	K. floribunda *Wall.*
Calophylum polyanthum *Wall.*	C. polyanthum *Wall.*
Ternstroemiaceae	
Ternstroemia japonica *Thunb.*	absent.
Adinandra Griffithii *Dyer*	absent.
Eurya acuminata *DC.*	E. acuminata DC.
Gamellia drupifera *Lour.*	C. drupifera *Lour.*
C. caudata *Wall.*	absent.
Actinidia cullosa *Lindl.*	A. cullosa *Lindl.*
Dipterocarpaceae	
Dipterocarpus macrocarpus *Vesque*	D. Turbinatus *Gartn.*
D. Mannii *King*	absent.
Shorea assamica *Dyer*	absent.
Vatica lanceaefolia *Bl.*	V. lanceaefolia *Bl.*
V. shinkeng *Dunn.*	absent.
Meliaceae	
Dysoxylum binectariferum *Hk. f. et. Bedd.*	D. binectariferum *Hk. f. et. Bedd.*
Amoora Rohituka *W.* &. *A.*	A. Rohituka *W.* & *A.*
A. cucullata *Roxb.*	A. cucullata *Roxb.*
A. Wallichii *King*	A. Wallichii *King.*
A. chittagonga *Heirn*	A. chittagonga *Hiern.*
Chickrassia tabularis *And. Juss.*	C. tabularis *And. Juss.*
Cedrella febrifuga *C. DC.*	C. febrifuga *C. DC.*
Celastraceae	
Microtopis discolor *Wall.*	M. discolor *Wall.*
Rhamnaceae	
Ventilago madraspatana *Gaertn.*	V. madraspatana *Gaertn.*
Smythea calpicarpa *Kurz*	S. calpicarpa *Kurz.*
Anacardiaceae	
Mangifera sylvatica *Roxb.*	M. sylvatica *Roxb.*
M. andamanica *King*	M. andamanica *King.*

Assam Valley.	Surma Valley.
Leguminosae	
Dalbergia assamica *Benth.*	Dalbergia reniformis *Hook.*
D. mimosoides *Franch.*	D. mimosoides *Franch.*
Derris marginata *Benth.*	D. marginata *Benth.*
D. ferruginea *Benth.*	absent.
Dalhousia bracteata *Grah.*	D. bracteata *Grah.*
Mezoneurum enneaphyllum *W. & A.*	M. enneaphyllum *W. & A.*
absent	Cynometra polyandra *Roxb.*
Entada scandens *Benth.*	E. scandens *Benth.* and many other species.
Hamamelidaceae	
Altingia excelsa *Noronha*	absent.
Rhizophoraceae	
Carallia lucida *Roxb.*	Carallia lucida *Roxb.*
Combretaceae	
absent	Anogeissus acuminata *Wall.*
Combretum decandrum *Roxb.*	C. decandrum *Roxb.*
Myrtaceae	
Eugenia formosa *Wall.*	absent.
E. Macrocarpa *Roxb.*	E. macrocarpa *Roxb.*
E. aquea *Burm.*	E. aquea *Burm.*
E. praecox *Roxb.*	E. praecox *Roxb.* and many other species.
Lythraceae	
Crypteronia paniculata *Bl.*	absent.
Datiscaceae	
Tetrameles nudiflora *R. Br.*	T. nudiflora *R. Br.*
Araliaceae	
Heteropanax fragrans *Seem.*	H. fragrans *Seem.*
Macropanax oreophilum *Miq.*	M. oreophilum *Miq.*
Cornaceae	
Alangium begoniaefolium *Roxb.*	A. begoniaefolium *Roxb.*
Nyssa sessiliflora *Hk. f.*	N. sessiliflora *Hk. f.*
Vaccinaceae	
Agapetes Kanjilali *Das.*	absent.
A. grandiflora *Hk. f.*	absent.

Myrsinaceae.

The genera Maesa, Embelia, Ardisia, Sadiria, Amblyanthus and Amblyanthopsis are well represented in both the valleys.

Assam Valley.	Surma Valley.
Sapotaceae	
Chrysophyllum Roxburghii *G. Don.*	C. Roxburghii *G. Don.*
Palaquium obovatum *Clarke*	Palaquium polyanthum *Benth.*
Ebenaceae	
absent.	Maba cacharensis *Das et. Kanjilal.*
Diospyros Toposia *Ham.*	D. Toposia *Ham.*
D. nigricans *Wall.*	D. nigricans *Wall.*

Assam Valley.	Surma Valley.
Styraceae	
Symplocos oxyphylla *Wall.*	S. oxyphylla *Wall.*
S. theaefolia *Ham.*	absent.
Styrax serrulatum *Roxb.*	S. serrulatum *Roxb.*
Apocynaceae	
Parameria polynuera *Hk. f.*	absent.
Chonemorpha Griffithii *Hk. f.*	absent.
Aganosma caryophyllata *G. Don.*	Aganosma marginata *G. Don.*
Asclepiadaceae	
Cryptolepis Buchanani *R. & Sch.*	absent.
C. elegans *Wall.*	C. elegans *Wall.*
Loganiaceae	
Strychnos laurina *Wall.*	S. laurina *Wall.*
Acanthaceae.	
Phlogacanthus thyrsiflorus *Nees*	P. thyrsiflorus *Nees.*
Myristicaceae	
Myristica amygdalina *Wall.*	M. amygdalina *Wall.*
M. angustifloria *Roxb.*	M. angustifolia *Roxb.*
Lauraceae	
Cryptocarya amygadalina *Nees.*	C. amygadalina *Nees.*
C. Andersoni King	C. Andersoni *King.*
Beilschmiedia Roxburghiana *Nees*	absent.
B. assamica *Meissn*	absent.
absent	Endiandra firma *Nees.*
Cinnamomum Tamala *Fr. Nees*	C. Tamala Fr. *Nees.*
C. obtusifolium *Nees*	C. obtusifolium *Nees.*
absent	C. cacharensis *Parker.*
Alseodaphne petiolaris *Hk. f.*	A. Owdenii *Parker.*
absent	A. Keenani *Gamble.*
Machilus bombycina *King.*	absent.
M. globosa *Das*	absent.
Phoebe goalparensis *Hutch.*	absent.
P. Cooperiana *Das*	absent.
Actenodaphne obovata *Messn.*	A. obovata *Messn.*
Litsaea citrata *Bl.*	L. citrata *Bl.*
L. polyantha *Juss.*	L. polyantha *Juss.*
Purkayasthaea pseudomacropora *Purk. ex Narayanaswami*	absent.
Euphorbiaceae	
Baccaurea sapida *Muell.*	B. sapida *Muell.*
Aporosa Roxburghii *Bail.*	A. Roxburghii *Bail.*
A. Wallichii *Hk. f.*	absent.
absent	Cyclostemon eglandulosa *Kurz.*
Cyclostemon assamica *Hk. f.*	C. assamica *Hk. f.*
Putranjiva Roxburghii *Wall.*	absent.

Moraceae

Species of Glochidion.

absent	Chaetocarpus castanocarpus *Thw.*

Assam Valley.	Surma Valley.
Many species of Ficus.	
Fagaceae.	
Quercus spicata *Smith*	absent.
Q. Milroyii *Purk.*	absent.
Castanopsis indica *A. Dc.*	C. indica *A.Dc.*
C. hystrix *A.Dc.*	C. hystrix *A.Dc.*
Podocarpaceae.	
Podocarpus nerifolius *Don.*	P. nerifolius *Don.*
absent.	P. latifolia *Wall.*
Gnetaceae	
Gnetum gnemon *Linn.*	absent.
G. scandens *Roxb.*	G. scandens *Roxb.*
Palmaceae	
Levistonia Jenkinsii *Griff.*	absent.
Pinanga gracilis *Bl.*	absent.
Bambusaceae	
Dendrocalamus Hamiltonii *Nees*	Melocanna bambusoides *Trin.*
Teinostachyum Dullooa *Gamble*	T. Dullooa *Gamble*
Bambusa arundunacae *Willd.*	B. arundinacea *Willd.*
Pseudostachyum polymorphum *Munro.*	absent.

There is also a dense evergreen undergrowth consisting of a considerable number of species which are not mentioned above. The uppermost storey is often represented by such species as *Dipterocarpus macrocarpus* Vesque., *Canarium bengalense* Roxb., *Artocarpus chaplasha* Roxb., *Tetrameles nudiflora* R. Br., and *Alianthus grandis* Prain. The type is also characterised by larger number of climbers belonging to the genera *Bauhinia, Acacia, Vitis, Unona, Uvaria, Mezoneurum* and *Calamus*, in addition to the species enumerated above.

(*ii*) *The Deciduous Forests.*—This type comprises the Sal areas of Goalpara, Kamrup, Garo Hills, Nowgong and major part of the deciduous forests of the province including N. Cachar Hills and also the western part of Darrang and drier plains of Surma Valley.

In sal (*Shorea robusta* Gaertn.) tracts, the usual associates such as *Millusa velutina* Hk. f. & T., *Lagerstroemia parvifolia* Roxb., *Kydia calycina* Roxb., *Sterculia villosa* Roxb., *Grewia elastica* Royle., *G. Microcos* Linn., *Schima Wallichii* Choisy., *Careya arborea* Roxb., *Terminalia belereca* Roxb., *Desmodium pulchellum* Benth., *D. pseudo-triquetrum* Dc., *Bauhinia malabarica* Benth., *B. tenuiflora* Watt., *Cassia Fistula* Linn., *Albizzia lucida* Benth., *A. odoratissima* Benth., *Randia dumetorum* Lamk., *Spatholobus Roxburghii* Benth., *Vitis latifolia* Roxb., and *Milletia auriculata* Baker., occur with local variation. A certain number of Gramineæ, *viz.* :—*Saccharum narenga* Wall., *Imperata arundinacea* Cyrill., and *Anthistiria giangantea* Cav., is present almost everywhere; but where Sal entirely disappears (N. C. Hills, drier parts of Nowgong, Mikir Hills, Sylhet and Cachar) the floristics consist of *Bombax malabaricum* Dc., *Hibiscus macrophylla* Roxb., *Garruga pinnata* Roxb., *Adina cordifolia* Hk. f. & T. *A. polycephala* Benth., *Mitragyna diversifolia* Haviland., *M. parviflora* Korth., *Sarcocephalus cordatus* Miq., *Ficus* sp. and many of the Sal associates.

(*iii*) *Grassland.*—The grassland in the Province has been classified into two types by Rai Bahadur U. N. Kanjilal, F.L.S. and Mr. H. G. Champion in his book referred to above adopted more or less similar classification.

(1) Riparian flats of Assam and Surma Valleys are generally inundated every year during the rains and remain under water for a considerable period. Species of Saccharum, Anthistiria, Erianthus, Arundo and Phragmites, most of them attaining gigantic size, represent the riparian type of vegetation.

(2) Drier but extensive savannas are often suitable for production of Sal. Here the species are more hardy and comparatively smaller in size.

The representative species are *Imperata arundinacea* Cyrill, *Apluda varia* Hack., *Pollinia ciliata* Trin., *Anthistiria gigantea* Cav., *Saccharum narenga* Wallich *ex* Hackel, *Papsalum scrobiculatum* Linn., *Ischæmum ciliare* Retz., *Bombax malabaricum* Dc., *Zizyphus Jujuba* Lamk., *Terminalia belerica* Roxb., *Macaranga* sp. and *Grewia sapida* Roxb.

(*iv*) *Riparian forests.*—This type extends over all alluvial formations along the large rivers or the streams in both the valleys.

Floristics of the riparian trees

Lagerstrœmia Flos-Reginæ *Retz.*	..	Dillenia indica *Linn.*
Pterospermum acerifolium *Willd.*	..	Bischofia javanica *Bl.*
Terminalia myriocarpa *Heurek.*	..	Cudrania javanensis *Trecul.*
Duabanga sonneratioides *Ham.*	..	Flemingia lineata *Roxb.*

(*v*) *The Swamp Forests.*—This type extends over the whole Province in all Jheels, lakes and depressions containing water and large *beels* (sometimes constituted of abandoned river channel). These *beels* full of aquatic vegetation abound in the Brahmaputra valley (Dhemaji swamps, north bank Lakhimpur, Kamrup, Goalpara and Garo Hills) as well as in the Surma Valley.

Floristics of the Swamp vegetation

Acquatic families such as Nymphæaceæ, Lemnaceæ, Araceæ, Cyperaceæ, Eriocaulaceæ and Naiadaceæ are common. *Trapa bispniosa* Roxb., *Typha elephantina* Roxb., and several shrubby species, *e.g.*, *Cratæva lophosperma Kurz.*, *Eugenia cuneata* Wall., *Rotula acquatica* Lour., *Homonia riparia* Lour., *Draceana spicata* Roxb., *Salix tetrasperma* Roxb., *Clynogyne dichotoma* Salisb., *Arundo Donax* Linn., and *Phragmitis Karka* Trin., are abundant.

II. Temperate

This type of vegetation occurs between 4,000 to about 8,000 feet in Khasi and Jaintia Hills, Naga Hills, part of Lushai Hills, Mikir Hills and far Eastern Himalayas (the Northern Frontier of the Province—Balipara Frontier Tract and N. E. F. Tract).

It may also be mentioned here that transitional forms predominate in suitable localities and that floristics also overlap. Some species of this region descend down to the evergreen type at the foot-hills and some, on the other hand, reach an altitude above 8,000 feet in the sub-alphine zone.

Ranunculaceæ.
Clematis montana *Ham.*
Anemone elongata *Don.*
Thalictrum foliolosum *Bl.*
Delphinium altissimum *Wall.*

Magnoliaceae.
Michelia lanuginosa *Wall.*
M. punduana *Hk. f. & Th.*
Schizandra propinqua *Hk. f. & Th.*

Berberidaceæ.
Berberis Wallichiana *DC.*
Mahonia nepalensis *DC.*

Rutaceæ.
Xanthoxylum khasianum *Hk. f.*
Skimmia laureola *Hk. f. & Th.*

Aquifoliaceæ.
Ilex theæfolia *Hk. f.*
I. khasiana *Purk.*

Celastraceæ.
Euonymus Hamiltonianus *Wall.*

Ampelidaceæ.
Vitis Sp.

Aceraceæ.
Acer lævigatum *Wall.*

Leguminosæ.
Piptanthus nepalensis *D. Don.*
Indigofera nigrescens *Kurz.*
I. Dosua *Ham.*
Desmodium racemosum (*Thunb.*) *DC.*
Lespedeza eriocarpa *DC.*
Flemingia prostrata *Roxb.*
Albizzia Julibrissin *Durazz.*
Rubus birmanicus *Hk. f.*
R. ellipticus *Sm.*

Rosaceæ.
Prunus cerasoides *D. Don.*
Potentilla Mooniana *Wight.*
Rubus assamensis *Focke.*
Agrimonia Eupatorium *Linn.*
Spriæa callosa *Thunb.*
Neillia thyrsiflora *Don.*
Rosa longicuspis *Thunb.*
Eriobotrya angustissima *Hk. f.*
Pyrus khasiana *Dcne.*
Sorbus expansa *Koehne.*
Photinia Notoniana *W & A.*
Cotoneaster Simonsii *Baker.*

Hamamelidaceæ.
Corylopsis himalayana *Griff.*
C. manipurensis *Hemsl.*
Bucklandia populnea *Br.*

Melastomaceæ.
Osbeckia crinita *Benth.*
Melastoma Sp.
Medinilla himalayana *Hk. f.*

Cucurbitaceæ.
Momordica dioica *Roxb.*

Begoniaceæ.
Begonia laciniata *Roxb.*

Araliaceæ.
Aralia pseudo-ginseng *Benth.*
Pentapanax Leschenaultii *Seem.*

Cornaceæ.
Cornus controversa *Hemsl.*

Saxifragaceæ.
Saxifraga sarmentosa *Linn.*

Caprifoliaceæ.
Viburnum Simonsii *Hk. f. & Th.*
V. corylofolium *Hk. f. & Th.*
V. foetens *Dcne.*
Lonicera macrantha *DC.*

Rubiaceæ.
Leptodermis Griffithii *Hk. f.*
Coffea Jenkinsii *Hk. f.*
Psychotria symplocifolia *Kurz.*
Chassalia lushaiensis *Fischer.*

Valerianaceæ.
Valeriana Wallichii *DC.*

Compositæ.
Siegesbeckia orientalis *Linn.*
Sonchus arvensis *Linn.*
Senecio densiflorus *Wall.*
Taraxacum officinale *Wigg.*
Carthamus tinctorius *Linn.*
Lactuca macrorhiza *Hk. f.*

Vacciniaceæ.
Agapetes marginata *Don.*
Pentapterygium rugosum *Hk. f.*
Vaccinium Griffithianum *Wight.*

Ericaceæ.
Gaultheria fragrantissima *Wall.*
G. codonantha *Airy-Shaw.*
Pieris ovalifolia *D. Don.*
Craibodendron Henryi *W. W. Smith.*
Rhododendron arboreum *Sm.*
R. formosum *Wall. & R.* inæquale *Hutch.*
Pyrola rotundifolia *Linn.*

Primulaceæ.
Lysimachia racemosa *Wall.*
Primula denticulata *Smith.*

Myrsinaceæ.
Ardisia khasiana *Clarke.*

Styraceæ.
Symplocos Sp.
Parastyrax Lacei *Smith.*

Oleaceæ.
Osmanthus fragrans *Lour.*
Ligustrum Massalongianum *Vis. Pl. Orto.*
Fraxinus floribunda *Wall.*

Apocynaceæ.
Melodinus khasianus *Hk. f.*

Ascelpiadaceæ.
Marsdenia Griffithii *Hk. f.*
Cynanchum deltoideum *Hk. f.*

Loganiaceæ.
Buddleia paniculata *Wall.*
Gardneria angustifolia *Wall.*

Convolvulaceæ.
Porana racemosa *Roxb.*

Scrophulariaceæ.
Wightia gigantea *Wall.*

Acanthaceæ.
Strobilanthes auriculatus *Nees.* & other species

Verbenaceæ.
Callicarpa psilocalyx *Clarke.*

Labiatæ.
Colquhounia coccinea *Wall.*

Polygonaceæ.
Polygonum paniculatum *Bl.*

Aristolochiaceæ.
Aristolochia platanifolia *Duchart.*

Lauraceæ.
Beilschmiedia Gammieana *King.*
Machilus Gamblei *King.*
Phoebe pallida *Nees.*
Lindera caudata *Benth.*

Thymeleaceæ.
Daphne cannabina *Wall.*
Wikstroemia canescens *Meissn.*

Elaeagnaceae.
Elaeagnus umbellata *Thunb.*

Ulmaceæ.
Ulmus lancifolia *Roxb.*
Gironniera reticulata *Thw.*

Myriacaceæ.
Myrica Nagi *Thunb.*

Betulaceæ.
Betula alnoides *Ham.*
Alnus nepalensis *Don.*
Carpinus viminea *Wall.*

Fagaceæ.
Quercus Griffithii *Hk. f. & Th.*
Q. lineata *Bl.*
Q. pachyphylla *Kurz.* & other species.
Castanopsis armata *Spach.* & other species.

Salicaceæ.
Salix eriophylla *And.*

Gramineæ.
Arundinaria khasiana *Munro.*
A. collosa *Munro.*

Podocarpaceæ.
Podocarpus latifolia *Wall.*

Taxaceæ.
Taxus bacata *Linn.*
Cephalotaxus Mannii *Hk. f.*
C. Griffithii *Hk. f.*

Pinaceæ.
Pinus khasya *Royle.*

III. Alpine Forests.

The altitudinal limits for this type of plant community lie generally between 9,000 and 12,000 feet ; but some species also descend below 9,000 feet or ascend higher even up to 15,000 feet (in Aka Hills Dr. N.L. Bor made extensive exploration of this zone). This type comprises the far Eastern Himalayas (Aka Hills, N. E. F. Tract) and summits of Naga Hills and Manipur and the floristics enumerated below are mainly based on Dr. Bor's collections:—

Agapetes discolor *Clarke.*

Vaccinium nummularia *Hk. f. & Th.*

Rhododendron Maddeni *Hk. f.*

R. Elliotii *Watt Mss ex Brandis.*

R. Macabeanum *Watt Mss ex Balfour.*

Strobilanthes Wallichii *Nees.*

Mastixia rostrata *Bl.*

Aucuba himalaica *Hk.*

Potentilla monanthes *Lindl.*

Sorbus Wenzigiana *Koehne.*

Arundinaria Maling *Gamble.*

Thamnocalamus aristatus *Camus.*

Saxifraga brachypoda *Don.*

S. hispidula *Don.*

Rubus pectinavis *Flocke.*

Deutzia purpurescens (*Hk. f. & T.*) *Engl.*

Sanicula hacquetoides *Franch.*

Abies Webbiana *Lindl.*

A. Delavayi *Franchet.*

Tsuga Brunoniana *Carr.*

Pinus excelsa *Wall.*

Juniperus recurva *Ham.*

Bromus tectorum *Linn.*

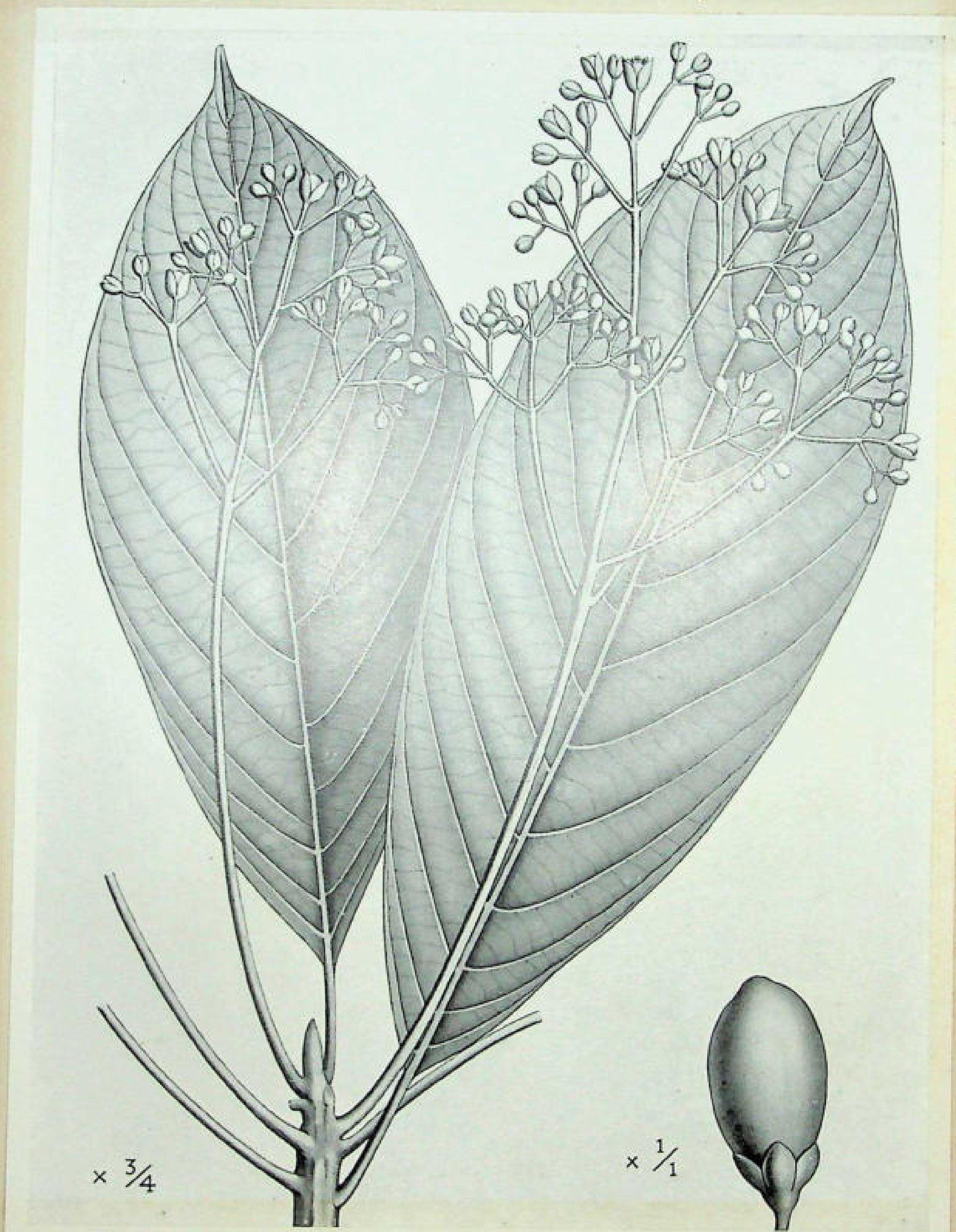
Stipa Roylei (Nees) *Mez.*

A systematic and intensive study of plant ecology of Assam is thus indicated above.

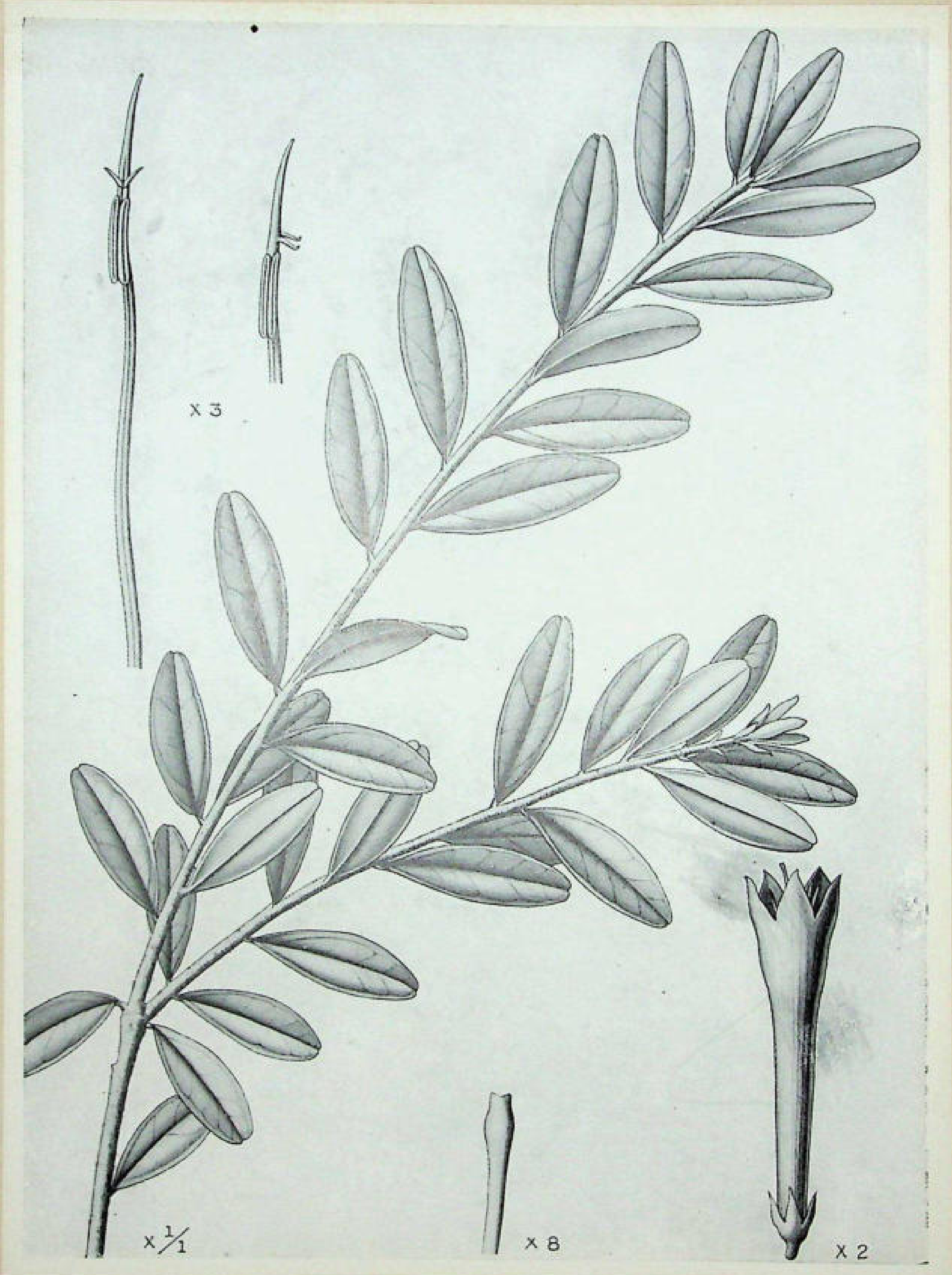
Assam owes a deep debt of gratitude to the Royal Botanic Garden, Sibpur, for the kind assistance rendered in every way for over 50 years for determination of her own plants. The author is grateful to Dr. K. Biswas for reading the proof of his paper.

"Flora of Assam" (Kanjilal and Das) "Aims and methods in the study of vegetation" (Tansley and Chipp) and " Indian Forest Records " (New Series), Vol. I, No. I (Champion), have freely been consulted in drawing up this paper.

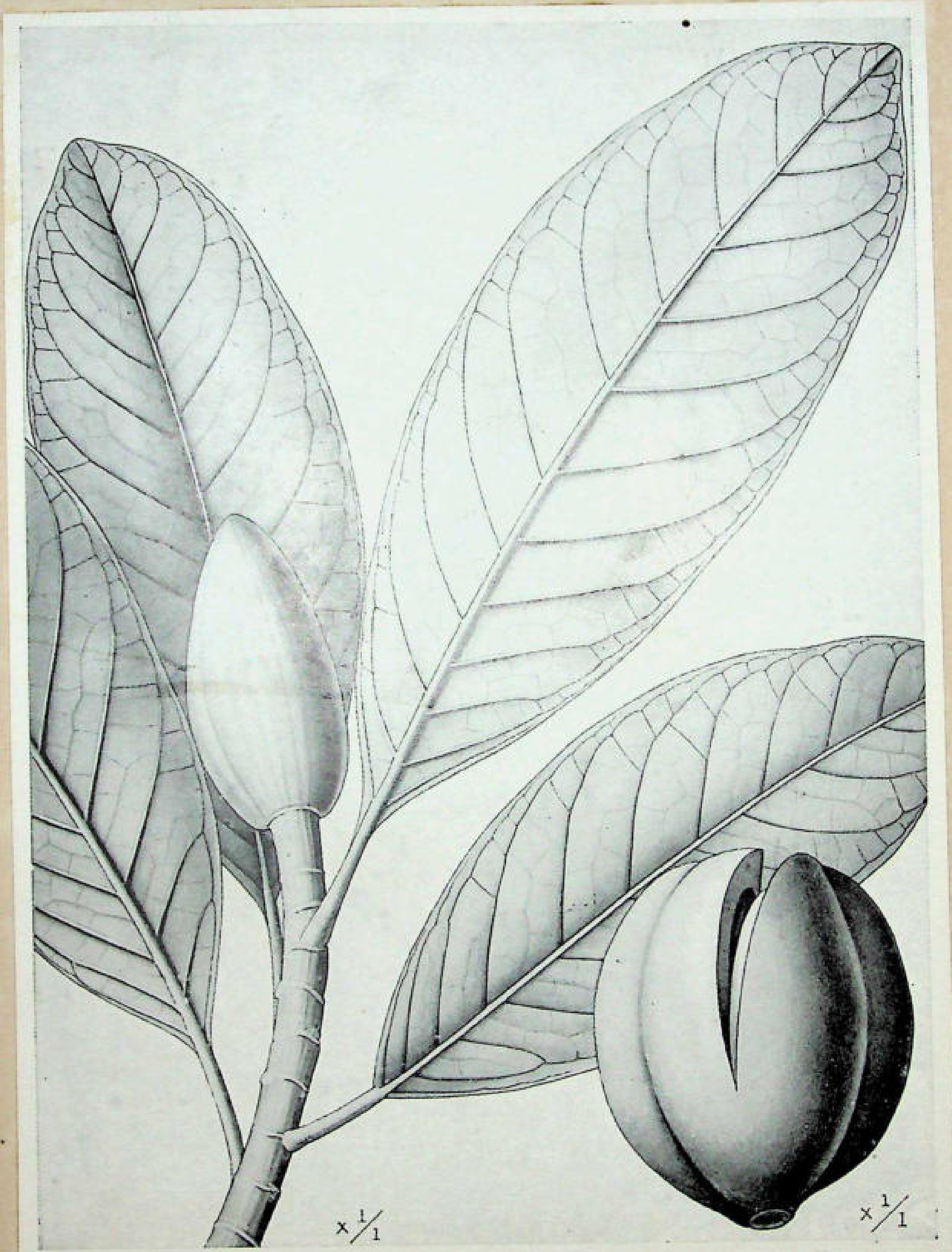
Machilus globosa *Das*, a twig with leaves and flowers and a fruit shown separately (all natural size).



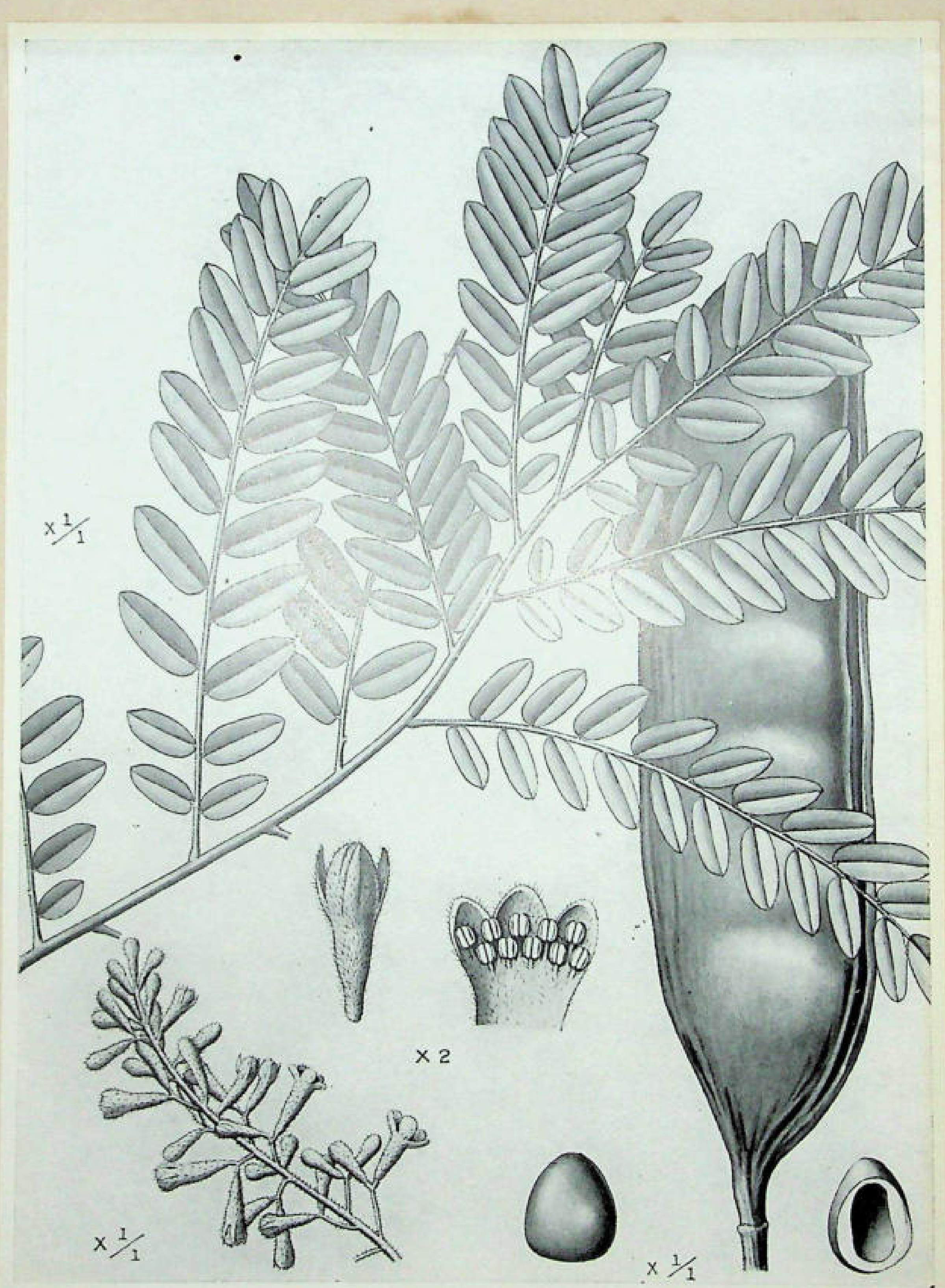
Phoebe Cooperiana *Kanjilal et Das*, a twig with leaves and flowers (¾ natural size) and a fruit shown separately (natural size).



Agapetes Kanjilal *Das*, a branch (normal size) showing leaves; flower more or less diagrammatic (×2); anthers (×3) showing the beak and bifurcated process; stigma (×8). (*cf.* tab. 5012 Curtis's Botanical Magazine, Vol. XIII, 1857).



Pachylarnax Pleiocarpa *Dandy*, one branch with a solitary flower and a concrescent fruit showing dehiscence. Each valve is composed of united halves of two adjacent carpels (normal size).



Gymnocladus assamicus *U. N. Kanjilal ex P. C. Kanjilal,* part of the leaf; pod; inflorescence (normal size); calyx and longitudinal section of the flower ×2; seed and section of seed showing the hard horny tesia (normal size).

Maba cacharensis *Das et Kanjilal*, Branch; inflorescence on old wood; fruit (normal size); 6-celled ovary (×6); calyx (×2); pilose ovary and calyx (×3).

Synplocos Pealii *King ex Das*, a branch (½) showing inflorescence; 2. Flowers (×5); 3. Petals (×5);
4. Mature fruit showing seed (×½); 5. a young fruit (×1½).

Chirita mishmiensis *Debbarman ex Biswas,* the whole plant and floral parts dissected to show the calyx and pistil in one and stamens in another (all natural size).

Eugenia cyanophylla *Kanjilal et Das*, Branch; inflorescence; dissection of flower and ovary (natural size).

Principal Citrus Fruits of India[1]

by

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(1) *Citrus chrysocarpa* Lush. in Ind. Forester 36 (6/7): 343, 1910=*Citrus poonensis* Hort. ex Tanaka in Mem. Tanaka Cit. Exp. Stat. 1:29, 1927=*Citrus Khasia* Marc. in Trud. Prikl. Bot. 24:434, 1931=*Citrus Suntara* Hort. ex Tanaka l.c.p.32. (nomen)=*Citrus Aurantium* Linn. subsp. *Suntara* Engl. in Engl. and Pr. Pflfam. 3. Abt. 4:199, 1896.

Bushy tree of upright habit with many fine branches, attaining to 20 feet or more in height. Leaves elliptic, subacute, emarginate at the tip, petiole short, wing linear. Fruits medium large, heavy, apex concave in a large area and always with regular radial grooves from the stylar end, base often projected, surface deep orange in colour with very minute oil cell dots, to some extent forming miliary convexities at the basal half. Calyx small. Rind thin, in uniform thickness, becoming detached from segments in full maturity, brittle; oil cells congested, large, much graded. Segments easily detached, central column large, hollow. Pulp meaty, orange-coloured, extremely good tasted; vesicles rather large sized, moderately elongate-netted in cross section. Seeds few, small, plump, smooth, somewhat striate-netted, light straw-coloured, tegmen yellow whitish, chalaza part ochre yellow, containing yellow-green polyembryos.

This is the commonest commercial orange in India, Ceylon, Java, Southern China and Formosa. The Santara (Sùntara) of Nagpur, Poona and Punjab; Kamala of Bengal, Walaja Kamala of Madras, Emmey Doddy or Kadug Aranj (Coorg orange) of Mysore, Kittale Hanno of Coorg, Soh Niamtra, Soh Myntra or Ushamantra of Assam, and Jamanaran of Ceylon. The Nagpur type is identical with South China race, but Lahore variety is very characteristic having long pyriform shape with a few number of segments very loosely attached. The Nagpur type never gets taste in U. P. Those from high altitude, for instance, Kalimpong (so-called Darjeeling orange), Sylhet (from Cherr and Shella Ghat of Assam), Coorg (Mercara region), etc., are by no means forming any particular variety, though the fruits are small, very deep coloured, and intensely flavoured.

(2) *Citrus sinensis* Osbeck Reise Ostind. China. p. 250, 1765=*Citrus Aurantium* Lour., non. Linn., Fl. Cochinch. 2 : 466, 1790, and later Authors=*Citrus Aurantium* subsp. *sinensis* Engl. l. c. p. 198.

Tree of somewhat spreading habit, branches thick, not bushy, attaining to 25 feet or more. Leaves rather large, thick, ovate, acute, generally pointed at the tip, venation rather strong. Fruits medium large, nearly globose, ends rounded, surface gold yellow or orange, smooth, oil cell dots very minute and graded, generally flat convex, large ones may be pitted distantly, sometimes areolate. Calyx very large, irregularly 5-lobed, lobes acuminate and sharp pointed. Rind moderately thick, tightly fitted, oil cells minute, not much graded. Segments adherent, very uniform, inner end acutely chisel-pointed,

[1]Communications from the Horticultural Institute, Taihoku Imperial University, No. 61.

central column small, filled. Pulp firm, gold yellow or orange, highly flavoured though not so sugary as the preceding, vesicles abundant, finely parallel-netted and closely inter-woven. Seeds large, plump, rectangular, often with pointed base, smooth, sometimes oblique-striated, light cream-coloured, tegmen ochraceous, chalaza part pale brick-coloured, containing white polyembryos.

The sweet orange or Malta orange of N. W. India, Chinese or Batavia orange of Madras, Satladi of Coorg, etc. The Musembi of Poona, Bombay, Nagpur, etc., is a form with longitudinal corrugation, and acidless pulp. There are several allied species in Assam, telling its eastern origin, but it is almost not known in Himalayan region. This is the species most widely cultivated in large citrus producing centres of the world, such as California, Spain and other Mediterranean countries, Florida, Palestine, South Africa, Australia, and South China. Several varieties are tried in U. P. and Punjab, and blood red Malta and allied strains are found most fitted and the Washington Navel is not promising. The Chamouti (Palestine), Valencia (California), Parson Brown (Florida), etc., must be tried for improving the crop.

(3) *Citrus aurantifolia* Swingle in Wash. Acad. Sci. 3(18) : 465, 1913=*Citrus acida* Roxb. Fl. Ind. 3 :390, 1932, pro parte=*C. lima* Lunan Hort. Jam. 1 :451, 1814 ; Raf. Syl. Tell. 143, 1838=*Citrus bergamia* Voigt, non Risso et Poit., Hort. Suburb. Calc. 142, 1845, and later authors.

Generally small tree with somewhat flexuose very spiny branches; leaves small, ovate, thin, finely reticulate, petiole winged. Flowers small with white petals, forming a small raceme. Fruits small, globose or oblong, slightly mamillate at the apex, base also sometimes nippled, very smooth, pale lemon yellow ; rind very thin, tightly attached, central column small, filled or split ; pulp yellow green, hard in texture, semi-transparent, very acid, vesicles extremely fine and parallel, shiny and elastic. Seeds gathered at the centre and varying in size, small, elliptic, plump, base sharply pointed, often curved in comma-shape, creamy white, smooth, sometimes obliquely striated, testa thin, tegmen light incarnate-testaceous, chalaza part vinous, secondary embryos often greenish.

The common kaghzi lime of India, widely cultivated in gardens but its wild occurrence has not been confirmed. There are several varieties known in Bengal and other places.

(4) *Citrus medica* Linn. Sp. Pl. ed. 1. p. 782, 1753=*C. limonimedica* Lush. in Ind. Forest. 36 :348, 1910=*C. medicolimonum* Lush. 1. c. 349.

Low branching tree with much flexuose spring twigs. Leaves lanceolate, serrate on the margin, petiole short, nearly naked, often confluent with the lamina. Flower large forming a small receme or panicle, petals purple outside (rarely white), filaments often pubescent. Fruit cylindric or lemon shaped with conspicuous apical projection often terminated by persistent style. Calyx very large and thick, lobes almost uncut and dentate. Fruit surface lemon yellow, generally uneven, often much tuberculate, oil cell dots frequently very far apart. Rind very thick and pure white, inside texture very hard, with remote oil cells of indefinite margin. Segment wall very thick ; pulp lemon yellow, very transparent, solid, mildly acid or insipid, vesicles elongated, linear, often undulate or contorted, nearly obtuse at end, faintly grooved, dark coloured on side, testa firm, tegmen yellowish brick coloured, chalaza part bay coloured, very deep in tone, creamy monoembryonic. (In white flowers variety, the tegmen also nearly colourless.)

The Citron (Mahlung) with many varieties. Bonavia classes them into three large groups : (1) Turunj, the large-fruited acid variety, (2) Madhkankree, large-fruited sweet variety, and Bajoura, small-fruited acid variety. Some large-fruiting variety has leaves with well developed petiole wing.

The Ferns of Mussoorie and Dehra Dun

by

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The following list is the result of the collecting of seven summers beginning with 1930. I have also gone through the excellent collection of ferns in the Herbarium of the Forestry Research Institute at Dehra Dun and the E. W. Trotter collection in the Herbarium of Gordon College, Rawalpindi. Colonel E. W. Trotter collected widely in the western Himalayas and he exchanged with a good many correspondents as his collection contains specimens of Thomson, C. B. Clarke, Duthie, Blanford, King, Bliss, Mann, Watt the Mackinnons, etc. I have checked many identifications at the Royal Botanical Garden at Kew and at the New York Botanical Garden where there are valuable Indian collections and I am grateful to Mr. Ballard at Kew and to Dr. E. D. Merrill at New York for their courtesy and consideration.

Mussoorie is 30° 27′ north latitude and 78° 15′ east of Greenwich. It is a Himalayan hill station and with its suburb, Landour, occupies the summits of a range of hills which forms part of the watershed between the Jumna and the Ganges rivers. The greatest height is almost 7,500 feet. Dehra Dun, as the crow flies, is hardly ten miles from Mussoorie and has an altitude of 2,200 feet. The district of Dehra Dun is separated from the plains of the United Provinces by the Siwalik Range. Both places have a heavy monsoon rainfall of some 70 inches a year while the rest of the year is comparatively dry. The climate is damp enough to permit the growth of epiphytes and epiphytic ferns are very abundant at the higher levels, becoming less frequent as one descends to Dehra.

The synonymy of ferns presents a difficult problem. I have tried to follow the names accepted by C. Christensen in his Index Filicum, and for the convenience of those who use Beddome's Ferns of British India I have given the name he uses as a synonym.

(1) Trichomanes bipunctatum Poir.

Collected several times from 5,500 to 6,500 feet on rocks and trees in the dampest ravines.

(2) Woodsia elongata Hook.

Reported by Duthie and Mackinnon. I have only found it on Nag Tibba, a few miles to the northwest.

(3) Dennstaedtia scabra (Wall) Moore.

Found occasionally from Dehra Dun to 4,000 feet, Hope, Herschel and Mackinnon.

(4) Dryopteris cochleata (Don) C. Chr. var Schimperiana (Clarke) C. Chr.

Lastrea Filix-mas var. elongata Bedd. Handb. p. 250.

Lastrea Filix-mas var. Schimperiana Bedd. Handbook Suppl. 58.

In Mussorie this is a very common fern in the oak forest and I do not think that it should be considered a form of cochleata which grows at much lower levels and is dimorphic and fruits much later. There is no danger of mixing them when seen in the field. 5—7,000 feet. Should be called D. Schimperiana.

(5) Dryopteris cochleata (Don) C. Chr. Index 258. 1905.

Lastrea Filix-mas var cochleata Don ; Bedd. Handb. p. 250.

In this area this fern is quite distinct from the last and is fairly common from Dehra Dun to 4,000 feet. Champion states that it is common in chir forests.

(6) Dryopteris odontoloma (Moore) C. Chr. Acta Hort. Gothob I. 59. 1924.

Lastrea Filix-mas var odontoloma, Bedd. Handb. Suppl. 55.

Fairly common in the oak forest, but is usually in more shady places than Schimperiana. The pinnae are more finely divided and the sori are much smaller. Usually above 6,000 feet.

(7) Dryopteris marginata (Wall) Christ 1901.

Lastrea Filix-mas var marginata Bedd. Handb. Suppl. 56.

This fern is common at the same altitudes as odontoloma and Schimperiana, but it may grow as low as 4,500 feet. It is usually larger and the outline of the frond is more triangular. It is not tufted like the others but the stipes are usually single. Grows in rich humus in the forest.

(8) Dryopteris crenata (Forsk) O. Kze. Rev. Gen. Pl. II. 811. 1891.

Lastrea crenata (Forsk) Bedd. Handb. p. 258.

This is a very common fern on cliffs and grows from 2—7,000 feet. The fronds vary greatly in size and are triangular. They bear at their base a fine, long tuft of chestnut covered scales. The rhizomes are often hard to extract from the rock crevices in which they grow.

(9) Dryopteris gracilescens (Bl) O. Kze., Rev. Gen. Pl. II. 812. 1891.

Lastrea gracilescens Bl., Bedd. Handb. p. 234.

Rare ; reported by Duthie from Phedi, east of Landour, 4—5,000 feet.

(10) Dryopteris calcarata (Bl) O. Kze. Rev. Gen. Pl. II. 812. 1891.

Lastrea calcarata Bl., Bedd. Handb. p. 235.

Apparently rare ; Inayat Nos. 26042, 43, Dehra Dun.

(11) Dryopteris sparsa (Ham) O. Kze., Rev. II. 813. 1891.

Lastrea sparsa Don, Bedd. Handb. p. 252.

Rare ; Phedi, Duthie 4—5,000 feet, September, 1881 and " Muss " 1877.

Sterile leaves resemble D. cochleata.

(12) Dryopteris Boryana (Willd) C. Chr. Index 255. 1905.

Lastrea Boryana (Willd) Bedd. Handb. p. 266.

Rare ; collected by Herschel and Hope from 3—4,000 feet. The specimen of Duthie collected in 1877 is D. late-repens.

(13) Dryopteris brunnea C. Chr. Index 255. 1905.

Phegopteris distans Don, Bedd. Handb. p. 292.

This fern is distinguished from late-repens by the absence of a creeping rhizome but as none of the specimens marked brunnea in the Dehra Herbarium or in Gordon College have a root stock I am inclined to think that they are all late-repens which is not rare. The rhizome is neglected by too many collectors.

(14) Dryopteris late-repens (Trotter and Hope) C. Chr. Ind. 274. 1905.

This species is found in wet soil near water. It is common in the ravine below the Jabberkhet Spring at 7,000 feet.

(15) Dryopteris Levingei (Clarke) C. Chr. Ind. 275. 1905.

Leptogramme aurita var. Levingei (Clarke) in Bedd. Handb. p. 379.

This has been collected on Nag Tibba and on the Mussoorie-Chakrata Road and may turn up in the Mussoorie area.

(16) Dryopetris repens (Hope) C. Chr. Ind. 288. 1905.

Lastrea ochthodes Kze. Bedd. Handb. p. 240 in part.

This fern is close to ochthodes but the lower pinnae are not gradually reduced as they are in papilio and ochthodes but are suddenly reduced to tuberculated glands. It grows in damp, rich soil near streams, 5—7,000 feet.

(17) Dryopteris ochthodes (Kze) C. Chr. Ind. 280. 1905.

Lastrea ochthodes Kze. Bedd. Handb. p. 240 in part.

The auricles down the stem are intermediate between those of papilio and repens. Not common. I seem to have collected it only in the gorge on the north slope of Landour in the same sort of place favoured by late-repens and papilio. A specimen in Dehra collected in " Muss " in 1871 is labelled Polypodium auriculatum Wall.

(18) Dryopteris papilio (Hope) C. Chr. Ind. 282. 1905.

Nephrodium papilio Hope.

Nephrodium molle (Desv) var. major Bedd. Handb. Suppl. 76.

Rather rare, near water. A handsome fern with a shuttlecock like tuft of fronds with butterfly like auricles down the stem. 4—6,000 feet usually, but Trotter collected it in Dehra Dun.

(19) Dryopteris molliuscula (Wall) C. Chr. Ind. 278. 1905.

Nephrodium microsorum (Clarke) Bedd. Handb. p. 270.

Only reported from near Dehra, Lachiwala ; Hope and Parker. This is a strongly creeping plant related to arida and subpupescens (molle).

(20) Dryopteris arida (Don) O. Kze. Rev. Gen. Pl. II. 812. 1891.

Nephrodium aridum Don, Bedd. Handb. p. 272 also Suppl. 69.

Not common, usually below 3,000 feet although Duthie has a specimen in Dehra collected in 1877 marked " Muss ". A specimen of Parker's from Phandawala in the Dun is labelled Nephrodium aridum Don var. maximum Haines.

(21) Dryopteris rampans (Baker) C. Chr. Index Suppl. III. 96.

Dryopteris penangiana (Hook) C. Chr. Index. 283. 1905.

Nephrodium costatum (Wall) Bedd. Handb. p. 275 and Suppl. p. 73.

The sterile fronds come up first in rich soil near water from 5—7,000 feet. The fertile leaves come up in August. The plant resembles moulmeinensis, but the whole plant is smaller, the leaflets are narrower and this is a plant of higher levels.

(22) Dryopteris moulmeinensis (Bedd) C. Chr. Index 278. 1905.

Nephrodium moulmeinense Bedd. Handb. p. 275.

Usually from 2—4,000 feet. More coriaceous than the last species.

(23) Dryopteris erubescens (Wall) C. Chr. Index 263. 1905.

Phegopteris erubescens Bedd. p. 289.

This is a common fern below springs and by the side of streams and like Woodwardia radicans lasts well into the winter. The fronds are arching and are often 5—6 feet in length. The sori are in rows close to the midrib. 5—7,000 feet.

(24) Dryopteris africana (Desv) C. Chr. Ind. 251. 1905.

Leptogramme Totta Schl. Bedd. Handb. p. 377.

Rare in the area. Herschel reported it from Mussorie but Hope doubted the record. I have found it at the bottom of the ravine on the north slope of Landour at about 6,000 feet.

(25) Dryopteris subpubescens (Bl) C. Chr. Gardens Bull. Straits Settlements 4·390. 1929.

Nephrodium molle Desv., Bedd. Handb. p. 277.

The synonymy of this species is very difficult and I am not certain that the north Indian specimens of " molle " or " parasitica " are true subpubescens. This is a plant of the lower levels and is usually found in the Dun but Duthie reports one specimen from Mussoorie and Campbell and Hope at 5,000 feet below Khiarkuli.

(26) Dryopteris prolifera (Retz) C. Chr. Index. 286. 1905.

Goniopteris prolifera Roxb. Bedd. Handb. p. 296.

This is another plains and foothills plant usually found below 3,000 feet. Common about Dehra on the banks of rivers and ditches.

(27) Hypolepis punctata (Thunb) Mett. ; Kuhn Fil. Afr. 120. 1868.

Phegopteris punctata Thunb., Bedd. p. 295.

Not common, reported by Herschel at 4,000 feet., near Bhatauli at 4,500 feet and on the Mussoorie-Chakrata Road. The hairy, creeping rhizomes are thin for the size of the plant.

(28) Tectaria macrodonta (Fée) C. Chr. Index. Suppl. III. 181. 1934.

Aspidium cicutarium Sw., Bedd. Handb. p. 220.

Fairly common from 2—4,500 feet. Very variable in size and lobing.

(29) Polystichum squarrosum (Don) Fée, 1850.

Polystichum aculeatum Sw. var. rufo-barbatum Wall., Bedd. Handb. p. 207.

One of the commonest, if not the commonest fern in the oak forest. It is coriaceous and evergreen. The new set of leaves matures in August. 5,500—7,000 feet.

(30) Polystichum aculeatum (L) Schott Gen. Fil. ad. t. 9. 1834.

This is also a very common and variable fern, but it is much softer in texture than the last and grows in damper, more shaded places, especially in the deeper gorges. Has been found in Dehra Dun but usually from 5—7,000 feet.

(31) Polystichum lentum (Don) Moore Ind. 86. 1858.

P. auriculatum (L) var. lentum Don, Bedd. p. 204.

In our area it does not seem to have been collected above 4,500 feet. Phedi, 4—5,000 feet; near Bhatauli on the Chakrata Road; Suarna Nala, Hope 4,500 feet. Campbell, Hope, Mackinnon.

(32) Polystichum obliquum (Don) Moore Ind. 87. 1858.

P. auriculatum (L) var. coespitosum Wall., Bedd. p. 204.

Found occasionally in sheltered places where rocks overhang, from 5,500—7,000 feet.

(33) Cyrtomium caryotideum (Wall) Pr. 1836.

C. falcatum Sw. var. caryotideum Wall., Bedd. p. 211.

Occasional from 5—7,000 feet.

(34) Oleandra Wallichii (Hk) Presl. Tent. 78. 1836.

Occasionally found as an epiphyte climbing the trunks of trees. I have only found it twice, once near the old Brewery, and on rhododendron below Woodstock Hostel in Landour. P. N. Mehra found it on Benog. 6—7,000 feet.

(35) Leucostegia pulchra (Don) J. Sm. 1842.

Very rare in Mussoorie. Hope reports from Khiarkuli at 5,500 feet; Herschel, "Muss." Usually 8—11,000 feet.

(36) Leucostegia pseudo-cystopteris (Kze) Bedd. 1876.

This is the commonest epiphytic fern in Mussoorie and is found on banks and walls as well. Usually above 5,000 feet.

(37) Leucostegia immersa (Wall) Pr. 1836.

Fairly common from 6—7,000 feet but not seen as an epiphyte. Nalota Khala near Dehra, 2,700 feet.

(38) Stenoloma chusanum (L) Ching, Sinensia 3. 337, 1933.

S. chinensis. Swartz, Bedd. p. 70.

Duthie found at Phedi near Landour, 4—5,000 feet. Usually above 5,000 feet.

(39) Microlepia platyphylla (Don) J. Sm. Lon. Jo. Bot. I. 427. 1842.

Tehri Garhwal, near Muss. 4,000 feet. Mackinnon 1879.

(40) Athyrium falcatum Bedd. Ferns S. Ind. t. 151, 1863.

A. drepanophyllum (Bedd) Hk and Baker, Bedd. Handb. Suppl. p. 32.

There is a specimen in Herb. Dehra marked " Muss " Sept. 1879, but Hope says that it was collected on Bodh Raj Mt. overhanging the Jumna at the west and of the Mussoorie Range at 5,000 feet.

(41) Athyrium macrocarpum (Blume) Bedd. Ferns S. Ind. t. 152. 1863.

Mackinnon has a sheet in Herb. Dehra marked " Muss " but Hope thinks that it is a mistake. In Simla from 5—7,000 feet.

(42) Athyrium setiferum C. Chr. Index 146. 1905.

A. tenellum Hope, Journ. Bomb. Nat. Hist. Soc. 12, 529. t. 4. 1899.

There are two specimens in Herb. D., one from the Suarna Nala at 4,000 feet. and one 4—4,500 feet. Mackinnon and Hope. Also Dehra Dun.

(43) Athyrium Mackinnoni (Hope) C. Chr. Ind. 143. 1905.

A. nigripes Bedd. Handb. p. 166. in part.

In Herb. D. one of Herschel's specimens collected in 1878 is placed in this cover by Hope. It has no rhizome and I suspect that it is A. Schimperi.

(44) Athyrium Clarkei Bedd. Ferns. Brit. Ind. Suppl. 11. t. 360. 1876,

A. nigripes Mett. var Clarkei Bedd. Handb. p. 166.

This resembles A. Schimperi but the caudex is erect. A number of pteridologists still consider this to be a form of nigripes. Occasional from 3—7,000 feet, usually above 5,000.

(45) Athyrium rupicola (Hope) C. Chr. Ind. 145. 1905.

Rare, seen once by Hope at 7,000 feet and I have collected it once on Benog, No. 16,093 at 7,000 feet and at Jabberkhet, 7,000 feet.

(46) Athyrium Schimperi Moug.; Fée, Gen. 187. 1850-52.

Athyrium Filix-fœmina var. polyspora Clarke, Bedd. Handb. 170.

This is the common "lady fern" of the oak forest. It is often very abundant and is very like A. filix-foemina var. retusa except that this has a creeping rootstock.

(47) Athyrium pectinatum (Wall.) Pr. 1836.

A. filix-foemina Bernh. var. pectinata Wall. in Bedd. p. 169.

This has a wide creeping rootstock with the fronds more delicately cut than in Schimperi. It is found at Nalota Khala, Dehra, and ascends to about 6,000 feet.

(48) Athyrium spectabile (Wall.) Pr. Tent. 98. 1836.

Diplazium umbrosum J. Sm. var. multicaudatum Wall., Bedd. 190.

Not common, tends to grow in beds and fertile fronds are rare, rhizome creeping and the fronds are triangular. Mossy Falls, 5,500 feet ; Head of Suarna Nullah, 4,500 feet.

(49) Diplazium polypodioides Bl. Enum. 194. 1828.

Common in damp places from 5,500 feet to 7,500 feet. A very large form from 3-6 feet. The young fronds are eaten and called "lingra."

(50) Diplazium japonicum (Thunb.) Bedd. Ferns Br. Ind. Suppl. 12. 1876 ; Handb. p. 180.

Rare, near Muss. 1879, Mackinnon ; Bhatauli 4,000 feet, also a specimen of Herschel's in Herb. D., 3—4,000 feet.

(51) Diplazium esculentum (Retz) Sw. Schrad Journ. 1801^2. 312. 1803.

Anisogonium esculentum Presl. 1836, Bedd. p. 192.

A fern of lower levels ; has been collected a number of times in the vicinity of Dehra Dun.

(52) Diplazium lobulosum (Wall.) Pr. Tent. 114. 1836.

D. longifolium Don, Bedd. p. 179.

Not common. Has been found by Hope from Mundi koti ke Kalla 5,100 feet, 2-11-1881, and near the old Brewery 5,500 feet.

(53) Asplenium ensiforme Wall. List n. 200. 1828.

Fronds linear like those of Loxogramme and some Polypodiums. Rare. Has been found in the Park by Hope at 6,500 feet and I have found it in the gorge at the bottom of the north slope of Landour, 6—6,500 feet.

(54) Asplenium trichomanes L. sp. 2. 1080. 1753.

Not rare in the rich humus soil of the oak forest, 6—7,000 feet.

(55) Asplenium unilaterale Lamk. Enc. 2. 305. 1786 var. udum Atk.

Not common ; hangs from dripping rocks ; 4,500 feet to 7,000 feet. There is a fine patch in the gorge below the Jabberkhet Spring.

(56) Asplenium planicaule Wall. 1828.

A. laciniatum Don ; Bedd. Handb. p. 154.

An occasional epiphyte. It is firm in texture and rolls up in dry weather. 5—7,000 feet.

(57) Asplenium adiantum-nigrum L. sp. 2. 1081. 1753.

Herschel reports from Mussoorie but Hope doubts the record. I have seen no specimen.

(58) Asplenium exiguum Bedd. Ferns S. Ind. t. 146. 1863.

A. fontanum (L) Bernh. var. exiguum Bedd. p. 158.

This fern is close to A. varians, but it is usually found in rock crevices while A. varians is a plant of rich humus soil. Normal leaves lengthen out as though they were going to root at the tip. 5,500—7,000 feet.

(59) Asplenium tenuifolium Don, Prodr. Fl. Nepal. 8, 1825.

Sowarna Nullah, 4,500 feet Mackinnon 1878, in the Trotter Collection; north slope, Landour according to Marten.

(60) Asplenium varians Hk. and Grev. Ic. Fil. t. 172, 1830.

Common in shady oak forest, 5,500—7,000 feet.

(61) Ceterach Dalhousiae (Hk) C. Chr. Index 170. 1905.

Asplenium alternans Wall. 1828 nomen, Hk. 1860.

Common, usually in more open, sunny places from the Dun to 7,000 feet.

(62) Woodwardia radicans (L) Smith Mem. Acad. Turin. 5. 411. 1793.

Common near water or in damp ravines from 6—7,000 feet.

(63) Gymnopteris vestita (Wall.) Underwood Bull. Torr. Bot. Club 29. 627. 1902.

Syngramme vestita Wall., Bedd. p. 386.

Often overlooked in grass or in thin forest, 6—7,500 feet.

(64) Anogramma leptophylla (L) Link Fil. sp. 137. 1841.

Gymnogramme leptophylla Desv. Bedd. p. 382.

With the single exception of Trichomanes this is the smallest and most delicate fern in Mussoorie and it is likely to be overlooked as a seedling of some other species. Not rare in the second half of August in the crevices of steep banks of soil, not a plant of rock crevices, 6—7,000 feet.

(65) Coniogramme fraxinea (Don) Diels 1^4. 262. 1899.

Syngramme fraxinea Don, Bedd. p. 386.

The low level form is found in Mussoorie with only the lowest pinna divided into two. It is called C. affinis (Wall.) Hieron. by some authors. Not common except at the bottom of the gorge on north slope of Landour 5,500—7,000 feet. The Mackinnons collected a twice pinnate specimen about 3 feet tall at 5,500 feet.

(66) Ceratopteris thalictroides (L) Brongn.

Floats in swamps and ditches. Occasional in the Dun.

(67) Blechnum orientale (L) ed. II. 2. 1535. 1763.

Occasional in Dehra Dun; Swarna Rau, Western Dun, J. Marten.

(68) Cheilanthes rufa Don, Prodr. Fl. Nepal, 16. 1825.

Usually below 4,000 feet; ravine by Body Guard Lines, Dehra Dun, Parker; Rajpur, Hope; Rajpur-Mussoorie Cart Road, etc.

(69) Cheilanthes dubia Hope, Journ. Bom. Nat. Soc. 12. 528 t. 2. 1899.

"Cart road, Rajpur to Mussoorie, 4,000 feet, near the highest range of rufa and lowest range of C. albomarginata and may be a hybrid between the two."—Hope.

(70) Cheilanthes albomarginata Clarke Tr. Linn. Soc. II Bot. I. 456 t. 52. 1880.

C. farinosa, Kaulf. var. albomarginata Bedd. Handb. Suppl. p. 22.

This and Selaginella are the commonest plants on walls and banks; 5—7,500 feet, rarely lower.

(71) Cheilanthes farinosa (Forsk) Kaulf. Enum. 212. 1824.

This is the common silver fern in Dehra Dun and the lower levels. Usually below 4,000 feet.

(72) Cheilanthes farinosa Kaulf. var. anceps (Blanf.) C. Chr. Index 171. 1905.

Cheilanthes anceps Blanford, Simla Nat. Hist. Soc. 1886.

Beddome in the supplement to his Handbook, page 21, states that this in only a form of C. farinosa, not worth separation, but Hope agrees with Blanford that it is worth separation. It is reported by Miss Parrott from Woodstock on the Tehri Road at about 6,500 feet. Hope 2,800 feet, etc.

(73) Onychium chrysocarpum (Hk et. Grev) C. Chr. Index Suppl. III 133. 1934.

Onychium auratum Kaulf. Bedd. p. 96.

Occasional about Dehra Dun and Rajpur, 2—3,000 feet.

(74) Onychium lucidum (Don) Spr. Syst. 4. 66. 1827.

O. japonicum Kze. var multisecta Hend. Mss., Bedd. p. 96.

Not rare in open places in the forest, 6—7,500 feet.

(75) Onychium japonicum (Thunb) Kze. Bot. Zeit. 1848.

Resembles the last species closely, but is more coriaceous in texture and the leaves are not so finely divided. It lasts longer after the rains. 5—6,500 feet.

(76) Adiantum philippense L. sp. 1094. 1753.

A. lunulatum Burm. 1768, Bedd. p. 82.

A plant of the lower levels, common below 4,000 feet, on damp banks and near water.

(77) Adiantum caudatum L. Mant. 308. 1771.

Like the last, common at the lower levels but in drier places and can stand a good deal of drought. Usually below 5,000 feet.

(78) Adiantum Edgeworthii Hook. sp. 2, 14. t. 81B. 1851.

A. caudatum L. var. Edgeworthii, Bedd. p. 84.

Replaces A. caudatum above 5,000 feet. It is less hairy and more delicate, smaller, and grows on shady banks.

(79) Adiantum Capillus-veneris L. sp. 2. 1906. 1753.

From the plains to 6,000 feet on dripping banks and near falling water, common.

(80) Adiantum venustum Don, Prodr. Fl. Nepal., 17. 1825.

Fairly common in the oak forest from 6—7,500 feet.

(81) Pteris vittata L. sp. 2. 1074. 1753.

P. longifolia L. Bedd. p. 106.

One of the few ferns which grow in the plains. Usually below 5,000 feet.

(82) Pteris quadriaurita Retz. Obs. 6. 38. 1791.

One of the common ferns of the oak forest in the same situations as Polystichum squarrosum and Athyrium Schimperi, above 5,000 feet.

(83) Pteris biaurita L. sp. 2. 1076. 1753.

Campteria biaurita L. Bedd. p. 116.

Does not seem to have been collected above Dehra Dun.

(84) Pteris cretica L. Mant. 130. 1767.

Very common in the drier parts of the forest, above 5,000 feet.

(85) Pteris stenophylla Wall., Hk. et Grev. Ic. Fil. t. 130. 1829.

P. pellucida Presl. var. stenophylla Bedd. p. 107.

Fairly common 5—7,000 feet, but has been collected at 2,500 feet. Very variable, leaves often undivided. Requires more shade than P. cretica.

(86) Pteris excelsa Gaud., Freyc. Voy. Bot. 388. 1827.

Seems only to have been reported from the Muss. Dhobi Ghat by Mackinnon, 5,500 and 6,000 feet.

(87) Pteridium aquilinum (L) Kuhn, v. Deck. Reisen 3³ Bot. 11. 1879.

Pteris aquilina L. Bedd. 115.

Very common on sunny hillsides, usually in grass, 6—7,000 feet.

(88) Vittaria flexuosa Fee, 3 mem. 16. 1851-2.

V. lineata Sw. Bedd. p. 407.

There is one specimen marked Landour, Vicary, but no one else seems to have found it. Doubtful.

(89) Polypodium microrhizoma Clarke, Bak. Syn. 511. 1874.

Goniophlebium microrhizoma Clarke, Bedd. p. 322

One of the commonest ferns on trees, rocks and walls , 5—7,000 feet.

(90) Polypodium lachnopus Wall. List No. 310 nomen, Hk. Ic. pl. t. 952. 1854.

Goniophlebium lachnopus Wall., Bedd. 319.

Common, but not as abundant as the last. It grows in damper places and tends to be pendent. It is easy to recognize by the black, hairy, rhizome. From 2,500—6,000 feet.

(91) Polypodium oxylobum Wall., List 294 nomen : Mett. Pol. 202. 1857.

Pleopeltis hastata Thunb. in part ; Bedd. p. 362.

Fairly common from 6—7,000 feet on tree trunks and in soil.

(92) Polypodium amoenum Wall., List n. 290. 1828, nomen ; Mett. Pol. 80 n. 131. 1857.

Goniophlebium amoenum Wall., Bedd. p 317.

Not epiphytic like the three last, fairly common 6—7,000 feet.

(93) Polypodium argutum Wall. List n. 308. 1828 nomen ; Hk. sp. 5. 32. 1863.

Goniophlebium argutum Wall., Bedd. p. 323.

Reported by Hope, Castle Hill Estate, 6,500 feet, on Rhododendron arboreum ; Henry Martin without altitude.

(94) Polypodium Stracheyi Ching, C. Chr. Index. Suppl. III 159. 1934.

P. Stewartii (Bedd) Clarke.

Pleopeltis malacodon Hk. in part, Bedd. p. 363.

Rather rare, on rocks or trees, Jabberkhet and Landour, 7,000 feet.

(95) Polypodium Stewartii (Bedd) C. Chr. Index 566. 1906 (non Clarke).
P. cyrtolobum Clarke.

Pleopeltis malacodon var. majus Hk. Bedd. p. 363.

Seems to have been collected only by Hope, The Park, Mussoorie, 6,300—6,500 feet, 6-9-1895.

(96) Polypodium Wallichianum Spr., Syst. 4-53. 1827.

Pleopeltis juglandifolia Don, Bedd. p. 368.

Common in Landour and Jabberkhet, 6,500—7,500 feet.

(96*a*) Polypodium ellipticum Thunb., Fl. Jap. 335. 1784.

Selliguea elliptica Bedd. 390.

Rare, Dehra Dun, Trotter ; Nalota Khala, Hope; Sowarna Nullah, Mackinnon, 4,500 feet.

(97) Polypodium membranaceum Don, Prodr. Fl. Nepal., 2. 1825.

Pleopeltis membranacea (Don) Bedd. 355.

Not rare, moist rocks and trunks of trees, very variable in size, 2,700—7,000 feet.

(98) Polypodium nudum (Hk) Kze. Linn. 23.281. 1850.

Pleopeltis linearis Thunb. (in part) Bedd. p. 346.

Common from Dehra Dun to about 6,500 feet. The leaves are thick and evergreen and roll up in dry weather. Common as an epiphyte in the drier parts of the forest.

(99) Polypodium loriforme Wall. 1828. Mett. 1857.

Pleopeltis linearis Thunb. var. steniste Clarke; Bedd. Handb. p. 347 in part.

Reported by Duthie, Dehra Dun, July 28, 1881.

(100) Polypodium excavatum Bory; Willd. sp. 5. 158. 1810.

Pleopeltis simplex Sw. Bedd. 347.

Very common, usually epiphytic on every large tree above 6,000 feet. At lower levels and in drier places it tends to be replaced by P. nudum. It is very delicate and its withering is a sign of the end of the monsoon.

(101) Polypodium Kashyapii P. N. Mehra, still unpublished.

Usually collected with excavatum which it closely resembles when dry. It has a thicker texture, the veins being invisible until the plant is dried. The ends of the rhizomes do not closely adhere to the tree trunks and there are rhizophore like roots. 7,000 feet.

(102) Loxogramme involuta (Don) Pr. Tent. 215. 1836.

A common epiphyte from 5—6,500 feet.

(103) Drynaria mollis Bedd., Ferns Br. Ind. t. 216. 1867.

An occasional epiphyte. I have found it at Cloud End and Benog, the Upper Chakker, Landour and on the north slope of Landour, all at about 7,000 feet.

(104) Cyclophorus flocculosus (Don) C. Chr. Index 199. 1905.

Niphobolus flocculosus Don, Bedd. p. 331.

Fairly common as an epiphyte from Dehra Dun, where it is often on mango trees, up to 5,500 feet at Mossy Falls. Like Polypodium nudum and Loxogramme the fronds are evergreen.

(105) Cyclophorus porosus (Wall.) Pr. Epim. 130. 1849.

Niphobolus fissus Bl., Bedd. p. 330.

Reported once by Mackinnon and I have collected it once at about 5,000 feet about a mile west of Jabberkhet.

(106) Cyclophorus beddomeanus (Gies) C. Chr. Ind. 198. 1905.

Niphobolus stigmosus Sw., Bedd. p. 328.

Below Beong, Mackinnon; Dehra and Muss. fide Marten.

(107) Cyclophorus lanceolatus (L) Alston Jur. Bot. 1931. 102.

Niphobolus adnascens Sw. Bedd. p. 325.

Duthie's no. 2419 Sept., 1882, Dehra, Birini? Nadi may be this.

(108) Lygodium japonicum (Thunb.) Sw. Schrad. Journ. 1800. 106. 1801.

Robber's Cave, Dehra Dun.

(109) Lygodium salicifolium Pr. Suppl. 102. 1845.

Lygodium flexuosum (Sw) Bedd. p. 457.

Reported from Muss. without data by Herschel and Duthie. I have only found it near Rajpur at 3,000 feet.

(110) Ophioglossum vulgatum L. sp. 2. 1062. 1753.

Reported by Mackinnon, 6,000 feet. I have found it only below Caineville School in grass at about 6,000 feet and near Rajpur at 3,000.

(111) Botrychium ternatum (Thunb.) Sw. Schrad. Journ. 1800[2] 111. 1801.
Only reported by Mackinnon from about 6,000 feet.

(112) Botrychium lanuginosum Wall. List. n. 48. 1828. Hk. et Grev. Ic. Fil. t. 79. 1829.

Botrychium virginianum Sw. Var. lanuginosum Wall. Bedd. p. 471.

Fairly common both in soil and on trees from 6—7,500 feet.

FERN ALLIES

(113) Equisetum debile Roxb.

Dehra Dun.

(114) Equisetum diffusum.Don.

Near Landour Burning Ghat 5—6,000 feet.

(115) Selaginella pallidissima Spring.

Common on the Castle Hill Estate, 6,500 feet.

(116) Selaginella chrysocaulos Spring.

Very common from 2—7,500 feet.

(117) Selaginella chrysorhizos Spring.

Locally common 4,000?—6,500 feet.

(118) Selaginella adunca A. Br.

Selaginella yemensis Spring.

North slope of Landour toward the Aglar in dry crevices at about 4,500 feet. A xerophytic type.

Seven species are reported from Nag Tibba in Tehri Garhwal, across the Aglar river which have not been found in Mussorie :—

(1) Athyrium acrostichoides (Sw.) Diels.
(2) Athyrium foliolosum (Wall.) Moore.
(3) Notholaena Marantae (L.) R. Br.
(4) Polypodium ebenipes Hk.
(5) Osmunda Claytoniana L.
(6) Botrychium Lunaria L.
(7) Dryopteris paleacea C. Chr.

A few records have been rejected as being very doubtful including Polystichum Thomsoni, Leucostegia Delavayi, Athyrium fimbriatum and Cheilanthes Dalhousiae.

Some new species of Acrocarpous Mosses from the North-West Himalaya with notes on Himalayan Moss Flor

by

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Considering the wealth of the Himalayan Flora, it is rather remarkable that so comparatively little has been published on its Bryophytes. Brühl in his very useful Census of Indian Mosses [Records of the Bot. Survey of India, XIII (1931), No. I, p. 3] has given a list of the principal works dealing with Indian Bryology. Of these only three are specially concerned with the Himalayan Flora, viz. :—

Mitten, W. Musci Indiae Orientalis, in Journ. Linn. Soc., Bot., Suppl. to Vol. III, 1859. (This includes the results of earlier works by Hooker, Harvey, and Griffith.)

Dixon, H. N. Report on the Mosses of the Abor Expedition, in Records of the Bot. Survey of India, VI (1914), No. 3.

————Mosses collected in Gilgit, etc., by J. Garrett and W. Lillie, op. cit. IX (1926), No. 5.

To these the following should be added :—

Brotherus, V. F. Contributions to the Bryological Flora of the North-Western Himalaya, in Acta Soc. Scient. Fennicae, XXIV (1898), No. 2.

Dixon, H. A. Mosses from the Mount Everest Expedition, 1924, in Journ. of Bot., 1925, 221.

————Additions to the Mossflora of the North-Western Himalayas, in Annales Bryologici, III (1930), 51.

————Mosses collected in Assam, in Journ. Bombay Nat. Hist. Soc. XXXIX, (1937) 769.

————and Badhwar. Some new North-West Himalayan Mosses, in Records of the Bot. Survey of India, XII, (1938), No. 2.

Herzog, Th. Botanische Ergebnisse der Deutschen Hindukutsch-Expedition 1935, in Fedde, Repert., Beih. CVIII (1938), 3.

The summary of these publications give results which no doubt confirm pretty closely those derived from the study of the higher plants. They show the following elements of the bryophytic flora, probably roughly in a decreasing order of frequency, as follows :—

(1) Palaearctic Element, including a considerable number of arctic-alpine European, Asiatic, and North American species.

(2) Endemic.

(3) Indian peninsula generally. The number of species common to the Himalayan range and the southern part of the Indian Continent is much smaller than either of the two previous categories.

(4) Burmese, Chinese, Malayan affinities. A considerable number, chiefly in the Eastern ranges, and especially marked in the Assam Moss Flora.

(5) Affinities with Western Asia, Caucasus, etc. A small number, principally, as is natural, in the western part of the range, and particularly shown in the Hindu-Kush, (*cf.* Herzog, 1938).

There are, of course, in addition to the above, smaller elements, of cosmopolitan species, and a few others of a disjunct distribution. Of the latter one of the most remarkable is *Aongstroemia julacea* (Hook). Mitt., which was collected by Somervell on Mt. Everest at 19,800 feet (6,000m.), much the highest altitude of any moss so far recorded ; a species only known elsewhere from the summit of Giant's Castle, Natal, and from one or two of the highest summits of the Andes. [For a wider study of this geographical distribution Herzog's Geographie der Moose (Jena, 1926) may be consulted.]

The high range of altitude among some of the Himalayan mosses is one of the most striking features of the bryophyte flora.

It is a well known fact that an alpine flora at a given level is richer in proportion to the height of the ground above it. Thus an alpine flora of an altitude from 3,000-4,000 m., will be richer when it is the flora of slopes of a much higher range than when it forms the summit flora of a range of about that altitude. This is well instanced by the comparison of the altitude of some species of palaearctic mosses common to the European Alps and the Himalayans ranges, in both regions. Highest altitudes of European mosses have been given by Herzog (op. cit.), Györffy, Amann, Kern, Pfeffer, Bottini, Limpricht, and others. I have given below a list of some of these highest altitudes as compared with altitudes of Himalayan specimens in my herbarium. These it may be noted include a considerable number of records of highest altitudes which have not hitherto been published.

European.	Himalayan.
Distichium capillaceum 3,650m., Matterhorn	4,725 m., Chandra Valley ; Badhwar. 4,575 m., Kangra, Lahul ; Koelz. 4,400 m., Koksar, Lahul ; Bor. 4,270 m., Apharwat, Kashmir ; Stewart. 4,200 m., Zaskar, Kashmir ; Stewart.
Distichium inclinatum 2,450 m., Brenta, S. Tirol	3,250-5,300 m., Baralacha Pass, Lahul ; Kerr and Lillie. Above 3,000 m., Chandratal, Kangra ; Koelz.
Dicranoweisia crispula 3,800 m., Mte. Rosa	4,750 m., Bhaga Valley, Lahul ; Badhwar. 3,960 m., and 3,660 m., Apharwat, Gulmarg. Kashmir ; Stewart.
Oncophorus virens 2,700 m., Rhaetian Alps (Pfeffer)	3,960 m., Koksar, Lahul ; Bor. 3,000 m., Above Gulmarg, Kashmir ; Stewart. 3,000 m., Sonamarg, Kashmir ; Stewart.
Oncophorus Wahlenbergii 2,660 m., Valais (Amann)	Above 3,050 m., Sonamarg, Kashmir ; Stewart. 3,058 m., Kidarkanta, Tihri Garhwal ; Bahadru.
Didymodon rubellus 3,650 m., Combin (Amann)	Above 3,660 m., Pahlgram, Kashmir, Stewart. Between 3,350 m. and 5,400 m., Baralacha Pass, Lahul ; Kerr and Lillie.
Desmatidon latifolius 3,500 m., Mte. Rosa	4,900-5,500 m., Chitichun, Tibet ; T. L. Walker. 4,800 m., Chandra Valley, Lahul ; Badhwar. 4,575 m., Zanskar Valley, Kashmir ; Badhwar. 4,250-4,580 m., Arni Gadh ; Dr. Duthie. Above 3,660 m., Beas Valley, Kulu ; Badhwar. 3,350 m., Mattezan, Kashmir ; Dr. Neve.

European.	Himalayan.
Grimmia apocarpa 3,500 m., Jungfraujoch (Herzog) ..	4,100 m., Zanskar Valley, Kashmir; Badhwar. 3,350 m., Beas Valley, Kulu; Badhwar.
Grimmia alpicola 3,800 m., Matterhorn ..	5,580 m., Kongribungri Pass, Kamaon; T. L. Walker. 3,800 m., Bhaga Valley, Lahul; Badhwar.
Grimmia commutata 1,600 m. (Limpricht) ..	circa 4,250k., Sach Pass, Mid Himalaya; Miss Stanfield. 4,100 m., Rotang Pass; Bor.
Grimmia unicolor 3,600 m., Combin, Amann ..	Between 3,350 m. and 5,200 m., Baralacha Pass; Kerr and Lillie.
Grimmia elongata 3,980 m., Gletscherhorn (Herzog) ..	4,400 m., Nepal; J. D. Hooker.
Grimmia alpestris 2,500 m., Silvretta (Kern) ..	4,900 m., Bhaga Valley, Lahul; Badhwar.
Encalypta ciliata 2,960 m., Graubunden; Pfeffer ..	4,250 m., Kalahoi, Kashmir; Stewart. 3,960 m., Apharwat, Kashmir; Stewart. Above 3,660 m., Pahlgram, Kashmir; Stewart.
Encalypta rhabdocarpa 3,130 m., Graubunden; Pfeffer ..	5,650 m., Damal, Tibet; Kashyap. 4,575 m., Above Koksar, Lahul; Bor. 3,150 m., Gondhla, Lahul; Bor.
Amphidium lapponicum 4,200 m., Matterhorn ..	3,660 m., Lahul; Bor.
Funaria hygrometrica 2,400 m. (Amann) ..	4,400 m., Indus Valley, Lahul; Badhwar. Above 3,350 m., Lahul; Kerr and Lillie. Circa 3,350 m., Sonamarg, Kashmir; Stewart.
Leptobryum Pyriforme 2,750 m., Stilfserjoch; Breidler ..	4,700 m.. Baralacha Pass; Badhwar. 4,100 m., Chandra Valley, Lahul, Badhwar. 3,500 m., Putsco Camp; Badhwar. Above 3,300 m., Baralacha Pass; Kerr and Lillie.
Bryum Schleicheri 3,250 m. (Amann) ..	4,250 m., Koksar, Lahul; Bor. 3,960 m., Sissoo, Lahul; Bor. 3,400 m., Burrit Pass, North-West Himalaya; Troll. 3,350 m., Kolahoi Glacier, Kashmir; Stewart. 3,350 m., Sonamarg, Kashmir; Stewart.
Bryum caespiticium 2,600 m., Bavarian Alps (Limpricht)	Circa 4,200 m., Sach Pass, Mid Himalaya; Miss Stanfield. 3,000 m., Above Gulmarg, Kashmir; Stewart. Above 2,750 m., Ladakh, Kashmir; W. Lillie.
Cratoneuron filicinum 2,540 m., Glockner; Molendo ..	5,500 m., Hindukush Mts., 1923; Herb. H. N. D. 3,950 m., Tibet; Dr. Thomson. 3,660 m., Gulmarg, Kashmir; Stewart. Circa 3,000 m., Sonamarg, Kashmir; Stewart. 3,000 m., Kyelang, Lahul; Badhwar.
Hypnum revolutum 3,600 m., Combin; Amann ..	4,800 m., Indus Valley, Lahul; Badhwar. 4,100 m., Zanskar Valley, Kashmir; Badhwar. 3,000-3,500 m., Chamurikette; C. Troll (var. Molendoanum).

European.	Himalayan.
Polytrichum alpinum 2,900 m., (Limpricht) ..	Circa 3,660 m., Apharwat, Gulmarg, Kashmir; Stewart 2,745 m., Dharmsala; Stewart.
Polytrichum piliferum 3,400 m., Rhaetian Alps (Limpricht)	4,800 m., Bhaga Valley, Lahul; Badhwar. 3,660 m., Chandra Valley; Badhwar.
Polytrichum juniperinum 3,600 m., Combin (Amann) (3,900 m., on Chimborazo).	Above 3,660 m., Tulion, Pahlgram; Kashmir; Stewart. Circa 3,000 m., Sonamarg, Kashmir; Stewart.

New Species

The collections on which the following descriptions are based are mainly the following :—

A large collection made between the years 1922 and 1932 by Professor R. R. Stewart of New York, mostly made in the North-West Himalaya of the Punjab and Kashmir.

A considerable collection sent me by Winfield Dudgeon, of the Ewing Christian College, Allahabad, principally from the neighbourhood of Landour, Mussoorie.

Large collections made under the direction of the late Professor Kashyap, of Government College, Lahore, principally by R. L. Badhwar, in the higher ranges of the North-West Himalaya of Lahul, Kashmir, etc. Some of the results of these collections have been recently published (*see* Dixon and Badhwar, 1938, in the above list of works), and a fuller account is planned.

Large gatherings sent me by Rev. David Lillie, made over a number of years among the higher Himalaya by Mr. W. Lillie, Mr. and Mrs. Garrett, and others.

Several collections sent me by the late Dr. T. L. Walker, made in the neighbourhood of Kamaon in 1899, and in other districts; including some of the highest recorded altitudes for several species.

A small number, but including several interesting plants, collected by Kinnear, in the neighbourhod of Dalhousie, in 1917.

One or two small collections made in 1933 by Babu Lal Gupta, of Agra College.

A small but interesting collection by Walter Koelz in 1933, sent from the U. S. A. Nat. Museum.

A small collection made by P. Maheshwari, of Agra, in 1937.

Several small collections made recently by Dr. N. L. Bor, in Lahul, etc., in the higher regions, and about Dehra Dun.

I have not included any new species of Bryum in the following list. The above collections included a rather large number of these, but they call for separate treatment.

The types of the new species are in my herbarium.

Fissidentaceae

Fissidens brevidorsus Dix. sp. nov.

§Bryoidium. Pusillus. Ab affinibus indicis differt lamina dorsali haud basin folii attingente, *plerumque, longe supra basin costa desinente.* Lamina vaginans dimidium folium *sar longe superans.* Costa valida, rufescens, percurrens. Folia inferiora breviter, superiora sat longe acuminata. Cellulae et limbidium eis *F. bryoidis* subsimilia. Seta *brevis,* 3 mm. alta. Theca minuta, erecta, oblonga, sicca sub ore constricta.

Hab. Abbottabad, Hazara Distr., circa 1,250 m. apr. 1927; coll. R. R. Stewart (12456).

Leaves more acuminate than in *F. bryoides,* with longer vaginant lamina, and very short dorsal lamina, often not reaching three-fourths down the leaf. The short seta and minute, erect theca are also characters.

Dicranaceae

Dicranella papillinervis Dix. sp. nov.

§Anisothecium. Elata, 3 cm. alta ; caulis flexuosas, parce ramosus. Folia laxiuscula, sicca *crispata,* e basi erecta, longa, pallida, sub-amplexicauli, *sat raptim in subulam longam, canaliculatum, sensim tenui-acuminatum, integram* contracta. Costa latiuscula, sat tenuis, *superne dorso muriculato.* Cellulae superiores *minutae, obscurae, quadratae;* basilares sensim elongatae, juxta-costales lineares, pellucidae.

Folia perichaetialia longe convoluta, erecta, breviuscule acuminata. Seta rubra, flexuosa, circa 1 cm. Theca subcylindrica, *erecta, aequalis, laevis*; operculum longerostratum. Exothecii cellulae *perlaxae,* subquadratae vel brevissime rectangulares. Peristomii dentes breves, infra orem siti, ad basin seape connati, irregulares, plerumque inaequaliter fissi, *dense papillosi, haud striolati.* Spori 10-15 w.

Hab. Har Nag, Kashmir. 3,700 m.; coll. R. R. Stewart (12490A), type. Near Mt. Kolahoi, Kashmir, 4,250 m., Aug. 1927; coll. R. R. Stewart (9427). Ibidem, Aru Nofru, 2,500-3,000 m., 5 Sept. 1931; coll. R. R. Stewart (12461X). Ibidem, Lidar and Sind Valleys, 2,200-4,000 m., Aug. 1931; coll. W. Garrett and W. Lillie (2466).

D. spiralis (Mitt.) has plicate capsules. The peristome here is not striolate, and this, with the sheathing leaves, minute, quardrate cells, symmetrical, smooth capsules distinguishes it from all the allied species. The papillosity of the nerve varies, and may be very inconspicuous.

Dicranella is said to have the perichaetial leaves not differentiated, but that is not the case here, nor in *D. spiralis.*

Paraleucobryum himalayanum Dix. sp. nov.

Dense caespitosum, sat humile, nitidiusculum, pallide virens. Folia sat conferta, falcato-secunda, 3-4 mm. longa, e basi *brevi, alb*-escente, ovata, sat cito in subulam *canaliculatam, integerrimam,* angustam contracta. Costa tertiam partem basis latitudinis aequans, supra pessime notata, pertenuis, sectione 2-3-stratosa, versus basine *cellulis fere homogeneis laxis,* supra minoribus, substereideis hic illic interpositis, instructa. Cellulis folii basilares lineares, pellucidae, infra sensim laxiores, alares *tenerrimae, laxae, hyalinae,* facile destructae ; cellulae superiores *longissime lineares, perangustae,* parietibus tenuibus.

Hab. Near Kyelang, above Chumba, Punjab, alt. 2750-4800 m., 1935 ; coll. Mr. & Mrs. John Garrett (2601).

The nerve structure is not quite that of Paraleucobryum, as I have not found a median row of chlorophyllose cells, but it closely resembles it, and otherwise the leaf structure agrees well, *e.g.*, with *P. Sauteri*, from which it is at once distinct in the entire leaves, as well as in the smaller size, short seta, etc. The general appearance is rather that of a *Dicranodontium*.

Calymperaceae

Calymperes mussoriense Dix. sp. nov.

§Eu-calymperes. Climacina. Corticola. Sat robustum, caespites extensos, fuscescentes formans. Caulis circa 1 cm. altus. Folia sicca fortiter incurva, e basi oblonga paullo dilatata, concava, apice lato, subobtuso ; margines incurvi, saepe angustissime incrassati, medio folio integri vel subintegri, versus apicem dense argute denticulati, ad ventrem *arcte fortiter argute* denticulati. Costa sat valida, prope apicem dorso saepe rugulosa vel denticulata. Cellulae sat parvae, subquadratae, opacae, humiliter papillosae ; eae cancellinae magnae, perbreviter rectangulares, distincte sed haud alte apud costam adscendentes, marginales seriebus pluribus versus basin angustissimis ; teniola *nulla*. (Sexta, in Nos. 236, 250, 3-4 mm. longa, theca minuta, erecta, cylindrica, nitida, laevis. Calyptra haud visa.)

Hab. Trunks of *Rhododendron arboreum*, near Woodstock school, Landour, Mussooree, 1850 m., 2 July 1922 ; coll. W. Dudgeon (64), type. Thall to Dindihat, Kamaon, on Pieris, 1,000-1,500 m., June, 1926 ; coll. A. Sawhney (236, 250), c. fr.

The only other species of the genus, *C. Griffithii* C. M. known from the Himalayan region, is quite different. The present plant is vegetatively different among the Climacina in the rather narrow base with the margin at shoulder with a few sharp, almost spiculose denticulations. The toothing of the margin varies greatly.

The fruit (in the co-types) is remarkable ; it is in fact exactly that of Syrrhopodon, and in no way that of Calymperes. Vegetatively, however, the plant is an undoubted Calymperes, and I have thought it best, though with hesitation, to place it in the genus. The altitude is a remarkable one for Calymperes.

Pottiaceae

Hymenostylium grandirete Dix. sp. nov.

Densissime caespitosum, humile sed robustiusculum ; caules fere ad apicem *rufo-tomentosi*. Folia conferta, sicca rigide hamato-incurva, *magna*, 3-5 mm. longa, 5mm. lata, *fragillima*, e basi *angustiore* longe lanceolata, e medio folio sensim acuminata, acutissima, superne concava, marginibus incurvis, inferne planis. Costa infra *pervalida*, 90-120w, lata, fere tertiam partem latitudinis folii apud basin occupans, superne angustata, concolor, dorso laevis, percurrens vel in mucronem brevem excurrens. Cellulae superiores *majusculae*, 11-14w, rotundatae, regulares, laeves, basilares paucae rectangulares, pellucidae, haud laxae. Fructus generis, theca collo distincto.

Hab. Wet limestone, near Kapkate, Kamaon, alt. 1,100-1,200 m., July, 1899 ; coll. Dr. T. L. Walker (377), type. Dehra Dun, U. P., 1925 ; coll. A. Sawhney (264).

Sufficiently distinct in the rather large, concave, very fragile leaves, the strong nerve and large, clear cells. *H. validinerve* Dix. & Varde, from Travancore, has shorter, less acuminate, subobtuse leaves, smaller cells, etc.

Rhamphidium laticuspe Dix. sp. nov.

Robustum ; caules 2 cm. vel ultra, sordide virides ; folia laxiuscula, e basi erecta patula, sicca *leniter rigide incurva*, 1. 5-2 mm. longa, e basi sat latiore, distincta, *pallida*, superne *haud dilatata*, supra in laminam *opacam* oblongo-lanceolatam, nunc breviter, nunc longe, semper late acuminatam angustata ; marginibus planis, integris. Costa *valida, rubra*, cum apice desinens vel in mucronem brevem, crassum excedens, dorso laevis vel tenerrime muriculata. Cellulae superiores *perobscurae, opacae*, humillime papillosae, minutae, subquadratae, basilares *abrupte elongatae, rectangulares*, infra sensim longiores, pellucidae.

Seta 1 cm. alta, vel paullo ultra, theca majuscula, anguste elliptica vel sub-cylindrica, fusca, operculum longe aciculare ; peristomium praelongum, valde torquatum.

Hab. On earth, " Pipe Line," Murree Hills, North-West Himalaya, 2,150 m., June, 1927 ; coll. R. R. Stewart (9111).

A robust species, with short, broad, rather solid leaves, the basal part very distinct, but less from the form than from the strong contrast between its pellucid rectangular cells and the opaque, obscure ones of the lamina. The operculum may be as long as the capsule, and the peristome almost equally so.

Rhamphidium crispifolium Dix. sp. nov.

Praecedenti (*R. laticuspe*) simile, sed foliis siccis valde crispatis, multo *longius, tenuius acuminatis*, peracutis, et basi vaginante supra *distincte dilatata*. Fructus haud visus.

Hab. Choongtam, Sikkim, 2,450 m., May, 1849 ; coll. J. D. Hooker ; Herb. Mitten (195).

Very similar to the last, and possibly a varietal form, but apparently distinct in the very acute, longly acuminate leaves, from a more distinct base which is markedly broader above.

The generic position would have been difficult to determine were it not for the fruiting *R. laticuspe*.

Rhamphidium mussooriense Dix. sp. nov.

R. laticuspi peraffine. Differt foliis confertioribus, madidis leniter recurvis, siccis *fortiter incurvis, costa dorso nitente* ; e basi multo minus distincta, ovali, sensim in laminam lanceolatam *late acumiatam, vix acutatam* angustata ; apice latiusculo, cum costa excedente *abrupte cuspidato*. Costa paullo angustior, supra subpellucida ; cellulae superiores paullo minus opacae, basilares *multo minus distinctae*, breviores, ad infimam basin tantum pellucidae. Gemmae numerosae parvae, obovatae, purpureae, multicellulares, in foliorum axillis inveniuntur.

Hab. Mussoorie, June, 1915 ; coll. Mrs. Bremner (105).

This, too, though near *R. laticuspe*, seems distinct. The leaf base is much less differentiated, the nerve weaker, glossy at back when dry, and the apex is not acutely pointed but rather broad, and abruptly cuspidate with the nerve point, as in many species of *Trichostomum*.

Trichostomum uncinifolium Dix. sp. nov.

Humile. A *T. Lilliei* Dix. peraffini differt folii basi *bene distincta*, paullo latiore, propter cellulas *laxiuscule lineares vel rectangulares, inanes, parietibus tenuibus, albescente*; costa *multo angustiore*, 40-45 w (Ibi 60-70 w), dorso laevi, (ibi leniter muricata), marginibus superioribus distincte *papilloso-crenulatis*. Folia superiora madida *incurvo-hamata*; siccitate fortiter crispata ; fragilia.

Fructus ignotus,

Hab, Nassim Bagh, Srinagar, Kashmir, Aug. 1922 ; coll. Mrs. Garrett (2515).

A not very marked species, but distinct enough from *T. Lilliei* in the characters noted above, especially the well marked, pellucid base and much narrower nerve. The South Indian *T. perannulatum* Dix. and Varde has much larger leaves, larger cells, and stouter nerve.

Tortella undulatifolia Dix. sp. nov.

Dense caespitosa. Humilis, atrovirens, robustiuscula. Folia conferta madida subsquarrosa, sicca valde contorta, e basi *parum latiore, oblonga*, sensim in laminam longe ligulato-lanceolatam, acutissimam, *fragilem, perundulatam*, integram (cellulis prominentibus papillosam), angustata. Costa valida, in cuspidem longiusculum, crassum, subdenticulatum, excurrens. Cellulae eis *Pleurochaetis squarrosae* similes, basilares autem per totam folii latitudinem *subsimiles*, lineares, pellucidae, ad margines altiuscule adscendentes.

Cetera ignota.

Hab. Lidar and Sind Valleys, Kashmir, alt. 2,200-4,200m., Aug. 1931 ; coll J. Garrett and W. Lillie (2453).

This has the habit and structure almost of *Pleurochaete* ; the leaves, however, differ markedly from that in the character which, mainly, separates *Pleurochaete* from *Tortella*, namely, the median cells short and coloured in *Pleurochaete*, with a very distinct broad band of hyaline marginal cells reaching to the base ; here, on the contrary the basal cells are all subsimilar, elongate, thin and pellucid, and the border at and above shoulder is formed by these cells, ascending high, but not nearly so high, at margin. The leaf base also is scarcely at all widened, the upper margins, except for the prominent cells, entire, and the lamina strongly undulate.

Didymodon (Erythrophyllum) stricto-rubellus Dix. sp. nov.

Gracillis, altiusculus, rufescens. Caules pergraciles, folia madida *e basi suberecta rigide, patula*, sicca arcte appressa, incurva, subcatenulata, leniter contorta ; e basi *lata, subamplexicauli* in laminam brevem, lanceolatam, sensim angustatam, breviter acutatam contracta, Costa ubique valida, rufa, in apice folii obscura. Margines plani vel infra anguste recuri supra *paullo incrassati, integerrima*. Cellulae sat distortae, basilares sensim elongatae, subpellucidae, brevissime rectangulares, parietibus firmis.

Fructus ignotus.

Hab. Near Kyelang, above Chumba, Punjab, 2,750-4,500m., 1935 ; coll. Mr. & Mrs. J. Garrett (2615).

Differs from *D. rubellus* and its allies in the form of the leaves, entire apex, etc. ; it most resembles the European *D. ferruginascens* (Stirt.) (*Barbula botelligera* Moenk.), but that is less rigid, with longer leaf points, wider base, more strongly recurved margins, not thickened above.

Barbula catenulata Dix. sp. nov.

Caespitosa, sat humilis, *rufo-virens*. Folia conferta, *rigida, patula,* sicca *arcte incurva,* unde caulis *catenulatus* ; a basi *latissime ovali,* per totam insertionem decurrente, raptim in subulam subaequalem strictam, latiusculam, acutam contracta. Margines *plani,* nonnunquam superne angustissime, arctissime reflexi. Costa latiuscula sed tenuis, *male definita,* infra apicem soluta, dorso saepe leniter rugulosa. Cellulae distinctae, sublaeves, subincrassatae, ad infimam basin tantum paucae elongatae, haud pellucidae.

Cetera ignota.

Hab. Dalhousie, Kashmir, Oct. 1917 ; coll. Kinnear (510b, type, 535).

Although sterile this is a quite clearly distinct species ; the broad leaf bases with the subula rigidly incurved when dry give a quite peculiar appearance to the stems ; the almost entirely plane margin is another feature ; the leaves also when removed from the stem always detach portions of the stem cortex across the width of the base.

Orthotrichaceae

Anoectangium pallidicaule Dix. sp. nov.

Dense caespitosum ; 4 cm. altum, saturate viride, inferne pallidum, tomentosum. Caules gracillimi, ramis filiformibus. Folia sat remota, interrupta, sicca leniter incurva ; parva, a basi paullo latiore *pallida* breviter lanceolata, late acuminata, acuta. Margines plani vel inferne leniter recurvi. Costa tenuis, angusta, dorso leniter muriculata. Cellulae *majusculae,* 6-10w late, juniores chlorophyllosae, vetustate pellucidae, subquadratae, *papillosae,* basilares sensim longiores, laxiusculae pellucidae. Folia ramoram laxa, subrecurva, uno latere longe reflexo. Setae numerosae tenues, pallidae, breves ; thecae fere omnes distructae, parvae, cylindricae.

Hab. In alpine meadow, Sirroo, Lahul, 4,250m., 1938 ; coll. N. L. Bor (408), type. In alpine meadow, Koksar, Lahul, 4250m., 1938 ; coll. N. L. Bor (402).

Differs from the allied Indian species (*A. Stracheyanum,* etc.) in the leaves not spirally contorted, only slightly inflexed when dry. *A clarum* Mitt., to which it is perhaps most closely related, is more robust, with denser foliation, smaller, smooth cells, the basal scarcely pellucid, and seta longer, reddish. The whittish stem between the leaves and the pale leaf give the present plant, in its laxer forms, a marked appearance under the lens.

Marcomitrium himalayanum Dix. sp. nov.

Macrocoma. A *M. Perrottetii* C. M. differt folliis *basi latiore,* superne brevius acuminatis, cellulis minoribus ; seta *multo breviore,* circa 4mm., et peristomio externo *bene evoluto,* e dentibus pallidis, brevibus, pellucidis instructo. Calyptra haud visa.

Hab. On trees, Landour, Mussoorie, June 1921 ; coll. Kenoyer and Dudgeon (40), type. Binsar, Almora, 2,150m., 1910 ; coll. Miss E. Shephard (18). On oak, Dindihat, Kamaon, 1,500m., June 1926 ; coll. A. Sawhney (247).

Differs at once from *M. Perrottetii,* the only other Indian species of the subgenus Macrocoma, in the very short seta and the well developed peristome. Only old capsules have been seen, and it is uncertain therefore if the calyptra be hairy or not.

It appears to be by a slip that Brühl in his census of Indian Mosses, Part I, p. 64, has credited this species, then ined., to Garhwal.

Webera synoica Dix. sp. nov.

Humilis, dense caespitosa, ditissime fructificans ; caules breves, folia conferte comosa, *rigida,* e basi *latiore breviter lanceolata,* breviter, late acuta, *integerrima,* ad apicem tantum nonnunquam leniter denticulata ; margines nunc plani nunc anguste revoluti, in foliis comalibus late fortiter revoluti. Costa *valida, vix percurrens.* Cellulae omnes *parvae, breves,* anguste rhomboideae, perietibus, firmis.

Synoica. Seta perbrevis, circa 5mm. alta, cassiuscula. Theca *pallida,* nutans, e collo lato, basi abrupto clavato-pyriformis ; operaculum *pallidum,* conicum, *subobtuse mamillatum.* Annulus latus. Spori 16-19w Exothecii cellulae breviter, late rectangulares, parietibus *rectis.* Peristomii dentes majusculi, pallide fusci, lanceolatis, marginibus integris, aparse papillosi, dense sed haud alte trabeculati. Processus *lineares,* papillosi, subintegri ; cilia O.

Hab. Sonamarg, Sind Valley, Kashmir, 3650mm., 28 July, 1928 ; coll. R. R. Stewart (9811).

Extremely close to *W. carneoides* Badhwar & Dix. (Records of Bot. Survey of India, XII, 171), and only differing in certain fruiting characters. The peristome there is reddish, the teeth much narrower, less densely barred, with the trabeculae prominent within, and the spores appreciably larger, 20-24w. The inflorescence there is paroicous, here it appears to be truly synoicous.

Brachymenium himalayanum Dix. sp. nov.

§Orthocarpus. *B. turgido* Broth. foliis simile, sed foliis siccis leniter *spiraliter tortis., latioribus,* oblongo-spathulatis, limbo paullo angustiore, nerve longius, fortius excedente. Theca *angustior,* pyriformis, inclinata vel subpendula, microstoma. Peristomii dentes dense trabeculati, lamellis intus alte prominentibus. Endostomium imperfectum, processubus rudimentariis.

Hab. Above Rajpur, Mussoorie Road, circa 1600m., 14 Aug. 1930 ; coll R. R. Stewart (II 190), type. Simla, 2100m., Aug. 1935 ; coll. Lal Gupta (2).

Distinct from the allied species of Orthocarpus in the horizontal or subpendulous capsules, as well as in the almost entire leaves (at most with one or two apical denticulations) ; from *B. turgium* in the characters emphasized above, and the less turgid capsule. Nearly all the capsules in both specimens are immature, and are narrower (clavate), and less nutant than in the mature condition.

On the distribution of some Indian Charophytes

by

G. O. ALLEN

In the first paper even published on Indian charophytes (Characeae Indiae orientalis et insularum maris pacifici, Hooker's Journal of Botany I, 1849, pp. 292-301) Alexander Braun opened with the remark that " The East Indian Characeae are far less peculiar than those of Australia, the greater part of them being found also in other parts of the world, although exhibiting different varieties." He went on to state that "It is remarkable that several of the East Indian species agree with those of South America and the warmer parts of North America."

I propose here to touch in turn on the three points about the pecularity of Australian charophytes, the comparative paucity of endemic forms in India and the alleged resemblance between those of India and America.

Any observation by the illustrious Alexander Braun, as James Groves used to call him, is worthy of the greatest respect. The authors of " British Charophyta " speak of him in the following terms : " That wonderfully acute and clear-sighted botanist, Alexander Braun, was the first who can be said to have acquired any real grasp of the distinctive characters of the charophyta from a systematic point of view, and prior to the commencement of his publications on the subject in 1834, the descriptions, based for the most part on superficial and unimportant characters, were, when unaccompanied by drawings, practically valueless for the purpose of identifications."

We read that, born in 1805, he was collecting plants in his sixth year and by his fourteenth, being well acquainted with phanerogams, was studying mosses, lichens and fungi with the aid of a microscope. Whilst still a schoolboy he published his first paper at the age of 16½. He died in 1877, his greatest work, the "Fragmente einer Monographie der Characeen," being compiled by Nordstedt from his MSS and published in 1882.

It is in his "Charae australes et antarcticae" (Hooker's Journal of Botany I, 1849, pp. 193-203) that Braun shows how impressed he was by the pecularity of Australasian forms. He begins by remarking that "Aquatic plants have been in general regarded as cosmopolities, which, unrestrained by the common limits of phytographical regions, are to be found with unchanged specific types in the most distant parts of the world. The following enumeration, however, by no means confirms this assumption, being confined to a series of quite peculiar species representing the family of Characeae in Australia."

The list contains only nine now recognized species of Nitella, one Tolypella (from Kerguelen's Island) and six species of Chara, but this original impression about the peculiar nature of the charophyte flora of this region has been abundantly borne out by later discoveries, Braun himself describing several more endemic species, and after his death Nordstedt continued the investigation and published in 1918 a Synopsis of the Australasian Characeae, additional species being added by him and later by Groves and others.

Though it is impossible to give exact figures, as some determinations for example are coupled with an element of doubt, the present position approximately is that, with a total of fifty-eight in all, no less than twenty-five of the thirty-six Australasian Nitellas are endemic, the figures for Chara being nine out of twenty. The list includes only two Tolypellas (one in Australia): hence the proportion of Nitellas is very high.

Two peculiarities (of the Nitellas) to which Braun drew attention are worth mentioning, viz., the high proportion of dioecious species (seventeen out of thirty-six) and the prevalence of the mucous-headed (gloeocephalous) character. Also in this genus Braun's major group of Polyarthrodactylae (dactyls composed of three to six cells) are particularly well represented and number ten.

His observation about the Charas being all haplostephanous (having a single circle of stipulodes), whereas in other parts of the earth the diplostephanous (having a double circle) predominate, no longer entirely holds good as later on such widespread diplostephanous species as *C. contraria* Kütz., and *C. vulgaris* L., *C. globularis* Thuill. (*C. fragilis* Desv.) and *C. zeylanica* Willd. have been added, though the high proportion of haplostephanous species is still very marked.

So much for the singularity of the Australasian charophytes.

Braun's somewhat depreciatory remarks about the East Indian charophytes being mainly found in other parts of the world would seem to apply equally well elsewhere. Most large areas produce some endemic species though the proportion nowhere approximates to the figure for Australasia: but it is not easy to make comparisons owing to the very varied ideas about what degree of difference should constitute a species.

When Groves was considering the publication of his "Notes on Indian Charophytes" which appeared in the Linnean Society's Journal (XLVI-1924), it was little realized what an amount of steady work he, and in earlier days his brother, had been doing on Indian collections of these plants for many years. In their "daybook" where all their determinations, amounting to over six thousand in all, are entered I find for instance that the very first entry for non-British relates to some charophytes collected by J. F. Duthie in Central India in 1888. (It is largely these daybook entries on which I have relied when referring to the "records" of the distribution of the various species.) They began their study of this group in 1877, earlier years naturally being devoted mainly to British and European species.

This paper by Groves, in 1924, imparted a great impetus to the study of these plants in India, particularly as collectors began for the most part to follow his advice about preserving also in fluid some portions bearing ripe fruit. It is often impossible to resuscitate dried material sufficiently well to make a satisfactory investigation of it. The importance of keeping localities near at hand under continuous observation should not be overlooked as many of these plants come and go with surprising rapidity.

So far about fifty-five species have been found in India. The charophytes flora is therefore a fairly rich one and the plants themselves, at any rate in North Indian ponds, abundant. The Nitellas comprise about half, of which ten at most are endemic and a few have a very limited distribution. There are three species of Tolypella recorded; also Nitellopsis obtusa Gr. and Lychnothamnus barbatus Leonh. Of the twenty-three species of Chara five or at most six are endemic.

The endemic Nitellas include *N. Annandalei* Pal, *N. Wattii* Gr., *N. Grovesii* Kundu, *N. patula* Gr. & G. O. A., *N. flagellifera* Gr. & G. O. A., *N. superba* Pal, *N. elegans* Pal, *N. globulifera* Pal and *N. dispersa* Br.

Amongst Nitellas with a limited range are *N. mirabilis* Gr. which has been recorded once from China: *N. leptodactyla* Gr. from Ceylon and N. India only, with the exception of a plant referred by Groves "with some doubt" to a variety *megaspora* of this species from Madagascar: and *N. Stuartii* Br., known elsewhere only from Australasia and Japan. A plant from Benares I consider to be *N. myriotricha* Br., otherwise only known from Australia: and another I have had lately from S. India appears to be *N. dualis* Nordst., originally described from W. Africa (Liberia) and recorded also from Indo-China and perhaps the Straits Settlements.

Of the three Indian Tolypellas *T. hispanica* Nordst., collected by Duthie at Quetta is only found here (and perhaps Persia) and round the Mediterranean. *Nitellopsis obtusa* Gr., recorded from Kashmir and Burma occurs widely in Europe though nowhere else (except Palestine). *L. barbatus* Leonh., found in several Indian localities, otherwise occurs very sparingly in central Europe.

The endemic species of Chara include *C. Wallichii* Br., *C. nuda* Pal, *C. pashanii* Dixit (not very different from the last-named and both closely connected with *C. Braunii* Gmel.), *C. Grovesii* Pal and *C. Handae* Pal.

Of the others *C. erythrogyna* Griffith is almost confined to India, there being single records from Java and Cochin China. (Groves considered *C. Thwaitesii* Br. from Ceylon "perhaps hardly separable" from this species.) *C. infirma* Br., "a rather doubtful species" in the opinion of Groves, was originally described from Afghanistan.

The number of charophytes found only in Burma is remarkable. All Pal's new species are from that region. There may also be observed the increasing number both of those Nitellas which are much enveloped in mucus (especially the fruiting heads) and of those belonging to the group with many-celled dactyls, characters not infrequently combined. These two features, it will be recalled, were specially noticeable in Australasian plants.

So far four members of the polyarthrodactylous group—and all of them highly mucous—have been found in the Indian area. Three are dioecious, *N. superba* Pal, *N. Grovesii* Kundu and *N. myriotricha* Br. and there is an undescribed monoecious one. *N. dualis* Nordst., though actually having only two-celled dactyls, seems by reason mainly of its long slender dactyls and allantoid end-cells to be much more closely allied to the many-celled than to the two-celled group. Groves would describe it as *arthrodactyla* (*bicellulata*) *allantoteles*. This group is unrepresented in the British Isles: in Europe there are at most two species: whilst in North and South America there are one and three, respectively.

Other gloeocephalous Indian Nitellas include *N. mucosa* Gr., *N. hyalina* Ag., *N. globulifera* Pal and *N. elegans* Pal.

As to the alleged similarity between East Indian and American charophytes, it has to be borne in mind that Braun's observation of 1849 was in one of his earlier papers, though he had already published two papers on the charophytes of North America in 1844 and 1845, and that it was based on the examination of a very limited number of forms. He enumerates twelve in all, four Nitellas and eight Charas.

To take them in turn, giving them where necessary their present-day names.

1. *N. acuminata* Br.—"A widely distributed tropical and sub-tropical species" (Groves), common in India and found in other parts of the East: also in U.S.A., Central America and the northern parts of South America as well as in Africa but not in Europe or Australia.

2. *N. furcata* Ag.—This common Indian species is known from several places in the East and from South Africa and Australia. It is not recorded from North America, but I find a record of a single gathering of it from Brazil by Ule in 1909.

3. N. (*exilis* var. ?) *flagelliformis* Br.—This (*vide* notes in the Fragmentse) was found to be a mixture of two Nitellas, *N. dispersa* Br. and *N. pseudoflabellata* Br., the former an endemic Indian species and the latter confined to Asia and Australasia.

4. *N. tenuissima* Kütz. var *byssoides.*—*N. tenuissima* is essentially a European and North American plant, recorded also from North Africa and a variety from South Africa. The Indian form recorded by Braun from the coast of Coromandel over a hundred years ago has, if I am correct in my determination, been found again recently in South India. As Groves remarks " it would appear to differ considerably from the typical form," being for one thing very much smaller.

5. *C. corallina* Willd.—Another fairly common species in North India and found in a few other localities further East. The only other recorded place of occurrence is Mauritius.

6. *C. Braunii* Gmel. is very widely distributed, being found in every continent.

7. *C. flaccida* Br. is almost confined to East Asia, there being a single record from the African Desert and from the Fiji Islands. Dr. T. F. Allen, the leading American authority on this group, indicated this species in his Synopsis as North American and included figure of it, but I can find no other reference to it in his papers and neither the fragments nor Grove's lists included it as such. C. B. Robinson, however, who has created so many new species out of the material dealt with by Allen, has described as *C. Curtisii* a plant from Florida distributed by Allen as *C. flaccida.*

8. *C. hydropitys* Reichb. occurs sparingly in India and is found in North, Central and South America with single records from North Africa and Madagascar. It has not been found in Europe or Australasia.

9. *C. vulgaris* L. Braun refers to a specimen in Sir William Hooker's herbarium that had been collected by Dr. Wallich in Nepal. It is not only widely distributed in India but is one of the commonest species all over the world with the exception of Australasia where there are only two records. T. B. Blow's collecting in this latter area, which amounted to over a hundred and twenty gatherings, not including a single example.

10. *C. brachypus* Br., a fairly common plant in India is confined to East Asia and Africa.

11. *C. zeylanica* Willd., common in India, is a polymorphic species widely distributed in tropical and sub-tropical regions, being found in every continent except Europe and particularly abundant in the West Indies.

12. *C. javanica.*—Of this Braun writes : "I cannot exactly define this species." It does not appear to have ever been recognised by him as a species and from the description was a form of *C. zeylanica.*

There does not, therefore, appear to be very much on which to base a similarity between the charophytes of the two areas and later studies do not seem to bear it out. Four of the twelve are widely distributed either in tropical and sub-tropical regions, or elsewhere, and only four at most of the remaining eight are common to both, all four being also found in either Africa or Australasia.

Allen too set out to illustrate the resemblance between the Characeae of America and Asia in a short paper in 1880, "although," as he writes," as yet out acquaintance with the forms of this order, both Asiatic and American, is comparatively slight." He too only cited a few species in suport of his view.

The first is styled *N. polyglochin* Br. The plant was in fact *N. microcarpa* Br. Allen considered it answered perfectly to *N. Roxburghii* Br. (*N. furcata* Ag.), but *N. furcata* is distinguished markedly from *N. microcarpa* by the peculiar character of the upper tier of coronula cells being conspicuously elongated. *N. microcarpa* in addition to occurring in North and South America, the West Indies, India and East Asia is reported from Africa and once from Australia, being mainly an American and East Asiatic plant.

Allen's next species is *C. hydropitys* Reichb. already referred to in Braun's list.

He then turns to some diplostephanous triplostichous (*i.e.*, double circle of stipulodes and three-ranked stem-cortex) plants in which the lowest branchlet-Segment is ecortricate as being common to America and Asia, viz., *C. sejuncta* Br. and various forms of *C. zyelanica* Willd. These two are closely allied. The former differs in the gametangia being at separate branchlet nodes instead of together at the same nodes in the usual way and is almost confined to North, Central and South America and the West Indies with the exception of two gatherings in Japan by Miki in 1923 and 1926.

I have already referred to *C. zeylanica* in Braun's list. Braun when familiar with only a few forms was inclined to consider them as separate species and described them as such, but when the number rose to sixteen or eighteen he considered them all varieties of a single species which he chose to style as *C. gymnopus* as "the most fitting, though not the oldest name." Allen at first accepted this view but when in 1894, he was considering what was the correct name decided that Braun's one species ought to be abandoned altogether and the several varieties raised to the rank of species with their appropriate names and incidentally added some more. Robinson in his "Chareae of North America" (1906) mentions that Allen finally seems to have reverted to his original position. Robinson himself, however, revived Braun's and Allen's species and added still more. Writing on the charophytes of the West Indies in 1911 the brothers Groves took quite the opposite view and did not even consider all these as varieties but held them to be rather "stages of variation between which series of intermediates are to be found" and treated them as forms.

Allen's paper, therefore, does not appear to add a great deal to the force of Braun's original observation about the similarity between the Charophytes of Asia and America.

There are a few other species whose known distribution might be mentioned in this connection.

N. axillaris Br. was found in North India in 1926. A variety is reported from Java and Allen's *N. sublucens* "which," according to Groves, "seems almost identical," from Japan. Elsewhere it occurs only in North, Central and South America. A closely allied undescribed form has been found in South Africa.

N. oligospira Br. mainly occurs in Asia and America, but is also recorded from South Africa and Australia.

Amongst the Tolypellas *T. prolifera* Leonh., though not recorded from India before 1922, is fairly common in the Upper Gangetic Plain : it is mainly found in Europe and North and South America with a single record from China. *T. glomerata* Leonh, alone occurs in all the continents.

The peculiar case of *C. altaica* Br. might be mentioned. Braun originally described this species, which is very similar to *C. canescens* Lois. except for its being monoecious, from a plant found in the Altai mountains of Asia. Allen's *C. evoluta*, more or less restricted to the middle of the Western side of North America, he admits is "probably identical" with Braun's plant. It has not been recorded from anywhere else.

The Role of the Common Algal Communities of The River Hooghly on the Drinking Water of Calcutta

by

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Our knowledge of algal ecology has not yet sufficiently advanced. It is only during the last few years that synecology and also aut-ecology of algae are rightly engaging the attention of the European and the American algologists. Very little work on the various algal communities of this vast country has been done. Some of the Indian algologists including the writer are engaged in the investigation of this aspect of Indian algae, but more detailed and systematised work on modern lines is overdue. Study of algal communities of static and flowing waters of India, apart from its purely scientific value, is of considerable importance in pisciculture, soil fertility, sanitation, public health (Malariological Survey), purification of drinking water, irrigation and problem of water pollution.

My study of the algal communities of the river Hooghly is confined to the small portions of the river in front of the Royal Botanic Garden, Sibpur, and of the Calcutta Waterworks at Pulta. The investigation was made mostly during the rains between July and August, when summer communities of freshwater algae in addition to the permanent river dwellers are available in fairly large numbers.

This river, like some of the more or less similar rivers in other parts of the world such as the Thames in England, the Elbe in Germany and the Ohio in America, is also polluted by sewage and waste water from human habitations and industrial plants. Strong current, the amount of pollution and influence of tide particularly at these portions of the river (due to its proximity to the sea) are so much that the physical forces, such as gravity and light, the chemical forces such as oxidation, reduction, etc., and the biological forces such as the action of bacteria, algae, lower aquatic animals favourable for sustaining rich vegetable life—are all reduced to a minimum degree. The biotic factors operating nearly twenty-four hours also interfere with the plant and animal life of the river. Acidity and alkalinity, temperature, free Co_2, total solid and total bacterial count as recorded in the following table indicate the nature of the raw river water. Thus conditions for the growth of algal communities in this river are not so much favourable as in the other flowing waters.

Raw River Water

Months.	PH.	Dissol-ved oxygen.	Tempe-rature.	Free carbon dioxide.	Total solid.	Total bacterial count per 1 c.c.
July ..	5·3	0·65	83°	0·82	53·7	4,000 to 40,000
August ..	6·8	0·62	83°	0·93	53·6	4,000 to 60,000

Suspended solids or silt about 78·5.

N.B.—The figures represent parts per 100,000.

Lyngbya subconfervoides, Cladophora glomerata, Rhizoclonium riparium, Enteromorpha intestinalis, Polysiphonia angustissima and *Caloglossa Leprieurii* are the common hardy perennial river dwellers. They are found throughout the year within the tidal zone growing in abundance on stones, bricks, old wood and other hard substrata lying along the banks. Some of these are also sometimes seen to develop along the sides of sailing vessels, the ferry boats, the buoys, the jetties and the wharfs. These algae lend characteristic blue-green, green, greyish brown and pale pink colour to the substrata due to the prevalence of blue-green, green or red algae growing on them. The fronds of these algae are thickly coated with colonies of epiphytic diatoms of which *Melosira jurgensii, Biddulphia laevis* and *Terpsinoë indica* are predominant. The perennial algae of this portion of the river are commonly represented by 10 species of blue-green, 4 species of green and 4 species of red algae and 12 species of diatoms. The phytoplankton indicates onrush of sea-water during high tide carrying with it some of the cosmopolitan marine and brackish water species of which the diatom, *Consinodiscus radiatus,* is dominant. Empty frustules of this diatom were collected with the rhizoids of some deep sea algae by Colonel R. B. Seymour Sewell, SC.D., F.R.S., in 1933, the then Director, Zoological Survey of India, at a depth of about 700 fathoms during his oceanographic survey in the Indian Ocean.

Four communities of algae are distinguished in the river. (1) the crustaceous or the encrusting community of *Caloglossa Leprieurii;* (2) the straggling community of Oscillatoria-Cladophora-Rhizoclonium-Polysiphonia; (3) the epiphytic community of Melosira-Terpinsoe-Biddulphia; (4) the micro-phytoplankton community of:—(*a*) marine and brackish water Diatoms: Synedra-Rhopalodia-Coscinodiscus-Cyclotella; and (*b*) freshwater blue-green and green algae. The crustaceous community which can be distinguished by the naked eye is composed purely of *Cloglossa Leprieurii.* It grows forming a network on hard substrata along the banks of the river within the tidal zone. The fronds of this red alga, particularly the basal portions of the older fronds are thickly covered with chained groups of diatoms: These diatoms get themselves attached to the body of the red alga by means of their gelatinous excretions. The thallus of *Caloglossa Leprieurii* is more or less succulent, di- or trichotomously branched and perennates vegetatively rooting at the nodes by means of tufted, unbranched, non-septate and long colourless rhizoids. In contrasts to this community the second community of algae are attached to the substrata only at their bases by means of simple holdfasts and the filamentous portions remain straggling or floating in the water. These algae serve more or less as hosts to the chained or stalked groups of epiphytic diatoms. The common stragglers are *Lyngbya sub-confervoides, L. aestuarii, Cladophora glomerata* var. *rivularis, Rhizoclonium riparium, Chaetomorpha linum, Enteromorpha intestinalis* and *Polysiphonia angustissima.* Growing within the tidal zone these algae become exposed to the sun and air during the low tide and remain submerged during the high tide. The green and red algae reproduce vigorously both vegetatively and sexually and the blue green ones only by simple cell-division. In the struggle for existence these straggling algae gain the upper hand over the encrusting algae. The stragglers prefer a higher zone to that of the crustaceous algae. Both the communities are met with in profusion throughout the year. The crustaceous algae and stragglers can be kept under culture for more than three months and studied indoors, but if they are kept submerged all along in stagnant river or freshwater they show signs of degeneration after about a month. The permanent epiphytic community chiefly consists of *Melosira jurgensii, Terpsinoë indica, Biddulphia laevis, Gomphonema constrictum* and *Achnanthes brevipes.* Apart from growing epiphytically on *Caloglossa Leprieurii* and straggling algae they settle also on other hard substrata and grow there exposed to the action of the tides. When, however, they get dislodged by strong current or other mechanical action they rise to the surface, form part of the plankton community and are thus carried away by the velocity of the water. But with the ebb tide they are deposited again with the silt along the banks as the water level gradually falls low down. These epiphytic diatoms when kept under culture indoors for some time appear more green than brown due to loss of diatomin which imparts brown colour to their cell walls. Among these diatoms the species most adaptable to varying conditions are *Synedra affinis* and *Rhopalodia gibba.*

The algal members of the micro-phytoplankton of the river though found nearly throughout the year are, for reasons stated above, not very rich. The Rheo-plankton flora is mainly represented by diatoms as one naturally expects in such a flowing muddy river with strong rushing current. The characteristic floating diatoms of the river are: *Synedra ulna, S. affinis, S. affinis* var. *fasciculata, Rhopalodia gibba, Cyclotella Kutzinghiana* and *Coscinodiscus radiatus*. Scattered filaments of two species of iron-bacteria—*Leptothrix ochracea* and a form of *Crenothrix polyspora*—forma *indica* are also met with occasionally in the plankton catches. The blue-green, green and brown algae form, what may be called, monsoon micro-phytoplankton of the river. They are transient in nature. During the monsoon with the great influx of the freshwater discharged into the river due to floods and rain large numbers of freshwater algae (many of these with spores and other reproductive bodies produced after their fragmentation during hot months) are washed down the river from various kinds of inland waters. They are then distributed again far and wide by the flood-water of the river entering through the canal or other waterways, or by the overflow water filling up jheels, tanks, ponds, ricefield, swamps, etc. The spores and other reproductive bodies thus drifted when settle down in suitable areas germinate and renew their life history under favourable conditions. The plankton catches show that many algae recorded from lakes, tanks, jheels, ponds, canals, khals and ricefields-swamps and similar other static freshwaters find their passage into the river during the rains. The river, therefore, acts as an important disseminating agent in the distribution of the microscopic lower plants over a large part of the country. This, what may be termed, more or less ephemeral Rheo-micro-phytoplankton association during the monsoon represents roughly about 57 per cent. green algae, 33 per cent. blue-green and 10 per cent. diatoms. It would be worth investigating how far this algal flora, as also the more permanant marine and brackish members of the micro-phytoplankton of this river, serve as food directly to fishes or other lower aquatic animals such as protozoa, crustacea, worms, etc., which in their turn serve as food to larger edible fishes.

The River algae and the Filter-Water of Calcutta

The river algae play a very important part in the biology of the settling tanks and the filter-beds which form the main source of drinking water of Calcutta. A comparison of the algae found in the filter-beds with those of the freshwater micro-phytoplankton of the river, will reveal a very close relation between the algae of the river and the algae of the settling tanks and the filter-beds at Pulta and also elsewhere in Bengal where the river water is filtered for drinking purpose. In fact, as far as the Pulta waterwork is concerned, it can be stated that the chief source of algal infection to the filter-beds is the water of this river. Very few algae find access to the filter-beds by wind, birds, beasts or man. Some of the algae of the filter-beds forming part of the adhesive organism composing the vital layer aid filtration and thereby purify the water. Whereas some other algae act as harmful agents and interfere directly or indirectly with proper filtration. The passage of some of the common algae and iron-bacteria and even freshwater sponges and other animals from the river to the settling tanks and to the filter-beds and finally sometimes to the taps through the underground pipes has been traced. The muddy water of the river as it flows down carries along with it abundant materials for the development of a rich vegetation. When this water finds its way into the settling tanks after alum treatment, the germination of the reproductive bodies conveyed into the tank—in addition to the old stock already deposited in the tanks for years—goes on vigorously in the usual seasonal rotation. Here in these tanks the reproductive bodies of both the higher and lower aquatic plants find ideal conditions for their growth. Masses of dead leaves and other parts of submerged vegetation lie at the bottom of the tanks and gradually get decomposed and the dissolved mineral matter serve as ideal plant food. The water of the settling tanks thus surcharged with plant food passes into the filter-beds, and with it flows down minute microscopical reproductive bodies of lower plants and animal organisms. Here again in the filter-beds, within a few days after the beds are charged with water, the vegetable organisms under the favourable conditions of luminosity, temperature and physico-chemical composition of the water repeat their life-cycle in full swing much to the inconvenience of those who are in charge of the water and also those who drink the water. The algal vegetation, the magnitude of the growth of which in the settling tanks and the filter-beds of Calcutta cannot be over-estimated, starts its life history immediately after the rains. The reproductive bodies are distributed far and wide during the rains and flood by the river as described above, and as soon as these bodies get into any static water they settle down and under favourable conditions grow up. Some of them finish their life-history in late autumn while others pass a vegetative period during the short cold months and thus check the flow of water in the filter-beds. They reach their optimum growth in the early spring and afterwards floating on the surface of the water in the late spring go on reproducing sexually. Finally during the hot months before the rains they fragment as a result of fructification leading to their decomposition. The masses of algæ thus set up in the post reproductive stage of their life-history a very insanitary state in the water.

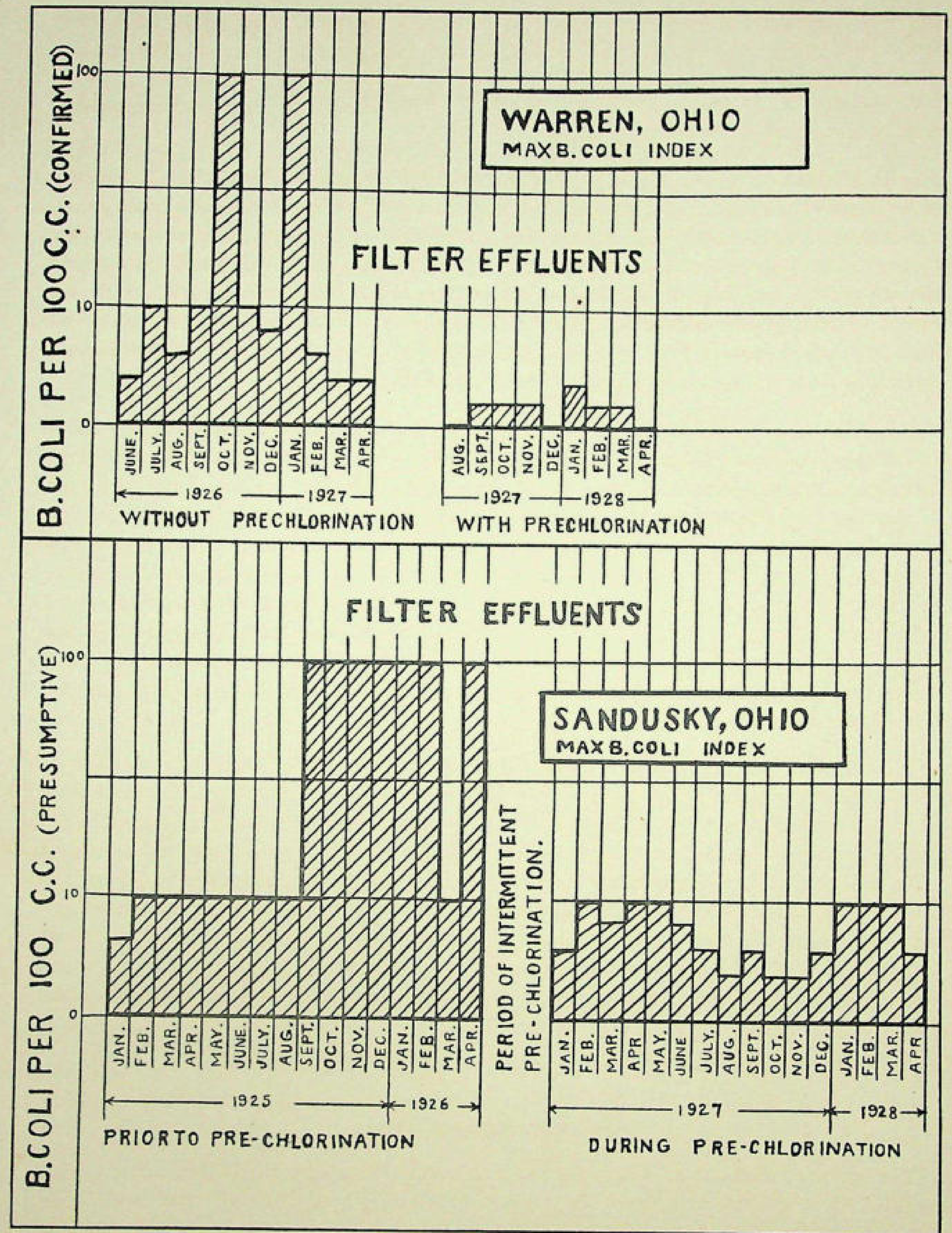
Conditions of filtration become complicated due particularly to the present arrangement and situation of the filter-beds at Pulta and to the climatic conditions of Calcutta. The trouble is inevitable and starts from the ground layer of organisms. This layer, known as " Schmutzdecke " by the German investigators, is commonly called the " vital layer." The slimy vital layer is formed of bacteria, some aquatic Fungi, minute blue-green algae, abundant diatoms intermixed with fine particles of clay strained out of water in close proximity to the surface of the sand. The accumulation of undesirable organisms in this spreading mat however tend to clog the filter-beds resulting in a rapid loss of head. Algal and fungal spores settling on the suitable substratum of " Schmutzdecke " rapidly develop. Plankton algae which impart characteristic red, blue-green or green colour to the water is known as " wasser-bloom "—water flowers. These are found to be predominant in some of the beds in their early stages. But when these ephemerals disappear the autumnal and the vernal filamentous members chiefly " *Tribonema bombycinum, Cladophora crispata, Hydrodictyon reticulatum* " gain the upper hand. At first these larger algae grow on the bottom layer of the filter-beds and discharge considerable amount of oxygen to the water as a result of photo-synthesis, but soon due to gases caught up in their interstices they are lifted up and finally float on the surface of the water in dense masses. Such congested vegetable growth in the filter-beds leads to the development of equally large masses of lower animal organisms which find in such a mass of vegetation sufficient food and ideal shelter. Thus invading the filter-beds the enormous zoo-algal growth causes fissures in the vital layer and directly affects the filtering operation. Moreover, the decaying vegetable and animal matter produces an offensive vegetable odour and obnoxious taste in the water used for drinking. The unpleasant taste, vegetable odour and colour of the water, however, depend on the nature and amount of plant and animal growth which varies at different seasons. Such water may bacteriologically be free either with or without chemical treatment, but it stimulates inside the conduit pipes growth of certain species of fungus and iron bacteria such as " *Leptothrix ochracea, Crenothrix polyspora* forma *indica, Gallionella ferruginea* and *Arcella Vulgaris.* These iron bacteria by their chemosynthetic activities can live in darkness inside the underground iron pipes. During the hot months due to heating of the pipes or some other causes these organisms are dislodged and come out of the tap water as brown gelatinous matrix. The problem becomes complicated if such matrix gets contaminated with sewage or unfiltered water containing rotton organic matter, pathogenic and non-pathogenic bacteria, algae, and lower animals. The gelatinous matrix, as my examination of the samples of contaminated tap waters from the different parts of the city in 1929 and in May 1939 reveals, consists of algae, fungi and iron bacteria such as *Protococus viridis, Chlorella vulgaris, Synedra affinis* (diatom), *Fungus sp., Gallionella feruginia, Leptothrix ochracea* and *Crenothrix polys-pora* forma *indica.*

Algae Control

It is often complained that there is fishy, aromatic and vegetable odour in drinking water. " Experiments have shown that the amount of oil present in microscopic organisms is sufficient to account for the odours observed in drinking water. " " The odours caused by the use of chlorine is due to four causes : (1) Excess of free chlorine, (2) substitution of compounds of chlorine with organic matter of animal or vegetable origin, (3) substitution of compounds of chlorine with phenoloid or comparable substances, and lastly (4) destruction of organisms resulting in the refuse of aromatic substances which in some cases unite with chlorine. " Fishy odours are also due to the presence of various plankton algae in the water of the filter-beds.

The sources of contamination is traced in the leakage of the pipe system as stated above. To tackle this problem is a " stupendous " task. But considering the prime importance of such a task it must have to be done. In this connection I refer to the valuable paper entitled " Benefits of Leakage Surveys at Sandusky, " by Mr. O. F. Schoepfle, Chairman of the Ohio Conference on Water Purification, held at Columbus, Ohio, in 1930. In this paper he has laid down certain methods for the survey of underground leaks in the distribution system employing the use of " pitot tubes. "

After-growth is, what may be called, organic growth in the pipes forming the distribution system. Occurrence of iron bacteria and allied organisms in some of the filter-beds too are tangible signs of these organisms occurring in underground pipes as well. Their existence in the pipes also speaks of leakages as they flourish in filter water mixed up with ground water containing iron and carbonic acid and devoid of oxygen. When there is considerable amount of growth of iron bacteria choking up the pipes, as may sometimes happen, the mass is known as the common " pipe moss. " The abundance of pipe moss depends on the quantity of organic contents of the water. Chlorination destroys these organisms and velocity of the water dislodges them from the sides of pipes, and finally forces them out of the taps. Mr. L. H. Enslow, Research Engineer, Chlorine Institute of New York City, in his paper on " Recent Developments in Application of Chlorine in Water Purification, " advocates the beneficial quality of applying chlorine to the raw water as illustrated in his chart No. 3 reproduced below.



The latest researches carried in New York and in Hamburgh on water purification have proved that considerable good results in controlling bacteria and algae can be achieved by judicious pre-chlorination of the water at its source, that is using chlorine at the intake pipe before the water is pumped into the settling tanks. Mr. L. H. Enslow, Research Engineer of New York City, in his paper on the "Recent Developments in Application of Chlorine in Water purification", states, "O. F. Schoepfle, Chemist in charge at the Sandusky plant began pre-chlorination of raw water in May, 1926, with the sanction of the Ohio State Department of Health". "The outstanding results have included longer filter runs, algae reduction, improved coagulation, reduction of chemical costs and improved filter-effluents". "The reduction in monthly averages for B. Coli is of interest, but of greater interest is the elimination of the spasmodic presence of high coli content in the effluent occurring prior to pre-chlorination as shown in the figures prepage. This effect is of far great importance than a reduction of the average figures."

L. B. Mangum, Chemist in charge of Water Purification, Kansas City, U. S. A., states : "We had a growth, a year ago, of protococcus, some variety and the water became green as any you ever saw. Copper sulphate treatment was used in that as it was used in other reservoirs, daily or weekly, but we could not do anything. The water became greener and greener, and finally we put the reservior out of service and used the super-chlorine treatment which was sufficient to destroy all the growth. We got along very nicely that year." (Algae control by Chlorination at Kansas City by L. B. Mangum, Chemist in charge, Water Purification, Kansas City Jour. of America Water Works Asso., Vol. 21, 1929.)

John Bowman in his article on Water Supply of Hamburg writes as follows : "Since 1923 the application of chlorine in the form of chlorine gas has been applied. One of these chlorinating stations is at the intake works, another at the pumping station, and one on each pipe line leaving the filtering station. The chlorinating of the water from the settling reservoirs resutls in the prolongation of the running time of the filters. Especially is this the case in April and May when inflowing of diatomaceous algae resulted before filtration, in the filters requiring cleaning about every four days. By the application of sulphate of alumina over 30 filter cleanings have been rendered unnecessary and as a result of the application of chlorine the speed of filtration has been raised from 60 milimetres per hour to 113 milimetres per hour (or from $2\frac{1}{2}''$ to $4\frac{1}{2}''$ per hour). Some of the filters now run for nearly 30 weeks without cleaning."

The action of chlorine on algae is fairly well established and the effect of pre-chlorination is accepted and more or less confirmed by other well-known investigators of filter works. The extracts quoted above speak for themselves. In some of the filter beds, as in Hamburgh and a few cities in U. S. A., the conditions, as regards source of water and arrangements of the filter-beds, are somewhat allied to the Calcutta waterworks. But the filamentous members and other tropical species of algae grow under different edaphic, and climatic conditions in the filter-beds and pre-settling tanks in Calcutta. The history and construction and other factors such as the chemical and physical properties of the water governing the life-history of algae also complicate the question to such an extent that the study of the organisms in the Pulta Water Works of Calcutta amounts to tackling a new problem under new environments.

Pollution of River Water

The pollution of the river Hooghly is so much that they may gradually prove detrimental to organic life and thus complicate the problem of the supply of drinking water and fishes. Apart from indiscriminate catching, it is perhaps due more to the biological causes that the delicious *hilsa* and other fishes of the river Hooghly might be getting less and less and, who knows, they may in some remote future disappear like salmon and trout of the Thames. It is, therefore, high time that a water pollution research board, like the one in England, consisting of chemist, physicist, botanist, zoologist and engineer, should be formed in India to investigate the problem of water pollution in its various aspects.

I am deeply indebted to Mr. R. Ross, Assistant Botanist (Diatomist), British Museum (Natural History, Botany), London, for his kindly checking the identification of the diatoms with reference to the type slides in the museum.

SYSTEMATIC ENUMERATION OF THE SPECIES FORMING DIFFERENT COMMUNITIES OF ALGAE FOUND IN THE RIVER HOOGHLY.

I. Crustaceous Community of Red Algae

RHODOPHYCEAE.

Genus Caloglossa.

Caloglossa Leprieurii J. Ag.

Genus Catenella.

Catenella Opuntia (Gord. et Woodw.) Grev.

II. Straggling Community of Blue-green, green and Red Algae

CYANOPHYCEAE.

Genus Lyngbya Agdh.

Lyngbya aerugineo-coerulea (Kütz.) Gom.
„ aestuarii (Mart.) Lieb.
„ sub-confervoides Borge.

Genus Oscillatoria Vauch.

Oscillatoria amphibia Ag.
„ laetivirens (Crouan.) Gom.
„ paucigranata Brühl et Biswas.
„ salina Biswas.
„ splendida Grev.
„ tenuis Ag.

Genus Scytonema Ag.

Scytonema crispum (Ag.) Born.

CHLOROPHYCEAE.

Genus Chaetomorpha Kütz.

Chaetomorpha Linum Kütz.

Genus Cladophora Kütz.

Cladophora glomarata Kùtz.
var. rivularis.

Genus Enteromorpha Harv.

Enteromorpha intestinalis (L.) Link.

Genus Rhizoclonium Kütz.

Rhizoclonium heiroglyphicum Kütz.
„ riparium (Roth.) Harv.

III. Epiphytic Community of Diatoms

BACILLARIOPHYCEAE

Genus Achnanthes Bory.

Achnanthes brevipes Ag.

Genus Biddulphia Gray.

Biddulphia laevis Ehrb.

Genus Ghomphonema Agdh.

Ghomphonema constrictum Ehrb.
var. capitata (Ehrb.) Cleve.

Genus Melosira Agdh.

Melosira varians C. A. Ag.
„ jurgensii C. A. Ag.

Genus Terpinsoe Ehrb.

Terpinsoe indica (Ehrb.) Kütz.

IV A. Perennial Microphytoplankton Community of Diatoms and Iron Bacteria

BACILLARIOPHYCEAE

Genus Cocconeis Ehrb.

Cocconeis placentula Ehrb.

Genus Coscinodiscus Ehrb.

Coscinodiscus radiatus Ehrb.

Genus Cyclotella Kütz.

Cyclotella Kuetzingiana Thw.

Genus Fragilaria Lyngb.

Fragilaria cupucina Desm.
var. lanceolata Grun.
var. acuta Grun.

Genus Rhopalodia O. Müller.

Rhopalodia Gibba (Ehrb.) O. Müll.

Genus Synedra Ehrb.

Synedra affinis Kütz.
var. fasciculata (Kütz.) Grum.
Synedra ulna Ehrb.

IRON BACTERIA.

Genus Crenothrix Cohn.

Crenothrix polyspora Cohn. *Forma* indica Biswas.

Genus Leptothrix Kütz.

Leptothrix ochracea kutz.-Lyngbya ochracea (Kütz.) Gom.

IV B. Temporary Microphytoplankton Community of Blue-green, Green and Brown Algae.

CYANOPHYCEAE.

Genus Anabaena Bory.

Anabaena flos-aquae (Lyngb.) Breb.
,, sphaerica Born. et Flah.
,, sphaerica, *var.* attenuata Badj.
,, spiroides Kleb.
,, variabilis Kütz.

Genus Aphanocapsa Naeg.

Aphanocapsa Grevillei (Hass.) Rabh.
,, Koordersi Ströem.

Genus Arthrospira Stizenb.

Arthrospira tenuis Brühl & Biswas.

Genus Gloeocapsa (Kütz.) Naeg.

Gloeocapsa aeruginosa (Carm.) Kütz.

Genus Gloetrichia J. Ag.

Gloetrichia natans Rabh.
,, pisum Thur.

Genus Lyngbya Agdh.

Lyngbya aerugineo-coerulea (Kütz.) Gom.
,, aestuarii (Mart.) Leibmann
,, orchracea (Kütz.) Gom.
,, rivularianum Gom.

Genus Merismopoedia Meyen.

Merismopoedia convoluta Breb.
,, elegans A. Br.

Genus Microcoleus Desmaz.

Microcoleus Chthonoplastes Thur.

Genus Microcystis Kutz.

Microcystis aeruginosa Kütz.
,, flos-aque (Wittr.) Kirchn.
,, marginata Kütz.

Genus Oscillatoria Vauch

Oscillatoria Agardhii Gom.
,, amphibia Ag.
,, animalis Ag.
,, formosa Bory.
,, laetivirens (Crouan.) Gom.
,, limosa (Roth.) Ag.
,, princeps Vauch.
,, quadripunctulata Brühl & Biswas.
,, splendida Grev.
,, tenuis Ag.

Genus Phormidium Kütz.

Phormidium autumnale (Ag.) Gom.
,, papyraceum Gom.
,, tenue (Menegh.) Gom.

Genus Scytonema Agdh.

Scytonema acrispum (Ag.) Brown.
,, ocellatum Lyngb.

Genus Spirulina (Link). Turpin.

Spirulina major Kütz.
,, platensis (Nordst.) Geitler.

CHLOROPHYCEAE.

Genus Ankistrodesmus Corda.

(1) Ankistrodesmus falcatus (Corda.) Ralfs.

Genus Chaetomorpha Kütz.

(2) Chaetomorpha Linum Kütz.

Genus Chaetophora Schrank

(3) Chaetophora elegans (Roth) Ag.

Genus Chlorella Beyer.

(4) Chlorella vulgaris Beyrs.

Genus Cladophora Kütz.

(5) Cladophora crispata (Roth) Kütz.
(6) ,, glomerata Kütz.

Genus Coelastrum Naeg.

(7) Coelastrum cambricum Arch.
(8) ,, sphaericum Naeg.

Genus Enteromorpha Harv.

(9) Enteromorpha compressa Link.
(10) „ intestinalis Link.
(11) „ prolifera J. Ag.

Genus Gonium Müll.

(12) Gonium pectorale Müll.

Genus Hydrodictyon Roth.

(13) Hydrodictyon reticulatum (L.) Lagerh.

Genus Kirchneriella Schmidle.

(14) Kirchneriella lunaris (Kirchn.) Moebius.

Genus Oedogonium Link.

(15) Oedogonium Sp.

Genus Oocystis Naeg.

(16) Oocystis elliptica West.
(17) „ solitaria Wittr.

Genus Pandorina Bory.

(18) Pandorina morum (Müll) Bory.

Genus Pediastrum Meyen.

(19) Pediastrum Clathratum Lemm.
(20) P. duplex Meyen.
(21) P. tetras (Ehrb.) Ralfs.

Genus Pithophora Wittr.

(22) Pithophora oedogonia (Mont.) Wittr.
(23) „ polymorpha Wittr.

Genus Protococcus Agdh.

(24) Protococcus viridis Ag.

Genus Rhizoclonium Kütz.

(25) Rhizoclonium heiroglyphicum Kütz.
(26) „ riparium (Roth.) Harv.

Genus Scenedesmus Meyen.

(27) Scenedesmus bijuga (Turp.) Lagerh.
(28) „ quadricauda (Turp.) Bréb.

Genus Tetraëdron Kütz.

(29) Tetraëdron bengalicum (Turn.) Wille.
(30) „ caudatum (Corda) Hansg.

Genus Tribonema Derb. & Sol.

(31) Tribonema bombycinum (Ag.) Derb. & Sol.

Genus Ulothrix Kütz.

(32) Ulothrix subtilis Kütz.

Genus Vaucheria DC.

(33) Vaucheria sessilis DC.

Genus Volvox (L.) Ehrb.

(34) Volvox aureus Ehrb.
(35) „ globator (L.) Ehrb.

CONJUGATAE.

Genus Arthrodesmus Ehrb.

(36) Arthrodesmus convergens Ehrb.
(37) „ crispus Turn.

Genus Closterium Nitzsch.

(38) Closterium Leibleinii Kütz.
(39) C parvulum Naeg.
(40) C. moniliferum (Bory.) Ehrb.
(41) C. rostratum Ehrb.

Genus Cosmarium Corda.

(42) Cosmarium granatum Bréb.
(43) „ impressulum Elfv.

Genus Euastrum Ehrb.

(44) Euastrum inermius (Nordst) Turner.

Genus Hyalotheca Ehrb.

(45) Hyalotheca dissiliens (Smith) Bréb.

Genus Micrasterias Agdh.

(46) Micrasterias Crux-Melitensis (Ehrb.) Ralfs.
(47) „ foliacea Bailey.
(48) „ incisa (Bréb.) Ralfs.

Genus Mougeotia Ag.

(49) M. Mougeotia affinis Kütz.
(50) M. „ laetivirens (A. Br.) Wittr.
(51) M. „ parvula Hass.

Genus Penium Breb.

(52) Penium Libellula Nordst.

Genus Spirogyra Link.

(53) Spirogyra maxima (Hass.) Wittr.
(54) S. neglecta (Hass.) Kütz.
(55) S. nitida (Dittw.) Link.
(56) S. setiformis (Roth.) Kütz.
(57) S. varians (Hass.) Kütz.

Genus Staurastrum Meyen.

(58) Staurastrum dejectum Bréb.

BACILLARIOPHYCEAE.

Genus Cocconeis Ehrb.

(59) Cocconeis Placentula Ehrb.

Genus Fragilaria Lyng.

(60) Fragilaria capucina Desm.

Genus Navicula Bory.

(61) Navicula viridis Kutz=Pinnularia viridis (Nitzsch) Ehr.

Genus Nitzschia Hass.

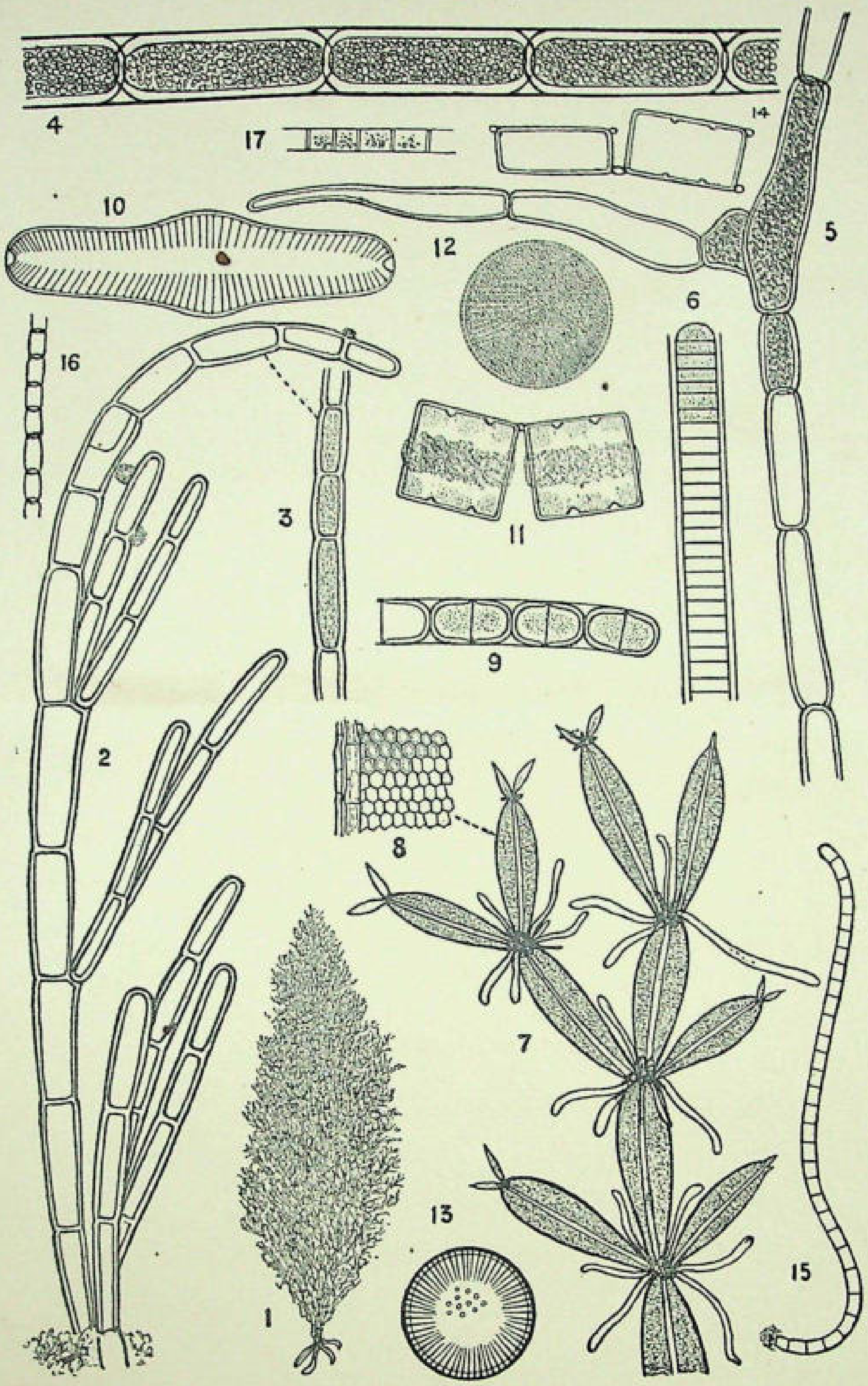
(62) Nitzschia linearis W. Smith.

Genus Rhopalodia O. Muller.

(63) Rhopalodia gibba (Ehr.) O. Müller.

Genus Synedra Ehr.

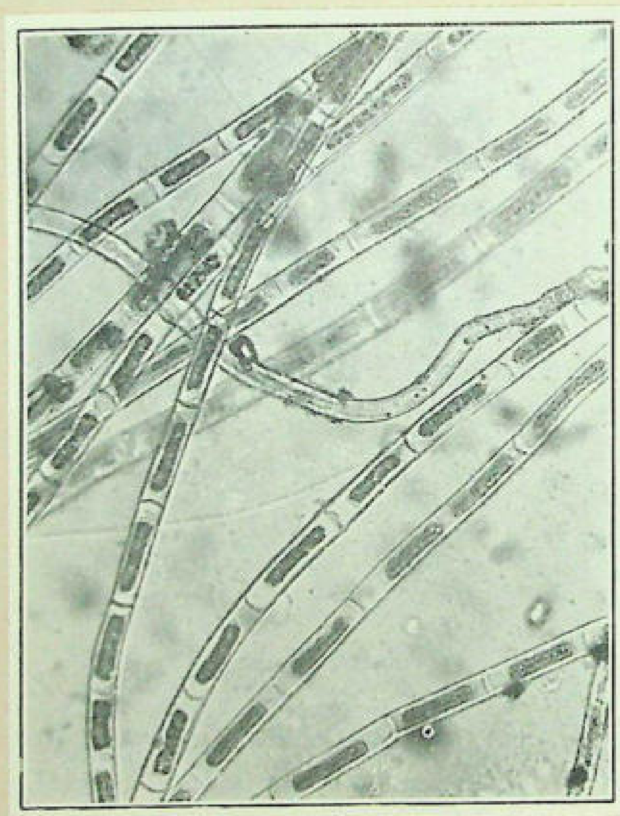
(64) Synedra affinis Kütz. var. fasciculata Kütz.
(65) S. ulna (Nitzsch) Ehr.



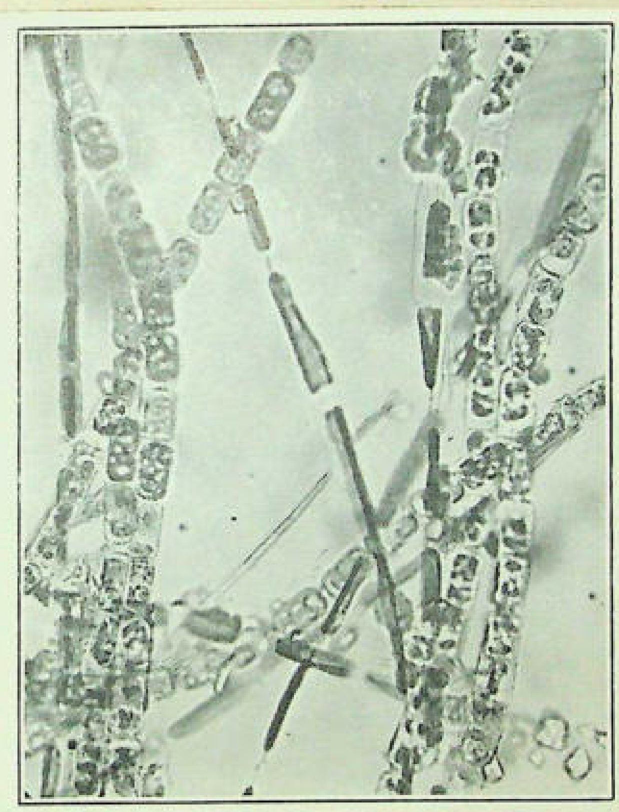
Explanation of Figures

Fig. 1.—Cladophora glomerata *var.* rivularis, a full size plant with basal rhizoids X natural size.
Fig. 2.—C. glomerata *var.* rivularis, portion of frond showing branching X 200.
Fig. 3.—C. glomerata *var.* rivularis, portion of frond showing the structure of the cells X 250.
Fig. 4.—Tribonema bombycinum, portion of filament X 650.
Fig. 5.—Rhizoclonium riparium, portion of frond showing a lateral branch spreading out horizontally X 250.
Fig. 6.—Lyngbya subconfervoides, portion of the filament X 350.
Fig. 7.—Caloglossa Leprieurii, fronds showing the branching and basal rhizoids X 10.
Fig. 8.—C. Leprieurii, portion of the frond showing the structure of the cell X 100.
Fig. 9.—Melosira jürgensii, portion of the chain enclosing plants X 250.
Fig. 10.—Rhopalodia gibba, single plant X 600.
Fig. 11.—Terpsinoe indica, single plant X 200.
Fig. 12.—Coscinodiscus radiatus, single plant X 250.
Fig. 13.—Cyclotella kützinghiana, single plant X 1000.
Fig. 14.—Terpsinoe indica, empty frustules X 250.
Fig. 15.—Crenothrix polyspora *forma* indica, a filament X 400.
Fig. 16.—Crenothrix polyspora *forma* indica, portion of young filament with cells without sheath X 400.
Fig. 17.—Crenothrix polyspora *forma* indica, portion of mature filament with cells containing microgonidia X 500.

I



II



III

Microphotographs

I. Caloglossa Leprieurii with eliphytic diatoms—Melosira jurgensii, Terpsinoe indica and Biddulphia laevis X 40.

II. Filaments of Rhizoclonium riparium with colourless basal portion X 200.

III. Chained groups of Melosira jurgensii mixed with a few portions of filaments, with collapsed cells, of Rizoclonium riparium X 200.

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My thanks are due to Mr. R. Ross, Diatomist, for his checking the names of some of the difficult and unrecorded species of Diatoms in comparison with the type slides at the British Museum (Natural History), and to Mr. G. Tandy, Assistant Keeper of Botany, British Museum (Natural History), London, for determining some of the species of Rhodophyceae by comparing them with the co-type sheets at the Museum.

An Abnormal Sterile form

of

Polystictus sanguineus (Linn.) Mey.

by

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An abnormal specimen of *Polystictus sanguineus* (*Linn.*) Mey. was collected in August and September 1937 from a split bamboo kept in a very slanting position on the terrace of the dwelling house of Professor Anutosh Das Gupta of the Bangabasi College, Calcutta; the bamboo log is used as a hanger for drying wet cloths in the open fully exposed to the sun. *Polystictus sanguineus* ordinarily is very thin and characteristically scarlet red. But in the present case it assumed a very much swollen appearance like a piece of red loaf (Fig. 1) and the excessive growth of the context-tissue led to complete obliteration of pores on the hymenial surface where no basidia or spores could be found; in the tissue of the sporophore only conidia of different sizes (2-4 μ broad) were found (Fig. 2). From the adjacent areas of the same bamboo-piece a number of a little thicker sporophores with elongated and irregular pores and with broad bases were collected in September and October of 1937 and 1938 in which basidia and spores were normal (Fig. 3). These are the trametoid forms of *Polystictus sanguineus* known as *Trametes cinnabarina* (Jacq.) Fr. which is usually found in the temperate regions. In this connection Cleland (Journal of Proc. of Roy. Soc. New-South Wales, Vol. LI, pp. 485-486, May, 1918) rightly remarks that "in colour and general appearance these two species are identical, the only difference being that the former is much thinner and contracted with a short lateral stem-like base, whilst the latter is thicker and has generally a broad attachment. *Polystictus sanguineus* (Linn.) Mey. is the tropical species while *Trametes cinnabarina* (Jacq.) Fr. is the temperate one, usually found in the cooler parts of Australia." In the neighbourhood of Sydney Dr. Cleland could find typical instances of both the species almost at any time of the year after sufficient rains on fallen logs.

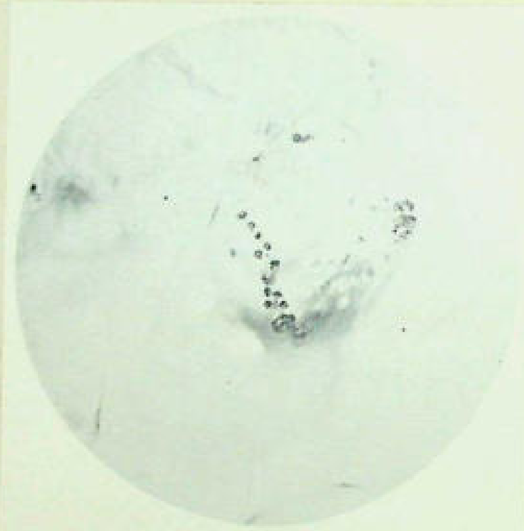
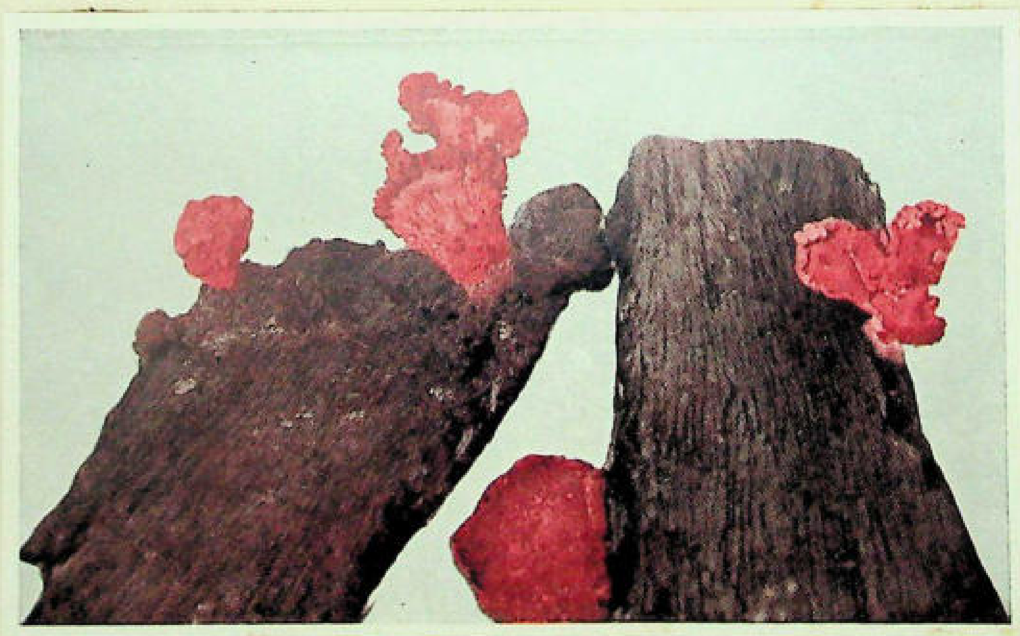


Fig. 2. Conidia of different sizes in chains in the tissue of the swollen abnormal sporophore under oil immersion lens with eye-piece No. 5.

G. Oehm (Beihefte Z. Bot. Centralbt. Bd. LVII Abt. A 1937) in *Polystictus hirsutus* (Wulf.) Fr. got abnormal secondary cushion-like growths in cluster in connection with the white overwintered fruit-bodies under the cover of snow and in an excessively moist condition, he calls such forms the *Paramyces* state of *Polystictus hirsutus*. He found that these secondary fruit-bodies developed only round colourless conidia ($5\frac{1}{2}$ to 9 μ) in chains, attached sideways to some of the principal stems of the brush-like hairy outgrowths and that they were independent of the regular basidia-bearing fruit-bodies though necessarily connected with them. In higher fungi the secondary spores are widely distributed as a subsidiary phenomenon. According to Oehm very high humidity and want of light might be the factors responsible for such abnormal formations. But in our case the abnormal specimens of *P. sanguineus* were equally exposed to the sun and the rains.

By keeping in a slanting position two small pieces of logs bearing normal sporophores of *Polystictus sanguineus* within a bell jar at the diffused light of the laboratory-chamber with moist cotton wool at the base for about two months (July to September 1938), I could get very abnormal development of freshly formed, small, and swollen fruit-bodies not very far off from the normal ones in the form of dendroid irregular elongations (Fig. 4). Some of these irregular elongations developed pores on the lower surface ; most of these pores were quite vacant but some had abnormal basidia in series which were very narrow and very much elongated like hyphal elongations from the hymenium ; spores, however, could not be found. This probably explains how abnormal forms are formed in nature due to a large extent, I think, to the slanting position of the host.



Circinoconis, A New Genus of Dematiaceae (Fungi Imperfectae).

by
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Introduction

On several occasions I collected in West Java and on Krakatoa Island a remarkable dematiaceous fungus, clearly belonging to the *Helicosporae*, which seems to be undescribed.

Its most outstanding characters are formed by the peculiar branching of the conidiophores and by the shape of its relatively large conidia. Conidia of this type are new, though they may be derived from those as found in the genus *Helicoma*.

Circinoconis BOEDIJN nov. gen.

Conidiophoris atrobrunneis, infra apicem sterilem furcatus, rami plerumque simplices, apice conidio circinato disciformi longe rostrato muniti. Conidiis brunnei, pluri-septatis.

Conidiophores straight, dark-coloured, mostly provided with two equally long branches, arising opposite each other near the apex. The part of the main thread cut off by the side branches is short and pale-coloured. Conidia solitary, only on the side branches, relatively large, dark-coloured, racket-shaped, consisting of one coil of cells ending into a rostrum.

Circinoconis paradoxa BOEDIJN nov. spec.

Late effusum, aterrimum; conidiophoris 300-477*u* longis, basi 10-24*u* apice 8-15*u* crassis. Rami 36-127*u* longi, 8-14*u* crassi. Conidüs pluri-septatis, circinato disciformi, longe rostrato, 80-119*u* longis, 45-63*u* crassis. Rostrum 6-12*u* crassis.

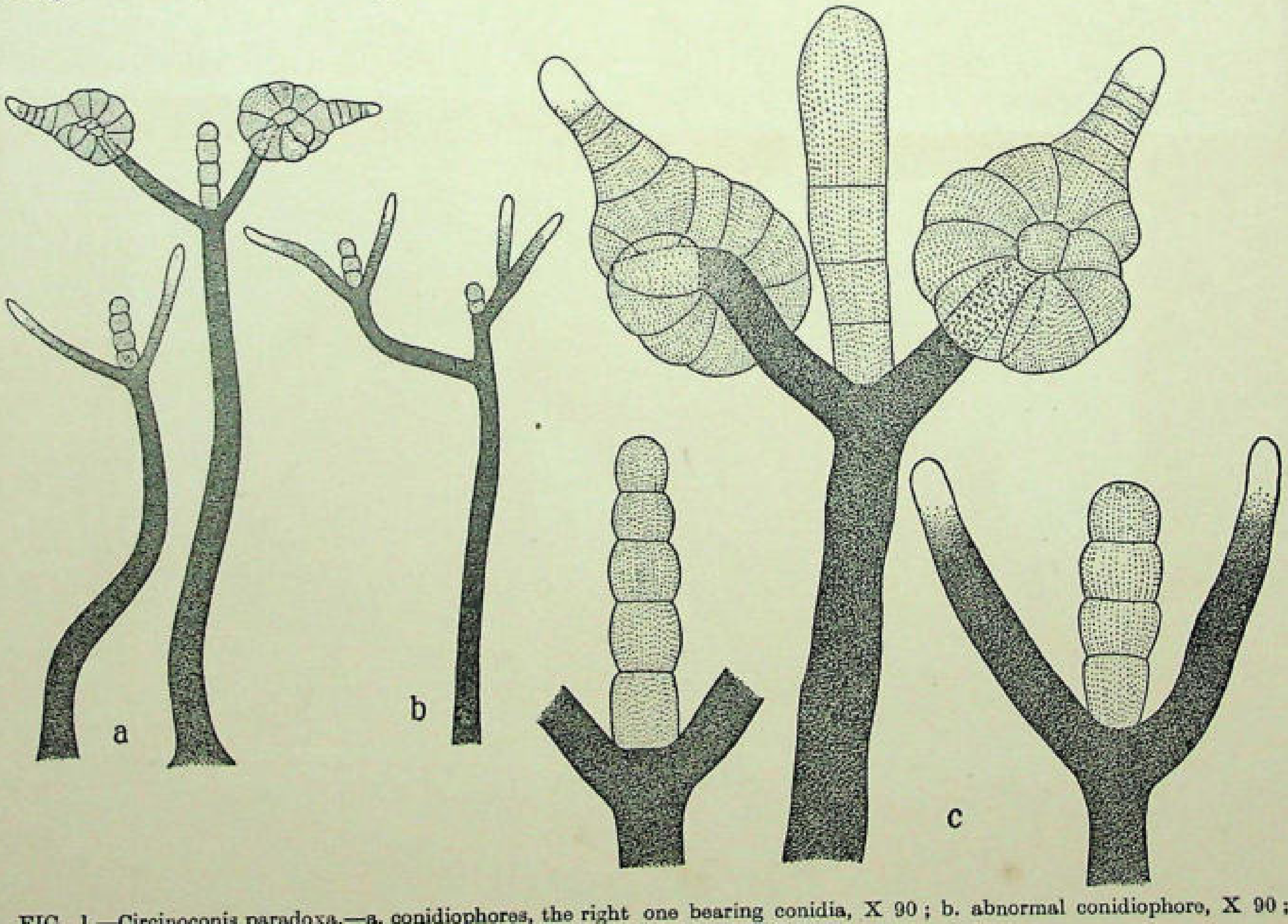

FIG. 1.—Circinoconis paradoxa.—a. conidiophores, the right one bearing conidia, X 90; b. abnormal conidiophore, X 90; c. tops of conidiophores, X 300.

Mycelium dark-coloured, mostly submerged into the substratum. Conidiophores erect, septate, rarely forked at the base ; 300-477*u* long, 10-24*u* broad at the base and 8-15*u* near the top, very dark blackish brown coloured, mostly opaque-black below ; near the top provided normally with two opposite branches; exceptionally one or both branches are forked. They are 36-127*u* long, 8-14*u* broad, of a dark colour, fading towards the apex. The part of the main hypha cut off by the side branches is 45-87*u* long, 12-19*u* broad and consists of 2-5, mostly 4, cells, which are usually constricted at the septa. This part, which always remains sterile, is much paler in colour than the rest of the conidiophore. Conidia solitary on the side branches, the normal conidiophore producing two conidia. The development of the conidia starts with a more or less horizontally directed, nearly hyaline thread. This thread forms one coil and at the point of contact the cellwalls are attached to each other, giving rise to a closed ring. Crosswalls are then formed and from the last but one cell a rostrum-like appendage originates. Sometimes this appendage is formed by the last cell. The colour of the conidia gradually becomes dark brown except for the top of the rostrum, which remains nearly hyaline. Ripe conidia are racket-shaped ; and consist normally of a ring of 10 cells, which on the circumference are constricted at the septa and terminate into an appendage, which is 2-8, mostly 6-celled. Length of conidia including the appendage 80-119*u*, breadth 45-63*u*. Rostrum 6-12 *u* broad.

SUMATRA. Lampongs Res. Krakatau Island, on dead stems of *Flagellaria indica*, April 1933, BOEDIJN 2501.

JAVA. Preanger Res. Tjibodas, on dead stems and petioles of *Plectocomia elongata*, April 1930, BOEDIJN 424, 443, 470, 599, September 1931, BOEDIJN 1563.

This remarkable fungus is rather common at Tjibodas where it chiefly grows on dead parts, specially petioles, of the ratan : *Plectocomia elongata*. I firstly believed that the species was specialised on this substratum and, moreover, only occurred on the mountains. But afterwards it was also collected at sea-level on a wholly different plant, viz., *Flagellaria indica*.

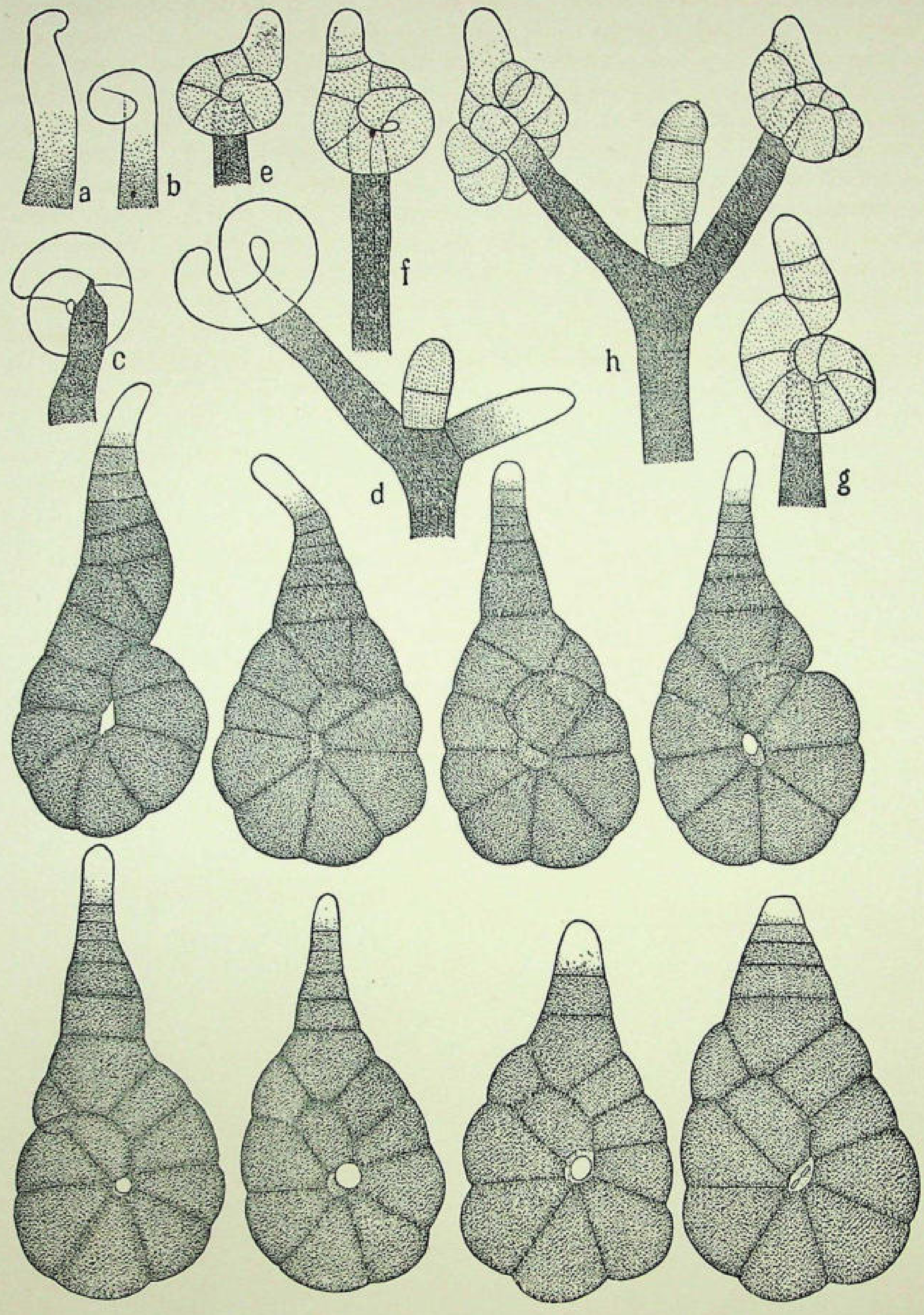

FIG. 2.—Circinoconis paradoxa.—a-h. successive stages in the development of the conidia, X 300; two rows at the base representing the variability of the ripe conidia, X 300.

Some problems of control of Soil-borne Fungal Diseases in Plants

by

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There is perhaps no group of plant diseases which has attracted more attention during recent years than the soil-borne diseases. These diseases are not so obvious as those of aerial parts and it was not until some of the more conspicuous diseases had been tackled vigorously that new fields of endeavour were sought and attention was drawn to what at one time appeared to constitute an unimportant group. With refined methods of isolation it became evident that fungi are commonly associated with the roots of diseased plants and as knowledge progressed the immense economic importance of this group of invaders became evident.

Most attention was at first paid to the soil-borne diseases of cereals. The methods of studying these became fairly well standardised ; in fact, one might say, stereotyped. Two processes were adopted. Invaded roots were washed with water, surface sterilized by immersing in a solution of mercuric chloride, washed in alcohol or water, and plated on agar. The fungi found were then grown on a rich organic medium which was added as inoculum to sterilized soil in which the suspected host was grown. By this method the parasitic organisms were sorted out and their nature was studied under various soil conditions.

The reason for this stereotyped method of approach is not difficult to find. It was simply that the fungi did not fruit readily on the underground portions of the plant, so that isolation in pure culture was an absolute necessity. Futhermore no reliance could be placed on infection tests in unsterilized soil which might harbour other organisms capable of parasitising the plant.

In this way the causes of many soil-borne plant diseases were discovered and something was learned of the biology of the fungi. But the greatest stimulus to modern research on diseases of this type came from the discoveries of Porter (1924), working with *Helminthosporium* blight of wheat seedlings and *Fusarium* wilt of flax, Millard and Taylor (1927) with potato scab and Broadfoot (1930) and Henry (1931) with foot-rots of cereals, that other organisms may have an important effect in reducing the abundance of a parasite in the soil. The problem has been well reviewed by Garrett (1934a, 1938), Porter and Carter (1938) and Weindling (1938), but the case may be briefly stated, for it has an important bearing upon the complex problem of soil-borne diseases.

It was found by Henry that when a soil-borne cereal root-invading fungus was added to ordinary soil the amount of disease in the subsequent crop was much less than when the same organism was added to sterilized soil. The effect of sterilizing the soil was lost if after sterilizing it was recontaminated with a comparatively minute quantity of the original unsterilized soil, and the conclusion was reached that the loss in virulence of the parasite was due to antagonism by other organisms. Upon this line work developed and the organism most popularly chosen for study was *Ophiobolus graminis* Sacc., the "take-all" fungus of wheat. This was chosen by many workers for two reasons, firstly its economic importance and secondly its high susceptibility to antagonism. The study of the nature of the antagonistic action has been vigorously pursued by Garrett who used a valuable new technique for studying the organism (1934b) by which it was possible to observe the actual linear growth of the fungus along plant roots in a direct manner rather than by the indirect and admittedly rather unsatisfactory method of giving infection ratings to plants. Sanford and Broadfoot (1931) were of opinion that antagonism towards *Ophiobolus graminis* was due to production of toxic substances. Garrett (1936, 1937) has produced some evidence that it is due to accumulation of carbon dioxide in the soil.

The take-all disease, then, has been studied from the point of view of the reaction of one parasite to the soil micro-organisms "en masse." The phenomenon has been studied from the other direction also. Weindling (1932) has tackled it from the point of view of one particular saprophyte, namely, *Trichoderma lignorum* (Tode) Harz. towards various parasites, namely, *Rhizoctonia solani* Kuhn, *Phytopthora parasitica* Dastur, and species of *Pythium*, *Rhizopus*, and *Sclerotium*, and the application of *Trichoderma* has had encouraging results in controlling diseases caused by these fungi. It has been found that *Trichoderma lignorum* produces a substance of definite chemical composition (Weindling and Emerson, 1936) which is highly toxic.

Brooks (1935) has remarked that "it is not too much to say that a new chapter in microbiology has been opened with the recognition of the factor of biological antagonism," and he adds: "It may be true that saprophytic organisms sometimes starve out the parasitic fungus, but another explanation is that the saprophytes secrete toxins which kill the pathogen."

Working under the guidance of A. W. Henry at Alberta the author was able to demonstrate (1935) that *Ophiobolus graminis* was unable to spread through black loamy soil in the absence of the host, but when the soil was planted with a susceptible host it spread quite rapidly. Later (1936) it was shown that *Ophiobolus graminis* is a fungus with peculiar nutritional requirements in that it fails to grow in ordinary synthetic media but requires a "growth factor," a chemical substance probably of rather complex organic structure which is produced by many plants. It was suggested that the inability of *O. graminis* to spread appreciably in unplanted soil might be due to both antagonism of other organisms and lack of "growth factor." Whether this is correct or not it is at present impossible to say, but it is an interesting coincidence that this fungus which shows very high susceptibility to antagonism, is one with an unusual metabolism, something half-way between a soil-inhabiting saprophyte and an obligate parasite. It may well be that the most marked effects of antagonism may be observed only in such semi-obligatory parasites.

It appears that there are two kinds of antagonism—antagonism due to a complex chemical substance such as that formed by *Trichoderma lignorum* and that due to carbon dioxide which may be produced by many organisms. The *Ophiobolus* type of antagonism may be enhanced by any method which will increase the general level of soil microbiological activity. The *Trichoderma* type of antagonism will be produced only when a specific organism is increased far above its normal proportions. The success of the biological method of control of soil-borne diseases will depend on the extent to which various parasites respond to antagonism of the general, or *Ophiobolus* type, and antagonism of the specific, or *Trichoderma* type. A fundamental method of testing the general applicability of the biologic method of control is to find which parasites respond to specific and which to general antagonism, and to find also those parasites which are able to grow in ordinary soil and those which have peculiar nutritional requirements like *Ophiobolus*.

Another aspect of soil-borne diseases to which increasing attention will have to be paid in future if control measures are to be on a sound basis is the complexity of the root-invading flora. Three cases which have come to the notice of the author will illustrate what is meant.

The first instance is concerned again with *Ophiobolus graminis*. When isolating this fungus from infected wheat roots an unexpectedly large number of cultures of a *Fusarium* were obtained from what looked like typical *Ophiobolus* lesions. The fungus proved to be *Fusarium avenaceum* (Fr.) Sacc. or a closely related form. In order to see whether the two fungi could invade the tissues together an experiment was made in which four treatments were given. One series of pots was prepared in which wheat was sown in sterilized soil; a second in which it was sown in sterilized soil heavily inoculated with *Ophiobolus graminis*; a third in which the seed was immersed in suspension of *Fusarium avenaceum* spores before sowing in sterilized soil; and a forth in which sterilized soil was inoculated with *Ophiobolus* and planted with *Fusarium* infected seed. The controls grew into healthy seedlings; the seeds sown in *Ophiobolus* infested soil became severely attacked, the entire root system became rotten and the stems completely blackened to an inch or so above soil level, and the plants were severely stunted; the seeds inoculated with *Fusarium* and sown in sterilized soil produced slightly stunted seedlings with distinct reddish-brown lesions on the stems and roots; and the seedlings which had both *Fusarium* and *Ophiobolus*, though significantly more stunted than those with *Ophiobolus* alone, showed externally only the symptoms produced by the latter *Fungus*. When isolations were made by surface sterilizing the stem tissue with silver nitrate followed by sodium chloride and plating on agar an unexpected thing happened. The plants inoculated with *Ophiobolus* alone yielded only *Ophiobolus*, and those with *Fusarium* alone, only *Fusarium*. But the plants inoculated with the two fungi and showing symptoms of *Ophiobolus* attack only, yielded *Fusarium* in every case and there was no sign of growth of the fungus which was clearly causing the major disease.

The second instance is that of gram (*Cicer arietinum* L.). The author working in conjunction with Mr. Nirankar Prasad found an extraordinarily varied collection of species of *Fusarium* growing out from surface-sterilized stem tissue of wilted plants. A number of probably distinct species of *Fusarium* were obtained. Experiments later proved that some of these could cause seed rotting and others wilting, so that two distinct types of disease were caused by closely related species. This work will shortly be published.

The third instance worthy of mention, and in some ways the most interesting, was the result of systematic isolations made by the author recently from roots, stems, stipules and leaves of betle vine (*Piper betle* L.) suffering from the disease known as "foot-rot." That several fungi may take a part in causing this disease appears evident from work that has already been done on the subject. Dastur (1935) showed that *Phytophthora parasitica* var. *Piperina* Dast. and *Pythium Piperinum* Dast. are both parasites on roots and underground stems of *Piper betle* in the Central Provinces; rotting of the underground stem is caused by *Sclerotium rolfsii* Sacc. Infection tests with *Rhizoctonia bataticola* (Taub.) Butler and *Rhizoctonia solani* Kühn gave negative results. *Phytophthora parasitica* var. *Piperina* may also cause a leaf-rot. Species of *Colletotrichum* attacked the aerial stem and branches, and occasionally the underground stem, but at the time of publication he had not observed leaf attack. McRae (1934) found *Rhizoctonia solani* an important cause of foot-rot of *Piper betle* in Bengal.

Diseased and healthy plants were collected by the author from several gardens in the State of Chhatarpur and isolations were made by surface sterilizing ten pieces of root, stem, stipule or leaf with a one per cent. aqueous solution of silver nitrate followed by immersing in one per cent. solution of sodium chloride according to the method of Davies (1935). The two genera chiefly represented among the isolates were *Colletotrichum* and *Fusarium*, as indicated in Table I.

TABLE I

Isolations from roots, stems, stipules and leaves of Piper betle L.

Garden No.	Tissue.	Number of isolates of *Colletotrichum.*	Number of isolates of *Fusarium.*	Number of isolates of other fu ngi.
1	Leaves (spotted)	4	1	2
	Stipules of healthy leaves	6	4	0
2	Stems of wilted plants	4	2	0
	Roots of wilted plants	0	2	0
3	Stipules of leaves of wilted plants	0	9	0
	Stems of wilted plants	10	5	0
	Roots of wilted plants	1	10	1
4	Stipules of healthy leaves	0	10	0
5	Stems of diseased plants	5	0	0
	Roots of diseased plants	0	5	0
6	Stipules of diseased plants	4	2	0

The salient facts of Table I are briefly summarized in Table II, which gives the distribution of isolates of *Colletotrichum*, *Fusarium*, and other fungi from stipules, stems, leaves and roots.

TABLE II

Distribution of Colletotrichum, Fusarium and other fungi in the tissues.

Tissue.	Number of isolates of *Colletotrichum.*	Number of isolates of *Fusarium.*	Number of isolates of other fungi.	Number of pieces of tissue used for isolation.
Stipules ..	10	25	0	40
Stems ..	19	7	0	30
Leaves ..	4	1	2	10
Roots ..	1	17	1	30

It is seen that *Fusarium* was abundant on the roots as well as on the stipules where it was first observed, and that *Colletotrichum* was found not only on the stems where it was fruiting abundantly, but also on leaves and stipules and even on roots. There were several species of *Fusarium* and apparently more than one of *Colletotrichum*. Species of *Fusarium* are not common leaf parasites and *Colletotrichum* is rarely found on roots. Neither *Phytophthora* nor *Rhizoctonia* was isolated, though the former was observed in sections of some leaves. These results suggest the possibility that the disease is caused by a fungal complex, a point which it is hoped may be ascertained by experiment.

The three cases mentioned show amongst other things the following facts :—

(1) A fungus like *Ophiobolus* which is highly susceptible to biological antagonism may, when infecting a host, work in complete compatibility with another parasite.

(2) Isolations by surface sterilization, even when done in a highly systematic way may not yield the fungus which is the most serious parasite.

(3) The symptoms produced by one fungal parasite may completely mask those of another.

(4) A diseased plant may harbour a considerable number of different but closely related species of fungi each of which causes a distinct type of damage.

(5) Fungi such as *Colletotrichum*, normally considered to be restricted to stems and leaves of a plant, may, under the mask of symptoms produced by other fungi, be present on the roots of the plants.

We may add to this the following facts which have emerged from the widespread studies of root-rot diseases generally :—

(6) Antagonism of micro-organisms is an important factor in the prevalence of disease and it may be antagonism of a general nature, due to production of a certain soil condition by a large number of organisms, or antagonism of a specific nature due to production of a particular toxic substance by certain special organisms.

(7) Some root-rotting organisms may possess a metabolism of a very special type reminiscent of the obligate parasites and this may perhaps influence the growth of these fungi in the soil.

Many plants are known to suffer from several root-rot diseases due to different fungi. That these may work together to cause complex diseases is an idea which, it is suggested, is gaining ground. In this connection reference may be made to the recent publications in which it has been suggested by Hull (1937) and by the author (1938) that pea seeds may suffer from complex rotting and by Wollenweber (1938) that certain *Fusarium* diseases are due to several species of this genus. We should avoid the pitfall of assuming that in all cases of a mixture of fungi isolated from diseased plant tissue we are dealing necessarily with " primary " and " secondary " parasites.

One more aspect of root diseases has recently attracted attention, and in this workers in India can claim to have led the recent advances. McRae and Shaw (1933) showed that cattle manure, superphosphate and green manure increase the wilt disease of *Cajanus cajan* (*C. indicus*) caused by *Fusarium udum* Butler, referred to by them as *Fusarium* *vasinfectum.* Experiments with wheat in which *Fusarium culmorum* (W. Sm.) Sacc. and *Helminthosporium Sativum* P. K. and B. were used as the root-rotting fungi by Greaney (1938) and Broadfoot and Tyner (1938), respectively, showed no sign that the quantity of phosphorus within ordinary limits appreciably influenced susceptibility of the hosts, although a general lowering of the nutrient supply did increase susceptibility to *Helminthosporium sativum.* Their work was done with artificially inoculated plants growing in nutrient solution in quartz sand, so that probably in this case the complications of antagonism and of fungal nutrition were eliminated and the susceptibility of the host was being directly studied, whereas in the work of McRae and Shaw, conducted in the field, the influence may have been on the growth of the fungus in the soil. A possible breakdown of resistance due to excessive soil moisture has been suggested recently by Viswa Nath (1936) in the case of the betle vine foot-rot disease. Viswa Nath concluded that " the effect on the plant of supersaturated condition of the substrate in regard to water, is not merely defective root aeration, but to induce defective water balance in the leaf to the detriment of the general health of the plant." Vasudeva (1937) found that cotton root-rot due to *Rhizoctonia solani* and *R. bataticola* is severe only in wet soil. The effect of water balance of the host on parasitic relationships was pointed out in the case of *Botrytis cinerea* Pers. by Brown (1934). Again, Hull (1937) showed that the fungal rotting of pea seeds is related to a high moisture content in the soil. Howard (1936, 1938) as a result of many years of study in India concluded that " Disease resistance seems to be the natural reward of healthy and well-nourished protoplasm."

We may thus add our eighth point in regard to root-rot diseases, namely :—

(8) The possibility of altering the susceptibility of a plant to root-rot diseases is not entirely without promise.

It seems that if practical advances in the control of root-rot diseases of agricultural crops are to be hoped for a certain new orientation of ideas may have to be made. It is of importance to learn in general the ability of root-rotting fungi to grow in soil and their susceptibility to antagonism. It may be necessary to regard certain root-rot diseases as complex and to avoid laying undue stress on particular fungi which under artificial conditions of inoculation cause severe damage and to rid our minds of the " primary-secondary " parasite notion ; and finally it is just possible that we may have to pay attention in the near future to a reconsideration of our present indifference to the idea of predisposition. For it is not certain that even the most strenuous efforts at working with individual fungi are going to solve permanently the complex diseases if they are in fact due to a general breakdown of resistance on the part of the plant.

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NOTE.—Since the above article was written, several papers have appeared which strongly support the views expressed with regard to the peculiar behaviour of *Ophiobolus graminis.* Garrett (Nature CXLV, 3664 pp. 108-109, 1940) confirmed my previous finding that in the presence of a suitable source of growth factor, *O. graminis* can utilize nitrate nitrogen. He has also, in a recent paper (Ann. Appl. Biol. 27:199-204, 1940) accepted the view first expressed by me (Sci. Agric. 16:365 -372, 1936) in 1936, that much of the antagonistic action of other organisms towards *O. graminis* is a matter of competition for available food. He concludes that the disappearance of *O. graminis* from the soil under conditions of good æration is probably due to rapid consumption of available food material by the fungus itself and by associated micro-organisms.

Taxonomic studies of Indian Smuts

by

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Studies on the taxonomy and nomenclature of the smuts occurring in India date back to the years 1851 to 1854 when Berkeley (1) in his "Decades of Fungi" published notes on collections sent to him by Sir Joseph Hooker. These collections were made in Sikkim and Assam and included four new species of smuts, *Ustilago bursa, U. emodensis* [now called *Liroa emodensis* (Berk.) Cif.], *U. ocrearum* and *U. vittata* [now called *Tilletia vittata* (Berk.) Mundkur] and one more species, *U. endotricha* [now called *Farysia endotricha* (Berk.) Syd.], which had already been named by Berkeley from New Zealand material. A second report on Indian smuts appeared in 1874 when Cooke (4) described *U. pulveracea* on *Zea mays*, at present a synonym of *Sorosporium Reilianum* (Kuehn) McAlp., and two more new species thirteen years later in the collections made and sent by Mr. C. B. Clarke. These species are *Cintractia cryptica* and *C. pulverulenta.*

Smuts were also collected by Dr. D. D. Cunningham and Major A. Barclay, two Indian Army Medical Officers, who were pioneer investigators of the fungi of India during the years 1871 to 1895. Their collections were sent to Brefeld (2) who was then an intensive investigator of the smut fungi in Germany. He found nine new species in the material but Brefeld's chief interest lay in the pathology, the method of germination of the spores and the further growth of the smuts rather than in their morphology or taxonomy so that his descriptions of these species are very meagre and fragmentary.

Two more species of Indian smuts were described by American Mycologists. The first of these is *Schroeteria annulata* of Ellis and Everhart (6) [now called *Sphacelotheca annulata* (E. & E.) Mundkur] who found it on *Andropogon annulatus*, a binomial that is now included in the synonym of *Dicanthium annulatum* (Forsk) Stapf and the second is *Ustilago Duthiei* [now a synonym of *S. annulata* (E. & E.) Mundkur] found on the same host by Ricker (12). The latter smut was collected in 1888 at Dehra Dun by Mr. J. F. Duthie. Ricker, of whom enquires were kindly made on my behalf by Dr. J. A. Stevenson, Senior Mycologist, in charge of Mycological Collections in the U. S. Department of Agriculture was not in a position to state how he came by the smut, but suggested that he possibly found it on a phanerogamic specimen he had occasion to handle at that time. A search in the U. S. National Herbarium, which was made by Dr. Stevenson, led to the discovery of what is apparently this phanerogamic specimen, showing the place where the smutted heads had been removed. I have not so far been able to find out the date and place of collection and the name of the collector of Ellis and Everhart's fungus. I suspect that that smut also was from some collection made by Duthie; at any rate a critical examination of the type specimens of both the smuts has indicated that they are one and the same species.

While collections of smuts were made and sent abroad for determination, their study in India itself was by no means neglected. In 1887 Cunningham (5) studied a smut found by him in the leaves of two species of *Nymphaea* at Calcutta. He founded the genus *Rhamphopsora* to accommodate this smut which he called *R. Nymphaeae* [now called, however, *Entyloma Nymphaeae* (Cunn.) Setchell].

It will thus be noted that up to the end of the last century twenty smuts had been recorded for our country, of which eighteen were new species. This is indeed a noteworthy record, considering that with the exception of the two pioneers, Cunningham and Barclay, there were no mycologists working in India. But unfortunately all the collectors, with the solitary exception of Mr. Duthie, kept no duplicates of the collections which they sent abroad for naming and want of cotypes or authentic specimens combined with the fact that descriptions of the species are fragmentary, has adversely affected the naming of many of the Indian smuts.

While examining for instance eleven collections designated *Ustilago Andropogonis-annulati* Bref. in the Herbarium Cryptogamae Indiae Orientalis of the Imperial Agricultural Research Institute, New Delhi, I found that seven of these have echinulate spores with a mean diameter of 10·2u. and three collections have smooth spores with a mean diameter of 11·3u. while the eleventh collections has spores with large spines and a mean diameter of 12·2u. Brefeld's (2) description of *Ustilago Andropogonis-annulati* was too vague to be useful in deciding which collection was of that fungus; but at the same time there was little doubt that they belonged to three different species.

After some deliberation I concluded that the seven collections with echinulate spores and 10·2u mean diameter were of *U. Andropogonis-annulati*, [now called *sphacelotheca Andropogonis-annulati* (Bref.) Zundel], that the three others with smooth spores and 11·2u mean diameter, were of *U. Duthiei* (now a synonym of *S. annulata*) and the last collection with prominent spines and 12·2u mean diameter, was a new species (named *Sphacelotheca Sahayai* Mundkur). On receipt of the type specimens of the first two fungi, I found that my surmise was correct.

The task of obtaining type specimens or fragmets of them is not, however, easy. Many times it is difficult to find out where the type may have been deposited. Very often the type material is so scanty that curators of herbaria hesitate to divide the material or to trust it to the vagaries of the post office. The policy of some herbaria, like the Farlow Herbarium, is against lending specimens. With the help of the Imperial Mycological Institute, Kew, and its distinguished Director, Mr. S. F. Ashby, I was able, however, to obtain fragments of the types of many of the Indian smuts. Sir Arthur Hill, Director of the Kew Herbarium, very kindly placed at my disposal fragments of Berkeleyan species.

These efforts enabled me for instance to place, on what I consider as a sound basis, the taxonomy of the smut attacking *Coix Lachryma-Jobi L.* two collections of which are in the Herb. Crypt. Ind. Orient. and one at Poona. Smutted specimens of *C. Lachryma-Jobi* were first collected by collet in Assam and sent by Barclay in February 1891 to Brefeld (2) who named it *Ustilago Coicis* four years later. A second collection of a smut on this same grass was made by Professor S. L. Ajrekar in 1913 on the Girnar Hills in Kathiawar. On the basis of the description of *U. Coicis* given in Saccardo, the smut was identified at Pusa to be that fungus. When I compared it with the type specimen of *U. Coicis* which was secured for me by Mr. Ashby from Dr. E. Ulbrich, Kustos and Professor at the Berlin-Dahlem Botanical Museum, I found that the spores of the Girnar fungus are smooth and have a mean diameter of 11·4u while the type has echinulate spores with large pits on the epispore surface and a mean diameter of only 9·2u. Likewise two other collections of a smutted grass, *Polytoca barbata* Stapf, which is very nearly related to *C. Lachyma-Jobi*, had also been identified as *U. Coicis* but which, I now find, belong to a new species. (*Ustilago Polytocae* Mundkur.)

These difficulties in correctly identifying Indian smuts were rectified by Dr. E. J. Butler who arrived in India at the beginning of the present century as the Cryptogamic Botanist to the Government of India, later designated Imperial Mycologist. Extensive collections of smuts and other fungi were soon made and Dr. Butler endeavoured to identify the collections in India itself with the aid of such literature as was then available. These were then carefully mounted and numbered and parts of the collections were sent to Dr. H. Sydow for confirmation of the identifications by comparison with the types or authentic specimens. About seventy-six collections of smuts were thus dealt with during the years 1904 to 1914, of which thirty were found to be new species. In each and every case arrangements had been carefully made to receive back the types, cotypes or identified specimens so that there is hardly any difficulty now in matching later collections of many of these smuts.

In justice to Dr. Butler it has to be stated that about nineteen smuts had been recognised by him as new species and their latin diagnoses were even written before sending them to Sydow for publication in the "Fungi Indiae Orientalis." series (13). When publishing the names, however, I find that Sydow's name has been added as the senior authority responsible for the specific name.

While examining some of these collections, I discovered that some of the host identifications were incorrect, which fact has led to errors in the naming of the smuts. For instance I found three collections of smutted "*Andropogon Schoenanthus* L." named as *Ustilago Schoenanthi* Sydow and Butler. But the binomial "*Andropogom Schoenanthi* L." no longer exists as the grasses said to comprise that species have been split up into a number of species by Stapf and other agrostologists. An examination of the three smuts themselves showed that they did not belong to one species. A re-determination of the grasses by Dr. K. Biswas and Mr. V. Narayanaswami of the Royal Botanic Gardens at Sibpur indicated that the type specimen of Sydow and Butler's *U. Schoenanthi* and one other collection were *Cymbopogon flexuosus* (Steud.) Watson and the third collection was. *C. coloratus* Stapf. Furthermore I found that the smut on the first two collections was *U. Schoenanthi* and that the one on *C. coloratus* was a new species (*Ustilago Barberi* Mundkur).

Another smut collected by Mr. Duthie, on *Carex hirtella* in 1884 at Darma, North-West India, was named only in 1935 by the Finnish Ustilaginologist, Liro (8), as *Cintractia disciformis*. Even in this case I have not been able to ascertain how this smutted specimen found its way to Helsingfors. The description and the name of the smut are published in a rather inaccessible Finnish Journal, which reached me only very recently, so that, I could not include it in my Supplement to the Fungi of India (10).

Within recent years smuts have been collected and named by Indian mycologists themselves. A smut on *Eleusine coracana* Gaertn. *f.* was named *U. Eleusinis* by Kulkarni (7) and a bunt occurring on wheat in the plains of the Punjab and the Frontier Province was named *Tilletia indica* by Mitra (8). Studies in the germination of this bunt have shown, however, that its promycelium forms 32 to 128 or more primary sterigmata (primary conidia of Brefeld) which do not conjugate. This fact unmistakably shows that the bunt belongs to the genus *Neovossia* and I have recently suggested its transfer (10) to that genus as *Neovossia indica*. I may state here that the number of primary sterigmata in *Tilletia* is eighteen or less and that they invariably conjugate. A third smut, *Urocystis Brassicae* was recently named by myself. Other chief smut collections of recent years are those by Dr. and Mrs. R. R. Stewart, which were examined by Clinton and Zundel (3) who found that they included four species until then unrecorded for India.

In conection with a critical study of the Indian smuts that has been recently started, I have so far examined forty-four collections* of Indian smuts and I find that they resolve themselves into twenty-five species, of which seven are new and five have been made into new combinations, as our concepts of some of the genera have now become clearer. A critical examination of a little over fifty collections of sugarcane smuts has also been made and here also I am led to the conculsion that the culmicolous smut which forms a flagelliform whip in sugarcane and now known as *Ustilago scitaminea* Sydow, may consist, on definite morphological grounds, of one species and two varieties.

In conclusion I should like to point out that a taxonomic study of Indian smuts, and indeed of other fungi found in our country, is not without its economic uses. Unless the correct name of the infesting smut is definitely known, efforts to control the disease it causes are not worth while. In the case of barley smuts, for example, it is now recognised in the United States of America that there are more than two species of smuts attacking this crop. Some of these are externally seed-borne and others are internally seed-borne. A correct determination of the pathogen can alone show which should be the proper method for controlling a particular smut. Even in developing resistant varieties, the necessity of knowing the correct name of the pathogen is fairly obvious.

Summary

A short historical account of the smut collections made in India is given and it is stated that up to the end of the last century twenty smuts had been discovered, of which eighteen were new species. Six of these were named in England, nine in Germany, two in America and one in India. Types or cotypes of these smuts were unavailable in India.

During the present century many collections of smuts were made by Dr. E. J. Butler, included in which were thirty new species. Several other collections have also been and the total number of smuts recorded for India up to the end of 1938 was 110.

A brief account of the investigation of forty-three collections of Indian smuts, included in which are seven new species, five new combinations and thirteen other species, is given and mention is also made of the taxonomic study of over fifty collections of sugarcane smuts.

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The Relationship of Agricultural Science with Taxonomy and Cytology

by

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The hundred and fifty years which the present volume celebrates have seen an astounding development of Botany. Once upon a time it was *scientia amabilis*, the lovable science, eminently suitable for leisured amateurs. It has now grown into a galaxy of sciences each in itself a new world.

The older botany was naturally much occupied with description and classification. Classification became taxonomy when a scientific basis was provided by the doctrine of evolution. Laboratory specialists may decry the taxonomist, but a botanical education which has somewhere in its foundations an acquaintance with the many and varied forms to be found in the field and a knowledge of how their relationships may be ascertained, is a good start for narrower studies.

The older taxonomists had to rely purely on external morphological characters, of at least such a size that they could be observed with a hand lens. The modern taxonomist has at his command the study of the cell nucleus and its chromosomes. Recent improvements in microscopy and microtechnique have enabled him to study in detail the behaviour of chromosomes which provide the mechanism of heredity and evolution. The importance of this study in relation to taxonomy and genetics is well illustrated by the rise of the modern sciences of Cytotaxonomy and Cytogenetics which have shed considerable light on the origin and evolution of many of our cultivated plants. The number and morphology of the chromosome complement in any one species (known as the karyotype) has been found to be a definite character and is related to the karyotypes of other species of the same genus. An understanding of species and other categories of taxonomic classification must ultimately be based upon an analysis of chromosome complements. Considerable work has been done on this aspect and along with phytogeographical surveys has tended to elucidate how new species arise in nature. Apart from their historical and scientific value, phytogeographical and cytological studies provide priceless indications as to what to attempt and what to avoid in plant introduction and plant breeding.

It may not be out of place to give a few recent Indian examples of the relationship of Agricultural Science with Taxonomy and Cytology, which make it plain that the oftdrawn line between pure and applied botany is a very shadowy frontier.

Cotton

The classification and origin of the various species and cultivated forms of *Gossypium* has been the subject of study for a long time and recent cytological and genetical work have

*Since this article was written (December 1938) various books and papers have appeared, adding considerably to our knowledge of the subject and developing the theory. Among these we may particularly mention "The New Systematics" (1940), edited by Julian Huxley.

led to considerable advances towards a solution of the problem. Zaitzev (quoted by Gates, 1938) from extensive and comprehensive studies of cotton from all parts of the world, concluded that cotton species have been independently brought into cultivation by man in four separate regions, two in the Old World and two in the New, *i.e.*, Indo-China, Africa, Central America and South America. Applying the conceptions of Vavilov he found homologous variations in cotton species of these four regions which have often led to mistaken conceptions of relationships between species native to these regions. Recently Hutchinson and Ghose (1937) have dealt brilliantly with the classification and phytogeography of the various species and cultivated forms of this genus. These species fall naturally into three divisions, the wild and cultivated cottons of the Old World with n=13 chromosomes, the cultivated American cotton and three wild species from islands of the Pacific with n=26 chromosomes, and the wild cottons of the New World with n=13 chromosomes. Hutchinson shows that the history of cultivated species of cotton provides an example, such as is not often obtainable, of considerable evolutionary progress in historic times, the main line of progress in the cultivated species of both the Old and the New World being from highly monopodial, perennial, subscandent bushes to sympodial, annual, erect small shrubs. The details of the process, according to Hutchinson, have been very different in the two species, owing to the difference in the distribution of the wild forms from which those of cultivation have been derived. Climate, commercial requirements and exigencies of farming have been the agencies influencing this evolution.

The problem of greatest significance and importance is of course the origin of the so-called New World Cottons with n=26 chromosomes. Since Denham (1924) examined *G. barbadense* (Egyptian) and another cotton collected in the interior of Columbia and discovered that these species had n=26 chromosomes, while the Asiatic cottons had only n=13 chromosomes, American wild cottons with n=13 chromosomes have also been discovered. Skovsted (1934) showed by cytological studies that the tetraploid species are allopolyploids, *i.e.*, they have arisen through a doubling of the chromosomes in a sterile hybrid between two diploid species with n=13 chromosomes. From chromosome measurements in Old World and New World diploid species and in the American tetraploids he concluded that the American tetraploids arose from doubling of the chromosomes in crosses between Asiatic and American diploids. He found that the Asiatic diploids (*G. Sturtii* and *G. Stocksii*) had larger chromosomes than the North American diploids and the American tetraploids contained a set of smaller and a set of larger chromosomes. The question of chromosome sizes has been examined by Artjunova (1936) who made a comparison of the sizes of chromosomes, of *G. herbaceum* (diploid) and *G. hirsutum* (tetraploid) and concluded that there is no basis for Skovsted's hypothesis that American cottons have two distinct sets of chromosomes. On the face of this evidence, it appears that the tetraploids, at least some of them, arose from crosses between nearly related diploid species or even without crossing by chromosome duplication in single species, *i.e.*, by autopolyploidy. The importance of autotetraploidy as a factor in evolution and differentiation of species is well known due to the work of Müntzing (1936). So it would appear that the American cottons with n=26 chromosomes have arisen independently, some as a result of crossing between distantly related diploid species and some between nearly related ones, followed by chromosome duplication and others by simple autotetraploidy, *i.e.*, chromosome duplication in single species. This view appears to be in accord with that of Harland, who, on extensive genetical data, differs from the view of Skovsted that the American tetraploids form a more closely related group than either the American diploids or the Old World species.

Then as regards the primitive ancestors of cotton, detailed cytological analysis of cotton species and their relatives has shown that the chromosome number 13 has been derived in evolution from an original smaller fundamental number. The evidence for this conclusion is based on the association of more than two chromosomes at meiosis, which was first observed by Kuwada (1910) in *Oryza sativa* and later in *Prunus* by Darlington (1928). Lawrence (1931) showed that this " secondary association " of chromosomes is of wide occurrence in polyploid plants and provides the " criterion for homology " in such plants. Analysis of such associations at metaphase of meiosis has shown that they are variable according as the similar chromosome pairs were within each other's sphere of attraction during their movement in the viscous cytoplasm during meiosis, but the maximum grouping, whenever found, was characteristic and provided the indication for the basic number. In cotton, Davie (1934) found that the 13 bivalent chromosomes arranged themselves in six pairs with one single, indicating that 7 was the fundamental number. Skovsted, however, found, in some cells, a group of three bodies in addition to various pairs indicating the previous number to be six. Examination of chromosome numbers in the Malvaceae lends support to both the views. In *Malva, Malvastrum* and *Pavonea*, etc., the chromosome number is seven or multiples of it and in *Gossipoides* and *Kokai*, the number is 2n=24, a multiple of six. According to Gates (1938) six is probably a transitional number between 7 and 13. The idea of cotton having been derived from ancestors with a smaller chromosome number is very well supported by the genetical evidence which shows the presence of the multiple-factor type of inheritance for several characters.

Cotton has also been the subject of the first serious attempt to schedule the nature and normal limits of variation in certain characters. This was done in order that plant breeders might have some means both of describing and comparing the strains produced by them. In cotton, as also in rice, several agricultural botanists set out to construct a classification of varieties. No two of them agreed and often such a classification was of little use outside a limited field. The system now recommended is not a classification in the taxonomic sense and does not demand the full description of every strain listed. It deals with certain important characters including some not usually handled by the taxonomist, and goes into some detail regarding these, giving certain colour tables when required. The schedules prepared for cotton and rice are the result of the work of two sub-committees appointed by the Imperial Council of Agricultural Research with the collaboration in the case of cotton of the Indian Central Cotton Committee (Hutchinson, Ramiah and others, 1938).

Sugarcane

The work of sugarcane breeding done at Coimbatore first by Barber and then by Venkatraman is known throughout the world. The use of the wild sugarcane (*Saccharum spontaneum*) to introduce certain characters into sugarcane hybrids, is also well known. Since the discovery that sugarcane produces true seeds and hybridisation for improvement of canes was resorted to, the first result was the beginning of " nobilisation," *i.e.*, successive crossing of wild *S. spontaneum* with noble or cultivated sugarcanes which have thick stems, to secure forms resistant to diseases. Coimbatore was the first station deliberately to use *S. spontaneum* in crosses with *S. officinarum*, the cultivated species, and several of the improved types evolved there are from crosses of the two species.

The cultivated sugarcanes are probably derived from the wild species *S. spontaneum* and *S. robustum* which are widely distributed in the old world. The number of sugarcane varieties found in nature is legion and most of these are of hybrid nature owing to their being able to cross readily, under the right conditions, not only amongst themselves but with related genera of other grasses. There are varieties recently collected in New Guinea, which appear to be crosses between *Saccharum* and *Erianthus.* The stems of these are rich in starch rather than sugar and the plants are utilized by the natives for their edible flowers. The ability of the sugarcanes to cross freely with other grasses is confirmed by the success that has attended the efforts of the staff at the Sugarcane Breeding Station, Coimbatore, in crossing them with a wide variety of grasses, *i.e.*, sorghum (Venkatraman and Thomas 1932), bamboo (Venkatraman 1937) and maize (Janaki Ammal 1938).

A phytogeographical survey of the sugarcanes and their cytology reveals interesting facts about their origin and evolution. It is remarkable that in the year 1936-37 alone, a collection of 80 new types of *S. spontaneum* was made during a tour in Orissa, Assam and the Godavery district of Madras. The collection of *S. spontaneum* now being grown at Coimbatore has to be seen to be believed, ranging from thin desert grasses to large thick canes. The large collections of *Saccharum* made by Roxburgh and housed at Kew and herbarium sheets of other early collections have been studied by Dr. E. K. Janaki Ammal with a view to determining the distribution of the genus.

In recent years cytological evidence is being added to those derived from phytogeographical studies, regarding inter-relationships of this genus. The work of Bremer in Java and Janaki Ammal and her co-workers in India have thrown some light on this problem. Janaki Ammal (1936) worked with Indian varieties of *S. spontaneum* collected from different places and found their chromosome numbers to be $2n=48$, 56, 64 and 80. She found evidences of hybridity in many of the forms and opined that forms with $2n=56$ and 64 chromosomes are natural hybrids between those with $2n=48$ and 80 chromosomes. She has also indicated a tentative line of descent of the several India *spontaneums* based on cytological investigations. Secondary association of chromosomes in sugarcane was also observed by her, the chromosomes arranging themselves into 5 or 10 groups, which apparently is the basic number for the *Andropogoneae*, the tribe to which *Saccharum* belongs. Further cytogenetic studies of other varieties of canes and intergeneric hybrids are in progress at Coimbatore, which, in time, are expected to throw more light on this question of interrelationships. It is interesting to note that in the hybrid between *Saccharum* and *Zea*, cytological examination (Janaki Ammal, 1938) has confirmed the hybrid nature of the seedling which resembles more the *Saccharum* parent and has not flowered even after twenty-two months. The hybrid has 50 chromosomes, the sum of the haploid chromosomes for the two parents and includes the satellited chromosome contributed by *Zea*.

Rice

The cultivated rices, of which several distinct varieties and races are known, belong to the genus *Oryza* which is widely distributed in the tropics of both the hemispheres. *O. sativa* is the species cultivated in India and the eastern countries, while *O. glaberrima* is cultivated to some extent in Africa. Other species, which, according to Roschevicz (1931) and Chevalier (1932), number about 25, are known only in the wild state and are distributed over India, Africa, the Philippines, Java, South and Central America and islands lying close to the latter. These authors divide the genus into four sections, although the species included by them in the different sections are not the same. According to Roschevicz the first section includes *O. sativa* var. *spontanae* $=$ *O. sativa* var. *fatua* (Chevalier) which is widely spread, embracing the entire range of distribution of the genus and is the progenitor of our cultivated forms. He also believes that *O. breviligulata* has given rise to some of the African cultivated rices and *O. minuta* to some of the small-fruited forms. Although it is possible that *O. sativa* var. *spontanae* might have given rise to some of the cultivated rices, it is not likely that *O. minuta* could have been the ancestor of small-fruited forms in view of recent cytological findings. *O. minuta* (Ramanujam

1938) has 2n=48 chromosomes, while all the small-fruited cultivated rices so far examined have only 2n=24 chromosomes. The cytological evidence points to *O. minuta* being the younger species, having resulted from hybridisation between species with 24 chromosomes and later doubling of the chromosomes in the sterile hybrid. It is possible that *O. officinalis* with 2n=24 may have given rise to the small-fruited cultivated forms. There are also other species with 2n=48 chromosomes such as *O. latifolia*, *O. cubensis*, *O. coarctata*, all of which, like *O. minuta*, presumably arose through polyploidy.

A detailed phytogeographical survey of this genus has not been made and our knowledge of species and their inter-relationship is still imperfect. Sometimes the same species is designated by two different names as for instance *O. Barthii* and *O. longistaminata*, or two different species are called by the same name *e.g.*, *O. latifolia* and *O. officinalis*. *O. glaberrima*, the cultivated rice of Africa, is very similar to *O. sativa* and they cross readily with each other, giving simple Mendelian segregation for several characters in the progeny. It is, therefore, possible that *O. glaberrima* is only a variety of *O. sativa*.

Recent cytological investigations have, however, tended to throw some light on the phylogeny of the tribe *Oryzeae*. Based on the analysis of secondary association in *Oryza sativa* (Sakai, 1935, and Nandi, 1936) and *O. Barthii* and other species (Ramanujam, 1938) it has been recently established that the basic number of *Oryza* is 5 and not 12 as was supposed earlier. This finding is in accord with genetical data which conform to polyploid inheritance in respect of several characters. Further proof of this basic number for *Oryza* was provided by Ramanujam (1938) who found in the related genus *Zizania*, the American wild rice, the chromosome number 2n=30, which is a hexaploid on the basis of 5 chromosomes. From counts of chromosomes in several species from different genera in the tribe, he confirms the general classification of the tribe into *Zizaninae* and *Oryzinae* adopted by taxonomists (Hutchinson, 1934) and indicates the lines of evolution therein. He observes that the *Zizaninae* retained the original basic number 5 as a basis for polyploidy, while the *Oryzinae* came to be built up on a secondary basic number 12.

Oil Seeds

In India various species of *Brassica* are of importance as oil-seed crops, particularly in the United Provinces, the Punjab and Sind. The species grown, with their vernacular names, are the following :—

Brassica juncea—Rai.

B. campestris v. *sarson*—Sarson.

B. napus v. *dichotoma*—Toria.

There is a lack of satisfactory differentiation between these species and there is a probability that some of them are not valid. It is in fact necessary to determine what are the real genetic groups.

In these *Brassica* species there are varying degrees of self-sterility, the causes, conditions and inheritance of which are still imperfectly known.

Work is in progress on some of these problems at various centres in India, *e.g.*, at the Imperial Agricultural Research Institute (under the Imperial Economic Botanist), at

Lyallpur in the Punjab (under the Oilseeds Botanist of the Punjab Department of Agriculture) and also in the United Provinces and in Sind (under the Botanists of the Agricultural Departments of these Provinces).

Cytological studies in the *Brassicae* (Morinaga and others, in Japan) have shown that there are species with various chromosome numbers, viz., 8, 9, 10, 17, 18 and 19. It has been suggested (Catcheside, 1934) that all these are secondarily balanced numbers and perhaps represent different balances of the same primary number, viz., six. Alam (1936) working with some Indian species of *Brassica* also confirmed the basic number of *Brassica* species to be six. The occurrence of this wide and more or less continuous range of haploid numbers in *Brassica* indicates crossing between species, with subsequent establishment of varieties with secondarily balanced chromosome numbers. It is this polyploid nature of many of these Brassica species that has been found to be responsible for the rather complicated inheritance of self-sterility factors in the group. Kakizaki (1930) found this to be the case in *B. oleracea* and the work in progress at the Imperial Agricultural Research Institute under the Imperial Economic Botanist on some of the Indian Brassicas appears to confirm Kakizaki's findings.

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Recent advances in Plant Breeding with special reference to the work of the Imperial Agricultural Research Institute

by

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INTRODUCTION

Man from early times began to gather seeds from fields and plant them for his own use and capture young animals and tame them. By a slow and crude process he built up the major agricultural types of plants that we have to-day ; he took the plants that seemed to yield the most and increased them and discarded the others. As time advanced, the needs of man for food and raw materials increased and scientific breeding as an important tool for better and increased production came into being and to-day we have in all progressive countries well organised Departments of Agriculture devoted to agricultural research and plant breeding. In India where agriculture is the chief occupation and source of livelihood of over 70 per cent. of the population, such research was even more necessary and the Government of India founded the Imperial Agricultural Research Institute at Pusa in 1905 for undertaking research work on agricultural problems, including the production of high yielding and superior types of crops, the study of the properties of soils and their irrigation and manurial requirements, and methods of combating diseases and pests. Already tangible results have been achieved (Report of the Director, Imperial Agricultural Research Institute, 1937) in the different branches, which have considerably benefited the farmer.

Perhaps no single branch of agricultural science has benefited the cultivator in India as much as plant breeding. The production and distribution of improved strains of crops enables the cultivator to increase his yield without incurring additional expenditure and without departing from his normal methods of cultivation. This is of special significance in India where the farmer is proverbially poor and cannot afford to adopt other improvements, cultural or manurial, which often involve extra expense, for increasing yields. The Botanical Section of the Imperial Agricultural Research Institute is engaged in the breeding of superior types of crops by scientific methods and investigating fundamental problems which will further such work. In this short article an attempt will be made to describe briefly the scientific advances in plant breeding in other countries and the work at the Institute.

ADVANCES IN PLANT BREEDING ABROAD

(a) *Single plant selection and hybridisation*

The development of plant breeding is closely associated with the growth of the science of Genetics—the study of heredity in plants and animals. Genetics for a long time did not advance further than the mere understanding of the fact that the characters of the parents were transmitted to their offspring. No exact laws of inheritance were known and the practical breeder could get no more guidance than the knowledge that like tended to beget like and that continuous selection assisted by inbreeding might fix the desired type. The beginning of the present century saw the re-discovery of Mendel's work which contained the first exact statement of the laws of inheritance. The significance of these laws to practical breeding was at once realised when it was shown that economic characters like disease resistance, better quality and high yield were in several cases inherited as independent characters and that they could be selected out from a mixed population and fixed or grouped together in fresh combinations as desired by the breeder by suitable hybridisation. Thus intensive selection in mixed populations and in hybrids of crosses between related races of plants followed by inbreeding was responsible for several agricultural achievements. For instance selection in sugar beet over a number of years resulted in raising the sugar content from 9 per cent. to more than double that figure (Hudson 1937). Disease resistant strains of flax in America (Bolley 1904) and jassid resistant strains of cotton in Africa (Parnell 1935) are also the results of pure line selection. The famous Marquis wheat of Canada which is outstanding for its earliness and superior quality and yield was selected from the progeny of a cross between a popular variety, Red Fife, and an early maturing Indian variety, Hard Red Calcutta.

(*b*) *Hybrid Vigour*

Inbreeding and selection as practised in self-fertilized crops is not ordinarily useful in cross-fertilized species like maize where inbreeding causes a considerable reduction in vigour and yield. As a result of genetical researches on hybrid vigour, this difficulty has been overcome in the United States of America where an ingenious technique of maize breeding has been developed. Pure lines are produced by continuous inbreeding and crossed among themselves to restore vigour. The hybrid corn produced by crossing two inbred lines has been found to give increased yields ranging up to 35 per cent. over commercial corn and their production for distribution as seed is comparatively easy. Elaborate breeding programmes for producing hybrid corn suited to specific environments are in progress in the United States, which hold out great promise for the future of maize growing. Exploitation of hybrid vigour for increased production is under study in other crops.

(*c*) *Search for new genes*

The possibilities of breeding desirable types by selection are dependent on the initial hereditary material with which a breeder starts his work. The hereditary elements or the genes which are situated in the chromosomes determine the expression of the several heritable characters in plants and animals. If a breeder starts work with a limited supply of such material, the possibilities of selection of useful genes and their recombination into desired types would soon be exhausted and further progress would become impossible. In fact such a stage had been actually reached in the case of the potato. The potato introduced into Europe three and half centuries ago set seed readily and gave rise to a number of varieties by segregation in the course of a number of years. The genes present in these varieties were utilized and all the desirable combinations of them were obtained and ultimately a position of stalemate was reached when no further improvement appeared possible although several problems such as those of Late Blight and virus diseases were still unsolved. The necessity for importing fresh genes for disease resistance was felt and a search for these genes in the original home of the potato was undertaken. Expeditions to Mexico, Peru, Bolivia and other places were undertakan and more than a thousand collections of potatoes, including many new species, were made. These included types suited to a wide range of conditions of temperature and some of them were highly disease resistant. As a result of this work, potato breeding was placed on a new footing and the production of disease resistant varieties by suitable hybridisation has been made possible. The recognition of this fundamental principle of breeding with a wide range of initial material led to the undertaking of elaborate surveys of the distribution of cultivated plants and their collection for breeding purposes. The pioneer work in this direction was done by the Soviet breeders under the direction of Vavilov, who undertook expeditions to several parts of the Old and New World and made extensive collections of plants of cultivated crops. As a result of these expeditions several interesting facts, having a direct bearing on breeding, have emerged. It has been found that the distribution of cultivated plants is subjected to certain laws. Distribution generally takes the form of a radiation from a centre. This centre for each crop, usually embraces a limited zone and is characterised by an exceptional abundance of forms which include a large number of genetically dominant characters. As we proceed outwards towards the periphery of the region of maximum diversity, forms with recessive characters become more evident which resemble highly bred cultivated types. While many of these recessive characters that are associated with cultivated plants are agronomically useful others are positively harmful such as excessive tenderness and susceptibility to diseases and pests. Disease resistance and ability to withstand drought and other adverse conditions, which are usually dominant characters could be imparted to these forms only from wild types, as no amount of breeding with recessive types would produce the desired result.

(*d*) *Wide crosses*

The search for new genes has shown that desirable genes are often situated in different species and therefore their combination in one species involves inter-specific hybridisation. Until recently inter-specific hybridisation was not considered a practical method owing to the high degree of sterility associated with such hybrids. But recent advances have opened the way to the utilization of such hybrids and now the exploitation of wide crosses for practical breeding is practised on a large scale. Significant successes have been obtained in transferring valuable characters from one species to another by inter-specific crossing in wheat (McFadden 1930) and cotton (Harland 1934). The wheat variety Hope which has done so much towards the solution of the problem of supplying rust resistant wheats for North America was produced from a cross between *Triticum vulgare* and *T. dicoccum.* In cotton, by repeated back-crossing of the hybrid with the parent possessing the desirable characters, it has been possible to transfer several unit characters from one species to another.

The interest evinced in these crosses in recent times is the consequence of another important discovery, *viz.*, the production of amphidiploids. Wide crosses, which are generally highly sterile, have occasionally been found to produce exceptional hybrids characterised by unusually high fertility. One of the first of these hybrids to be obtained and which explained this phenomenon was *Primula Kewensis*. The hybrid between *P. verticillata* and *P. floribunda* when first obtained was quite sterile and remained so far a long time until it gave a fertile branch, the seeds from which gave a perfectly fertile strain. This was named *P. Kewensis*. Newton and Pellew (1928-29) undertook a cytological examination of the hybrids and parents and showed that the parents contained 2n=18 chromosomes each, the sterile hybrid also 2n=18 and the fertile hybrid 2n=36 chromosomes. They observed that the sterility in the original hybrid was due to incompatibility of pairing between the chromosomes of the parent species, which, however, was overcome in the fertile hybrid by doubling of the chromosomes which restored perfect pairing and segregation of the chromosomes. Since this phenomenon was noted in *P. Kewensis*, similar cases were reported in a number of other species. Winge (1932) has reviewed the origin of such double diploids or amphidiploids in a number of different species of plants. The significance of this phenomenon to practical breeding was at once realised for it was noticed that these amphidiploids, in several cases, are better suited for growing under a variety of conditions and may be resistant to diseases and pests. The history of the wheat-rye hybrids in Russia affords an interesting example. Natural hybrids between wheat and rye were observed in the fields at Saratov in Russia in the year 1918 in the progeny of certain lines (quoted by Hudson 1937). These hybrids were highly sterile but suddenly in 1924 following an unusually severe winter certain of the hybrids were found to be highly fertile and survived the winter, while the wheat strains perished. The fertile hybrids ($2n=56$) have been found to be amphidiploids of the hybrid between wheat ($2n=42$) and rye ($2n=14$) (Lewitsky and Benetzkaia 1930). The hybrids have displayed great resistance to cold and drought together with many other valuable agricultural characters and are expected to be of much use in Russian agriculture. It is important to know in this connection that new species in nature are produced by this method (Müntzing, 1932, Huskins, 1931) and that many of our cultivated plants like wheat (Aase 1935) and tobacco (Kostoff 1936) have owed their origin to this process of chromosome duplication following inter-specific hybridisation. Recently Kostoff has produced experimental evidence of the origin by this method of the two important cultivated tobacco species, *Nicotiana Tabacum* and *N. rustica*. It is now definitely realised that tetraploidy in sterile hybrids has wrought changes of far reaching importance ; besides increase in size of organs, tetraploidy has been known to change a self-sterile species to a self-fertile one, a diœcious race to a hermaphrodite one, an annual to a perennial and so on ; therefore the ability to induce chromosome doubling in sterile hybrids is of great importance to theoretical and practical genetics. It may be stated here that this line of work is becoming increasingly important in view of the recent discovery of Blakeslee (1937) that tetraploidy can be induced artificially with some certainty by means of the alkaloid colchicine. The work of several other investigators, e.g., Dermen (1938), Nebel and Ruttle (1938), Levan (1938), and our own work (Pal and Ramanujam 1938), has amply confirmed Blakeslee's expectations.

(*e*) *Artificial Induction of Mutations*

Another field of study that has attracted a great deal of attention in recent times is the artificial production of mutations as a means of bringing about genetic variability. Mutations may involve either simple gene changes, or structural and numerical alterations of chromosomes. The origin of new genes by mutation was a rare and uncontrollable process until Muller (1927) in Drosophila showed that it could be speeded up about 200 times by the use of X-rays. Independently and almost simultaneously Stadler (1928) working on the genetic effects of X-rays on barley and wheat demonstrated the possibility of experimental modification of heredity in plants by subjecting them to penetrating radiations. In the relatively short time since then, several plant species notably datura (Blakeslee et al 1929), tobacco (Goodspeed 1929), cotton (Horlacher and Killough 1932), maize, barley and wheat (Stadler 1928, 29 and 30), wheat (Katayama 1935), and rice (Imai 1935, Ichijima 1934, Ramiah 1934) have been subjected to the action of X-rays for the production of mutations and a considerable body of data has been accumulated. Experimentally produced mutations generally lower the viability of the organism and are recessive and on that account are not of much use in practical breeding. There are, however, exceptional cases where progressive and dominant mutations have been produced (Horlacher and Killough 1932, Sapehin 1934). It appears possible that useful mutations involving quality factors such as low nicotine in tobacco, freedom from alkaloids in lupin, etc., which are usually recessive can be induced by this means. X-ray genetics at the present moment has become very important in the study of the nature and physiology of the gene itself. The whole subject is, however, yet in its infancy and further studies may open out new possibilities for the breeder.

It is now known that a variety of other external agencies such as high temperatures, narcotics and even ageing of seeds can bring about effects similar to those induced in plants by X-rays. The effect of colchicine in producing polyploids has already been mentioned.

(*f*) *Genetics of Physiological Characters*

The problem of yield, the most important of the agricultural characters, has up to now remained obscure, owing to the complex nature of its inheritance. Engledow and his co-workers (1923) have made an elaborate analysis of the individual components of cereal yield. Genetical analysis of yield has been made extensively in Sweden by Rasmusson (1933) who has calculated that at least 100-200 separate genes are involved in its inheritance. Recent researches on the genetics of yield by Boonstra in Holland (quoted by Hudson 1937) are based on the physiological conception that yield is the combined effect of the several metabolic processes taking place during the course of development of the plant, each of which is genetically controlled. Thus one variety may give a high yield mainly on account of its high assimilation rate, another because of its high absorption capacity of nutrient materials and a third by reason of its capacity to rapidly translocate the products of assimilation. For synthesising high yield, it would therefore appear necessary to combine these physiological attributes into one strain. Analysis of the physiological attributes of different strains and crossing them in suitable combinations is indicated for obtaining high yielding strains.

(*g*) *Vernalization*

Another remarkable development in recent years, which is of considerable significance to breeding, is the theory of vernalization developed by Lysenko. It has been shown that through vernalization the time of flowering of any variety of plant can be experimentally predetermined by appropriate treatment of the germinating seeds. " According to Lysenko, plant growth and plant development are two distinct and separate phenomena each of which is capable of proceeding independently of the other." At least two stages are recognised by him in the development of a plant, the first one being the thermo stage and the second the photo stage. Particular temperature conditions are required for completion of the first stage and certain light conditions for the second stage. If these conditions are provided to the germinating seed in appropriate amounts, the plant is in a condition to pass on to the reproductive phase without further recourse to temperature or light. Every variety has its own particular requirements with regard to temperature and light and these will have to be determined experimentally for successful treatment. The advantage of vernalization has been made use of chiefly in Russia for extending the cultivation of wheat further north where the growing season for wheat is very short. Vernalization has also been studied in other countries and the responses of different crop varieties are being tested. It has been found that vernalization responses are more complex than originally postulated by Lysenko (Purvis 1934, Purvis and Gregory 1937) and the different phases of development by no means as sharply differentiated as he assumed, but the fact that the time of flowering could be modified experimentally has been confirmed.

(h) *Plant Hormones*

Closely associated with this study of experimental control of the time of flowering of plants, is the study of the chemical control of growth and development in plants. Perhaps the most interesting chemical modification of plant development is that caused by organic substances of the hormone type.

It is becoming increasingly evident that certain specific chemical regulators (hormones) are responsible for causing tropic responses of plant organs to light and gravity, inducing cell elongation and root growth and also initiating and regulating growth of buds and flowers. Purvis and Gregory (1937) in a theoretical interpretation of their results of vernalization with winter ryes assume the existence of variable interactions between specific foliar and floral inductors. Müntzing (1938) cites another interesting case of modification of flowering due to a specific substance. There occur annual as well as biennial races of *Hyoscyamus niger*, this difference being caused by a single gene. However by grafting shoots of an annual plant on a biennial one, it has been possible to induce the latter to flower as an annual. Some of the organic substances (auxins) that initiate root formation are being extensively studied and used for propagating cuttings with great success (Tincker 1936). This new field of research is full of possibilities for the future.

Breeding Work at the Imperial Agricultural Research Institute

Since its organisation in 1905, the Botanical Section of the Imperial Agricultural Research Institute has been engaged in the economic improvement of Indian crops. Wheat and tobacco were the main crops to receive attention in the beginning and later on other economic plants like barley, oats, rice, oilseeds, pulses, fibres, tubers and vegetables were included in the programme of research. Besides breeding for improvement, fundamental genetic and cytological studies were also undertaken in the several crops and useful results have been obtained. In the following pages a brief reference to the results achieved and the work in progress in regard to a few crops will be made.

CEREALS. Wheat (*Triticum vulgare* Host)

The improved varieties of wheat produced by the Institute are well known. Pusa 4* and Pusa 12, selected by the Howards, may be said to be household words in large tracts in India. Pusa 52, Pusa 80-5 and Pusa 101 produced by hybridisation have also proved very successful. Among the more recent "Pusa" wheats, Pusa 111, a mutant from Pusa 4, is outstanding for its grain quality; Pusa 114 selected from a natural cross in Federation wheat is popular in the Barrage area in Sind on account of its rust resistance; Pusa 120 is highly rust-resistant, particularly to yellow rust, and Pusa 165 is a good all-round early wheat. The two last mentioned varieties have been derived from crosses between the Australian variety, Federation, and Pusa 52 and Pusa 4, respectively.

The breeding of rust resistant varieties of wheat which is in progress has been facilitated by the establishment in 1935 of a wheat breeding substation at Simla. This substation which is financed by the Imperial Council of Agricultural Research is concentrating on the development of rust resistant varieties for the hills of India. Work is also in progress in the Botanical Section on the development of wheat varieties immune from or highly resistant to flag smut, in co-operation with the Mycological Section.

* Since the paper was written (December 1938) the nomenclature of Pusa strains of crops has been changed and now the letters I. P. (Imperial Pusa) are put before the numbers instead of "Pusa."

Studies on heterosis in wheat have indicated that the expression of hybrid vigour is greatly influenced by external factors.

PULSES. Gram (*Cicer arietinum* L.)

Samples of gram were collected from different parts of India and pure lines with various morphological characters were fixed. Some of the strains which are particularly high yielding are under distribution to the *ryots*.

A genetic analysis of this species has been undertaken and several crosses have been selected for study. Of the characters already studied the inheritance of flower colour has been shown to depend upon the interaction of several factors (Khan and Akhtar 1934). Pink colour is produced by a factor P in the presence of B ; in the absence of B, the flower is white whether P be present or not. Greenness in the standard is developed in the absence of an inhibitory factor W. Single pedicel has been found to depend on a factor S and is dominant to the double condition.

The inheritance of seed colour and shape has also been studied (Hukam Singh and Ekbote 1936).

Several interesting naturally occurring mutations have been isolated and are under study. A gigantic mutant from one of the pure lines is found to have a bigger stature and leaves. Two other mutants, one involving considerably reduced leaflets and the other simple leaves, are also under study (Ekbote 1937). The former has proved to be a simple recessive to the normal type and the mode of inheritance of the latter is more complex, the recessive gene responsible for the mutant character being unstable. The usefulness of these mutant types for cultivation is also being investigated.

Recently gram has been subjected to treatment with colchicine and already several polyploids have been obtained. This line of work is being continued.

ROOT CROPS. Potato (*Solanum tuberosum* L.)

The potato is cultivated to a greater or lesser extent in all parts of India, both in the hills and in the plains. Little breeding work has hitherto been done and the potatoes commonly cultivated in this country are European and North American Varieties which have been imported either recently or in the past. In 1934, however, the breeding of potatoes suitable for Indian conditions was taken up at the Institute. As the plains are unsuitable for breeding work a substation* was founded at Simla for this purpose. A large collection of potato varieties cultivated in India has been built up and considerable material of the new South and Central American species has also been received from abroad and is under study.

The most pressing problems of potato production in India are those of losses due to disease, both in the field and in storage. In the hill where the potato is extensively cultivated, Late Blight is liable to destroy the crop. In the plains, virus diseases are common and cause serious loss. Early Blight is common both in the hills and the plains.

The problem of Late Blight has received particular attention. The relative resistance of a number of wild and cultivated varieties to Late Blight under conditions of severe natural infection has been studied at Simla. Most varieties of *Solanum tuberosum* proved highly susceptible. On the other hand *S. demissum*, *S. Antipoviczii* and *S. neoantipoviczii* were immune. Other species and varieties were found to show varying degrees of resistance.

*Financed by the Imperial Council of Agricultural Research.

Hybrids between *S. tuberosum* and other species have also been under study and a large number of resistant plants have been found in progenies of crosses between *S tuberosum* and *S. andigenum* and between the former species and *S. demissum*. There is thus hope that in due course strains of potatoes will become available which combine high resistance to Late Blight with other qualities desirable in commercial potatoes.

Studies on flowering, sterility, dormancy of tubers, cold resistance, etc., are also in progress.

STIMULANTS. Tobacco (*Nicotiana Tabacum* L. and *N. rustica* L.)

Tobacco is one of the most valuable crops in India and work on the improvement of the crop is being directed to all the three main types of tobacco cultivated in India, *i.e.*, cigarette, chewing and *hookah* tobaccos. Sixty-nine types of *N. Tabacum* and twenty types of *N. rustica* have been isolated of which Type 28 and 63 (chewing tobacco) among the former and Type 18 (*hookah* tobacco) among the latter are under distribution. As none of the indigenous tobacco varieties was found to be suitable for cigarette production hybridisation between exotic and indigenous varieties was resorted to and as a result two strains H. 142 and H. 177 have been evolved which are very suitable for growing for cigarette production, combining as they do the fine quality of the foreign tobaccos with the greater hardiness and yield of the indigenous varieties.

The inheritance of a number of quantitative and qualitative characters such as height of plant, time of flowering, number of leaves per plant, leaf shape, leaf margin, size and colour of corolla has been studied. In all the quantitative characters studied, the F_1 was intermediate between the parents, and in the F_2 the range of variation was as great as that of both parent varieties combined. The number of leaves per plant was independent of the plant height and distinct segregation was observed in respect of the arrangement of leaves on the stem. Venation of the leaves proved to be one of the most constant characters of the plant. Frilled leaf margin was dominant to smooth on a monohybrid ratio.

Interspecific crosses in tobacco were undertaken and two crosses which do not appear to have been hitherto studied, viz., *N. Tabacum* ($2n=48$) $\times$ *N. plumgaginifolia* ($2n=20$) and *N. glauca* ($2n=24$) $\times$ *N. plumbaginifolia* ($2n=20$) have been successfully made and grown to maturity. The hybrid in the former case was more or less intermediate between the two parents but showed a number of new characters such as streaking and striping of flowers, presence of accessory corolla lobes and complete sterility (Pal and Pushkar Nath 1936). The latter hybrid is also intermediate in character between the two parents and is completely sterile. Cytological examination of the two hybrids has shown that at pollen meiosis in the former case, up to about 12 bivalents are formed and in the latter rarely one or two bivalents are formed and as a consequence irregularities at reduction ensue and sterile pollen grains are formed. Attempts are being made to produce doubling of chromosomes in these hybrids with colchicine treatment.

VEGETABLES. Chillies (*Capsicum annum* L.)

A collection of pure lines of chillies has been built up and is being maintained, of which Types 34, 41, 46 and 51 are being distributed to *ryots*.

The inheritance of a number of characters, *e.g.*, stem, foliage, flower and fruit colour, fruit shape and position and nature of calyx, have been worked out (Deshpande 1933). The study of other characters and their linkage relations are being investigated.

The effect of colchicine in doubling chromosomes in plant cells leading to the production of polyploidy has been tried in chillies and striking results have been achieved (Pal and Ramanujam 1939). Seeds were immersed in aqueous colchicine solution of different strengths for different periods of time and planted in the field. Among the plants derived from treated seeds, as many as 77 polyploids were obtained which included one triploid. Some pollen lethal diploid mutations have also been observed to occur among the treated plants. Cytological study and breeding behaviour of these polyploids and mutations are under investigation.

Other important studies at the Institute include hybrid vigour in crosses of a number of crop plants, the effect of vernalization, and the role of heterauxins in initiating root growth.

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The Royal Agricultural and Horticultural Society of India

by

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There are many links between the Royal Agri-Horticultural Society of India and the Royal Botanic Garden and while we cannot claim to be an offshoot of this great institution, indirectly at any rate, the Botanic Garden is responsible for the formation of the Society.

In 1814 the Reverend W. Carey assisted in making a list of the plants then grown in the East India Company's Botanic Garden and in 1824 issued Roxburgh's Flora Indica which he edited on the death of his friend. The celebrated Missionary was an ardent botanist and found time to gather plants on his missionary itineraries. His collection of living plants was very large, perhaps second only to that at Sibpur. So competent was Carey considered that the then Government, who were in charge of the Botanic Garden, asked him to act as Superintendent till relieved by Dr. Buchanan Hamilton who had been nominated by the Court of Directors in England.

There has always been active co-operation between the Royal Botanic Garden and the Society since the early days when the Reverend Mr. Carey shared the spoils of the trips made to the Terai, Bhutan and elsewhere.

Foundation.—On the 14th September, 1820, "The Agricultural Society" came into being. The Reverend William Carey had discussed the formation of such an institution with his friends and having been promised support by thirty-two gentlemen, called a meeting in the Town Hall, but only seven supporters appeared. This did not look very hopeful but at subsequent meetings the numbers increased! The name of the Society was originally "The Agricultural Society"; "Horticultural" was added very shortly after the first meeting.

Objects.—As set forth in the Prospectus, the objects of the Society are the promotion and improvement of Agriculture and Horticulture in India in all its branches.

Gardens.—Seven years after the Society was founded a small piece of land was provided by Government at Alipore, at the head of Budge Budge Road, for a garden, as well as a few bighas in Akra where experiments in growing Tobacco, Sugarcane, etc., could be conducted. Both these plots had to be abandoned owing to the failure of Agencies in Calcutta and consequent financial loss to the Society. Unfortunately seven years' work had been put in on both these plots. In 1836 about 2 acres of land were allotted to the Society inside the Royal Botanic Garden. The area gradually increased to about 25 acres where the Society in co-operation with the Royal Botanic Garden officers conducted the greater part of its agricultural and horticultural operations for about 40 years. Here fruit and flowering plants as well as economic products were grown. In 1872, an area south of Belvedere, which was all waste land at that time, was made over to the Society by Government, under certain conditions, and this is the present site of the Society's Garden at Alipore.

Pioneers.—When Carey started the Society he found that the cereals of the country, the vegetables as well as fruit, were of very poor quality and immediately interested members of the Society in his scheme to import seeds from all parts of the world for free distribution. Sugarcane from Mauritius and other sources was obtained and propagated for distribution. Cotton seeds were annually purchased from America, and in 1838 a sum of Rs. 1,000 was set aside to get good seeds from South America, the West Coast of Africa, China, Manilla, and other parts. Tobacco seeds of improved varieties were also obtained for distribution. The acclimatised Patna cauliflower is the result of seeds which the Society obtained from the Cape of Good Hope and passed on to local cultivators. The famous Naini Tal and Shillong potatoes owe their origin to imported English strains. Fibres, tans, dyes, oils, fats, etc., were all items that the Society took up ; various fodder crops such as Guinea Grass, Reana and Lucerne were introduced partly through the agency of the Society. Annual introductions of maize from the U. S. A. and paddy from Carolina and New Granada were recorded. In 1852, the Society drew attention to the great advantage of growing in India the quinine yielding plants—the cinchonas, the cultivation of which has been developed so successfully in the hands of the able Superintendents of the Royal Botanic Garden from 1861 to the present date. Tea was another subject that has called for much ground work by the Society.

The Society was able to enlist the service of keen members who willingly carried out experiments and communicated their results which were embodied in the Journals and Transactions.

How improvement was maintained.—Commencing in 1822, we learn that medals and money prizes were offered for the introduction and improvement of coffee, cotton, cereals, indigenous fruits and other vegetables. In 1826, seeds and plants from Europe, Australia and South Africa were obtained and apparently for many years these imports were of annual occurrence. The first year we read that 76 market gardeners in Calcutta and 48 from Patna district benefited by the free distribution of vegetable seeds. Exhibitions were annually held in Calcutta shortly after the seeds had been distributed, and large monetary prizes as well as medals were awarded for the best vegetables such as cabbages, cauliflower, potato, etc. In 1828, one hundred and nine malis competed for prizes and the names of their holdings in and around Calcutta appear in the journals.

Essays on various subjects were written and generous rewards given to the best authors.

Branch Societies.—Keen members started branches of the Society all over the country; the Lucknow branch appears to have been the first (1835), followed soon afterwards by those in Western India, Madras and Dinapore. In 1836, mention is made in the journals of working branches in Bangalore, Beerbhoom, Burdwan, Hooghly, Meerut and as far afield as Singapore.

Agricultural efforts.—In its early years, as mentioned before, the Society practically did the work of the Agricultural Department. Experiments were conducted by its members in growing the staple products, cereals, etc. Gradually the demand for more detailed experiments in the cultivation of crops and the trials of fibres and other vegetable products was required and it was found impossible, with the small staff and land at its disposal, for the Society to cope with the work on proper lines. In 1900, the Society's work and Metcalfe Hall which had served as an Office, Economic Museum and Library for many years engaged Lord Curzon's attention and he relieved the Society of all agricultural work. Enquiries, however, even up to the present time, are constantly made to the Society on various agricultural subjects.

Monetary support.—In times past the Government of India were very generous with grants-in-aid for premia and prizes and at the same time arranged for land for our many gardens at a nominal rental. With the withdrawal of all agricultural work in 1900 the annual grant that had been received since 1886 was stopped and from that date the Society stands as a self-supported institution. We receive no monetary assistance from Government, municipality or other public body and depend entirely upon the membership subscriptions and sales to the public in order to maintain the Society and carry out its aims.

Official recognition.—The Marquis and Marchioness of Hastings were the first patrons of the Society and since then the several Viceroys have successively honoured us with their patronage. The Lieutenant-Governors, and subsequently the Governors of Bengal, have been vice-patrons.

Recognising the valuable service of the Society to horticulture His Majesty the King-Emperor graciously granted the Society the privilege of being known as the Royal Agri-Horticultural Society of India in the year 1935.

Membership.—Our membership in 1820 was recorded as 35, but the numbers gradually went up as the work of the Society became known. In 1934 we were able to show a thousand subscribing members on our books, excluding honorary and corresponding members, and the number at date has increased to 1,200.

Correspondence.—In addition to the normal routine, correspondence takes place with members in India, Europe and America. The Society maintains a Free Enquiry Bureau on matters connected with horticulture.

Library.—A good library of over 2,000 books dealing with agri-horticulture in all its branches is open to members for consultation. Many of the volumes are now out of print and cannot be obtained elsewhere.

Publications.—The issue of transactions and journals which embodied reports of experimental work made the publications of the Society very valuable. For the past few years, however, no journal has been issued and an Annual Report only is published. A useful handbook for amateur gardeners, "An Amateur in an Indian Garden" has been written by the Secretary of the Society while "Tennis Courts in India," a "Perpetual Gardening Calendar" and a leaflet "How to Hybridise" are issued by the Society. Since 1936 a Monthly News Sheet has been published.

Present work in relation to the past.—Mention has been made of the attempts to improve the existing products of the country by the introduction of improved types, and while the economic side has been touched on we should not forget the fruit. Indigenous fruits still stand in need of improvement but such work requires a specially trained staff and a large area to test the cross breeding results. There are more than five hundred varieties of mangoes, some only cultivated in one Province but worthy of greater notice. The Society introduced tropical and sub-tropical varieties in the early years of its existence and has continued to choose the best types, as far as hardiness and productiveness is concerned, for distribution to its members. Grape fruit from Florida, pomelos from Java and seedless litchi from China have been lately introduced.

It is not only on the useful side of gardening that the Society has worked but the introduction of beautiful flowering trees, shrubs and climbers has also received attention. During the past quarter of a century there has been a call for a better layout of gardens both from the Indian and European community. The old standards have been discarded and there is a continuous demand for new ideas. The Society introduced a Garden Competition for Calcutta amateurs in 1932 and arranges for judges to inspect gardens once a year, awarding two challenge cups and two medals as prizes for the best kept gardens. This has caused great improvement among those whose gardens are small.

Exchanges of seeds and plants with correspondents in all parts of the world has brought in novelties that members appreciate but the Society has also devoted some time to cross-breeding and been successful.

Insecticidal and Insect-Repellent Plants of India

by

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The extreme variability that India presents in its meteorological and climatic conditions as also in its topographical features is perhaps unrivalled in the world. It has the most massive and the loftiest range of mountains in the world, the Himalayas; there are also lower hills and plateaus, extensive rich alluvial plains, sandy wastes and deserts, hill streams, mighty rivers with their deltaic and estuarine systems, numerous lakes, canals, ponds, tanks and extensive marshy tracts, sandy or rocky coasts spread over an area of 1,575,107 square miles. It has in fact been described as an epitome of almost all climates, seasons and soils of the British Empire. No wonder, then, that India possesses what is perhaps the richest and certainly the most varied flora of all other areas of similar size on the surface of the globe. More than 2,000 plants, out of a total of about 13,000 species found in India, are alleged to have medicinal properties of some description or other and have been enumerated in the literature of indigenous medicine. The majority of these plants have not yet been fully investigated, but many among them contain powerful and toxic principles which, if introduced into the body of an animal in relatively small quantities, act deleteriously and may cause serious impairment of bodily functions or even death. They injure the basic live principle, the protoplasm of cells of which the animal body is built up. They are ordinarily called poisonous plants. Apart from the utilization of their potent properties in the treatment of diseases to alleviate the sufferings of man and animals, there appears to be no doubt that they are a source of great menace in this country through poisoning of livestock.

Although a considerable amount of work has been done in connection with poisonous plants in Europe, America, South Africa and other countries of the world, little or no systematic work was attempted in India till recently. Some years ago the Imperial Council of Agricultural Research gave the senior author a grant for this purpose and a botanical section was added to the already-existing unit composed of chemists and pharmacologists endowed by the Indian Research Fund Association, and with this team the work was started with. Investigations in the field, search in different herbaria and study of the literature showed that there were nearly 700 plants reputed to be poisonous to man, livestock, insects, fishes, etc. An intensive study of this problem has been undertaken and a monograph dealing with the existing knowledge in connection with poisonous plants, which will form a basis for future work, is now in press. A brief review of this work has recently been published elsewhere (*1*). One important object of the work was to find cheap insecticides and insect-repellent drugs from among the Indian flora for the diverse needs of agriculture, destruction of household pests and vectors of such diseases as malaria and many others borne by insects. In the present paper we intend dealing with this aspect of the Indian flora.

With the outbreak of war, the supply of many insecticides and insect-repellents from foreign sources has been cut off and we feel that it might be useful to take stock of the situation.

Insects are responsible for incalculable harm to man in many ways. It would be no great exaggeration to say that insects have been responsible for more loss of life and destruction of property than that caused by wars, floods, earthquakes, fires and famines in the history of man. Advances in civilization are producing conditions suitable for insect multiplication in many places, in spite of all efforts to the contrary. On a moderate computation the annual loss caused to India through insect pests has been put at 2,000 millions of rupees and over a million and a half of human lives. An effective defence against these enemies of social and economic progress will materially reduce this enormous wastage and facilitate national development. One of the necessities for combating this menace is to find cheap and effective insecticides, commensurate with the means of the great masses in India whose economic condition is very low. For several reasons vegetable insecticides are preferable to the mineral ones, such as arsenicals, copper compounds, mineral oils, etc. Those from vegetable sources are undoubtedly less deleterious to human beings and other warm-blooded animals generally, and they are also less harmful from the point of view of agriculture. Further, most of the mineral insecticides at the present time are being imported from foreign countries and are therefore expensive. So far as the insecticides from the plant kingdom are concerned, so little is known in this country that we have to depend on those growing in other countries. The larger the number of effective insecticides we discover from among the Indian poisonous plants and the more we encourage the cultivation of well-known insecticidal plants in India, the greater will be the chances of their being brought into extensive use by the people for medical, veterinary, agricultural and household purposes.

Important Insecticidal Plants

Of the vegetable insecticides of proved value may be mentioned *Chrysanthemum* (pyrethrum), *Derris* (tuba-root), *Lonchocarpus* (cube-root), *Nicotiana* (tobacco), *Tephrosia*, *Picrasma* (quassia), *Delphinium* (larkspur), *Veratrum*, etc. Amongst these, *Chrysanthemum cinerariifolium* Vis. and *Derris elliptica* (Roxb.) Benth. have acquired great importance as plant insecticides during the last 15 years. On account of the effectiveness of the flower-heads of *C. cinerariifolium* in destroying insects and mosquito larvae, Japan, Kenya and some other countries have taken up the cultivation of this plant and are reaping enormous profits by exporting them to other countries. In India its cultivation has been attempted only very recently and there is every likelihood of this country soon occupying a prominent position amongst the pyrethrum-producing countries of the world. A series of samples analyzed by the authors from the material grown in Kashmir, Murree Hills, Kangra Valley and Mayurbhanj State have given promising results and show it to be as good as any produced elsewhere. *Derris elliptica* is found wild to a very limited extent in India. The roots from plants cultivated in Mysore have been found to contain a high percentage of rotenone, one of the important insecticidal constituents occurring in the plant. Several allied species found in India need investigation. Of these *Derris ferruginea*, (Roxb.) Benth. has recently been shown to contain rotenone and may prove to be a good insecticide. Tobacco is largely cultivated in India. *Tephrosia vogelii* Hook. *f.* has been shown in foreign countries to be an efficient insecticide for fleas, lice and ticks, and it has been suggested that it may be used as a cheap commercial dip for cattle. This plant is cultivated in the tea gardens of Assam for use as a green manure, but the leaves examined by the authors showed poor insecticidal properties. Some of the other species of *Tephrosia* are also stated to have insecticidal properties but several of the Indian species, although met with in abundance, remain uninvestigated. Indian species of *Picrasma* also need investigation, and we have been informed that powdered young leaves and twigs of *P. javanica* Blume, var. *nepalensis* (Benn.) Badhwar (syn. *P. nepalensis* Benn.) are used to kill mosquito larvae in Assam. Several Indian species of *Delphinium* are even now used for destroying maggots in wounds and may be potential insecticides. Furthermore, it has been stated that the alkaloid cytisine is an important constituent of the Persian and Australian insect powder. This alkaloid, which resembles nicotine in its action, has been found in at least six genera of which *Euchresta* and *Sophora* are represented in India.

Insect-Repellent Plants

The importance of insect-repellents in the economy of nations also occupies a prominent place. Here again the cheaper and larger the number of effective insect-repellents that could be used from amongst plants growing in India, the greater the likelihood of the masses of India benefiting from their use. The leaves of neem (*Azadirachta indica* A. Juss.) and of patchouli (*Pogostemon heyneanus* Benth., syn. *P. patchouli* Hook. *f.* in Fl. Brit. Ind., *non* Pelletier), and the roots of costus (*Saussurea lappa* C. B. Clarke) are used to protect woollen fabric from insects. Articles placed in boxes made of sandalwood (*Santalum album* Linn.) are immune from the attacks of these pests. Some essential oils, such as the eucalyptus oil from *Eucalyptus globulus* Labill. and citronella oil from *Cymbopogon nardus* (Linn.) Rendle, Syn. *Andropogon nardus* Linn., when applied to the body, give relief from the bites of mosquitoes so long as the odour lasts. Hemp (*Cannabis sativa* Linn.), if spread under a bedsheet, affords ample protection against the fleas which disturb the sleep at night in many of the hill stations of India. The simple device of mixing the leaves of *Trigonella foenum-graecum* Linn. and of *Vitex negundo* Linn., etc., with the grains before storage, especially in rainy weather, as practised by the agriculturists in some parts of this country, saves the produce from the ravages of insects. Investigation of suitable plants which, when grown, will keep away the mosquitoes from habitations has been engaging the attention of malariologists for some time. No really effective plant for this purpose has so far been discovered, but it may be worthwhile giving extended trials to the shrubby basil (*Ocimum gratissimum* Linn.), absinthe (*Artemisia absinthium* Linn.), and such other plants which diffuse strong fragrance in the surrounding atmosphere. The use of repellent sprays for protecting cattle from attacks of flies constitutes, at the present time, an integral part of daily practice in the progressive countries of the world, although opinion would appear to be still divided as to whether the protection thus afforded results in an actual increase in yield of milk. Sen (2) reports that the use of a spray consisting of high-speed Diesel oil, " Pyrocide 20 " (a concentrated extract of pyrethrum flowers) and pine oil, when applied on Sahiwal cows for 21 consecutive days proved very effective against some species of biting flies and resulted in an appreciable increase in the yield of milk.

Potentialities in India

It follows, therefore, that the search of vegetable insecticides and insect-repellent plants from among the vast potential resources existing in this country will repay scrutiny. A list of those already in use is given in the conspectus which is appended. The distribution of such plants in India, their active principles, and the manner in which they are used for the purpose in view are briefly mentioned. In addition to plants described in the conspectus, a number of essential-oil-bearing plants could be usefully investigated, especially as insect-repellents.

In this connection attention is drawn to a closely allied group of plants which are poisonous to fishes as some of the piscicides are also insecticides and *vice versa.* A systematic investigation of plants poisonous to fishes may lead to the discovery of effective insecticides. The list of plants growing in India which are alleged to have a poisonous action on fishes is very long and a large number of them have been referred to by the senior author in the "Indigenous Drugs of India". During recent years further additions have been made (*1*). It is proposed to deal with this group in a separate paper.

Attention may also be drawn to a recent paper by Hackett and his collaborators (*3*) wherein naturalistic methods in practice for the control of mosquito larvae are discussed. They are of the opinion that the method of "herbage-packing" to shallow, small volume, running channels is unfavourable to larval growth. It is not every plant, however, that is suitable in the case of running water. According to these authors, "The best so far found in India are *Cleistanthus* species and *Holarrhena antidysenterica.*" There is no doubt that a number of plants mentioned in the following conspectus, as also many others amongst the Indian poisonous plants dealt with by Chopra and Badhwar (*1*), would be found to be equally good or even better for this purpose.

Name of plants.	Distribution.	Constituents.	Remarks.
(1) *Acorus calamus* Linn.	A semi-aquatic herb found throughout India in marshes or on river banks, wild or cultivated, up to 8,000 feet on the Himalayas.	An essential oil in all parts (*4, 5, 6*). A glucosidic bitter substance in rootstocks (*7*).	Aromatic rootstock used to protect clothes from insect attacks; in powder form effectively employed for destroying fleas in some parts of India.
(2) *Acorus gramineus* Soland.	A semi-aquatic herb found in the Khasia Hills and Sikkim Himalayas at 4,000 to 6,000 feet.	Essential oil (*8*) ..	Rootstock used in China as an insectifuge and insecticide (*9*).
(3) *Adina cordifolia* (Roxb.) Benth. & Hook. *f.*	A large deciduous tree found in Sub-Himalayan tract from the Jumna eastwards, ascending to 3,000 feet and extending throughout the moister regions of India. (Common in Western India, especially in the forests of Surat, Ratnagiri and Thana districts; also plentiful in Mysore, Upper Godaveri and Bhandara.)	Bitter principle (*10*) ..	Juice employed to kill maggots in sores.
(4) *Agave americana* Linn.	A stout shrubby plant with a rosette of spiny leaves. A native of America; planted in parks and gardens throughout India.	Acrid volatile oil in the leaves (*11*). A crystalline saponin in the roots (*12*). Leaves likely to contain saponins.	Wall paper impregnated with juice of the leaves is said to be proof against the ravages of white ants (*13*).

Name of plants.	Distribution.	Constituents.	Remarks.
(5) *Anacardium occidentale* Linn.	A small tree from South America; now established in the coastal districts of South India, Chittagong and the Andaman Islands.	A black, caustic, oily juice containing phenolic compound cardol, anacardic acid and an ether-soluble substance (*14*).	Juice used to protect timber, books, etc., from white ants.
(6) *Anamirta coculus* (Linn.) Wight & Arn.	A large climbing shrub found in Assam, Eastern Bengal, Oudh, Orissa and Konkan southwards to Ceylon.	Picrotoxin in the seeds (*12*).	A kind of ointment prepared from the drupes employed as an insecticide.
(7) *Andrachne cordifolia* Muell. Arg.	An erect shrub met with in the temperate Himalayas from the Indus eastwards to Nepal at 4,000 to 8,000 feet; common in shady places.	Hydrocyanic acid in the leaves (*15*).	Leaves believed by people in Jammu to have insecticidal properties. The powdered root-bark of *A. ovalis* Muell. Arg. of Africa used as a fly exterminator by the Zulus, after it is mixed with milk (*11*).
(8) *Annona reticulata* Linn.	A small American tree. Cultivated, but not so extensively as the following species, *A. squamosa.*	An alkaloid anonaine in the bark (*16*).	Properties similar to *A. squamosa.*
(9) *Annona squamosa* Linn.	An American tree about 20 feet high. Cultivated and naturalized in several parts of India.	Seeds contain an oil and a resin which contains an acrid principle (*13*). Leaves and seeds contain an amorphous alkaloid (*17*).	The seeds, leaves and the immature fruit contain an acrid principle fatal to insects; the dried unripe fruit, powdered and mixed with gram flour, used for killing vermin and the seeds to kill body lice. The powdered seeds and an aqueous infusion of leaves have valuable insecticidal properties (*18*).
(10) *Arisaema speciosum* (Wall.) Mart.	Tuberous herb found in the temperate Himalayas, from Hazara to Sikkim and Bhutan at 7,000 to 10,000 feet.	Acrid juice ..	Properties similar to *A. tortuosum.*
(11) *Arisaema tortuosum* (Wall.) Schott.	A tall tuberous herb found in the temperate and subtropical Himalayas from Simla to Bhutan at about 8,000 feet; also in Khasia Hills, Manipur, Chota Nagpur, Ranchi and Parasnath. In Western India, met with in Konkan; and in the Madras Presidency in Rampa Hills at 4,500 feet, Horsleykonda at 4,000 feet, and in Western Ghats at 3,000 to 4,000 feet.	Ditto ..	The tubers are used to kill worms which infest cattle during the rainy season. A decoction from the tubers prepared from some other species belonging to *Arisaema* also used to kill insects in India and abroad.
(12) *Aristolochia bracteata* Retz.	A slender prostrate herb growing on the banks of the Jumna and the Ganges, and in Bundelkhand, Sind and Konkan. In the Madras Presidency found in the Northern Circars, the Deccan and Carnatic, on dry especially the black cotton soil. Its occurrence in Bihar is doubtful.	A nauseous volatile substance and an alkaloid (*19*).	Juice applied to foul and neglected ulcers to destroy insect larvae. The vernacular name, *kirimar* (insect killer), is expressive of this fact.

Name of plants.	Distribution.	Constituents.	Remarks.
(13) *Artemisia absinthium* Linn.	An aromatic herbaceous perennial met with in Kashmir and Kurrum Agency at 5,000 to 7,000 feet.	Volatile oil (*12*), a bitter glucoside absinthin (*59*), and a bitter substances anabsinthin (*12*).	Used to protect garments from moth.
(14) *Azadirachta indica* A. Juss. (syn. *Melia azadirachta* Linn.)	A large evergreen tree planted all over India ; doubtfully indigenous to the Jhelum Valley.	Amorphous bitter principle and a crystalline substance, margosopicrin. Seeds also contain a bitter fixed oil with objectionable odour due to the presence of sulphur compounds and some fatty acids (*20*).	Leaves largely employed to protect woollen fabrics and books from insect attacks.
(15) *Bambusa arundinacea* Willd.	A common bamboo in Central and South India ; cultivated in many places in North-West India and in Bengal.	Benzoic acid and traces of cyanogenetic glucoside in shoots (*21*).	Shoots have lethal action on mosquito larvae (*21*).
(16) *Butea monosperma* (Lam.) Kuntze (syn. *B. frondosa* Koen. *ex* Roxb.)	A small or medium-sized tree, common throughout the greater part of India up to 3,000, sometimes reaching 4,000 feet.	Fixed oil, a small quantity of a resin and a large quantity of a water-soluble albuminoid in the seeds (*10*).	Maggots are killed by sprinkling the powdered seeds over them (*9*).
(17) *Calonyction muricatum* (Linn.) G.Don (syn. *Ipomoea muricata* Jacq.)	A large twiner found in the Himalayas from Kangra to Sikkim up to an altitude of 5,000 feet and also in the Upper Gangetic Plain, Bengal and the Deccan Hills ; often cultivated for the sake of its thickened pedicels which are edible.	Seeds contain a resin (*11*)	The juice of the plant is used to destroy bugs (*13*).
(18) *Cannabis sativa* Linn.	An aromatic, resinous annual herb found in some parts of India on waste ground and by the roadside. In the Himalayas it grows wild and is widely distributed.	Resinous substance which contains about 33 per cent. of a toxic red oil (*22*, *23*, *24*).	Has the property of driving away bugs. For this purpose, the leaves or the whole plants are scattered under the bedsheet before going to sleep. This method is effective in getting relief from these pests.
(19) *Cassytha filiformis* Linn.	A wiry leafless twining parasite found throughout the greater part of India, especially near the seacoast.	Alkaloid (*25*) ..	According to Pappe, quoted by Watt and Breyer-Brandwijk (*11*), it has been used as a wash in "scald head and for the destruction of vermin".
(20) *Centratherum anthelminticum* (Willd.) Kuntze (syn. *Vernonia anthelmintica* Willd.)	A tall annual met with throughout India up to 5,500 feet on the Himalayas and Khasia Hills.	Bitter principle in the seeds (*25*).	In Travancore, the bruised seeds ground up into a paste with lime juice are largely employed for destroying pediculi in the head and body. The plant roasted in a room, or pounded and thrown about the floor, is believed to expel fleas; hence the popular English name, purple fleabane (*13*).

Name of plants.	Distribution.	Constituents.	Remarks.
(21) *Chrysanthemum cinerariifolium* Vis.	A glaucous perennial, experimentally being cultivated in some parts of India, especially in the North-Western Himalayas.	Pyrethrin I and pyrethrin II in flower-heads (*27*). These, however, do not appear to be the only insecticidal principles in the plant, as watery extracts of the flower-heads are also toxic to mosquito larvae (*28*).	The flower-heads of pyrethrum have of recent years gained very great importance because of their insecticidal properties. They are employed in the form of powder or as a prepared extract for use as :— (*a*) household insecticides, (*b*) as livestock sprays, and (*c*) as horticultural dusts and sprays. Till recently Japan and Jugoslavia were the biggest producers of pyrethrum, but of late years Kenya is assuming increasing importance. It is also being grown on a commercial scale in Persia, Algeria, Australia, Brazil, France, Spain and Switzerland. Examination of various samples of flower-heads of *C. cinerariifolium* cultivated in Kashmir, Murree Hills, Kangra Valley and Mayurbhanj State has shown 0·702 to 1·300 per cent. of pyrethrins, which compares favourably with foreign-grown commodity which is imported. The biological tests against different species of mosquitoes and flies have also shown that the Indian-grown stuff compares favourably with the flower-heads imported from Japan and also with another powerful proprietary extract sold under the name of "Pyrocide 20". Thus both the chemical and biological tests carried out in connection with pyrethrum grown in India, lead to the conclusion that the cultivation of *C. cinerariifolium* should be extended at a rapid rate so that the large and growing demand for it in this country is met (*28*).
(22) *Chrysanthemum coccineum* Willd.	A glabrous perennial, experimentally being cultivated in Murree and some other places in India.	*See* under *C. cinerariifolium.*	A very important insecticide, but not nearly as efficacious as *C. cinerariifolium* at least in case of specimens grown in India (*28*).

Name of plants.	Distribution.	Constituents.	Remarks.
(23) *Cimicifuga foetida* Linn.	A tall robust perennial found in the Himalayas from Kashmir to Bhutan at 7,000 to 12,000 feet.	Rhizomes contain a saponin, a glucosidic tannin, a water-soluble glucoside, and a glucoside insoluble in water but soluble in alcohol (*29*). They also contain an essential oil.	The roots are used to drive away bugs and fleas in Siberia ; the flowers and unripe fruits have an extremely foetid smell and probably have the same property ; hence its English name, bugbane.
(24) *Cinnamomum camphora* Nees & Eberm.	A small tree indigenous to Formosa, China and Japan ; planted in some gardens in India up to 4,000 feet in the North-West Himalayas.	Source of camphor. ..	Camphor is used to protect woollen fabrics against insects, and enters into the composition of several insecticidal preparations.
(25) *Croton oblongifolius* Roxb.	A small deciduous tree found in the Sub-Himalayan tract from Oudh eastwards ; also in Bengal, Sylhet, Chota Nagpur, and in Central, Western and Southern India.	....	The seeds have an oil with properties similar to that of *C. tiglium*.
(26) *Croton tiglium* Linn.	A small evergreen tree planted in gardens more or less throughout India ; almost becoming naturalized in Bengal and Assam.	Seeds contain an oil which is the most violent of all cathartics. They also contain an alkaloid, ricinine, and two toxic proteins (*12*).	The oil is sometimes used as an insecticide.
(27) *Cucumis sativus* Linn. (wild form).	A hispidly hairy climber cultivated in all warm and warm-temperate countries ; also found wild in Northern India.	The fruits contain a proteolytic enzyme resembling erepsin (*60*); also a bitter substance the nature of which has not been ascertained.	It has been said that the juice banishes wood lice and fish insects, and freshly cut slices are strewn in their haunts for this purpose.
(28) *Curcuma longa* Roxb.	A tuberous herb, extensively cultivated all over India for its rhizomes known as turmeric.	Essential oil and alkaloid (*10*).	Turmeric is used to drive away ants by sprinkling in powder form on the ant holes. There are about fifteen species of *Curcuma* growing wild in India, and most of these could be used for similar purpose.
(29) *Cymbopogon nardus* (Linn.) *Rendle* (syn. *Andropogon nardus* Linn.)	A tall aromatic grass cultivated for the sake of its aromatic oil. According to some authors, this plant is also found wild in India.	Essential oil known as oil of citronella obtained from the leaves.	The commercial supply of oil of citronella is obtained principally from Ceylon, Burma and the Straits Settlements. It is an important constituent of mosquito repellents found in the market.
(30) *Cynanchum arnottianum* Wight	An erect plant found in Kashmir at 6,000 to 8,000 feet ; also in Baluchistan.	....	The leaves are dried and powdered and used to destroy the maggots which infest wounds in animals.
(31) *Delphinium brunonianum* Royle	An erect simple herb found in the Western Himalayas and Tibet between 13,000 and 17,000 feet.	NOTE.—Various species of *Delphinium* contain alkaloids, such as ajacine, ajaconine, delcosine, delphinine, delphinoidine, staphisagroine, etc.; of these delphinine and staphisagroine are the most important. *D. brunonianum* and *D. caeruleum* have not been analyzed so far.	Aitchison (*30*) remarks that the juice of the leaves is used in Kurrum Agency to destroy ticks on animals, particularly when they affect sheep.
(32) *Delphinium caeruleum* Jacquem. *ex* Cambess.	An erect herb met with on the Alpine Himalayas from Kumaon to Sikkim ; common in the Sutlej basin at 8,000 to 17,000 feet.		The root is applied to kill maggots in the wounds of goats (*13*).

Name of plants.	Distribution.	Constituents.	Remarks.
(33) *Delphinium elatum* Linn.	Sparingly branched herb found in the west temperate Himalayas from Kashmir to Kumaon and in the inner Tibetan Valleys at 10,000 to 12,000 feet.	Alkaloids (*31*) ..	In Europe the seeds are used as an insecticide (*13*).
(34) *Derris elliptica* (Roxb.) Benth.	A large, handsome climber reported from Kodala Hill near Chittagong. Commercial supply comes mostly from Malaya, Sarawak, British North Borneo, and the Dutch East Indies. Attempts being made to cultivate this plant in different parts of India, such as Travancore, the Punjab, Kashmir, Mysore and Dehra Dun.	Roots contain rotenone, deguelin, tephrosin, *iso*tephrosin, toxicarol, dehydrorotenone and other substances; of these rotenone said to be the most important (*32, 33*). In commercial assay of tuba-roots the total resinous content is regarded as a measure of its toxicity irrespective of the amount of crystalline rotenone because non-crystalline resin is also equally toxic. The fine lateral roots have been stated to contain higher toxic content than the larger tap roots.	The root, known as tuba-root or derris, is an important article of commerce on account of being valuable horticultural and agricultural insecticide. It is useful against many caterpillars, probably all larvae of leaf-eating wasps, many beetles and their larvae, turnip fleas, flower wasps, plant lice and red spider. In animal husbandry it has proved very effective against warble fly, poultry pests such as red poultry mite and forms the basis of proprietary sheep dips. An insecticidal wash effective against a wide range of pests may be made by adding 1 lb. of powdered root and 4 oz. of soft soap to 1 gallon of water (*32*). The powdered root mixed with forty parts of talc makes a very good insect powder for dogs and cats. The toxicity of tuba-roots varies with the age of the plant. Harvesting of plant about 23 months after planting is recommended. NOTE.—Over twenty other species of *Derris* are found in India. Of these, *D. robusta* (Roxb. *ex* DC.) Benth. and *D. scandens* (Roxb.) Benth. were shown to be devoid of insecticidal properties, while *D. trifoliata* Lour., var. *uliginosa* (Roxb. *ex* Willd.) Badhwar (*D. uliginasa* Benth.; *Robinia uliginosa* Roxb. *ex* DC.), examined by Tattersfield, was found to possess very little insecticidal value (*34*). *D. ferruginea* (Roxb.) Benth. yields a fair amount of rotenone—up to 2·4 per cent.—(*34, 35*).

Name of plants.	Distribution.	Constituents.	Remarks.
(35) *Duranta repens* Linn. (syn. *D. plumieri* Jacq.)	An evergreen shrub, one of the commonest hedge plants in Indian gardens.	The leaves contain a saponin *(61)*.	When macerated the berries exude a juice which is lethal to all anophelines and culicines. Manson has found that the juice is lethal to anophelines and culicines in dilutions of 1 in 100 *(62)*.
(36) *Eucalyptus globulus* Labill.	A gigantic tree of Australia and Tasmania. Introduction into India a complete success in the Nilgiris. Does not thrive in the plains nor on the outer Himalayan ranges.	Essential oil ..	Eucalyptus oil obtained from the leaves is largely used as a mosquito and vermin repellent and is an important constituent of many insecticidal and insect-repellent preparations.
(37) *Euphorbia antiquorum* Linn.	A fleshy much-branched large shrub or small tree with a few deciduous leaves. Found in dry places throughout the hotter parts of India up to 2,000 feet. Occasionally cultivated as a hedge plant in villages.	Acrid milky juice ..	Milky juice used to kill maggots in wounds (*9*).
(38) *Euphorbia thymifolia* Linn.	A small prostrate annual found throughout greater part of India, up to 4,000 feet on the Himalayas.	Essential oil ..	Essential oil used in sprays to keep off flies and mosquitoes from inhabited rooms (*36*).
(39) *Gardenia campanulata* Roxb.	A shrub found at the foot of the Sikkim Himalayas, Assam, Sylhet, Chittagong and at the summit of Parasnath in Bihar.	....	The fruit is used as a fish poison and the fruit juice is an efficient larvicide in dilutions up to 1 in 80 *(62)*.
(40) *Gaultheria fragrantissima* Wall.	A stout herb met with from Nepal to Bhutan at 6,000 to 8,000 feet; also on the Khasia Hills, Western Ghats, the Nilgiris, the Pulneys and Hills of Travancore at altitudes over 5,000 feet.	Essential oil in leaves and other parts of the plant (*10, 37*).	Essential oil a constituent of several insecticidal and insect-repellent preparations.
(41) *Gloriosa superba* Linn.	A tall herbaceous climber found throughout tropical India up to 7,000 feet on the hills; common in Mysore State.	Rootstock contains a toxic bitter principle, alkaloid colchicine and two other bases (*38, 39*).	Juice of the leaves used to destroy lice in the hair in Guinea (*9*).
(42) *Gynandropsis gynandra* (Linn.) Merr. (syn. *G. pentaphylla* DC.).	Strong smelling, somewhat foetid herb, abundant throughout the warmer parts of India.	An acrid volatile oil (*19*).	The seeds, rubbed with oil, are used to destroy head lice.
(43) *Hedera helix* Linn.	An evergreen climbing shrub found in the Himalayas from 6,000 to 10,000 feet and in the Khasia Hills at 4,000 to 6,000 feet.	Nearly all parts of the plant contain the glucoside - hederin and probably certain other glucosides(*40*). Leaves also contain a saponin which is closely related to -hederin (*41*).	A decoction of the leaves said to be applied externally to destroy vermin in the heads of children (*13*).

Name of plants.	Distribution.	Constituents.	Remarks.
(44) *Kalanchoe sapthulata* (Poir.) DC.	A succulent perennial found in the tropical and subtropical Himalayas from Kashmir to Bhutan generally between 1,000 to 4,000 feet; near Simla ascends to 6,000 feet.	....	The leaves are stated to be poisonous to insects.
(45) *Lagenandra toxicaria* Dalz. [Many authors view this species as synonymous with *L. ovata* (Linn.) Thw. of Ceylon.]	A herb found in marshes and along watercourses, often growing gregariously in Konkan, Southern Mahratta Country, North Kanara, Mysore, Coorg, and throughout the West Coast and Ghats of the Madras Presidency up to 4,000 feet.	Acrid juice ..	Plant said to have insecticidal properties (*9*).
(46) *Madhuca latifolia* (Roxb.) Macbride (syn. *Bassia latifolia* Roxb.)	A large deciduous tree found in Oudh, Bihar, Central Provinces, Central India, Gujerat, Konkan, North Kanara, Southern Mahratta Country and the Deccan. Largely planted elsewhere and liable to run wild.	The seeds contain a neutral saponin (*42*). Leaves contain a glucosidic saponin and traces of an alkaloid (*43*).	The smoke produced during the burning of the oil-cake is reported to kill insects. The oil-cake used as a worm killer for lawns—4 oz. per square yard—(*32*).
(47) *Madhuca longifolia* (Linn.) Macbride (syn. *Bassia longifolia* Linn.)	A large tree found in the forests of Western India from Konkan southwards to Travancore; common in Malabar, Mysore, Anamalais and the Circars at low elevations.	After extraction of the oil from seeds, a sapoglucoside called mowrin is obtained from the residue.	The residual cake, "mowrah meal," after the extraction of the oil from the seeds, is used as a worm killer for lawns as in the case of *M. latifolia* (*32*).
(48) *Melaleuca leucadendron* Linn.	An evergreen tree found in Tenasserim, Mergui, Malacca, Malay Islands and Australia. Var. *leucadendron* Duthie is cultivated in India.	Essential oil, known as cajuput oil, distilled from the leaves and twigs.	Cajuput oil is an excellent mosquito repellent and has the advantage over oil of citronella in that it volatilizes more slowly.
(49) *Milletia auriculata* Baker *ex* Brand.	A large robust woody climber, common in the Outer Himalayas from Sutlej eastwards to Sikkim up to 3,500 feet. Abundant in the forest tracts of Dehra Dun, the Siwalik range, Rohilkhand, North Oudh, Gorakhpur, and Bundelkhand; also in Bihar, Orissa and Bengal and in the forests of Ganjam and Vizagapatam up to 4,000 feet.	....	The powdered root applied to sores in cattle to kill vermin (*13*).
(50) *Nicandra physaloides* Gaertn.	An erect annual herb introduced from Peru, but now found as a weed on rich soils in many parts of India up to 7,000 feet on the Himalayas; often grown in gardens.	....	In Madagascar, a decoction of the leaf is stated to be used to destroy *pediculus capitis* (*9*). It is also stated to be used as a fly poison in parts of the United States of America (*15*).

Name of plants.	Distribution.	Constituents.	Remarks.
(51) *Nicotiana rustica* Linn.	An erect herb cultivated in the Western Punjab, Baluchistan, Bengal and other places in India, but sparingly as compared with *N. tabacum*.	*See N. tabacum.*	Properties similar to *N. tabacum*.
(52) *N. tabacum* Linn	An erect herb cultivated throughout India; sometimes met with as an escape.	Leaves, stems and roots contain a volatile alkaloid, nicotine. Leaves also contain several other alkaloids (*44*) and two glucosides (*45*).	Preparations from the leaves and crude solutions of nicotine are extensively employed as insecticides in horticulture by dusting or spraying or by vaporization. Similar preparations are sometimes used as external application and as parasiticides in veterinary practice. Tobacco leaves are also used to ward off leeches, for which purpose they are placed under the stockings during marches in damp forest localities that are infested with these pests.
(53) *Nigella sativa* Linn.	A pretty herb extensively cultivated in many parts of India for its seeds.	Seeds stated to contain 0·5 to 1·4 per cent. of an essential oil and a saponin-like glucoside, melanthin.	It appears to be a common practice in India to scatter the seeds between the folds of linen or woollen clothes to prevent them from being eaten by insects.
(54) *Ocimum gratissimum* Linn.	Cultivated in gardens throughout Bengal, East Nepal and the Deccan Peninsula; said to be a common wild plant in Western India.	Essential oil, thymol, eugenol, methyl chavicol (*10*).	The shrubby basil is popularly believed to be a good mosquito repellent and its plantation has been suggested as a measure of biological control of mosquitoes; it diffuses a stronger fragrance than any other member of the genus *Ocimum*. In this connection it may be remarked that *O. sanctum* Linn. is also believed to have similar properties.
(55) *Pachygone ovata* (Poir.) Miers *ex* Hook. *f.* & Thoms.	A lofty climber found in the sandy seashores of the Coromandel Coast from Nellore to Tanjore and Tinnevelly; also in the Deccan in Bellary, Cuddapah and Mysore.	....	The dried fruit is used for the purpose of destroying vermin (*9*).
(56) *Peganum harmala* Linn.	A densely foliaged bushy herb, common in the drier waste places and fields of Baluchistan, Waziristan, Kurrum Valley, Sind, Cutch, the Punjab, Kashmir, Delhi, United Provinces, Bihar, Konkan and the Western Deccan.	Seeds contain the alkaloids harmine, harmaline, harmalol and peganine (*44*); also a soft resin (*13*).	The smoke of the plant is commonly used in the Punjab as a disinfectant and is believed to keep off mosquitoes. According to Watt (*13*), the powdered root, mixed with mustard oil, is applied to the hair to destroy vermin.

Name of plants.	Distribution.	Constituents.	Remarks.
(57) *Picrasma javanica* Blume, var. *nepalensis* (Benn.) Badhwar (syn. *P. nepalensis* Benn.)	A moderate-sized tree found in Assam and Nepal.	....	We are informed that the powdered young leaves and the twigs of this plant are used as larvicide in Assam.
(58) *Pieris ovalifolia* D. Don	A small deciduous tree found in the Outer Himalayas from the Indus eastwards, usually from 3,000 to 8,000 feet; common east of the Ravi and in the Khasia Hills between 3,000 to 5,000 feet.	A toxic substance, andromedotoxin (*46*).	The young leaves are believed by people in Jammu to have insecticidal properties.
(59) *Pogostemon heyneanus* Benth. (syn. *P. patchouli* Hook. *f.* in Fl. Brit. Ind., *non* Pelletier)	A strongly aromatic herb found in Western Ghats from South Kanara southwards, in open forest land; often cultivated and then run wild. Also about Kofagiri in the Nilgiris at 6,000 feet. Sometimes cultivated in gardens in the Bombay and Bengal Presidencies.	Essential oil ..	The dried leaves are extensively employed for scenting linen and other clothes and to keep off insects from shawls, etc.
(60) *Polygonum flaccidum* Meissn.	Common throughout India in wet places, ascending the Himalayas to 4,000 feet.	....	It is locally used in Assam as a vermicide and as a fish poison. The greenish mucilaginous juice of the plant kills off mosquito larvae in 15 minutes, but is not lethal in dilution (*62*).
(61) *Polygonum hydropiper* Linn.	A rather robust annual found in damp places more or less throughout India up to 7,000 feet in the Himalayas.	The herb contains formic acid, acetic acid and baldrianic acid, much tannin and small amounts of an essential oil (*47*). Root said to contain oxymethylanthraquinones (*48*).	It is stated that insects avoid this plant; when dried and strewn among clothes it prevents the attacks of moths.
(62) *Randia dumetorum* Lam. [Split up into three species by Gamble (*49*).]	A small tree or rigid shrub found in the Sub-Himalayan tracts from Rawalpindi district eastwards, ascending in Sikkim up to 4,000 feet. Southwards it extends to Chittagong and the Peninsular India.	The fruits contain saponin in the pericarp, a glucosidic saponin in the pulp and the seeds are said to contain traces of an alkaloid (*50*). An essential oil also present (*10*).	In Konkan the bruised fruit is mixed with grain to preserve it from the attacks of insects (*19*). Subramaniyam (*51*) found that a 10 per cent. aqueous extract of the root sprayed against the green scale of coffee gave an 80 per cent. mortality of the insects in 4 days.
(63) *Ricinus communis* Linn.	A tall stout annual, or perennial and subarboreous. Originally probably from America, it is now extensively cultivated for its oil-bearing seeds and has also become naturalized near habitations in many parts of India.	Seeds contain a fixed oil and a toxalbumin, ricin, which does not pass into the oil (*52*).	Castor oil is said to be an active poison for flies (*52*).

Name of plants.	Distribution.	Constituents.	Remarks.
(64) *Ruta graveolens* Linn., var. *angustifolia* Hook. *f.*	Cultivated in gardens.	A volatile oil in the leaves, roots and seeds. Also a glucoside rutin, and a coumarin-like odoriferous principle (*11*).	The plant is sometimes spread on beds to keep off insects.
(65) *Santalum album* Linn.	A small evergreen tree, parasitic on roots to start with. Found in Mysore, Coorg, Coimbatore and Salem districts, southwards to Madura and northwards to Kolhapur; wild or cultivated.	Essential oil in the aromatic heartwood of the tree ; also in roots.	The essential oil is an efficient insecticide and insect-repellent. The wood is largely used in ornamental carving and cabinet work ; its odour drives away insects and it is, therefore, of value for making chests and boxes. Small chips and raspings of the heart-wood would serve the purpose of keeping off insects, when placed among clothes, at the same time imparting a pleasing odour.
(66) *Sarcostemma acidum* (Roxb.) Voigt (syn. *S. brevistigma* Wight & Arn.)	Leafless, trailing or twining, jointed shrub usually found on arid rocks in Konkan, the Deccan, Northern Circars, Carnatic and on Horsleykonda up to 4,500 feet. Also reported from Ranchi (Horhap forest), Singhbhum and Puri. Occurs in Bengal also.		Often used by farmers to extirpate white ants from sugarcane fields. A bundle of twigs is put into the trough of the well from which the field is watered, along with a bag of salt, hard packed, so that it may dissolve gradually. The water so impregnated has been stated to destroy the ants without injuring the crop (*13*). Three other Indian species of this genus which are almost indistinguishable in a dry state from this plant are similarly used. Two of them, *viz.*, *S. brunonianum* Wight & Arn. and *S. intermedium* Decne. are inhabitants of the Western and Southern India. The third, *S. stocksii* Hook. *f.*, is found in Sind and Southern Mahratta Country, and is more robust than any of the other three. These are known by the same vernacular names as *S. acidum*.
(67) *Saussurea lappa* C. B. Clarke	A tall stout perennial herb found in Kashmir and surrounding country.	Essential oil, alkaloid saussurine, resin, traces of a bitter substance, etc. (*53*).	The roots of costus are used in India to protect woollen fabric from insects. It is believed by Indian ladies that they do not tarnish gold embroidery on their clothing as does naphthalene.

Name of plants.	Distribution.	Constituents.	Remarks.
(68) *Schleichera oleosa* (Lour.) Merr. (syn. *S. trijuga* Willd.)	A large tree found in dry forests of the Sub-Himalayan tracts, from the Sutlej eastwards and throughout Central and Southern India.	Seeds contain a fixed oil and small quantities of a cyanogenetic compound (*54*, *55*).	The powdered seeds are applied to ulcers in animals for removing maggots.
(69) *Scleria pergracilis* (Nees) Kunth.	Widely scattered from Garhwal at an altitude of 5,000 feet to Assam, Bihar, Chota Nagpur and the Deccan.	....	The lemon-scented leaves are used to drive away mosquitoes (*63*).
(70) *Sophora mollis* R. Grah.	A low shrub found in the Himalayas and Sub-Himalayan tracts of North-Western India from Gilgit, Chitral, Hazara and the Salt Range to Kumaon and Nepal up to 7,000 feet. Also locally common near Malakand, in Kagan and Kilba, Bushahr, and Sahansradhara near Dehra Dun.	An alkaloid, sophorine, which is identical with cytisine has been isolated from *S. tomentosa* Linn. found in the Andaman and Nicobar Islands, and also occasionally cultivated in Indian gardens. This alkaloid has insecticidal properties although the use of the plant as an insecticide is not recorded. It is likely that *S. mollis* contains similar or identical alkaloid.	The seeds are stated to be useful for destroying vermin (*9*).
(71) *Tephrosia vogelii* Hook. *f.*	Cultivated in Assam by tea planters as a green manure.	Leaves contain tephrosin and deguelin (*56*). Seeds contain tephrosin, deguelin, dehydrodeguelin, *allo*tephrosin and *iso*deguelin (*57*, *58*).	The leaves are said to be an efficient insecticide against fleas, lice and ticks; in the dry state they are used as a flea powder. In fact, it has been suggested that the plant might be used as a commercial dip for cattle (*11*). The authors have recently examined the leaves of the Assam-grown plant. They do not possess insecticidal properties to any marked degree. It is possible, however, that this conclusion may have to be modified when leaves plucked at various times of the year are examined. Its seeds, which are stated to be the most toxic part of the plant, have not been examined so far. About a doxen species of Tephrosia are found in India and some of them are commonly met with. Two of them, *viz.*, *T. candida* (Roxb.) DC. and *T. purpurea* (Linn.) Pers., are reported to be used as fish poison. It is likely that some of the Indian plants may also have valuable insecticidal properties.

Name of plants.	Distribution.	Constituents.	Remarks.
(72) *Trigonella foenum-graecum* Linn.	An aromatic annual herb found wild in Kashmir, the Punjab and the Upper Gangetic plain; widely cultivated in many parts of India.	Alkaloid trigonelline (*10*) and essential oil.	Fenugreek is used as an insect repellent; agriculturists in the Kangra district in the Punjab mix the dried plant with their grains stored up in bags, in order to protect them from attacks of insects during rainy weather.
(73) *Vitex negundo* Linn.	A large aromatic shrub common throughout India up to 3,000 feet in the North-West Himalayas.	Alkaloid (*10*) ..	The leaves of Indian privet are laid over stored grains to keep off insects.
(74) *Zanthoxylum hamiltonianum* wall.	A climbing thorny shrub of Sikkim and Assam.	....	The roots are used as a fish poison. A boiled fresh solution of the roots killed 100 anopheline larvæ in 7 minutes. It acts equally on anophelines and culicines, but has no action on pupae (*62*).

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Investigation of the Annual Variation of the water content, Osmotic Values and Chloride Fractions of some plants in Port Canning, near Calcutta

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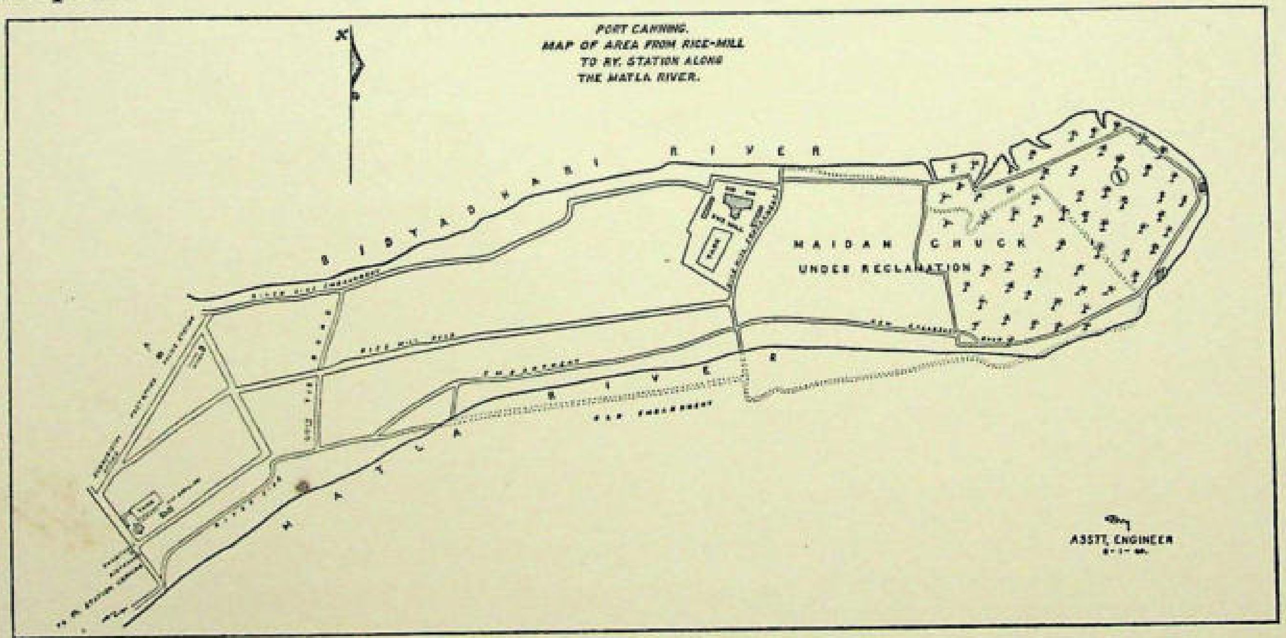
Walter[1] in his comprehensive work on the osmotic relations of plants gives an account of various aspects of plant in relalation to their osmotic values and their variations. In a previous paper the author[2] described the osmotic relations of some Bengal plants and this contained determinations of osmotic values of some common plants round Calcutta, Darjeeling, Calcutta Salt lakes and Port Canning.

More recently the chemical composition of the plant saps with reference to their partial osmotic values and the rolls of different substances and the variation of the osmotic values has received more attention. Steiner[3] at first investigated the sugar fraction in some evergreen woody plants and their seasonal variations. He also compared his results with those of Goldsmith and Smith[4] and Maximow and Krasnossjelskaja Maximow[5]. In a later work of the salt marsh vegetation of the North-Western United States of North America, Steiner[6] paid special attention to the chloride fraction of the soil and cell sap of the plants.



Walter and Steiner[7] working in the same direction investigated the mangroves of East Africa more accurately and compared the results with those of the West African mangroves and those found by Harris[8] for the American mangroves. Following this the author[9] investigated the osmotic values and chloride fraction of some Indian halophytes

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from the areas of the Calcutta Salt Lakes, Port Canning and the Khulna district of the Sundarbans. The four species common with the East African mangroves of Walter and Steiner were found to agree more or less in their osmotic and chloride fraction values. But no clear correlation was found between the values of the soil, water and plant samples with distances from the sea face. It was concluded that for a better understanding of the ecology of mangrove formations it is essential to restrict to smaller areas and take several readings including samples of soil from different depths.

In the present paper the area under investigation was restricted to a small stretch of land under reclamation about 4km. east of railway station Canning which is situated 42 km. to the south-east of Calcutta. (See map.) This area is bounded by river Matla on the south and river Bidyadhari to the north, the two rivers meeting in the east. The water of the river Matla which is directly connected with the Bay of Bengal is saline. Many mangrove plants characteristic of the Sundarbans are seen growing in the area mentioned. The annual variations of the water content osmotic values and chloride fractions of the plants of the locality, soil samples from the base of these plants and water from river Matla have been studied in this paper. Samples were taken once every month begining from November 1938 to October 1939.

Method and Material

Thirteen plants have been investigated. Of these Suaeda maritima, Avicennia alba, Excoecaria agallocha, Ceriops Roxburghiana, Aegialitis rotundifolia and Avicennia officinalis are most common; Sesuvium Portulacastrum, Finlaysonia obovata and Acanthus ilicifolius are fairly common; and lastly Bruguiera gymnorhiza, Acrostichum aureum, Aegiceras majus and Phoenix paludosa are not so common. The vegetation of the locality is supposed to be 25 years old. The plants which grow into trees are removed when their trunks become sufficiently stout to be used as fuel, so that their shoots are scarcely seen to grow beyond 2½ to 3½ meters. It is, therefore, said that the roots of these plants are 25 years old, the shoots 5 to 10 years old.

Though many of the commonly occuring plants are found to grow throughout the area (Avicennia alba being most common) species like Acrostichum aureum, Acanthus ilicifolious, Phoenix paludosa and Bruguiera gymnorhiza have been ovserved to grow in certain restricted localities.

For the investigation three localities are selected which are indicated in the map.*

Acanthus ilicifolius and Acrostichum aureum are collected from locality I. From the base of these two plants soil samples 5 cm. and 15 cm. from the surface were taken (5 cm. samples from March till October only).

Nine plants, viz., Aegiceras majus, Ceriops Roxburghiana, Avicennia alba, Avicennia officinalis, Excoecaria agallocha, Burguiera gymnorhiza, Finlaysonia obovata, Phoenix paludosa and Aegialitis rotundifolia were collected from locality marked II on the eastern, *i.e.*, the river side of the embankment. From this locality soil samples were taken from four depths, *e.g.*, 5 cm., 15 cm., 30 cm. and 60 cm. (the 5 cm. samples from April to October only).

The two succulents—Suaeda maritima and Sesuvium Portulacastrum—were collected from locality marked III—soil was taken from two depths, 15 cm. and 30 cm. (the latter from February to October only).

In addition to the above every month a sample of soil from the surface of the bank of river Matla from near the water level (except July—dropped by mistake) and a sample of water from river Matla were taken.

*The writer thanks Rai Sahib W. C. Dey, Agent and Principal Officer, Port Canning, for the outline map, the rainfall records given later and some other details about the area. The total area with mangrove vegetation as shown in the map is ¼ sq. km.

In every case the samples of soil and plants were collected from the same locality and as far as possible from the same plant every month and where not possible from similar plants of the immediate neighbourhood.

The plant, soil and water samples were collected in glass vessels with aluminium cover as used by Walter.[1] The plant samples consisted of leaves from apex of branches downwards and were collected after the surfaces were wiped clean. 10 gms. of fresh leaves were weighed out in the field with a field spring balance and brought in paper covers to the laboratory where they are dried in the thermostat at 105°C. and desiccator and the dry weight found. Thus the water content was determined. For the water content of the soil samples in the same way, both the fresh and the dry weight were found out in the laboratory. The plant samples were killed on exposure to boiling water in the usual way, brought immediately to the laboratory and the determination made. In case of delay these together with the soil and water samples were kept in a refrigerator till the readings were taken.

The soil[2] and the plant saps were pressed between two metal plates, the Cryoscopic determinations were done with the micro-cryoscope after Drucker-Burian, and all the precautions and modification suggested by Walter and Thren[3] were followed. All the values hold good for 20°C. and the under-cooling corrections were also made after the tables given by Walter.[4] The chloride was determined after the micro-chemical method of Prikladowiszky and Applonow[5] as employed by Steiner[6] as NaCl and expressed in atmospheres after the tables of Walter.

Experimental Results

The results of the determinations are given in the following tables (I to XII), each table containing the results of sampling of one month on the dates mentioned so that there are twelve such tables beginning with the month of November and ending in the month of October. In each table the percentage of water in terms of the fresh weight, total osmotic value in Atmospheres, chloride fraction in Atmosphere, and the percentage of the chloride fraction calculated from the last two are given.

In each table Nos. 1 and 2 are plants from locality I, Nos. 2A and 2B soil from the base of 1 and 2, Nos. 3 to 11 plants from locality II, and Nos. 3A, 3B, 3C, and 3D are samples of soil from the base of 3 to 11 ; Nos. 12 and 13 are plants from locality III, 13A and 13B soil samples from the base of 12 and 13. No. 14 is soil from the side of river Matla, and No. 15 is water from river Matla.

It will be seen that (*i*) no results are given for No. 1 in tables VII and VIII as no sampling could be done in May and June, the leaves having dried up completely, (*ii*) No. 2A is not included in tables I, II and III as this sample was taken from the month of February onwards, (*iii*) No. 3D is not included in tables I to V as it was sampled from April onwards, (*iv*) No. 13B is not included in tables I, II and III as this sample was taken from February onwards, and lastly (*v*) No. 14 is not included in table IX as this was dropped by mistake.

In every table (I to XII) the date of collection and the level of the river Matla are given and in some cases reference is made to special cases of rainfall and the general condition of the plant under remarks column. The same number is given for each type of sample.

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1 Walter, H. Hand. d. Biol. Arbeits methoden Abt. XI, teil 4, 352.
2 Ber. d. Deutsch. Bot. Ges. 1934, 52, 16.
3 Walter, H., u. Thren, R. Jahrb. d. Wiss. Bot. 1934, 80, 20.
4 Walter, H., Ber. d. Deutsch. Bot. Ges. 1936, 54, 329-
5 Prikladowiszky, S. u. Appolonow, A. Biochem. Zeitschr. 1928, 200, 135.
6 Steiner, M. Jahrb. d. Wiss. Bot. 1934, 81, 105.

TABLE I

Canning—1st Set. Collected on 20th November 1938. Water level normal.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	70	21·39	6·10	28	
2. Acanthus ilicifolius ..	75	22·41	14·71	62	
2A. Soil 15 cm. from the base of 1 and 2.	30	11·41	7·65	67	
3. Aegiceras majus ..	51	24·91	7·58	30	
3A. Soil 5 cm. from the base of 3—11.	27	20·15	17·18	85	
3B. Soil 15 cm. from the base of 3—11.	30	14·14	11·20	79	
3C. Soil 30 cm. from the base of 3—11.	25	11·16	9·19	82	
4. Aegialitis rotundifolia ..	58	18·13	5·94	32	
5. Excoecaria Agallocha ..	70	19·10	8·70	45	
6. Finlaysonia obovata ..	85	19·64	14·49	73	
7. Phoenix paludosa ..	60	19·89	7·17	36	
8. Ceriops Roxburghiana ..	63	25·41	13·25	52	
9. Avicennia officinalis ..	65	36·19	21·0	58	
10. Avicennia alba ..	63	30·92	24·39	78	
11. Bruguiera gymnorhiza ..	63	22·66	11·20	45	
12. Sesuvium Portulacastrum	91	27·40	18·80	68	
13. Suaeda maritima ..	88	31·44	21·28	67	
13A. Soil 15 cm. from the base of 12 and 13.	25	9·809	5·25	53	
14. Soil from river side ..	55	8·39	6·68	79	
15. Water from river Matla ..	..	7·90	6·89	87	

TABLE II

Canning—2nd Set. Collected on 18th December 1938. Water level normal.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	65	24·88	12·08	48	
2. Acanthus ilicifolius ..	75	29·42	22·01	74	
2A. Soil 15 cm. from the base of 1 and 2.	24	21·91	19·30	88	
3. Aegiceras majus ..	70	28·93	19·80	68	
3A. Soil 5 cm. from the base of 3—11.	30	12·68	10·59	83	
3B. Soil 15 cm. from the base of 3—11.	30	9·924	9·23	93	
3C. Soil 30 cm. from the base of 3—11.	28	9·402	8·74	92	
4. Aegialitis rotundifolia ..	58	38·99	31·72	81	
5. Excoecaria agallocha ..	73	21·41	13·53	63	
6. Finlaysonia obovata ..	90	19·90	14·97	75	
7. Phoenix paludosa ..	70	20·12	14·52	72	
8. Ceriops Roxburghiana ..	64	23·87	15·46	64	
9. Avicennia officinalis ..	63	31·94	26·11	81	
10. Avicennia alba ..	68	49·05	25·64	52	
11. Bruguiera gymnorhiza ..	70	21·41	20·73	92	
12. Sesuvium Portulacastrum ..	93	21·15	18·82	88	
13. Suaeda maritima ..	90	33·65	31·72	91	
13A. Soil 15 cm. from the base of 12 and 13.	25	12·89	12·59	97	
14. Soil from river side ..	30	9·322	8·24	88	
15. Water from river Matla ..	..	8·15	7·09	86	

TABLE III

Canning—3rd Set. Collected on 22nd January 1939, High flood level of river.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	70	30·22	10·38	34	
2. Acanthus ilicifolius ..	75	30·92	15·22	49	
2A. Soil 15 cm. from the base of 1 and 2.	26	11·66	9·61	82	
3. Aegiceras majus ..	61	20·89	10·83	51	
3A. Soil 5 cm. from the base of 3—11.	31	6·87	5·47	79	
3B. Soil 15cm. from the base of 3—11.	21	8·38	6·92	82	
3C. Soil 30cm. from the base of 3—11.	23	9·172	8·40	91	
4. Aegialitis rotundifolia ..	65	29·30	18·57	63	
5. Excoecaria agallocha ..	75	23·90	16·68	69	
6. Finlaysonia obovata ..	85	28·15	24·60	80	
7. Phoenix paludosa ..	71	20·40	16·20	79	
8. Ceriops Roxburghiana ..	63	25·66	16·68	65	
9. Avicennia officinalis ..	65	36·00	18·57	51	
10. Avicennia alba ..	65	39·46	24·60	62	
11. Bruguiera gymnorhiza ..	69	22·91	17·17	74	
12. Sesuvium Portulacastrum ..	92	24·41	18·57	76	
13. Suaeda maritima ..	92	29·42	24·60	83	
13A. Soil 15 cm. from the base of 12 and 13.	20	8·901	5·93	66	
14. Soil from river Matla side ..	25	6·154	5·44	88	
15. Water from river Matla ..	..	11·15	10·79	95	

TABLE IV

Canning—4th Set. Collected on 16th February 1939. High flood level, higher than the 3rd set.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	68	33·92	14·72	43	
2. Acanthus ilicifolius ..	70	33·42	16·16	48	
2A. Soil 5 cm. from the base of 1 and 2.	25	7·137	5·77	80	
2B. Soil 15 cm. from the base of 1 and 2.	25	1·708	0·20	11	
3. Aegiceras majus ..	68	23·66	11·44	48	
3A. Soil 5 cm. from the base of 3—11.	23	8·802	7·62	86	
3B. Soil 15 cm. from the base of 3—11.	25	6·404	6·23	98	
3C. Soil 30 cm. from the base of 3—11.	20	10·14	9·15	90	
4. Aegialitis rotundifolia ..	60	26·16	16·16	61	
5. Excoecaria agallocha ..	75	26·42	16·16	61	
6. Finlaysonia obovata ..	85	24·67	21·82	88	
7. Phoenix paludosa ..	70	26·95	16·16	60	
8. Ceriops Roxburghiana ..	68	28·42	16·16	56	
9. Avicennia officinalis ..	68	34·44	19·92	57	
10. Avicennia alba	60	33·68	21·82	64	
11. Bruguiera gymnorhiza ..	72	24·17	16·16	67	
12. Sesuvium Portulacastrum ..	90	26·88	15·22	56	
13. Suaeda maritima ..	88	24·11	23·76	98	
13A. Soil 15 cm. from the base of 12 and 13.	20	14·14	12·39	87	
13B. Soil 30 cm. from the base of 12 and 13.	23	1·708	0·10	5	
14. Soil from river Matla side ..	27	13·59	12·39	91	
15. Water from river Matla ..	..	11·65	10·59	90	

TABLE V

Canning—5th Set. Collected on 17th March 1939. Water level very high, higher than 4th set.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	81	15·90	9·56	60	
2. Acanthus ilicifolius ..	80	20·91	13·33	63	
2A. Soil 5 cm. from the base of 1 and 2.	23	16·90	16·16	95	
2B. Soil 15 cm. from the base of 1 and 2.	23	13·89	13·66	98	
3. Aegiceras majus	70	16·64	11·00	66	
3A. Soil 5 cm. from the base of 3—11.	23	7·89	6·24	79	
3B. Soil 15 cm. from the base of 3—11.	23	9·15	7·66	83	
3C. Soil 30 cm. from the base of 3—11.	25	10·63	8·21	77	
4. Aegialitis rotundifolia ..	53	26·41	21·84	82	
5. Excoecaria agallocha ..	75	22·17	10·50	47	
6. Finlaysonia obovata ..	88	23·67	17·55	74	
7. Phoenix paludosa ..	65	16·15	10·50	65	
8. Ceriops Roxburghiana ..	58	18·40	9·93	53	
9. Avicennia officinalis ..	43	26·89	23·19	86	
10. Avicennia alba	61	27·15	18·03	66	
11. Bruguiera gymnorhiza ..	70	22·91	21·84	95	
12. Sesuvium Portulacastrum ..	88	23·40	14·27	60	
13. Suaeda maritima ..	88	28·42	27·17	95	
13A. Soil 15 cm. from the base of 12 and 13.	25	14·62	11·89	81	
13B. Soil 30 cm. from the base of 12 and 13.	20	6·66	4·81	72	
14. Soil from river Matla side ..	27	16·64	16·16	97	
15. Water from river Matla ..	..	15·90	14·69	92	

TABLE VI

Canning—6th Set. Collected on 13th April 1939. River level very low. Shower of rain on 6-7th April 1939.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	70	16·42	9·23	56	
2. Acanthus ilicifolius ..	73	14·13	5·56	39	
2A. Soil 5 cm. from the base of 1 and 2.	13	8·11	7·37	90	
2B. Soil 15 cm. from the base of 1 and 2.	22	9·142	8·74	95	
3. Aegiceras majus	51	12·39	9·23	74	In fruits.
3A. Soil 5 cm. from the base of 3—11.	20	13·63	12·84	94	
3B. Soil 15 cm. from the base of 3—11.	17	9·142	8·74	95	
3C. Soil 30 cm. from the base of 3—11.	20	9·142	8·32	91	
3D. Soil 60 cm. from the base of 3—11.	42	13·63	12·43	91	
4. Aegialitis rotundifolia ..	53	16·42	12·84	78	
5. Excoecaria agallocha ..	69	18·90	9·68	51	
6. Finlaysonia obovata ..	83	22·68	17·83	79	
7. Phoenix paludosa ..	65	10·14	9·23	91	
8. Ceriops Roxburghiana ..	55	14·88	12·43	83	
9. Avicennia officinalis ..	53	20·66	15·58	75	In flower.
10. Avicennia alba	46	19·40	15·58	80	Ditto.
11. Bruguiera gymnorhiza ..	60	9·142	8·32	91	
12. Sesuvium Portulacastrum ..	85	24·84	15·10	61	
13. Suaeda maritima ..	85	23·92	18·77	78	
13A. Soil 15 cm. from the base of 12 and 13.	22	8·11	7·37	90	
13B. Soil 30 cm. from the base of 12 and 13.	23	8·38	7·72	92	
14. Soil from river Matla side ..	28	12·39	11·93	96	
15. Water from river Matla ..	..	17·90	16·12	90	

TABLE VII

Canning—7th Set. Collected on 12th May 1939. Water level low. Heavy shower on 10th May 1939. Low-lying areas had standing water on surface.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum . .	Could not be collected.		Leaves dried up.		
2. Acanthus ilicifolius . .	70	15·65	10·62	67	
2A. Soil 5 cm. from the base of 1 and 2.	23	17·90	15·10	84	
2B. Soil 15 cm. from the base of 1 and 2	24	28·42	25·63	90	
3. Aegiceras majus . .	53	12·88	8·11	62	
3A. Soil 5 cm. from the base of 3—11	20	9·142	8·11	88	
3B. Soil 15 cm. from the base of 3—11	23	11·65	10·13	86	
3C. Soil 30 cm. from the base of 3—11	23	9·142	7·62	83	
3D. Soil 60 cm. from the base of 3—11	20	10·38	9·60	92	
4. Aegialitis rotundifolia . .	50	31·18	24·10	77	
5. Excoecaria agallocha . .	72	20·65	13·61	66	
6. Finlaysonia obovata . .	88	19·65	15·10	76	
7. Phoenix paludosa . .	65	16·17	13·16	81	
8. Ceriops Roxburghiana . .	58	19·65	18·78	95	
9. Avicennia officinalis . .	67	20·65	13·12	63	
10. Avicennia alba	67	28·92	22·71	71	
11. Bruguiera gymnorhiza . .	65	18·79	17·05	90	
12. Sesuvium Portulacastrum . .	89	25·15	21·11	83	
13. Suaeda maritima . .	88	31·43	30·85	98	
13A. Soil 15 cm. from the base of 12 and 13	20	9·142	7·08	77	
13B. Soil 30 cm. from the base of 12 and 13	24	8·60	6·59	76	
14. Soil from river Matla side . .	28	19·91	16·12	84	
15. Water from river Matla . .	. .	19·65	18·98	96	

TABLE VIII

Canning—8th Set. Collected on 22nd June 1939. Raining heavily on 21st June 1939 and the previous days. Whole surface washed out. River level low.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	No samples available.				
2. Acanthus ilicifolius ..	65	46·00	38·20	83	
2A. Soil 5 cm. from the base of 1 and 2	37	9·38	8·68	92	
2B. Soil 15 cm. from the base of 1 and 2	35	19·90	18·18	91	
3. Aegiceras majus ..	48	12·16	6·76	55	Leaves drying up-spots.
3A. Soil 5 cm. from the base of 3—11	35	16·40	13·42	81	
3B. Soil 15 cm. from the base of 3—11	30	11·64	10·60	91	
3C. Soil 30 cm. from the base of 3—11	32	4·65	2·90	62	
3D. Soil 60 cm. from the base of 3—11	27	6·90	6·76	97	
4. Aegialitis rotundifolia ..	53	11·64	7·70	66	
5. Excoecaria agallocha ..	75	15·11	9·64	63	
6. Finlaysonia obovata ..	85	16·65	9·64	57	
7. Phoenix paludosa ..	66	13·88	9·64	69	
8. Ceriops Roxburghiana ..	65	16·65	13·42	80	
9. Avicennia officinalis ..	56	15·89	7·70	48	
10. Avicennia alba ..	53	11·64	7·70	66	
11. Bruguiera gymnorhiza ..	70	18·42	16·80	91	Leaves drying up-spots.
12. Sesuvium Portulacastrum ..	90	24·46	20·50	83	Great development.
13. Suaeda maritima ..	90	27·90	23·45	84	
13A. Soil 15 cm. from the base of 12 and 13	23	7·37	6·76	91	
13B. Soil 30 cm. from the base of 12 and 13	35	3·50	2·00	57	
14. Soil from river Matla side ..	35	10·535	8·68	82	
15. Water from river Matla ..	..	18·14	16·56	91	

TABLE IX

Canning—9th Set. Collected on 23rd July 1939. River level normal.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum* ..	76	11·64	6·15	52	*This sample was taken from a slightly different locality.
2. Acanthus ilicifolius ..	70	10·90	3·82	35	
2A. Soil 5 cm. from the base of 1 and 2	28	5·15	1·42	27	
2B. Soil 15 cm. from the base of 1 and 2	27	8·89	5·70	64	
3. Aegiceras majus ..	76	5·16	3·82	74	
3A. Soil 5 cm. from the base of 3—11	25	6·40	5·70	89	
3B. Soil 15 cm. from the base of 3—11	27	6·40	5·70	89	
3C. Soil 30 cm. from the base of 3—11	45	2·37	1·42	59	
3D. Soil 60 cm. from the base of 3—11	28	5·15	4·75	92	
4. Aegialitis rotundifolia ..	52	7·86	6·15	78	
5. Excoecaria agallocha ..	84	19·89	15·55	78	
6. Finlaysonia obovata ..	92	15·89	11·82	74	
7. Phoenix paludosa ..	68	7·38	5·70	77	
8. Ceriops Roxburghiana ..	76	15·40	12·25	79	
9. Avicennia officinalis ..	60	15·89	8·53	53	In fruits.
10. Avicennia alba ..	60	14·14	9·48	67	Ditto.
11. Bruguiera gymnorhiza ..	70	10·14	8·52	84	
12. Sesuvium Portulacastrum ..	90	14·14	6·15	43	
13. Suaeda maritima ..	90	21·70	20·20	93	
13A. Soil 15 cm. from the base of 12 and 13	25	6·65	5·70	85	
13B. Soil 30 cm. from the base of 12 and 13	25	5·15	4·75	92	
14. Soil from river Matla side ..	..	..	..	..	
15. Water from river Matla ..	..	17·38	16·20	93	

TABLE X

Canning—10th Set. Collected on 23rd August 1939. River level very low.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	73	7·86	5·74	73	
2. Acanthus ilicifolius ..	81	16·40	11·91	72	
2A. Soil 5 cm. from the base of 1 and 2.	35	18·65	17·00	91	
2B. Soil 15 cm. from the base of 1 and 2.	27	14·39	12·43	86	
3. Aegiceras majus ..	53	13·06	6·72	51	
3A. Soil 5 cm. from the base of 3—11.	27	10·64	10·18	95	
3B. Soil 15 cm. from the base of 3—11.	23	10·535	9·56	90	
3C. Soil 30 cm. from the base of 3—11.	20	12·14	11·42	94	
3D. Soil 60 cm. from the base of 3—11.	25	7·137	5·74	80	
4. Aegialitis rotundifolia ..	60	20·42	13·32	65	
5. Excoecaria agallocha ..	76	17·14	7·19	41	
6. Finlaysonia obovata ..	85	16·90	15·29	90	
7. Phoenix paludosa ..	65	10·535	7·19	68	
8. Ceriops Roxburghiana ..	63	25·12	18·98	75	
9. Avicennia officinalis ..	55	21·70	11·0	50	
10. Avicennia alba	53	22·92	11·0	47	
11. Bruguiera gymnorhiza ..	50	13·03	12·84	98	
12. Sesuvium Portulacastrum ..	90	16·40	6·74	41	
13. Suaeda maritima ..	90	22·17	18·98	90	
13A. Soil 15 cm. from the base of 12 and 13.	20	9·372	9·04	96	
13B. Soil 30 cm. from the base of 12 and 13.	25	9·372	8·12	86	
14. Soil from river Matla side.	35	9·372	8·12	86	
15. Water from river Matla ..	..	10·535	9·56	90	

TABLE XI

Canning—11th Set. Collected on 10th September 1939. River level very high.

Plant and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride in fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	75	11·90	3·01	26	
2. Acanthus ilicifolius ..	80	16·13	13·99	86	
2A. Soil 5 cm. from the base of 1 and 2.	28	7·638	5·90	77	
2B. Soil 15 cm. from the base of 1 and 2.	30	1·939	0·90	46	
3. Aegiceras majus ..	65	15·65	9·86	63	
3A. Soil 5 cm. from the base of 3—11.	22	1·939	0·90	46	
3B. Soil 15 cm. from the base of 3—11.	25	2·15	1·90	88	
3C. Soil 30 cm. from the base of 3—11.	25	3·032	1·90	62	
3D. Soil 60 cm. from the base of 3—11.	30	3·655	1·90	51	
4. Aegialitis rotundifolia ..	60	11·90	6·05	50	
5. Excoecaria agallocha ..	71	13·07	7·91	60	
6. Finlaysonia obovata ..	80	17·90	14·78	82	
7. Phoenix paludosa ..	65	7·899	4·50	56	
8. Ceriops Roxburghiana ..	60	17·66	12·32	69	
9. Avicennia officinalis ..	53	19·63	8·88	45	
10. Avicennia alba	58	17·90	6·05	33	
11. Bruguiera gymnorhiza ..	65	4·41	3·01	68	
12. Sesuvium Portulacastrum ..	90	13·07	4·50	34	
13. Suaeda maritima ..	90	22·16	17·15	77	
13A. Soil 15 cm. from the base of 12 and 13.	25	3·153	0·90	28	
13B. Soil 30 cm. from the base of 12 and 13.	20	3·032	0·90	29	
14. Soil from river Matla side ..	32	6·47	5·90	91	
15. Water from river Matla ..	..	13·07	10·87	83	

TABLE XII

Canning—12th Set. Collected on 3rd October 1939. River level very low.

Date and soil sample.	Percentage of water.	Osmotic value in Atmospheres.	Chloride in fraction in Atmospheres.	Percentage of chloride fraction.	Remarks.
1. Acrostichum aureum ..	73	11 ·15	7 ·60	68	
2. Acanthus ilicifolius ..	85	13 ·03	7 ·60	58	
2A. Soil 5 cm. from the base of 1 and 2.	25	3 ·26	1 ·92	58	
2B. Soil 15 cm. from the base of 1 and 2.	25	5 ·654	3 ·82	67	
3. Aegiceras majus ..	50	13 ·06	5 ·66	43	
3A. Soil 5 cm. from the base of 3—11.	22	6 ·142	4 ·77	77	
3B. Soil 15 cm. from the base of 3—11.	25	2 ·164	0 ·95	43	
3C. Soil 30 cm. from the base of 3—11.	23	5 ·18	3 ·82	73	
3D. Soil 60 cm. from the base of 3—11.	30	2 ·604	1 ·92	73	
4. Aegialitis rotundifolia ..	50	12 ·99	6 ·58	50	
5. Excoecaria agallocha ..	68	17 ·90	11 ·34	63	
6. Finlaysonia obovata ..	88	15 ·64	12 ·23	78	
7. Phoenix paludosa ..	63	14 ·62	7 ·60	51	
8. Ceriops Roxburghiana ..	40	18 ·90	14 ·15	74	
9. Avicennia officinalis ..	50	25 ·12	15 ·09	60	
10. Avicennia alba	73	19 ·90	12 ·23	61	
11. Bruguiera gymnorhiza ..	60	7 ·89	5 ·66	71	
12. Sesuvium Portulacastrum ..	85	14 ·39	9 ·92	61	
13. Suaeda maritima ..	78	27 ·65	20 ·21	73	
13A. Soil 15 cm. from the base of 12 and 13.	23	6 ·87	5 ·66	82	
13B. Soil 30 cm. from the base of 12 and 13.	30	5 ·18	4 ·77	92	
14. Soil from river Matla side ..	35	5 ·654	3 ·82	67	
15. Water from river Matla ..	..	6 ·87	5 ·66	82	

To compare and study the variations all the data are put together in the next table (Table XIII). Under each sample are put vertically downwards the water content values, the osmotic value, chloride fraction value and the percentage of chloride fraction and the values for the different months are placed side by side from November to October.

TABLE XIII

Plants, soil, etc.	20-11-1938.	18-12-1938.	22-1-1939.	16-2-1939.	17-3-1939.	13-4-1939.	12-5-1939.	22-6-1939.	23-7-1939.	23-8-1939.	10-9-1939.	3-10-1939.
1. Acrostichum aureum—												
Percentage of water ..	70	65	70	68	81	70	..	..	76	73	75	73
Osmotic value in Atmospheres	21·39	24·88	30·22	33·92	15·90	16·42	..	..	11·64	7·86	11·90	11·15
Chloride fraction in Atmospheres	6·10	12·08	10·38	14·72	9·56	9·23	..	..	6·15	5·74	3·01	7·60
Percentage of chloride fraction ..	28	48	34	43	60	56	..	..	52	73	26	68
2. Acanthus ilicifolius—												
Percentage of water ..	75	75	75	70	80	73	70	65	70	81	80	85
Osmotic value in Atmospheres ..	22·41	29·42	30·92	33·42	20·91	14·13	15·65	46·00	10·90	16·40	16·13	13·03
Chloride fraction in Atmospheres	14·71	22·01	15·22	16·16	13·33	5·56	10·62	38·20	3·82	11·91	13·99	7·60
Percentage of chloride fraction	62	74	49	48	63	39	67	83	35	72	86	58
2A. Soil 5 cm. from the base of 1 and 2—												
Percentage of water ..	..	..	..	25	23	13	23	37	28	35	28	25
Osmotic value in Atmospheres	..	..	..	7·137	16·90	8·11	17·90	9·38	5·15	18·65	7·638	3·26
Chloride fraction in Atmospheres	..	..	..	5·77	16·16	7·37	15·10	8·68	1·42	17·00	5·90	1·92
Percentage of chloride fraction	..	..	..	80	95	90	84	92	27	91	77	58
2B. Soil 15 cm. from the base of 1 and 2—												
Percentage of water ..	30	24	26	25	23	22	24	35	27	27	30	25
Osmotic value in Atmospheres ..	11·41	21·91	11·66	1·708	13·89	9·142	28·42	19·90	8·89	14·39	1·939	5·654
Chloride fraction in Atmospheres	7·65	19·30	9·61	0·20	13·66	8·74	25·63	18·18	5·70	12·43	0·90	3·82
Percentage of chloride fraction ..	67	88	82	11	98	95	90	91	64	86	46	67
3. Aegiceras majus—												
Percentage of water ..	51	70	61	68	70	51	53	48	76	53	65	50
Osmotic value in Atmospheres ..	24·91	28·93	20·89	23·66	16·64	12·39	12·88	12·16	5·16	13·06	15·65	13·06
Chloride fraction in Atmospheres	7·58	19·80	10·83	11·44	11·0	9·23	8·11	6·76	3·82	6·72	9·86	5·66
Percentage of chloride fraction	30	68	51	48	66	74	62	55	74	51	63	43
3A. Soil 5 cm. from the base 3—11—												
Percentage of water ..	27	30	31	23	23	20	20	35	25	27	22	22
Osmotic value in Atmospheres	20·15	12·68	6·87	8·802	7·89	13·63	9·142	16·40	6·40	10·64	1·939	6·142
Chloride fraction in Atmospheres	17·18	10·59	5·47	7·62	6·24	12·84	8·11	13·42	5·70	10·18	0·90	4·77
Percentage of chloride fraction	85	83	79	86	79	94	88	81	89	95	46	77
3B. Soil 15 cm. from the base of 3—11—												
Percentage of water ..	30	30	21	25	23	17	23	30	27	23	25	25
Osmotic value in Atmospheres	14·14	9·924	8·38	6·404	9·15	9·142	11·65	11·64	6·40	10·535	2·15	2·164
Chloride fraction in Atmospheres	11·20	9·23	6·92	6·23	7·66	8·74	10·13	10·60	5·70	9·56	1·90	0·95
Percentage of chloride fraction	79	93	82	98	83	95	86	91	89	90	88	43
3C. Soil 30 cm. from the base of 3—11—												
Percentage of water ..	25	28	23	20	25	20	23	32	45	20	25	23
Osmotic value in Atmospheres	11·16	9·402	9·172	10·14	10·63	9·142	9·142	4·65	2·37	12·14	3·032	5·18
Chloride fraction in Atmoshperes	9·19	8·74	8·40	9·15	8·21	8·32	7·62	2·90	1·42	11·42	1·90	3·82
Percentage of chloride fraction	82	92	91	90	77	91	83	62	59	94	62	73
3D. Soil 60 cm. below 3—11—												
Percentage of water ..	..	..	..	..	..	42	20	27	28	25	30	30
Osmotic value in Atmospheres	..	..	..	..	..	13·63	10·38	6·90	5·15	7·137	3·655	2·604
Chloride fraction in Atmospheres	..	..	..	..	..	12·43	9·60	6·76	4·75	5·74	1·90	1·92
Percentage of chloride fraction ..	..	..	..	..	..	91	92	97	92	80	51	73
4. Aegialitis rotundifolia—												
Percentage of water ..	58	58	65	60	53	53	50	53	52	60	60	50
Osmotic value in Atmospheres	18·13	38·99	29·30	26·16	26·41	16·42	31·18	11·64	7·86	20·42	11·90	12·99
Chloride fraction in Atmospheres	5·94	31·72	18·57	16·16	21·84	12·84	24·10	7·70	6·15	13·32	6·05	6·58
Percentage of chloride fraction ..	32	81	63	61	82	78	77	66	78	65	50	50
5. Excoecaria agallocha—												
Percentage of water ..	70	73	75	75	75	69	72	75	84	76	71	68
Osmotic value in Atmospheres	19·10	21·41	23·90	26·42	22·17	18·90	20·65	15·11	19·89	17·14	13·07	17·90
Chloride fraction in Atmospheres	8·70	13·53	16·68	16·16	10·50	9·68	13·1	9·64	15·55	7·19	7·91	11·34
Percentage of chloride fraction	45	63	69	61	47	51	66	63	78	41	60	63

Plants, soil, etc.	20-11-1938.	18-12-1938.	22-1-1939.	16-2-1939.	17-3-1939.	13-4-1939.	12-5-1939.	22-6-1939.	23-7-1939.	23-8-1939.	10-9-1939.	3-10-1939.
6. Finlaysonia obovata—												
Percentage of water ..	85	90	85	85	88	83	88	85	92	85	80	88
Osmotic value in Atmospheres	19·64	19·90	28·15	24·67	23·67	22·68	19·65	16·65	15·89	16·90	17·90	15·64
Chloride fraction in Atmospheres	14·49	14·97	24·60	21·82	17·55	17·83	15·10	9·64	11·82	15·29	14·78	12·23
Percentage of chloride fraction	73	75	80	88	74	79	76	57	74	90	82	78
7. Phoenix paludosa—												
Percentage of water ..	60	70	71	70	65	65	65	66	68	65	65	63
Osmotic value in Atmospheres	19·89	20·12	20·40	26·95	16·15	10·14	16·17	13·88	7·38	10·535	7·899	14·62
Chloride fraction in Atmospheres	7·17	14·52	16·20	16·16	10·50	9·23	13·16	9·64	5·70	7·19	4·50	7·60
Percentage of chloride fraction	36	72	79	60	65	91	81	69	77	68	56	51
8. Ceriops Roxburghiana—												
Percentage of water ..	63	64	63	68	58	55	58	65	76	63	60	40
Osmotic value in Atmospheres	25·41	23·87	25·66	28·42	18·40	14·88	19·65	16·65	15·40	25·12	17·66	18·90
Chloride fraction in Atmospheres	13·25	15·46	16·68	16·16	9·93	12·43	18·78	13·42	12·25	18·98	12·32	14·15
Percentage of chloride fraction	52	64	65	56	53	83	95	80	79	75	69	74
9. Avicennia officinalis—												
Percentage of water ..	65	63	65	68	43	53	67	56	60	55	53	50
Osmotic value in Atmospheres	36·19	31·94	36·00	34·44	26·89	20·66	20·65	15·89	15·89	21·70	19·63	25·12
Chloride fraction in Atmospheres	21·0	26·11	18·57	19·92	23·19	15·58	13·12	7·70	8·53	11·0	8·88	15·09
Percentage of chlorid fraction	58	81	51	57	86	75	63	48	53	50	45	60
10 Avicennia alba—												
Percentage of work ..	63	68	65	60	61	46	67	53	60	53	58	73
Osmtic value in Atmospheres	30·92	49·05	39·46	33·68	27·15	19·40	28·92	11·64	14·14	22·92	17·90	19·90
Chloride fraction in Atmospheres	24·39	25·64	24·60	21·82	18·03	15·58	22·71	7·70	9·48	11·0	6·05	12·23
Percentage of chloride fraction	78	52	62	64	66	80	71	66	67	47	33	61
11. Bruguiera gymnorhiza—												
Percentage of water ..	63	70	69	72	70	60	65	70	70	50	65	60
Osmotic value in Atmospheres	22·66	21·41	22·91	24·17	22·91	9·142	18·70	18·42	10·14	13·03	4·41	7·89
Chloride fraction in Atmospheres	11·20	20·73	17·17	16·16	21·84	8·32	17·05	16·80	8·52	12·84	3·01	5·66
Percentage of chloride fraction	45	92	74	67	95	91	90	91	84	98	68	71
12. Sesuvium Portulacastrum—												
Percentage of water ..	91	93	92	90	88	85	89	90	90	90	90	85
Osmotic value in Atmospheres ..	27·40	21·15	24·41	26·88	23·40	24·84	25·15	24·46	14·14	16·40	13·07	14·39
Chloride fraction in Atmospheres	18·80	18·82	18·57	15·22	14·27	15·10	21·11	20·50	6·15	6·74	4·50	9·42
Percentage of chloride fraction	68	88	76	56	60	61	83	83	43	41	34	61
13. Suaeda maritima—												
Percentage of water ..	88	90	92	88	88	85	88	90	90	90	90	78
Osmotic value in Atmospheres	31·44	33·65	29·42	24·11	28·42	23·02	31·43	27·90	21·70	22·17	22·16	27·65
Chloride fraction in Atmospheres	21·28	31·72	24·60	23·76	27·17	18·77	30·85	23·45	20·20	18·98	17·15	20·21
Percentage of chloride fraction	67	91	83	98	95	78	98	84	93	90	77	73
13A. Soil 15 cm. below 12 and 13—												
Percentage of water ..	25	25	20	20	25	22	20	23	25	20	25	23
Osmotic value in Atmospheres	9·809	12·89	8·901	14·14	14·62	8·11	9·142	7·37	6·65	9·372	3·153	6·87
Chloride fraction in Atmospheres	5·25	12·59	5·93	12·39	11·89	7·37	7·08	6·76	5·70	9·04	0·90	5·66
Percentage of chloride fraction	53	97	66	87	81	90	77	91	85	96	28	82
13B. Soil 30 cm. below 12 and 13—												
Percentage of water ..	..	..	..	23	20	23	24	35	25	25	20	3
Osmotic value in Atmospheres	..	..	..	1·708	6·66	8·38	8·60	3·50	5·15	9·372	3·032	5·18
Chloride fraction in Atmospheres	..	..	..	0·10	4·81	7·72	6·59	2·00	4·75	8·12	0·90	4·77
Percentage of chloride fraction	..	..	..	5	72	92	76	57	92	86	29	92
14. Soil from the side of river Matla—												
Percentage of water ..	55	30	25	27	27	28	28	35	..	35	32	35
Osmotic value in Atmospheres	8·39	9·322	6·154	13·59	16·64	12·39	19·91	10·535	..	9·372	6·47	5·654
Chloride fraction in Atmospheres	6·68	8·24	5·44	12·39	16·16	11·93	16·12	8·68	..	8·12	5·90	3·82
Percentage of chloride fraction	79	88	88	91	97	96	84	82	..	86	91	67
15. Water from Matla river—												
Osmotic value in Atmospheres	7·90	8·15	11·15	11·65	15·90	17·90	19·65	18·14	17·38	10·535	13·07	6·87
Chloride fraction in Atmospheres	6·89	7·09	10·79	10·59	14·69	16·12	18·98	16·56	16·20	9·56	10·87	5·66
Percentage of chloride fraction	87	86	95	90	92	90	96	91	93	90	83	82

The highest and lowest values and the months in which they are found are summarised in the next table (Table XIV) from the data of Table XIII.

TABLE XIV

Plants, soil, etc.	Highest value and the month.	Lowest value and the month.
1. Acrostichum aureum—		
Percentage of water	81, March	65, December.
Osmotic value in Atmospheres	33 ·92 Atm., February	7 ·86 Atm., August.
Chloride fraction in Atmospheres	14 ·72 Atm., February	3 ·01 Atm., September.
Percentage of chloride fraction	73, August	26, September.
2. Acanthus ilicifolius—		
Percentage of water	85, October	65, June.
Osmotic value in Atmospheres	46 ·00 Atm., June	10 ·90 Atm., July.
Chloride fraction in Atmospheres	38 ·20 Atm., June	5 ·56 Atm., April.
Percentage of chloride fraction	86, September	35, July.
2A. Soil 5 cm. from the base of 1 and 2—		
Percentage of water	37, June	13, April.
Osmotic value in Atmospheres	18 ·65 Atm., August	3 ·26 Atm., October.
Chloride fraction in Admospheres	17 ·00 Atm., August	1 ·42 Atm., July.
Percentage of chloride fraction	95, March	27, July.
2B. Soil 15 cm. from the base of 1 and 2—		
Percentage of water	35, June	22, April.
Osmotic value in Atmospheres	28 ·42 Atm., May	1 ·708 Atm., February.
Chloride fraction in Atmospheres	25 ·63 Atm., May	·20 Atm., February.
Percentage of chloride fraction	95, April	11, February.
3. Aegiceras majus—		
Percentage of water	76, July	48, June.
Osmotic value in Atmospheres	28 ·93 Atm., December	5 ·16 Atm., July.
Chloride fraction in Atmospheres	19 ·80 Atm., December	3 ·82 Atm., October.
Percentage of chloride fraction	74, April	30, November.
3A. Soil 5 cm. from the base of 3—11—		
Percentage of water	35, June	20, April-May.
Osmotic value in Atmospheres	20 ·15 Atm., November	1 ·939 Atm., September.
Chloride fraction in Atmospheres	17 ·18 Atm., November	0 ·90 Atm., September.
Percentage of chloride fraction	95, August	46, September.
3B. Soil 15 cm. from the base of 3—11—		
Percentage of water	30, November, December, June (same value).	17, April.
Osmotic value in Atmospheres	14 ·14 Atm., November	2 ·15 Atm., September.
Chloride fraction in Atmospheres	11 ·20 Atm., November	0 ·95 Atm., October.
Percentage of chloride fraction	98, February	43, October.
3C. Soil 30 cm. from the base of 3—11—		
Percentage of water	45, July	20, February, April, August (same value.)
Osmotic value in Atmospheres	12 ·14 Atm., August	2 ·37 Atm., July.
Chloride fraction in Atmospheres	11 ·42 Atm., August	1 ·42 Atm., July.
Percentage of chloride fraction	94, August	62, June, September.
3D. Soil 60 cm. from the base of 3—11—		
Percentage of water	42, April	20, May.
Osmotic value in Atmospheres	13 ·63 Atm., April	2 ·604 Atm., October.
Chloride fraction in Atmospheres	12 ·43 Atm., April	1 ·90 Atm., September.
Percentage of chloride fraction	97, June	51, September.

Plants, soil, etc.	Highest value and the month.	Lowest value and the month.
4. Aegialitis rotundifolia—		
Percentage of water	65, January	50, October and May.
Osmotic value in Atmospheres	38 ·99 Atm., December	7 ·86 Atm., July.
Chloride fraction in Atmospheres	31 ·72 Atm., December	5 ·94 Atm., November.
Percentage of chloride fraction	82, March	32, November.
5. Excoecaria agallocha—		
Percentage of water	84, July	68, October.
Osmotic value in Atmospheres	26 ·42 Atm., February	13 ·07 Atm., September.
Chloride fraction in Atmospheres	16 ·68 Atm., January	7 ·19 Atm., August.
Percentage of chloride fraction	78, July	41, August.
6. Finlaysonia obovata—		
Percentage of water	92, July	80, September.
Osmotic value in Atmospheres	28 ·15 Atm., January	15 ·64 Atm., October.
Chloride fraction in Atmospheres	24 ·60 Atm., January	9 ·64 Atm., June.
Percentage of chloride fraction	90, August	57, June.
7. Phoenix paludosa—		
Percentage of water	71, January	60, November.
Osmotic value in Atmospheres	26 ·95 Atm., February	7 ·38 Atm., July.
Chloride fraction in Atmospheres	16 ·20 Atm., January	4 ·50 Atm., September.
Percentage of chloride fraction	91, April	36, November.
8. Ceriops Roxburghiana—		
Percentage of water	76, July	40, October.
Osmotic value in Atmospheres	28 ·42 Atm., February	14 ·88 Atm., April.
Chloride fraction in Atmospheres	18 ·98 Atm., August	9 ·93 Atm., March.
Percentage of chloride fraction	95, May	52, November.
9. Avicennia officinalis—		
Percentage of water	68, February	43, March.
Osmotic value in Atmospheres	36 ·19 Atm., November	15 ·89 Atm., June, July (same value).
Chloride fraction in Atmospheres	26 ·11 Atm., December	7 ·70 Atm., June.
Percentage of chloride fraction	86 , March	45, September.
10. Avicennia alba—		
Percentage of water	73, October	46, April.
Osmotic value in Atmospheres	49 ·05 Atm., December	11 ·64 Atm., June.
Chloride fraction in Atmospheres	25 ·64 Atm., December	7 ·70 Atm., September.
Percentage of chloride fraction	80, April	33, September.
11. Bruguiera gymnorhiza—		
Percentage of water	72, February	50 , August.
Osmotic value in Atmospheres	24 ·17 Atm., February	4 ·41 Atm., September.
Chloride fraction in Atmospheres	21 ·84 Atm., March	3 ·01 Atm., September.
Percentage of chloride fraction	98, August	45, November.
12. Sesuvium Portulacastrum—		
Percentage of water	93, December	85 April, October.
Osmotic value in Atmospheres	27 ·40 Atm., November	13 ·07 Atm., September.
Chloride fraction in Atmospheres	21·11 Atm., May	4 ·50 Atm., September.
Percentage of chloride fraction	88, December	34, September.

Plants, soil, etc.	Highest value and the month.	Lowest value and the month.
13. Suaeda maritima—		
Percentage of water ..	.. 92, January ..	.. 78, October
Osmotic value in Atmospheres	.. 33 ·65 Atm., December	.. 21 ·70 Atm., July.
Chloride fraction in Atmospheres	.. 31 ·72 Atm., December	.. 17 ·15 Atm., September.
Percentage of chloride fraction	.. 98, May, February	.. 67, November.
13A. Soil 15 cm. from the base of 12 and 13—		
Percentage of water ..	.. 25 November, December, March July, September (same value).	20, January, February, May, August.
Osmotic value in Atmospheres	.. 14 ·62 Atm., March	.. 3 ·153 Atm., September.
Chloride fraction in Atmospheres	.. 12 ·59 Atm., December	.. 0 ·90 Atm., September.
Percentage of chloride fraction	.. 97, December ..	.. 28, September.
13B. Soil 30 cm. from the base of 12 and 13—		
Percentage of water ..	.. 35, June ..	.. 20, March, September.
Osmotic value in Atmospheres	.. 9 ·372 Atm., August	.. 1 ·708 Atm., Februay.
Chloride fraction in Atmospheres	.. 8 ·12 Atm., August	.. 0 ·10 Atm., February.
Percentage of chloride fraction	.. 92, April, July, October	.. 5, February.
14. Soil from river Matla side—		
Percentage of water ..	.. 55, November ..	.. 25, January.
Osmotic value in Atmospheres	.. 19 ·91 Atm., May	.. 5 ·654 Atm., October.
Chloride fraction in Atmospheres	.. 16 ·16 Atm., March	.. 3 ·82 Atm., October.
Percentage of chloride fraction	.. 97, March. ..	.. 67, October.
15. Water from river Matla—		
Osmotic value in Atmospheres	.. 19 ·65 Atm., May	.. 6 ·87 Atm., October.
Chloride fraction in Atmospheres	.. 18 ·98 Atm., May	.. 5 ·66 Atm., October.
Percentage of chloride fraction	.. 96, May ..	.. 82, October.

The months during which the different sample numbers show the highest value is summed up in Table XV, and Table XVI gives the total numbers of such samples. While the months during which the different sample numbers show the lowest values are summed up in Table XVII and XVIII gives the total numbers of such samples.

TABLE XV

Showing the sample numbers which showed the highest values under different heads in the different months.

	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
Percentage of water	3B, 13A, 14	3B, 4, 12, 13A	4, 7, 13	9, 11	1, 13A	3D	..	2B, 3A, 3B, 13B	3, 3C, 5, 6, 8, 13A	2A	13A	2, 10
Osmotic value ..	3A, 3B, 9, 12.	3, 4, 9, 10, 13	6	1, 5, 7, 8, 11	13A	3D	2B, 14, 15.	2	..	2A, 3C, 13B	..	..
Chloride fraction ..	3A, 3B	3, 4, 9, 10, 13, 13A	5, 6, 7	1	11, 14	3D	2B, 12, 15	2	..	2A, 3C, 8, 13B	..	..
Percentage of chloride fraction.	..	12, 13A	..	3B, 13	2A, 4, 9, 14	2B, 3, 7, 10 13B	8, 15	3D	5, 13B	1, 3A, 3C, 6, 11	2	13B

TABLE XVI

Showing the total number of samples which showed highest values under different heads in the different months.

	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September	October.
Percentage of water	3	4	3	2	2	1	0	4	6	1	1	2
Osmotic value ..	4	5	1	5	1	1	3	1	0	3	0	0
Chloride fraction	2	6	3	1	2	1	3	1	0	4	0	0
Percentage of chloride fraction.	0	2	0	2	4	5	2	1	2	5	1	1

TABLE XVII

Showing the sample numbers which showed the lowest values under different heads in the different months.

	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
Percentage of water	7	1	13A, 14	3C, 13A	9, 13B	2A, 2B, 3A, 3B, 3C, 10.	3A, 3D, 4, 13A	2, 3	4	11, 13A	6, 13B	3C, 4, 5, 8, 12, 13
Osmotic values ..	..	..	..	2B, 13B	..	8	..	9, 10	2, 3, 3C, 7, 9, 13.	1	3A, 3B, 5, 7, 12, 11, 13A.	2A, 3D, 6, 14, 15
Chloride fraction ..	4	..	..	2B, 13B	8	2	..	6, 9	2A, 3C	5	1, 3A, 3D, 7, 9, 10, 11, 12, 13, 13A.	3, 3B, 14, 15.
Percentage of chloride fraction.	3, 4, 7, 8, 11, 13.	..	..	2B, 13B	..	..	..	3C, 6	2, 2A,	5	1, 3A, 3D, 3C, 10, 12, 13A, 13B.	3B, 14, 15

TABLE XVIII

Showing the total number of samples which showed the lowest values under different heads in different months.

	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
Percentage of water	1	1	2	2	2	6	4	2	1	2	2	6
Osmotic value ..	..	..	..	2	..	1	..	2	6	1	7	5
Chloride fraction ..	1	..	..	2	1	1	..	2	2	1	10	4
Percentage of chloride fraction.	6	..		2	..	..	..	2	2	1	8	3

The rainfall records are given in Table XIX under three heads, viz., for 24 hours ending on the date of sampling, average for 7 days previous to that, and average for 14 days previous to that.

TABLE XIX

Month and date of sampling.	Rainfall in cm. during 24 hours ending on the date of sampling.	Average rainfall in cm. for 7 days previous to the date of sampling.	Average rainfall for 14 days previous to the date of sampling.
November (20-11-38)	Nil	Nil	Nil
December (18-12-38)	Nil	Nil	Nil
January (22-1-39)	Nil	Nil	Nil
February (16-2-39)	Nil	Nil	Nil
March (17-3-39)	Nil	Nil	Nil
April (13-4-39)	Nil	0·75	0·25
May (12-5-39)	5·95	1·0	0·50
June (22-6-39)	5·42	1·25	1·45
July (23-7-39)	Nil	0·50	0·75
August (23-8-39)	0·60	1·75	1·20
September (10-9-39)	Nil	1·50	1·20
October (3-10-39)	Nil	0·50	1·8

Mechanical analysis* of the soil from Port Canning from the base of the plant formation, by the international method, gave for two samples the following values :—

	Clay. Per cent.	Silt. Per cent.
Sample I	32·7	47·5
Sample II	32·61	47·04

To study the course of variation of the different plants and the soil from the different localities the data are represented graphically in the following figures. In the figures the vertical lines indicate the percentage of water in terms of fresh weight and the vertical columns indicate total osmotic value and the shaded portion the chloride fraction in Atmospheres. In every case the number of the sample is given below the column and in cases where soil and plant or other samples are denoted side by side, an S is put before the number of the soil sample (Figs. I and XII). The vertical columns of the soil samples are also made slightly broader. The only water Sample No. 15 is indicated by W (Fig. XIII).

*The author thanks Professor J. N. Mukherji, Professor of Chemistry, Calcuttta University, for the analysis of the soil samples in his laboratory.

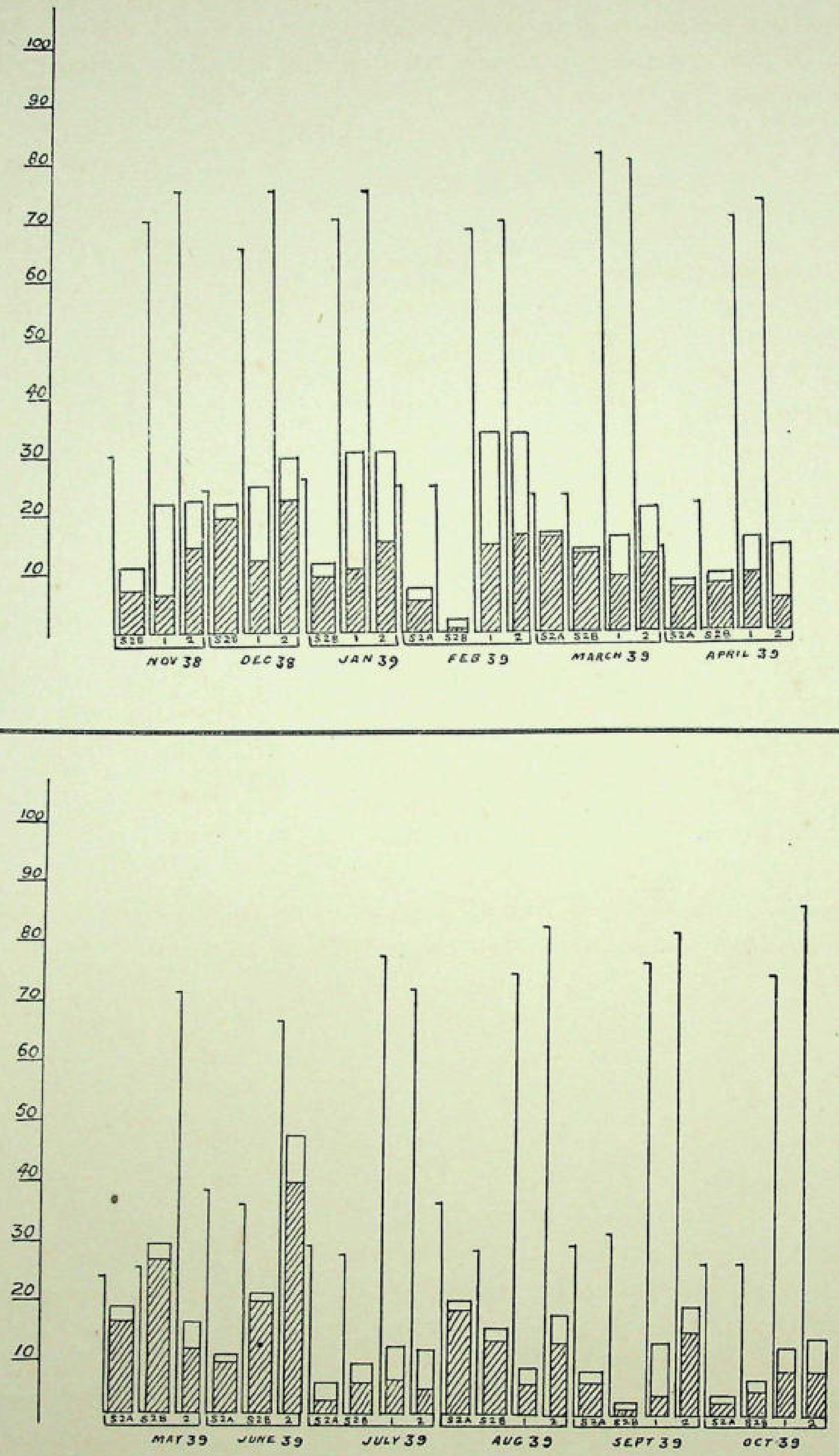

FIGURE I.

S2A—Soil Sample 5 cm. below the surface from the base of plants 1 and 2.
S2B—Soil Sample 15 cm. below the surface from the base of plants 1 and 2
1—Acrostichum aureum.
2—Acanthus ilicifolius.

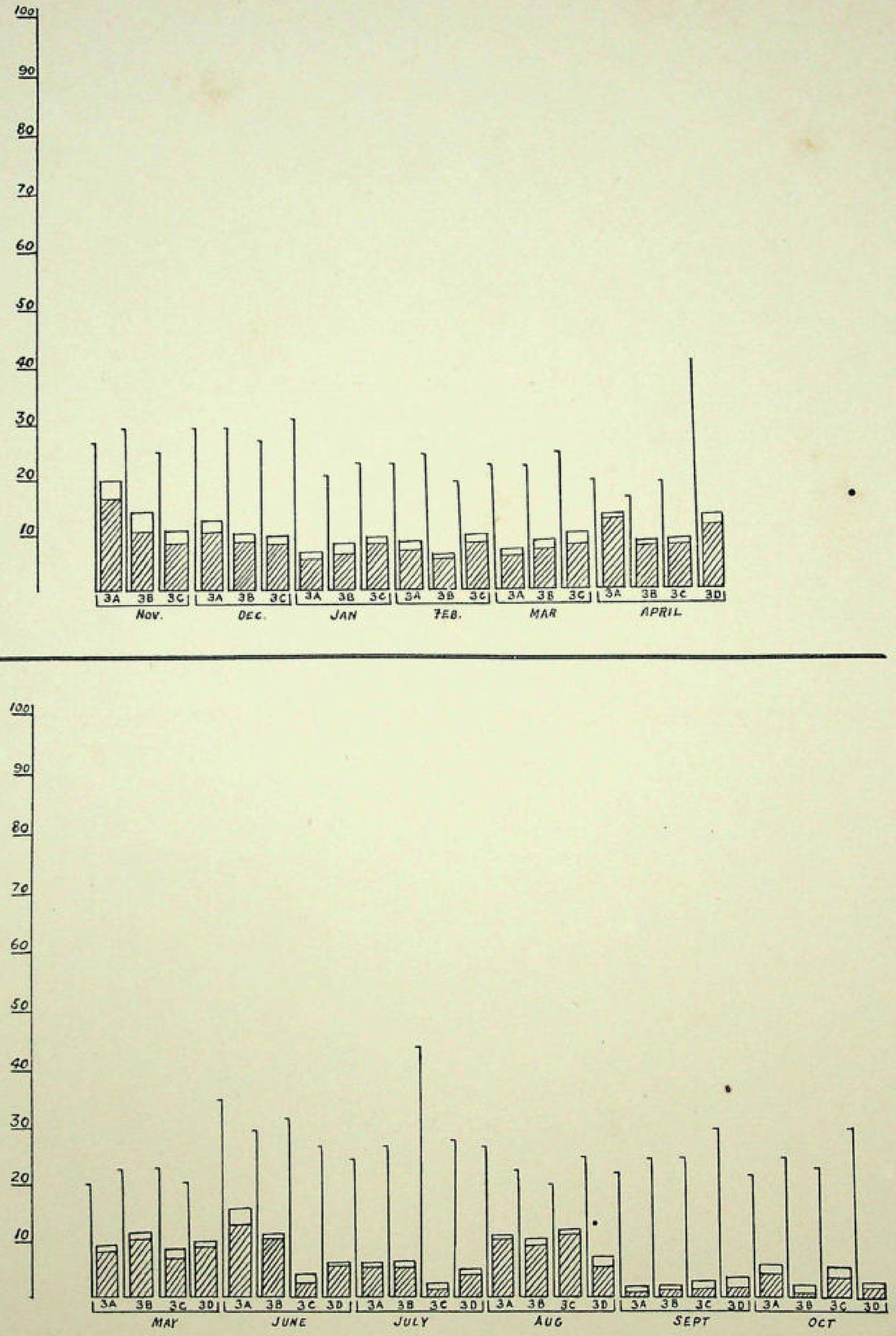

Figure II.

3A—Soil 5 cm. below the surface from the base of plants 3 to 11.
3B—Soil 15 cm. below the surface from the base of plants 3 to 11.
3C—Soil 30 cm. below the surface from the base of plants 3 to 11.
3D—Soil 60 cm. below the surface from the base of plants 3 to 11.

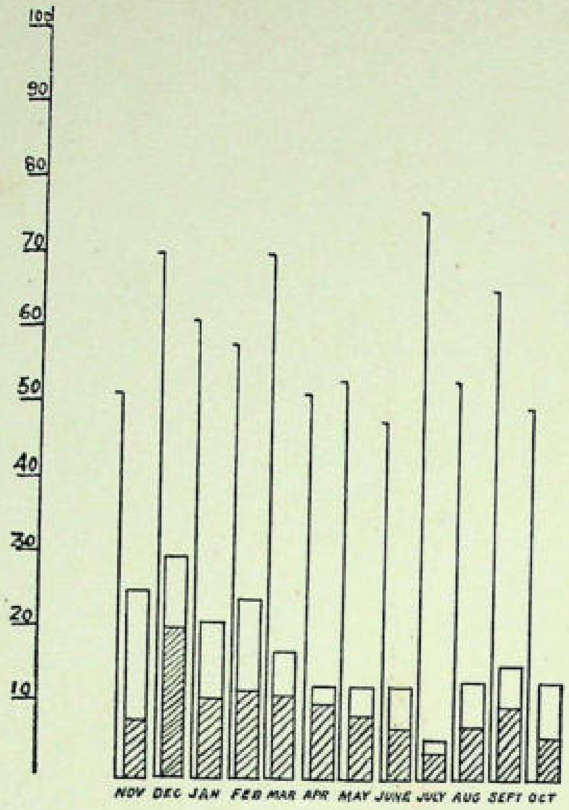

FIGURE III.
Aegiceras majus.

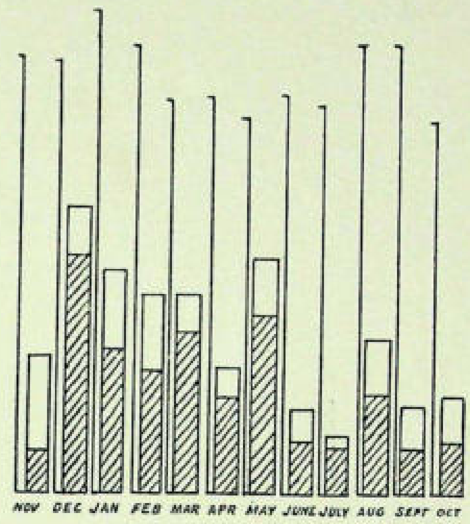

FIGURE IV.
Aegialitis rotundifolia.

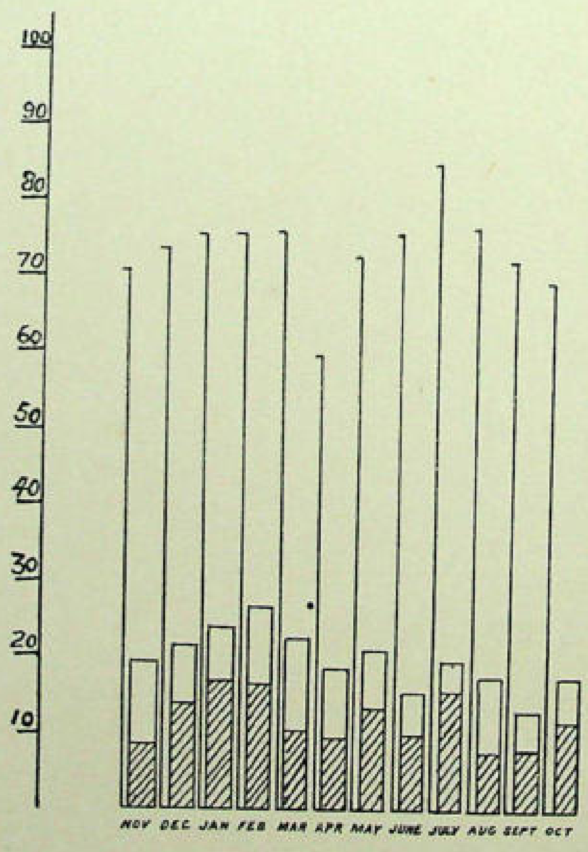

FIGURE V.
Excoecaria agallocha.

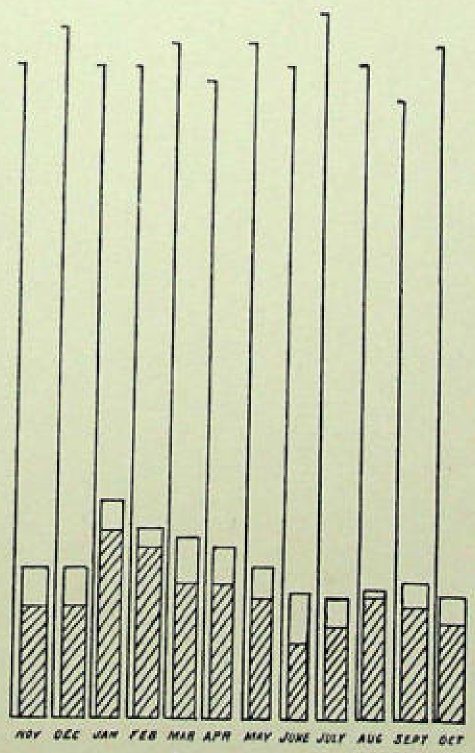

FIGURE VI.
Finlaysonia obovata.

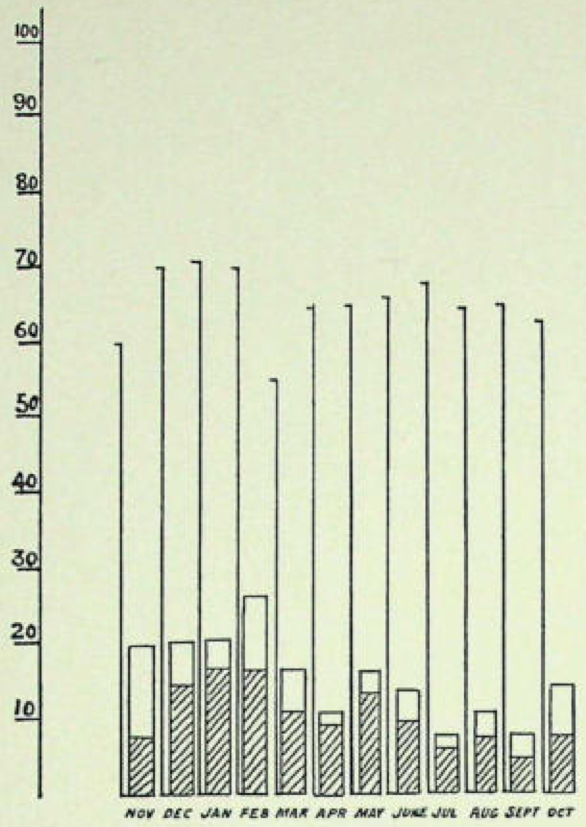

FIGURE VII.
Phoenix paludosa.

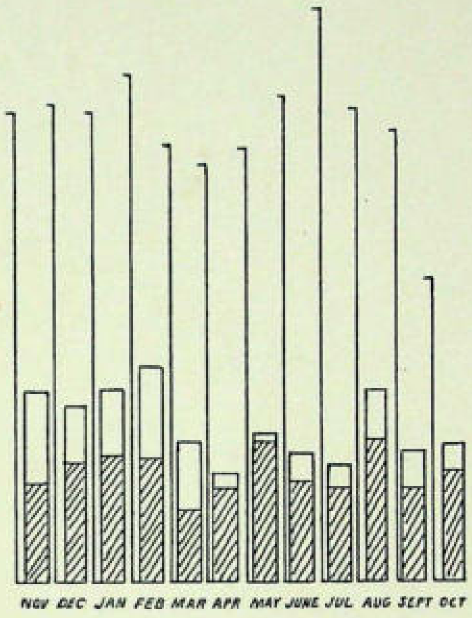

FIGURE VIII.
Ceriops Roxburghiana.

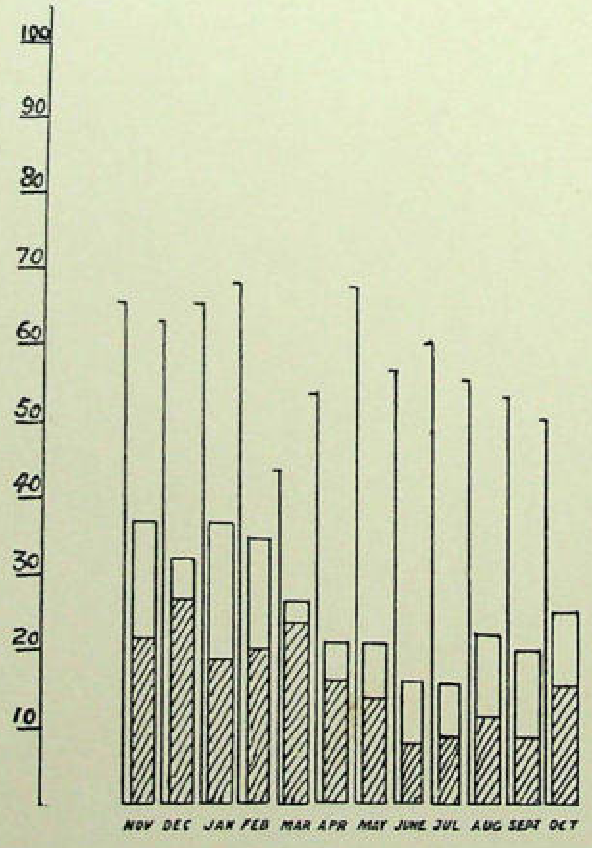

FIGURE IX.
Avicennia officinalis.

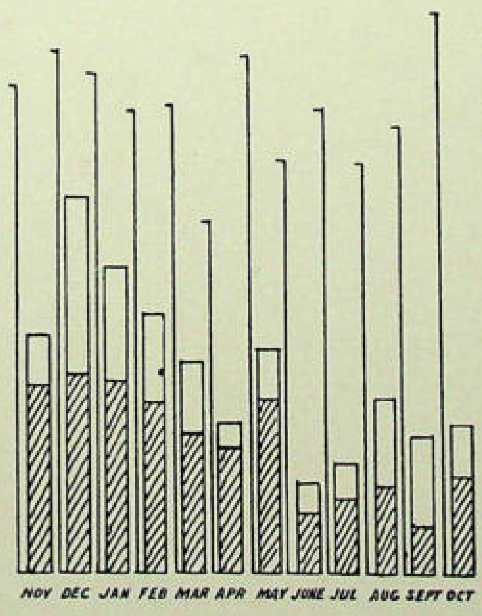

FIGURE X.
Avicennia alba.

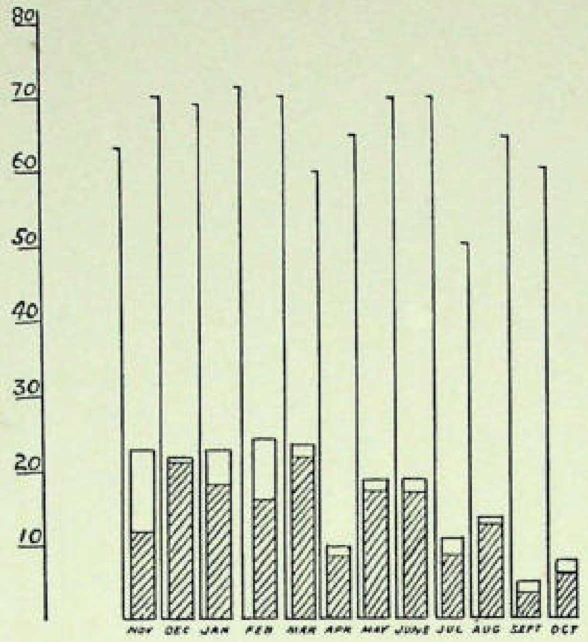

FIGURE XI.

Bruguiera gymnorhiza.

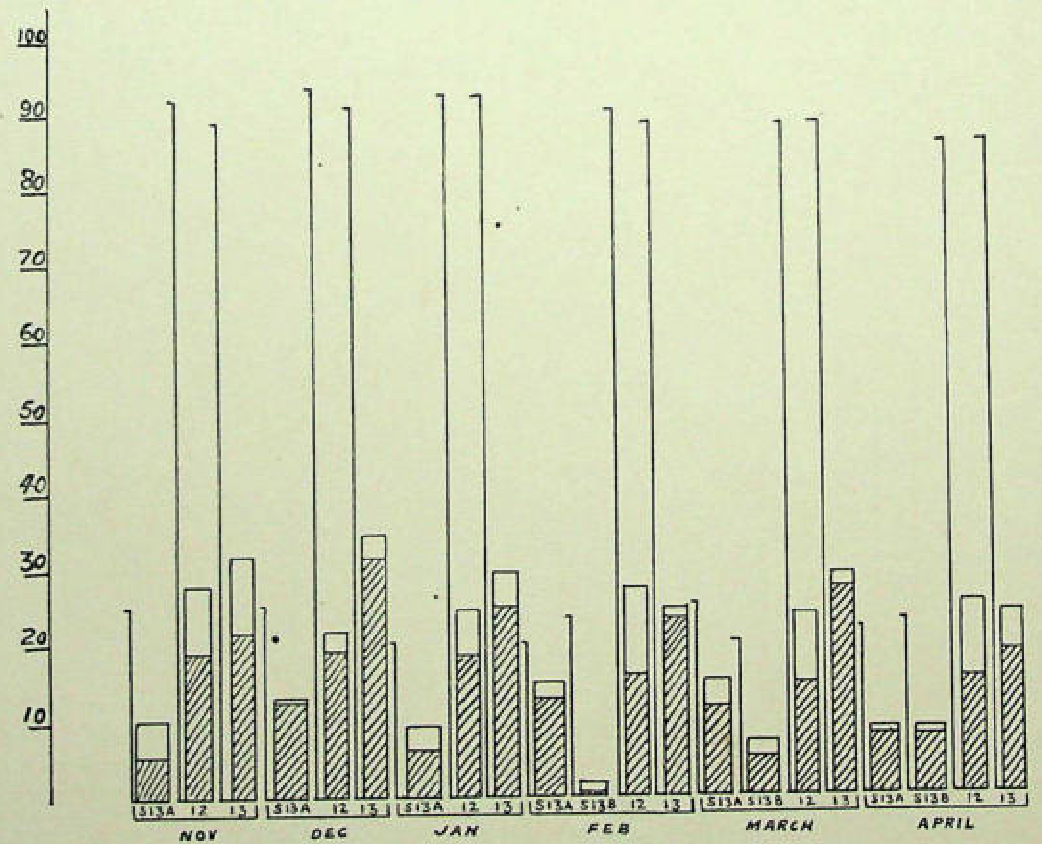

FIGURE XII.

S 13A—Soil 15 cm. below the surface from the base of plants 12 and 13.
S 13B—Soil 30 cm. below the surface from the base of plants 12 and 13.

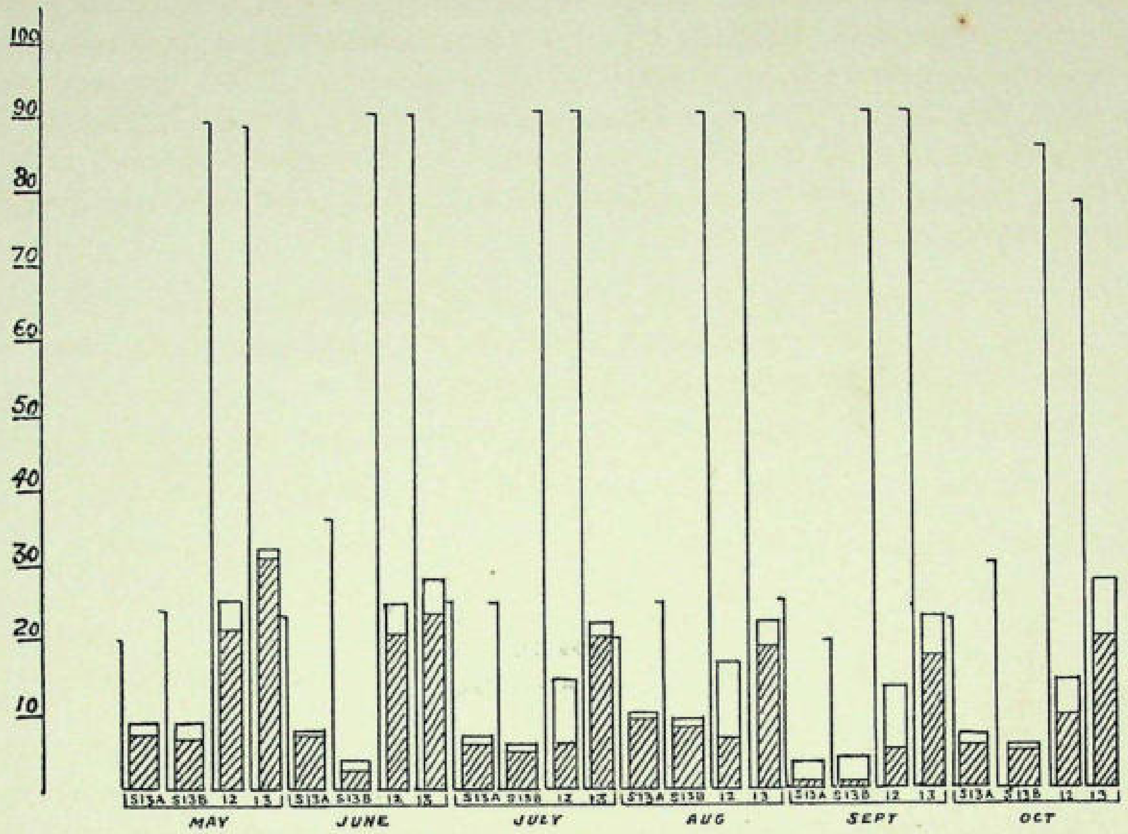

FIGURE XIIA.

12—Sesuvium Portuladastrum.
13—Suaeda maritima.

FIGURE XIII.

S 14—Soil from the surface of the bank of river Matla.
W—Water from river Matla (Sample No. 15).

The graphical representations are given as follows :—Samples Nos. 1, 2, 2A and 2B of locality I are put in the same figure side by side for every month (Fig. I), Sample Nos. 12, 13, 13A and 13B of locality III are indicated in the same manner (XII). For locality II with nine plants and four soil samples, the data for the soil samples Nos. 3A, 3B, 3C and 3D are indicated in Fig. II, and the data for the plants (Nos. 3 to 11) are indicated in Figs. III to XI. Lastly the data for the soil from the side of river Matla (No. 14) and the water from the river (No. 15) are indicated in Fig. XIII.

If the values obtained are compared with those of the author's last paper[1] in which only one reading was taken from different localities, it is found that all the values fall within the range of values obtained in this. The exceptions are :—

Sample.	Osmotic value and locality in the last paper.	Highest osmotic value and the month in this.
1. Ceriops Roxburghiana	.. 37·48 Atm. (Port Canning)	28·42 Atm. (February).
2. Bruguiera gymnorhiza	.. 27·90 Atm. (Talpatti khal)	24·17 Atm. (February).
3. Excoecaria agallocha	.. 42·98 Atm. (Mrigamari, Bagerhat Forest Range.)	26·42 Atm. (February).
4. Avicennia officinalis	.. 41·93 Atm. (Talpatti khal)	36·19 Atm. (November).
5. Aegiceras majus	.. 38·20 Atm. (Talpatti khal)	28·93 Atm. (December).

It is seen, however, that in all the cases except 1, the plants from the Khulna Sundarbans which has a higher salinity of the habitat and greater age of the plants show higher values.

Of the plants examined in this, there are three, viz., *Bruguiera gymnorhiza, Sesuvium Portulacastrum* and *Acrostichum aureum,* common with those investigated by Walter[1] in East African mangroves and records about the last two from American mangroves are found in the work of Harris whose results are quoted and compared by Walter.

It is found that *Bruguiera gymnorhiza* leaves showed a higher osmotic value at East Africa (30·3 Atm. to 34·6 Atm., as against the highest value of 24·17 Atm. in this). The percentage of the chloride fraction is high, viz., 74 to 86 per cent. and falls within the range obtained in this.

The values of *Acrostichum aureum* recorded for America and Africa fall within the range in this but are distinctly lower than the highest osmotic value obtained here, viz., Florida values—17·1, 17·5 and 20·7 Atm.; Kamerun values—17·9 and 18·8 Atm.; Tanga value—22·4 Atm., and West Africa value—17·9 Atm., as against the highest osmotic value of 33·92 Atm. recorded here. The chloride fraction of 56 per cent. in Africa falls within the range in this.

In *Sesuvium Portulacastrum* the highest osmotic value of 27·40 Atm. is much lower than many of those recorded from America, though one of the values for East Africa is almost equal (27·5 Atm.), another is higher (32·3 Atm.), and some values for American mangroves fall within the range in this, viz., *Jamaica*: between 43·0 and 52·6 Atm. in the sea coast, and between 19·5 and 49·9 Atm. in another locality of lower salinity ; *Florida* : between 11·6 and 34·2 Atm., in one locality 21·1 Atm., chloride fraction 41 per cent., in another locality 28·4 Atm., chloride fraction 44 per cent.; *Hawaii islands* 16·5, 26·1, 33·5 and 40·6 Atm. The chloride fractions where recorded in this are lower in America than those in East Africa, but all of them are within the range obtained in this.

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[1] Sen Gupta, J. Ber. d. Deutsch. Bot. Ges. 1938, **61**, 474.

[1] Walter, H., and Steiner M. Zeitschr. f. Botanik. 1936. **30**, 65.

If now the data presented in this paper are considered, it is found that some of the high osmotic values recorded are: Avicennia alba—49·05 Atm. in December, Acanthus ilicifolius—46·00 Atm. in June, Aegialitis rotundifolia—38·99 Atm. in December, Avicennia officinalis—36·19 Atm. in November, Acrostichum aureum—33·92 Atm. in February, Suaeda maritima—33·65 Atm. in December, and some of the low values are Bruguiera gymnorhiza—4·41 Atm. in September, Aegiceras majus—5·16 Atm. in July, Phoenix paludosa—7·38 Atm. in July, Aegialitis rotundifolia—7·86 Atm. in July, and Acrostichum aureum—7·86 Atm. in August (Tables XIII and XIV).

A more or less regular high water content is shown by the succulents Sesuvium Portulacastrum (85—93 per cent.), Finlaysonia obovata (80—92 per cent.) and Suaeda martima (78—92 per cent.); other plants with fairly high water content are Acanthus ilicifolius (65—85 per cent.), Excoecaria agallocha (68—84 per cent.), and Acrostichum aureum (65—81 per cent.). Lowest water content is shown by Aegialitis rotundifolia (50—65 per cent.) and Avicennia officinalis (43—68 per cent.). The rest show intermediate values.

Some of the high chloride fraction values are shown by Suaeda maritima (17·15 to 31·72 Atm.), Acanthus ilicifolius (5·56 to 38·20 Atm.), Aegialitis rotundifolia (5·94 to 31·72 Atm.), Avicennia officinalis (7·70 to 25·64 Atm.), and Avicennia alba (7·70 to 26·11 Atm.). Low chloride fraction values are found in Acrostichum aureum (3·01 to 14·72 Atm.), Bruguiera gymnorhiza (3·01 to 21·84), Aegiceras majus (3·82 to 19·80 Atm.) and Phoenix paludosa (4·50 to 16·20 Atm.). Others have intermediate values.

Some of the high percentage of chloride fraction values among plants are Suaeda maritima (67—98 per cent.), Finlaysonia obovata (57—90 per cent.), Ceriops Roxburghiana (52—95 per cent.) and Bruguiera gymnorhiza (45—98 per cent.). Some of the low values are Acrostichum aureum (26—73 per cent.), Aegiceras majus (30—74 per cent.). Others have intermediate values.

It is found that during the period of fruiting in April and drying of leaves with the appearance of dry spots in June in leaves of Aegiceras majus the osmotic and chloride fraction values became low and in the next month, *i.e.*, July it showed the lowest values of the year. In Bruguiera gymnorhiza leaves showed appearance of dried spots due to drying up in June when the osmotic and chloride fraction values became low and still lower in the subsequent months of July, September and October. Avicennia officinalis and A. alba flowered in April and fruited in July. It is seen that the lowest osmotic and chloride fraction values are reached during these months (Tables VI, VIII, IX and XIII; and Figs. III, IX, X and XI).

Coming to the soil samples it is seen that if some of the extremely high and low values are left out of consideration stated in a general way the water content, varied on the average between 20 and 40 per cent., osmotic values between 5 and 16 Atm., chloride fraction between 75 and 95 per cent. The water content, osmotic and chloride fraction values are distinctly lower and the percentage of chloride fraction values distinctly higher than those of the plant samples.

Of the different localities the soil from the river side (No. 14) which is directly moistened by the river water shows the highest values under all the four heads. Of the rest locality I shows the highest osmotic and chloride fraction values; next comes locality II and locality III comes last, though the differences are not great or of fundamental nature (*cf.* Table XIII and Figs. I, II and XII).

If the variation of the values with reference to the depth is considered it is seen that in most of the months the soil samples of locality III, *i.e.*, 13A and 13B (Table XIII and Fig. XII) showed a higher value nearer the surface than those deeper down. Many of the soil samples from localities II and III (Table XIII and Figs. I and II) also show similar results, but in some months reverse results ar also found, and from locality II, from where soil from four depths were taken, there are some months in which the rise and fall in values with reference to depths were irregular.

When the course of the annual variation is followed, it must be remembered that one of the most important factors which is expected to influence the variation in the values is the water relations which includes the rainfall and the salinity of the water of river Matla. It is seen from the rainfall records (Table XIX) that the highest rainfall recorded for 24 hours ending on the date of collection was in May, though the average values for 7 and 14 days previous to that are not high. The June values are however high under all the three heads. In July the rainfall on the day is nil and the average for 7 and 14 days also falls below the corresponding June values. The August and September values are high for the average for 7 and 14 days. There is a fall in October of the 7 days average value but a rise of the 14 days average value. From Novemver till March there is no rainfall under any of the heads. Though there is some rainfall in April when the average values for 7 and 14 days are 0·75 cm. and 0·25 cm., respectively, it is nil on the date of collection. It can be said therefore that the dry season commences after October and continues till May, and the rainfall starts in June with the monsoon and the rainy season continues up to September and October.

The osmotic and chloride fraction values of the water of river Matla (No. 15) show a very clear correlation with the course of rainfall. There is a gradual rise in the values from November onwards showing the highest value in May after which there is a gradual fall right up to October with only a slight intermediate rise in September (Table XIII and Fig. XIII). Soil from the side of river Matla (No. 14) also shows a similar gradual rise from November onwards reaching the highest osmotic value in May, though there are two intermediate falls in January and April, but after May the fall up to October is regularly gradual.

Of the different soil samples from the three localities 2A shows highest osmotic value in August, 2B in May, 3A and 3B in November, 3C in August, 3D in April, 13A in March and 13B in August. When the highest value is reached the rise up to that is not gradual nor is the fall afterwards gradual. But there is great agreement in all the soil samples in that the osmotic value and the chloride fraction is low during the months of July to October. Most of the soil samples showed the highest water content values in the months of June and July and lowest in April and May (Tables XIII to XVIII).

The details of the courses of annual variation in the different plants can be seen from Table XIII and Figs. I, III to XII.

The months showing the highest and lowest values of the largest number of samples are :

Highest : Water content—July ; Osmotic value—December and February ; Chloride fraction—December ; Percentage of the Chloride fraction—April and August (Table XVI).

Lowest : Water content—April and October ; Osmotic value—September ; Chloride fraction—September ; Percentage of chloride fraction—September (Table XVIII).

If all the samples of soil and plant are taken into consideration it is found that the largest number of them showed the highest osmotic and chloride fraction values between the months of November to May and the lowest values between the months of July to October, the former being the months of the dry season and the latter during the rainy season, though if their courses are followed the expected gradual rise and fall as recorded in the Matla water (No. 15) and the riverside soil (No. 14) are not found in many of the cases.

If an attempt is made to explain the irregular variations it may be mentioned for the soil samples that they were not sampled from the same exact spot every month as this is not possible, but from a similar spot of the immediate neighbourhood from the small restricted area of the locality, and similarly for the plants the samples could not possibly be collected from the same plant in the case of herbs and even in the case of shrubs it was not possible to collect from the same branch of the plant, and sometimes from exactly the same plant every month, but they were collected in many cases from similar plants of the immediate neighbourhood within the small restricted area of the locality. It is not unlikely that variations may be found to exist even in samples of the immediate neighbourhood and the results recorded here point to this. The difference in the highest value in this paper with the value obtained for Ceriops Roxburghiana from Port Canning in the last paper may be due to the same reason.

The soil samples at different depths do not show regular variations in many cases and these variations cannot be explained by the effects of drying up by evaporation during the dry season and of being washed out during the rainy season. The variation of the soil values in many cases do not closely follow the expected course as found in the river water and the soil from the river side. And the plants also in many cases do not closely follow the variation in the soil values from their base, which must be connected among other things with the physiology of absorption, conduction and tranpiration of the plant.

It seems, therefore, that to understand the reasons of variation more clearly it will be useful to restrict to small areas and investigate several similar samples of the same species and soil from several spots in the immediate neighbourhood in it, and in the same way the same species from known different habitats under statistical methods of sampling.

The British Association Delegation in India

by

A. H. REGINALD BULLER, D.Sc., F.R.S.,

Royal Botanic Garden, Kew

The British Association for the Advancement of Science sent a Delegation of about one hundred persons to the Silver Jubilee Meeting of the Indian Science Congress Association. The meeting was held at Calcutta, January 3-9, and was presided over by Sir James Jeans. The Delegation included the following botanists: Professor V. H. Blackman, Professor A. H. R. Buller, Dr. C. D. Darlington, Professor and Mrs. F. E. Fritsch, Professor R. R. Gates, Professor J. W. Harrison, Sir Arthur Hill, and Dr. A. B. Rendle.

On the way out Dr. Rendle was not well, but at Port Said he and I took a long walk through the city and enjoyed seeing its varied sights, including its ornamental trees and shrubs. That was Dr. Rendle's last botanical excursion, for, unfortunately, as the voyage proceeded, he grew worse, and at Bombay he was obliged to leave the party and return home. Shortly after his arrival in England, as readers of this Journal must have learned with great regret, he passed away.

The Delegation sailed from London on board the P. and O. steamer *Cathay* on November 26 and landed at Bombay on December 16. A pre-congress and a post-congress tour, in special trains, had been arranged by the Indian Association.

The pre-congress tour included: Bombay (University of Bombay, Parsee Towers of Silence, Hindu burning ghat); Hyderabad (Osmania University, where the instruction is given in Urdu, and the neighbouring Golconda Fort and tombs); Aurangabad (with visits to Daulatabad Fort and the rock caves of Ellora and Ajanta); Sanchi (great Buddhist Stupa); Agra (Taj Mahal, Agra Fort, Agra College); New Delhi (Viceroy's House, Imperial Institute of Agricultural Research); Delhi (Fort, Pearl Mosque, Kutb); Dehra Dun (Forest Research Institute); Mussoorie (ridge with view of snowy ranges of Himalayas); Benares (Benares Hindu University, the Ganges, Sarnath where Buddha first preached); Darjeeling (Botanical Garden, view of Kunchinjunga, Tiger Hill); and Calcutta.

The post-congress tour included: Madras (University of Madras, Aquarium, Hindu temple); Bangalore (Indian Institute of Science); Mysore (the Palace, hill view of the city, hydro-electric works, jungle); and Bombay.

At Port Said, on the outward journey, Dr. Rendle and I noted the following ornamental plants: *Casuarina equisetifolia, Eucalyptus globulus, Phoenix dactylifera, Quercus Ilex, Ficus Carica, Ligustrum ovaliforme, Lantana Camara* and species of *Bougainvillaea, Poinsettia, Cotoneaster, Hibiscus, Jasminum,* and *Ipomaea*; and, growing along the banks of the Suez Canal, we saw the great grass, *Arundo Donax*, and plantations of the Australian *Casuarina equisetifolia*. The *Casuarina* trees were well-grown and, at sunset, Kites were seen flying about them as if going to roost in their branches. At Aden the Delegation landed, visited the town of Crater, and walked around the ancient and enormous tanks

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The Delegation sailed from London on board the P. and O. steamer *Cathay* on November 26 and landed at Bombay on December 16. A pre-congress and a post-congress tour, in special trains, had been arranged by the Indian Association.

The pre-congress tour included: Bombay (University of Bombay, Parsee Towers of Silence, Hindu burning ghat); Hyderabad (Osmania University, where the instruction is given in Urdu, and the neighbouring Golconda Fort and tombs); Aurangabad (with visits to Daulatabad Fort and the rock caves of Ellora and Ajanta); Sanchi (great Buddhist Stupa); Agra (Taj Mahal, Agra Fort, Agra College); New Delhi (Viceroy's House, Imperial Institute of Agricultural Research); Delhi (Fort, Pearl Mosque, Kutb); Dehra Dun (Forest Research Institute); Mussoorie (ridge with view of snowy ranges of Himalayas); Benares (Benares Hindu University, the Ganges, Sarnath where Buddha first preached); Darjeeling (Botanical Garden, view of Kunchinjunga, Tiger Hill); and Calcutta.

The post-congress tour included: Madras (University of Madras, Aquarium, Hindu temple); Bangalore (Indian Institute of Science); Mysore (the Palace, hill view of the city, hydro-electric works, jungle); and Bombay.

At Port Said, on the outward journey, Dr. Rendle and I noted the following ornamental plants: *Casuarina equisetifolia, Eucalyptus globulus, Phoenix dactylifera, Quercus Ilex, Ficus Carica, Ligustrum ovaliforme, Lantana Camara* and species of *Bougainvillaea, Poinsettia, Cotoneaster, Hibiscus, Jasminum,* and *Ipomaea*; and, growing along the banks of the Suez Canal, we saw the great grass, *Arundo Donax,* and plantations of the Australian *Casuarina equisetifolia.* The *Casuarina* trees were well-grown and, at sunset, Kites were seen flying about them as if going to roost in their branches. At Aden the Delegation landed, visited the town of Crater, and walked around the ancient and enormous tanks and through the Gardens of Sheikh Othman. Aden Peninsula is a mass of barren volcanic rocks upon which rain rarely falls. Its natural vegetation is most scant and the Gardens are kept alive by constant watering with slightly brackish water drawn up 150 feet from wells. On the golf course at Aden there is no grass and the greens are called " browns". By the Tanks we saw our first Banyan tree, and in the Gardens species of *Hibiscus, Bougainvillaea, Oleander, Cassia* and *Croton*. At the oasis of Sheikh Othman, to which we drove, there were many Date Palms.

On arrival at Bombay, the Delegation was officially received by the Vice-Chancellor of the University, and at the function a garland of flowers was put around Sir James Jeans. Subsequently, Sir James was garlanded many times, and this pleasant Indian mode of welcoming an honoured guest was also experienced by several other members of the Delegation.

We visited the Towers of Silence, where vultures dispose of the Parsee dead, and in the grounds saw Mango trees. The Parsees, followers of Zoroaster, have a temple there in which they keep the sacred fire burning night and day continuously. The fuel used is the strongly scented wood of the Sandalwood tree. We also saw a Hindu burning ghat where a body was being cremated over large logs of wood.

Before beginning our pre-congress tour, we were each given a copy of "An Outline of the Field Sciences of India." This useful handbook, published by the Indian Science Congress Association in November, 1937, and edited by Dr. Sunder Lal Hora, contains a chapter entitled "An Outline of the Vegetation of India" by Mr. C. C. Calder, Superintendent of the Royal Botanic Gardens, Calcutta, and Director of the Botanical Survey of India.

At Agra we visited that masterpiece of the Mogul emperors, the Taj Mahal. On the outside of this beautiful building, which stands in a garden of Cypress trees and overlooks the broad Jumna river, there are carved in relief on the marble the graceful forms of tulips, lilies, narcissi, and other bulbous plants ; and in the interior the cenotaphs of Mumtaz and her husband, Shahjahan, are profusely inlaid with gems in flowered patterns.

At Agra College, Professor K. C. Mehta took us through his laboratory and his rust greenhouse, and gave us an account of his work—now in its fifteenth year—on the rust disease of cereals in India. It has been conclusively established that in the plains, during October and November when the cereal crops are sown, there is no local source of infection ; and, apparently, the suspected alternate hosts play but little part in the annual origin of the rust disease. From a study of the spread of the disease in the plains as well as in the hills, extending over a period of seven years, Professor Metha is convinced that the foci of infection lie in the hills and hilly tracts, where rusts oversummer in the uredo-stage. To lessen the incidence of the rust disease in the plains, Dr. Mehta therefore recommends : (1) sowing of wheat and barley in Nepal in October instead of August-September; (2) suspension of the first crop (sown in April-June) in the Nilgiris and Palni hills ; and (3) destruction of self-sown plants and tillers of wheat and barley 1-2 months before the sowings in the hills and hilly tracts (3,000 feet above sea-level) in general. Professor Mehta believes that his recommendations in respect to the Nilgiris and Palni hills could be acted upon by the Government with but little expense and that, if carried out, they would result in a considerable increase in the yield of Indian wheat and barley.

At the Imperial Institute of Agricultural Research at New Delhi there were various botanical exhibits, among them the hybrid sugarcanes raised by Rao Bahadur R. S. Venkatraman, at Coimbatore. By hybridization in and with the genus *Saccharum*, Venkatraman has sought during the past twenty-five years to improve the Indian sugarcanes, and already the area in which improved canes are grown is upwards of 70 per cent. of the total. Inter-varietal crosses have been made within the species *Saccharum offiicinarum*; economically important inter-specific hybrids have been obtained from *S. officinarum* and *S. spontaneum*; and inter-generic crosses have been made between *Saccharum* and *Sorghum* with a view to shortening the life-cycle of the sugarcane, and between *Saccharum* and *Bambusa* for the introduction into the sugarcane of greater vigour. The Bamboo parent grows to 60 feet high, but the F_1 generation consists of short plants closely resembling sugarcanes, thus showing the dominance of *Saccharum* characters. Whether or not the intergeneric crosses, which are of great interest botanically, will yield anything of economic value remains to be determined by further investigation.

At the Imperial Institute I visited the laboratory of Plant Pathology and there renewed acquaintance with Dr. G. W. Padwick, the newly appointed Imperial Mycologist, and met Dr. M. Mitra and Dr. B. B. Mundkur. Dr. Mitra has discovered a new bunt, *Tilletia indica,* and Dr. Mundkur a new smut, *Urocystis Brassicae.* The latter fungus has the peculiarity of forming large and curious galls on the roots of Mustard. Dr. Mundkur gave me some carbonized grains of *Triticum sphaerococcum,* which were obtained at Mohenjo Daro, a pre-Aryan city in the Indus Valley, and are, according to archaeological authorities, at least 4,000 years old. In this material Dr. Mundkur found some tiny fungus bodies which he regards as smut spores.

At Dehra Dun we visited the Forestry Research Institute, inspected its museum, and went through its laboratories and experimental factories. The Institute for some thirty years has been carrying on research upon the growth of trees and the profitable use of timber and other forest products. It was founded primarily for the benefit of the Indian Forest Department, for which it has produced results of acknowledged economic value, but its work has also been of use to other government departments, to Indian States, and to industrialists. In the experimental factories, among other things, we saw machinery at work : (1) producing wall-boards and insulation boards from bagasse (crushed sugarcane after extraction of the juice) ; (2) producing printing paper from *Dendrocalamus strictus* (bamboos grown in Orissa) ; and (3) testing the strength of various kinds of timber in respect of bending, compression, hardness, shear, glue adhesion in triple plywood, etc. In the wood work-shop section we saw the veneer-cutting plant in operation. About 8,000,000 plywood packing boxes for tea are imported into India every year. There are two plywood mills in India, but these contribute only a very small proportion of the tea boxes required, and the Institute is assisting this young industry in its attempt to meet foreign competition. On departing we were each given as a souvenir a writing-pad of excellent bamboo paper made in the Institute.

At the Benares Hindu University we visited the Botanical and other Departments, and then attended a Degree Congregation in a huge tent erected with the help of bamboo poles. At the ceremony several of our members, including Professor V. H. Blackman, were given honorary degrees.

From Siliguri we drove in motor-cars up to Darjeeling, which stands at a height of 6,900 feet above sea-level. We had an excellent driver, with Mongolian features, who knew no English. The pace permitted was ten miles per hour. The road wound round and round great mountain spurs amid forest and tea plantations on terraced slopes, and ever up, up, and up, past the 4,000-foot level, past the 5,000, and past the 6,000 until after three and a half hours of progress we arrived at our destination, where Bhutia women porters, who greeted us with smiles, carried our bags on their backs into the Mount Everest Hotel. During the ascent we saw bamboos, tree ferns, and rhododendrons, and we thought of Joseph Hooker and his famous botanical explorations. Early next morning from the windows of the hotel we watched the sun rise on Kinchinjunga (28,146 feet) as in snowy grandeur it towered up above its sister peaks some 45 miles away. The botanists found much to interest them at Darjeeling. There were : the tea-gardens, whose terraces could be seen up to a height of about 6,000 feet ; a Botanical Garden on a hill-side with many fine trees and other plants, mostly out of flower ; groves of *Cryptomeria Japonica* planted all about Darjeeling and formed by tall conical trees with thick trunks ; in the market place vegetable produce and, in an adjoining street, two querns, at one of which sat two women grinding grain ; and, finally, the wild plants growing about the hills. *Primula malacoides* was in flower on a bank not far from gardens, close by a wild *Mahonia* ; and we particularly noticed a fern, with large compound leaves and stems about as thick as a finger, *Gleichenia gigantea*, which was climbing freely over various bushes.

We drove to Tiger Hill (8,500 feet). Our cars wound in and out among the hill-sides for a distance of about seven miles, and then we climbed the last 700 feet. From the top we saw a magnificent panorama of mountains stretching half-way around the horizon ; and we looked over one great range hoping to see Mount Everest ; but, unfortunately, although two peaks, right and left of it, were often more or less clear of cloud, Mount Everest, 100 miles distant, never came distinctly into view. But we were well rewarded for our journey ; for, as the sun set, there were glorious tints of red and purple—red in the west and on the mountains and vast purple shadows. The sun went down in golden splendour and the leaden shadow of the earth rose on the eastern sky. When all was over and the whole earth was growing dark, we hurried down the 700 feet to our car, and then we drove with the help of headlights along the narrow road with numerous sharp S-shaped curves, downwards for 2,000 feet, and on to Darjeeling. An error in steering might have brought us to serious disaster ; but our driver was excellent, and we arrived back at the hotel in the dark, but safe and sound, and ready for tea.

In the Botany Section at the Calcutta meeting of the Indian Science Congress Association, Professor B. Sahni delivered his presidential address on "Palæobotany in India, a Retrospect"; and, in the course of a week, this was followed by numerous papers, a few special lectures, and six discussions on : (1) Discrepancies between the chronological testimony of fossil plants and animals (Sections of Botany and Geology) ; (2) The absorption of salts by plants (Sections of Botany and Chemistry) ; (3) Algal problems peculiar to the tropics with special reference to India ; (4) The dissemination of cereal rusts in India ; (5) A national Herbarium for India ; and (6) The species concept in the light of cytology and genetics (Sections of Botany, Zoology and Agriculture). On January 6, at the seventeenth annual meeting of the Indian Botanical Society, Professor S. R. Bose gave his presidential address on "The Effects of Radiation on some Polypores in Culture," and this was followed by a Conversazione with botanical exhibits and a luncheon given by the Botanical Society of Bengal.

In the afternoon of January 6, the members of the Botany Section proceeded by steamer down the river Hooghly to Sibpur to attend the one hundred and fiftieth anniversary celebration of the Royal Botanical Gardens, The function was presided over by the Nawab of Dacca, Minister for Industries and Agriculture, Bengal. Sir James Jeans, on behalf of the British delegation, offered the Gardens his hearty felicitations, and Sir Arthur Hill commented on the similarity of the situation of Kew Gardens and the Sibpur Gardens. He remarked that while Kew was located near London, the first city in the Empire, the Sibpur Garden was near Calcutta, the second city of the Empire, and both were on the banks of two of the busiest rivers in the world. Dr. K. P. Biswas, the Superintendent of the

Gardens, welcomed the guests, outlined the history of the Gardens, and reviewed the economic benefits which India had derived from Sibpur. Among these benefits he included : (1) a demonstration that the Teak tree could not be grown for timber in Bengal as, in the muddy soil of the Gangetic delta, its trunks become hollow near the base ; (2) the introduction of exotic timber trees ; (3) the introduction of exotic plants now found in private gardens ; (4) the final establishment of the tea industry in Assam and northern Bengal ; (5) the initiation of potato-growing ; (6) the cultivation of quinine cinchonas of the Andes and the establishment of a factory in the Darjeeling district, whence the Government hospitals and dispensaries have obtained large supplies of quinine required for the treatment of malaria ; (7) help given to the Agri-Horticultural Society of India in the improvement of Indian cotton and Indian jute ; (8) assistance given in the introduction of the best kinds of sugarcane from the West Indies ; and (9) experiments on the cultivation of such economic plants as flax, hemp, rhoa or ramie tobacco, henbane, vanilla, coffee, India-rubber, Japanese mulberry, cardamoms, tapioca and cocoa.

After the function was over, we walked about the Gardens, admired the beautiful Oreodoxa palm avenue, and visited the famous Banyan tree (*Ficus bengalensis*). This tree, from whose branches figs were hanging, is now about 163 years old and the circumference of its crown measures 1,151 feet. It has 641 aerial roots actually rooted and grown into posts, and it is still extending. Its main trunk, which was 51 feet in girth, decayed and has been removed, so that the tree is now in three parts ; but three young Banyan trees have been planted near where the original trunk was, and the intention is at some future time to graft these three trees together and also on to the three pieces of the original tree, and so once more to construct a single vegetative body.

At a special degree congregation of the University of Calcutta the Chancellor conferred the degree of Doctor of Law, *honoris causa,* on ten members of the Delegation, including the writer.

The Indian Association for the Cultivation of Science elected Sir Arthur Hill to be the Ripon Professor for the year 1938, and, in this capacity, he delivered three lectures at the Association during the week of the Calcutta meeting.

A short visit was made to the Bose Institute founded by the late Sir Jagadis Chandra Bose, and some of Bose's remarkable experiments were demonstrated to us. A detached, partially wilted, sagging leaf of one of the herbaceous Compositæ was placed in a glass vessels containing warm water, and its shadow was projected on to a screen. Immediately after the leaf had thus been given access to water, it began to recover and, with surprising speed, it soon became stiff and upright once more. And with the help of very sensitive apparatus making graphic records it was shown that the petiole of a compound leaf of one of the Leguminosae had risen very slightly in correspondence with the lowering of the temperature of the air during a recent brief storm.

In the streets of Calcutta and its suburbs we noticed Neem trees (*Melia Azadirachta*), Banyan trees *(Ficus bengalensis)*, the sacred Pipal tree (*F. religiosa*), and other species of shade trees which we could not identify. Near the race-course, in one tree, a brain fever bird called loudly and monotonously, and in and out and round about another tree flew several large fruit-bats, known as flying foxes ; and everywhere flying about the city were the scavenging kites and Indian crows, ever on the alert and searching for unconsidered trifles.

On the railway journey from Calcutta to Madras, from the carriage windows, we saw widespread stretches of rice fields broken up into irrigated plots and parted by earth divisions or *bunds* along which in some places were set stately rows of Palmyra palms (*Borassus flabellifer*) ; and we also saw many Coconut palms, wild Date palms (*Phoenix sylvestris*), and, near Madras, some fine plantations of *Casuarina equisetifolia*.

At Madras a visit was made to Professor M. O. P. Iyengar's laboratory at the University and here his own algal cultures and those of his pupils were examined.

With a Madras friend, I entered a Toddy palm grove and saw the inflorescences of several of the Coconut trees (*Cocos nucifera*) bent down into black bowls set high in the trees and presumably exuding sweet sap from their wounds.

Among the palms grown for ornament in Madras we noticed the Cabbage palm (*Oreodoxa regia*), the Royal palm (*Licuala grandis*), and *Caryota urens*. In the Adyar Gardens, in which stands the Hall devoted to the cult of Theosophy, was seen a splendid Banyan tree with a crown of leaves 300 feet in diameter, a perfect central trunk, and radiating arms supported by a great many rooted posts. This tree is said to be one of the three finest Banyan trees in India. In a beautiful private garden, the owner had one of his bearers pierce the leaf-bases of two Traveller's trees (*Ravenala madagascariensis*) so that I might see the water, which had accumulated there, gush out into a tumbler.

At Mysore, where we were guests of the Maharaja, a few of the party drove into the jungle where we saw huge sandy erections raised by white ants, traces of wild elephants, a hyæna, jungle fowl, and jungle people who never venture into towns ; and, at one place, we rode on the backs of working elephants up and around a hill, past tall bamboos, and through a wood in which grew Teak, Rosewood, and other commercial timber trees.

On the second day at Mysore, Sir Frederick Hobday and I, in one of the Maharaja's cars, drove about 150 miles through the countryside : we visited a Pinjrapole (to which decrepit cattle are brought and in which they are kept alive until the last moment), a very well managed Veterinary Institute, the Maharaja's stables in which were about 100 horses, and a cattle fair. The fair was being held at Chunchanakatte, some 34 miles from Mysore, and 10,000 cattle had already been assembled there. We were told by the director of the fair that within a few days the number of cattle would be increased to 25,000. Altogether, that day, Sir Frederick and I must have passed on the roads at least 400 bullock wagons, each drawn by two bullocks. The population of India (excluding Burma) in 1931 was 338,170,632 ; and, according to the "Outline of the Field Sciences of India," the number of bulls and bullocks, cows, and young stock of the ox tribe in India is 168,000,000, From these statistics it follows that in India there is one animal of the ox tribe for every two human beings ; and in keeping with these statistics were the sights witnessed by Sir Frederick and myself on the day we spent together in the country around Mysore.

On the way home from Bombay, the *Strathaird*, on which we had embarked, called at Port Sudan, and this enabled us to view the bottom of the harbour through a glass-bottomed boat and to see there strange and fantastic corals, sponges, and algæ, and fishes of varied form and colour swimming over them. At Port Sudan, too, we saw *Ipomaea biloba* (*I. pes-caprae*) creeping over the sandy shore. A runner of one of these plants was measured and found to be 45 feet long !

Many of us landed at Suez, drove over the desert to Cairo, saw the Pyramids and the Sphinx at Gizah, examined the magnificent Tut-ankh-amen collection in the Cairo museum, and then took the train to Port Said where we rejoined our boat. We noticed how sparse is the vegetation in the desert, but had no time to study it. Here and there were low thorny bushes with camels feeding upon them. At Cairo, brown again changed to green with Date palms, Bougainvillaeas, and *Hibiscus*. On sailing from Port Said our botanical observations had perforce to come to an end.

On the way west through the Mediterranean, one afternoon under unusually favourable conditions, we gazed upon the snow-covered peak of Mount Etna, and, at night, we saw Stromboli coughing and two red-hot streams of lava pouring down its side. Subsequently we called at Marseilles, Gibraltar, Tangier and Plymouth ; and, finally, on February 4, at Tilbury, we stepped once more on to English soil.

We all felt that the visit of the Delegation to India had been a great success and most profitable. For the warm hospitality that was extended to us both publicly and privately we owe a deep debt of gratitude to the Indian Government, Rulers, and people ; and we shall never forget the pleasure that was ours in meeting our Indian colleagues face to face and learning from them at first-hand some of the results of their scientific investigations.

B. G. Press—1942-43—882C—500.