FLORA
OF INDIA
Series 2

Flora of Goa, Diu, Daman, Dadra and Nagarhaveli

Volume 1

Rolla Seshagiri Rao

BOTANICAL SURVEY OF INDIA

FLORA OF
GOA DIU DAMAN DADRA & NAGARHAVELI

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FOREWORD

As part of the floristic survey and inventorisation of plants at the national and regional levels, the Botanical Survey of India has been publishing Flora of India series. The work on the Flora of Goa, Diu, Daman, Dadra & Nagarhaveli by Dr. R. S. Rao was done when he was in charge of the Western Circle of Botanical Survey of India, Pune and it was further supplemented with additional information later on. This Flora bears the stamp of the author's intensive and sustained floristic survey of a small area rich in floristic diversity. The critical observations and taxonomic comments given under each species reflect scholarly approach to the problem. The introductory chapter deals with topography, climate, vegetation, plants of botanical value, economic and medicinal plants. The vegetation analysis and the classification of vegetation are useful for evaluation of the floristic content. The enumeration is given in accordance with the Bentham & Hooker's system of classification with keys to genera and species.

The author deals with 1115 species of Angiosperms and 27 species of Pteridophytes. The Angiosperms are spread over 146 families with the family Fabaceae being the dominant containing 79 species covering 40 genera. The Flora of Goa is under threat due to population pressure and developmental activities (e.g. mining, quarrying, etc.). Some of the degraded mine sites, as per the author, can be rehabilitated by introducing species of evergreen and deciduous forests, i. e. species of *Ailanthus*, *Calophyllum*, *Canarium*, *Cinnamomum*, *Dipterocarpus*, *Hopea*, *Palaquium*, *Tetrameles*, etc.

There is urgent need to bring out state-of-art report on the ecosystem under threat in Goa which should indicate the necessity of sustained developmental acitvities. Popular and educational material for schools and colleges for the conservation of our fragile ecosystem and our threatened flora can highlight the corrective measures required for sustained conservation. I am sure this Flora of Goa will generate the above mentioned activities during the coming years.

Dated 27 Sept. 1985

Botanical Survey of India
P-8 Brabourne Road
Calcutta 1

M. P. NAYAR
Director

INTRODUCTION

Sir Joseph D. Hooker, in 1897, on completion of the seventh and last volume of his *Flora of British India* indicated the importance of preparation of local Indian Floras and monographs of the large Indian genera of a country like India, 'perhaps the richest and certainly the most varied botanical area on the surface of the globe'. Thus, the necessity for local or regional floras has been fully recognised and with the establishment of Botanical Survey of India in 1890, there have appeared a large number of monographs and regional floras. Considerable knowledge on the plants of Western India from Sind-Kutch-Saurashtra region to North Kanara-Coorg-Kerala zone both along the Western ghats and the narrow coastal belt, has been gathered and published in various works, starting with *Hortus Malabaricus* (van Rheede, 1680-1703) to the *Flora of the Presidency of Bombay* (Cooke, 1901-1908) and the *Flora of the Presidency of Madras* (Gamble & Fischer, 1915-1934) and a few subsequent publications covering small areas. The Portuguese during their supremacy along the West-Coast did not contribute much by way of describing the plants of their occupied areas. *Coloquios dos Simples e Drogas da India* (Garcia da Orta, 1563) and *Tratado de las Drogas* (Acosta, 1578), the two publications which helped to introduce to the Western world, a few of the commonly known Indian Medicinal plants, cover a wide variety of subjects like socio-political conditions of that period etc., other than the Botany of the Portuguese possessions. However, the Portuguese played a prominent role in the introduction of new plants from their New World territories. Subsequently, besides a small publication on the *Natural History of Goa* (d'Silva, 1862) with a list of hardly 163 species, during the fourth century celebrations of the Portuguese rule in India, *Flora de Goa e Savantwadi* (Dalgado, 1898) was published, presenting a list of 731 wild species and 279 cultivated species with vernacular names and very brief notes without any specific data on the localities and the specimens collected etc. The book is out of print and the work itself is out of date and unsuitable for revision. In contrast to this, a contemporary work (Cooke, 1901-1908) on the Flora of Western India (then British India) provides ample data based on Herbarium methods of study. Further, there is practically no work on the flora of the small enclaves Diu, Daman and Nagarhaveli except a couple of lists of no proper value with occasional notes on a few economic plants (Xavier Gracias, 1902 ; 1927). Such a wide disparity in the nature of approach and the standard of scientific study has brought about 'the lacunae' in the knowledge of the range of species and their distribution along the Western India.

Since 1960, my studies on the phytogeography of the Western ghats have revealed interesting aspects of the shifting of northern limit of evergreen vegetation along the ghats, to Phonda-Ambolighat belt of Ratnagiri district, from North Kanara belt which is hitherto considered as the beginning of the ever-green zone. At this stage, the absence of detailed floristic data on Goa, the region between Ratnagiri district of Maharashtra State and North Kanara district of Karnataka State, has become quite conspicuous. Similarly, for planning a comprehensive flora of Gujarat-Saurashtra region, data on Dadra, Nagarhaveli, Daman and Diu form the missing links. But nothing could be done either by earlier workers or by the author to fill up these gaps due to political restrictions and no time was lost in undertaking this project soon after these enclaves became a part of India on December 20, 1961, after a lapse of over 450 years.

History of work—Past and present : (Fig. 1).

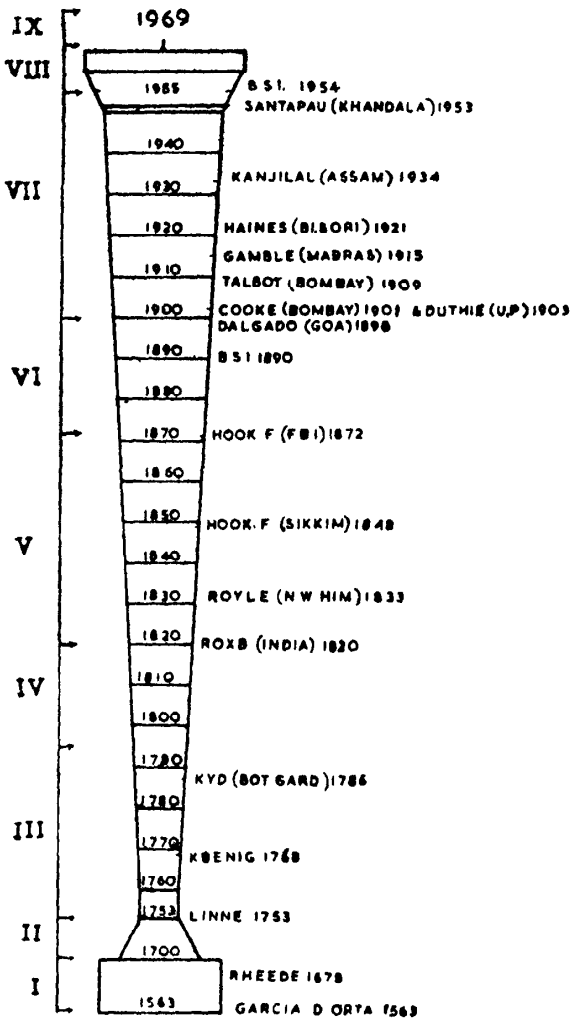


Fig. 1.
Phases of Botanical exploration & Publication

I	1563-1700	INITIAL PHASE (Pre-Linne)
II	1700-1753	Ceylon-Burmann & Linne
III	1753-1795	FIRST EXPLORATORY PHASE (Post-Linne)
IV	1795-1820	FIRST COMPILATORY PHASE (Pls. of Coromandel & Fl. Ind. by Roxburgh)
V	1820-1872	INTENSIFIED EXPLORATORY & DESCRIPTIVE PHASE
VI	1872-1900	CRITICAL GENERAL FLORA PHASE (FBI. by Hooker f. & Extensive Botanical Survey)
VII	1900-1955	DECENTRALISATION PHASE (Local & critical floras)
VIII	1955-1969	EXTENSIVE & INTENSIVE EXPLORATORY & DESCRIPTIVE PHASE (Botanical Survey.)
IX	1969	CRITICAL FLORA REVISION PHASE (Flora of India & State Floras by Botanical Survey & Universities).

Plants have been studied in India from times immemorial, particularly with reference to their medicinal properties. The Botany of *Vrikshyurveda* as it was called in ancient India, was a part of the curriculum in seats of learning, comprising collection and study in relation to environment and their efficacy as a medicine and classification was based on such studies. Sanskrit nomenclature has been quite clear and consistent which was adopted by Heinrich van Rheede in his *Hortus Malabaricus* (1680-1703), which is in fact the main source of inspiration for Linneaus in naming Indian plants in his *Species Plantarum* (1753). Even the remark of Sir William Jones, the great Orientalist and Botanist that Linneaus himself would have adopted the Sanskrit system of nomenclature, had he known the learned and ancient language of the country. Goa region, the Govapuri of the ancient times, with its rich heritage of Indian culture and study of Ayurveda, would have been another centre for the preparation of useful floristic treatise similar to *Hortus Malabaricus*, with the co-operation of Konkan Scholars and 'Ayurvedic Vydyas', had the Portuguese administrators who governed the region since 1510, expressed their interest on such projects.

However, Garcia da Orta, the personal Physician to the Viceroy of the Portuguese Colonies in India, with his vast experience of 30 years contact with local 'Ayurvedic Vydyas' and the use of Indian medicine, published *Coloquios dos Simples e Drogas da India*, in Goa in 1563, an interesting pre-Linnean publication, presenting a detailed account of fifty-seven more commonly used Indian medicinal plants in a dialogue form from first-hand knowledge, together with several digressions on social and political conditions of that period and other allied aspects quite unconnected with plants, expressing, however, many apologetic advertences. Inspite of it, various European workers connected with *Materia Medica* commented on the richness of information and the exactitude of the descriptions of Indian drug plants. Subsequently, it was the summarized Latin translation (omitting all the unnecessary data not directly related to plants) of Charles l'Escluse (Carolus Clusius), *Aromatum et Simplicium Aliquot Medicamentorum apud Indos nascentium Histora*, first published in 1567 at Antwerp, that had really made the data of *Coloquios* familiar to the European readers and this Latin translation became so popular that it ran into six editions between 1567 and 1595, subsequently followed by a folio-edition with illustrations in 1605. Simultaneously, Italian translation by Annibale Briganti, was published in 1576 at Venice followed by three more editions during 1582-1616. A French translation by Antione Colin had also come out at Lyons in 1609, and a second edition in 1619. These two translations are from the Latin of Clusius. Much later, in 1872 an edition of the *Coloquios* was published at Lisbon by F.A. de Varnhagen which is not sufficiently critical. This omission was recti-

fied by the publication of the standard annotated edition in two volumes by Count de Ficalho, an accomplished Botanist, the first volume published in 1891 and the second in 1895 at Lisbon with full and admirable notes with Botanical names to each Colloquy, evidently after consulting all books and research papers published on the subject since 1565. This edition as available with the author, was frequently consulted during the preparation of this Flora. To English readers, Sir Clements Markham's translation of Ficalho's edition, printed in 1913 at London, is a welcome addition, but A.X. Soares, in his article on "Garcia d'Orta, a little known owner of Bombay" [*Journal of Bombay branch of Royal Asiatic Society* 26 (2) : 195-229, 1922-23], citing the examples, indicates that Markham's translation is full of errors, lacunae and in many respects imperfect and unsatisfactory. However, only two hundred and fifty copies of this translation were printed and the copy No. 178 is available in Blatter Herbarium of St. Xavier's College, Bombay. Garcia da Orta, a Naturalist Humanist, Anthropologist and Ethnologist is always remembered for his famous work of that time along with distinguished names like van Rheede, Rumphius, Wight, Hooker and others.

The Spanish work of Christobal Acosta, *Tratado de las drogas y medicinas de las Indias Orientales*, published at Burgos in 1578, is another interesting book, appearing immediately after Orta's *Colloquios*. Though in preface of this book it is mentioned that it is the original work of Acosta, Markham indicates, that out of the 448 pages of text, giving sixtynine plants and other sources of drugs with good, original full-page illustrations to forty-six plants with the roots, the greater part of it is mostly copied from Orta. However, Acosta's drawings of the plants collected at Cochin and Goa are found to be useful to illustrate the Colloquios.

Thereafter, for more than three centuries, there has been no contribution on the botany of Goa and other Portuguese colonies, inspite of intense activity from 1768 in the study of Indian plants (following the binomial system of Linneaus), by the combined efforts of Koenig, Klein, Rottler, Heyne and subsequently, William Roxburgh, Wallich, Buchanan-Hamilton, Robert Wight and others on the eastern and peninsular India and of Victor Jacquemont (1832), John Graham (1839), A.N. Dalzell and A. Gibson (1861), J.C. Lisboa (1896), W.A. Talbot (1894), A.K. Nairne (1894), G.M. Woodrow (1897) and with the interesting collection by Law, Stocks, Ritchie, Sedgwick and Bell, Lush and others from the then undisturbed forests of Konkan ghats of Ratnagiri and North Kanara districts and Belgaum area, all surrounding the Goa region and by a host of other active workers reporting and publishing on the plants of various parts around the Portuguese colonies along the Western India. Except a few random collections made, possibly with the permission of the

Portuguese administration by Lush and a few others which are cited in J.D. Hooker's *The Flora of British India* (1872-1897), there is practically no record of any plant material or herbarium specimen from the Portuguese territories of India in the Indian publications on Botany of that period. The only half-hearted attempt made by the Portuguese Government to study the Natural History of Goa was to commission Manoel Galvao da Silva in 1780 to prepare the work, *Observacoes sobre a historia natural de Goa* which was finally published after a long break in 1862 at Nova-Goa (Panaji). This work consists of 46 pages with a list of 163 species, indigenous and exotic, covering more than half the book and the remaining pages with a brief outline of the Linnean system of classification. D.G. Dalgado says that d'Silva spent hardly two months in Goa and completed this work. Dalgado himself published *Classificacao botanica das Plantas e drogas descriptas nos "Colloquios da India"* in 1894 in Bombay, classifying the plants described by Garcia da Orta in his *Colloquios*, with their Botanical names and five drawings of plants. But later, probably with the publication of Hooker's *Flora of British India*, the Portuguese authorities might have encouraged Dalgado to prepare his *Flora de Goa e Savantavadi*, Lisbon (1898) to commemorate their rule of 400 years on Indian territory. Dalgado in his introduction to his flora indicates that he planned for seven years to complete this work and due to his stay for about 22 years as a Medical officer in Savantavadi State, he included that State besides Vengurla and Malwan talukas of Ratnagiri district along with Goa region, as the Flora is similar in the entire zone. Inspite of such systematic approach in the treatment of the Flora, covering 731 wild species under 478 genera classified into 134 families and cultivated exotic species 279 under 206 genera representing 69 families, he could not present the data in the proper form and the brief notes on either distribution outside Goa and Savantavadi or economic and medicinal use, are extracted from the Indian works like, Hooker's *Flora of British India*, Roxburgh's *Flora Indica* and others with occasional extracts from van Rheede's *Hortus Malabaricus*, as such references were not then available to Goa workers. As indicated by him, the vernacular names in 'Konkani' were adopted from *Diccinario-Konkani-Portuguez* by S.R. Dalgado and other local works and the Portuguese names from *Compendio de Botanica* by Felix Avellar Brotero and also *Coloquios* by Garcia da Orta. English and French names were from Indian and other various works. The vernacular names were carefully selected and presented; but he warned the reader not to depend on such vernacular names, as in many cases, a single name was used for two or three species. Dalgado expressed in very clear terms the importance of such floristic work and the practical utility of the study of plants used in medicine, food and industry ; he, however, indicated his limitations as not being a professional botanist. Thus his book as compared with others then published in British India turned out to be only an improved list of plants with brief notes. Details about his herbarium collections, their identifica-

tions, place or institution of their deposit, are conspicuously missing in his work, although such methods were sufficiently known to those working in India during that period.

The Flora of the former Portuguese colonies, Diu, Daman, Dadra and Nagarhaveli adjoining to Gujarat region has also not been so far worked out. Such data are of primary importance for any development programme, particularly after the liberation of these areas. As such, along with the Flora of Goa project, this work has been taken up by the author during the beginning of 1963. Eventhough three small books on the plants of Daman and Nagarhaveli were published in Portuguese by Caetano Gracias (1899) and C.F. Xavier Gracias (1902 & 1927), they are of no practical utility and are much out of date. Though the Flora of this group of colonies is closely allied to the coastal and hilly flora of Gujarat State, the data gathered by periodical field studies for nearly three years are included along with the Goa flora so that the data, after publication would be useful not only to various workers engaged in the projects of Goa administration as a whole, but also to those interested in the flora of Gujarat State. Similarly the bibliography given at the end of Vol. II comprises publications closely connected with the flora of Gujarat State and adjoining drier regions also.

Towards the end of the 19th century, Theodore Cooke and his associates started intensive botanical exploration covering wide areas around Goa, Daman and Nagarhaveli. At the beginning of this century, notable contributions were made by Cooke (1901-1908), Talbot (1909-1911), Saxton and Sedgwick (1918), Indraji Thaker (1910) (possibly the first floristic work in a regional language Gujarati in India) and by several others, like Blatter of St. Xavier's College and his associates (d'Almeida and McCann), Nairne and others. Inspite of such intensive work and a good number of papers on Western India plants published in various journals at that time, data on the plants of Goa, Daman, Nagarhaveli etc. based on authentic herbarium material were lacking, except for a few collections, that too mostly from Marmugao by Cooke, Talbot, Kanitkar, Bhide and Bhiwa and a few from Daman by Bhide (specimens available in BSI herbarium, Pune).

With such advancement of botanical knowledge in the Western India, some workers from Goa also published their botanical papers, a few of which, though of little significance for future reference or utility, are noted here. (1) Gracias (1896-on *Pogostemon*; 1902—147 species mostly cultivated; 1927—economic and medicinal plant data from Indian books), (2) Barreto (1954-'58 medicinal and aromatic plants data from Indian books), (3) Naronha and Pinto (1954), (4) Ramachandra Vaidya (1954-'55), (5) Souza de (1944—583 species list), (6) Gracias, C. (1899—on Cereals and legumes), (7) Souza, A.H. (1956—on Cashew nut) and (8) Alfonso (1924—on

Coconut ; 1940—on 24 species of fruit trees introduced by the Portuguese into India).

Studies from the Blatter Herbarium, St. Xavier's College, Bombay during 1940-60, also enriched floristic data of Khandala Ghats, Dangs forests and other Indian regions surrounding erstwhile Portuguese colonies.

Subsequently, with the reorganisation of the Botanical Survey of India and setting up of the Western Circle of the Department in December, 1955, a new line of activity in the exploration of various unexplored, under-explored regions along the Western parts of India, (hitherto inaccessable to the earlier workers) has begun. As there is practically no proper Flora volume and no herbarium material from Goa and other former Portuguese colonies, comprehensive study of the flora while however carrying out simultaneously other Department projects of research on Indian plants, were taken up by the author as a part-time project in the end of 1962 after their liberation. While such work is in active progress, V.D. Vartak, prepared a list of 1512 species, mostly gathered from published literature, covering the region from southern parts of Ratnagiri district to northern part of North Kanara district under an old regional name "Gomantak" (*Ennumeration of plants from Gomantak*, India, 1966). There are hardly 200 species, collected from Goa region proper, and those too from limited areas. Based on the data gathered by the author during his studies along the Western coast and the ghats of the Gujarat State on the north and the Maharashtra and Karnataka States on the south, botanical exploration of Goa region including Angidiv, an isolated island off Karwar coast and Terecol, a narrow coastal strip east of Vengurla (Ratnagiri district) and also Diu, Daman, Dadra and Nagarhaveli (except the small simbor island off Diu towards its east) has been carefully planned with three periods of field study covering pre-monsoon, late-monsoon and post-monsoon seasons of each year beginning with November 1962.

After the author's intensive study in the various field zones of the entire region for some period, he had collected further material from those zones through the Botanists of his Institution under his complete direct supervision For such assistance he is thankful to Sarvasri R.S. Raghavan, N.P. Singh, K.C. Kanodia and P.J. Cherian for Goa area and Sri M.Y. Ansari for Nagarhaveli area.

All such collections, numbering to more than 4000 field numbers for Goa region and 1800 numbers of Diu, Daman and Nagarhaveli region, have been identified and deposited in BSI herbarium, Pune and this major collection, the first of its kind from Goa, Diu, Daman, Dadra and Nagarhaveli region, forms the main basis for reference. He is thankful to Smt. B. Ahuja of his department for her assistance in the herbarium work.

Plan of the Flora :

Phytogeographically the two groups of former Portuguese enclaves namely, 1) the Goa region including Angidiv on the South and (2) the Diu, Daman, Dadra and Nagarhaveli on the north are quite distinct. Hence, the author has first presented this work in two parts so that the flora of the former which is akin to that of south Ratnagiri and north Kanara districts be studied as one composite unit and the Flora of the latter similar to that of Gujarat coast and hills, may be presented as another natural unit. However, for printing a concise flora for all the enclaves, both the parts are now merged and presented as one volume. Such long delay in publishing the flora is partly due to such merging work which disturbed the author quite considerably from his other scientific work.

Keeping in view of the present requirements of the Goa administration for the development plans both on the utilisation of vegetable wealth of the region and for improving the standard of Botany teaching at various levels, the data so far gathered from the region is very much condensed in such a form that only important aspects of its flora are presented as the first work of its kind for the region, introducing to the student as well as the research worker of Goa union territory, the taxonomic literature on the Flora of surrounding areas and enable them to understand the plants of their area, while utilising this Flora along with other major Floras on the Western India.

Further, in order to make the Flora concise without depriving the quality and its utility, every effort has been put in, to present upto-date data on distribution, nomenclature (even recent nomenclatural changes are given as Foot notes with asterik*) confirming to the *International Code of Botanical Nomenclature* (1978), synonymy, brief specific keys and taxonomic notes, deliberately omitting the descriptions of the species for which necessary reference is to be made to the regional Floras of Cooke, Gamble and others whose reprinted copies of Botanical Survey of India are available. The localities of Goa as per taluk-wise and also Diu, Daman and Nagarhaveli of the specimens collected are cited in the Flora omitting the field numbers and they are available for study at the BSI Herbarium, Pune. As such, Bentham and Hooker's System of Classification which is followed in all the Indian Herbaria and Floras, is also adopted in this work with, however, a few minor modifications particularly with reference to the circumscription of families as interpreted by Hutchinson (*Families and Flowering Plants*, ed. 2, 1959).

For the sake of brevity, a few unconventional abbreviations regarding references have been used under citations for each species. Besides many of the recognised abbreviations (I) such unconventional ones (II)

also are briefly explained below which are however fully cited under bibliography at the end of 2nd volume.

I. Fl.=Flowering ; Fr.=Fruiting ; Ill=Illustration ; Kan.=Kanarese name ; Konk.=Konkani name ; Loc.=Locality; Mar.=Marathi name ; *nom. cons.*=nomina conservanda ; Port.=Portuguese name ; *p.p.*=pro parte ; Recept.=Receptacle (under *Ficus*) ; Vern.=Vernacular name.

II. Aquat. Angiosperms=Subramanyam's Aquatic Angiosperms ; Blatt.=Blatter & McCann's Bombay Grasses; Bedd.=Beddome's ferns of Southern India ; Bedd. Fl. Sylv.=Beddome's Flora Sylvatica ; Bedd. Ic.= Beddome's Icones plantarum ; Bor.=Bor's grasses of Burma, Ceylon, India and Pakistan ; C.=Cooke's Flora of Bombay Presidency (pages as in BSI reprint vols.) ; DG.=Dalgado's Flora de Goa ; Dalz. & Gibs.=Dalzell & Gibson's The Bombay Flora ; Dangs.=Santapau's Botany of Dangs ; FBI.=Hooker's Flora of British India ; G.=Gamble's Flora of Madras Presidency (pages as in BSI reprint vols.) ; Holtt.=Holttum's Ferns of Malaya ; JBNHS.=Journal of Bombay Natural History Society-different volumes ; Pav.=Chavan and others Flora of Pavagadh ; Pflanzen f.=Engler & Prantl's Pflanzen familien ; Pflanzenr.=Engler & Das Pflanzenreich ; S.=Santapau's Flora of Khandala (pages as in 2nd ed.) ; Sant. & Irani.= Santapau & Irani's Asclepiadaceae & Periplocaceae of Bombay ; Sant.& Kapad.=Santapau & Kapadia's Orchids of Bombay ; Saur.=Santapau's Flora of Saurashtra ; Sena.=Senaratna's Grasses of Ceylon ; T.=Talbot's Forest Flora of the Bombay Presidency and Sind ; Uni. Bombay Bot. Mem.=Santapau's Acanthaceae of Bombay ; V.=Vartak's Enumeration of Plants of Gomantak ; Wt. Ic.=Wight's Icones Plantarum ; Wt. Ill.= Wight's Illustrations of Indian Botany.

TOPOGRAPHY

Goa, the land of scenic beauty with forested hills on the east and a net work of rivers flowing along the narrow undulating country, interspersed with picturesque coconut groves and joining the Arabian sea all along the projected rocky creeks which are here and there draped by small strips of soft sandy shores, is geographically situated between 73° 40'-74° 20' E and 14° 53'-15° 47' N, with Ratnagiri district of the Maharashtra State on the north, North Kanara district of the Karnataka State on the South and the Western ghats on the east and the Arabian sea on the west.

This region was known in ancient works as "Gomantak" or "Gomanchal" indicating it as the most fertile part of the Concan, with "Govapuri" (ollem Goem) as a great religious and commercial centre. The riches of the country soon made it the scene of several battles and territory changed hands from the 11th century onwards from the Kadamba Kings to

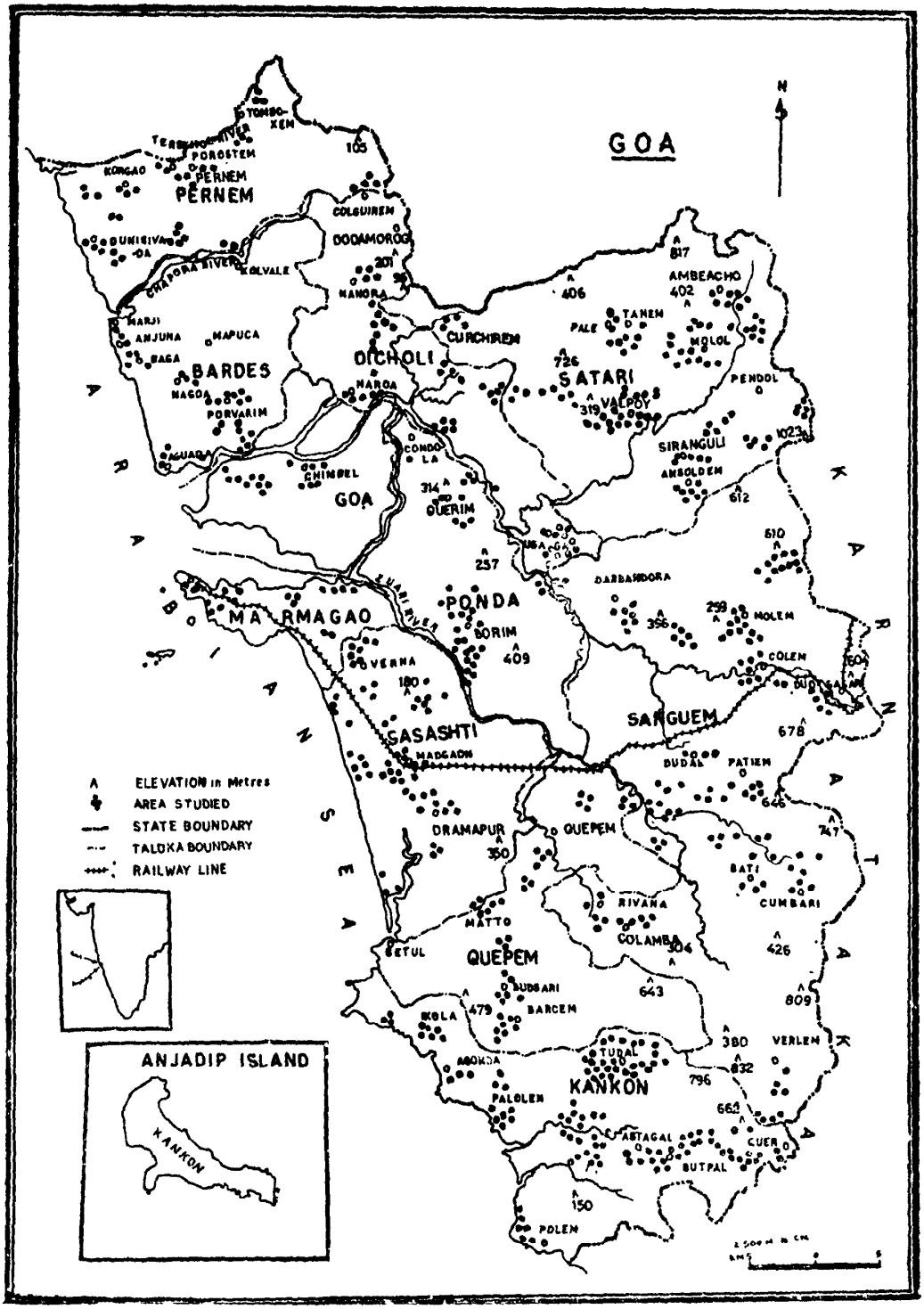
Vijayanagar rulers and subsequently to the Bahamani Kings and then to the Bijapur rulers from whom Afonso de Albuquerque annexed the city of Old Goa in 1510. After moving the seat of Portuguese Government from Cochin to old Goa and by further expansion during the 16th century, the Present Goa, with old and new conquests combined, as one sees it to-day, is finally organised into one territory in 1778 and the present capital Panaji came into prominence from 1818. Finally in December, 1961, after a lapse of 451 years, the old Portuguese colonies again became a part of India. With such interesting historical background, Goa provides several ancient monuments, temples, mosques and churches and forts, castles and arches, all of intrinsic archaeological, artistic or cultural value.

Angidiv, a part of the Goa territory, is a tiny island off Karwar coast, with no permanent residents but an old fort, built to house of Portuguese soldiers. It is situated at 74° 06′4″-74° 07′3″ E and 14° 45′1″-14° 45′7″ N and it is here that the battle of liberation began in December, 1961. It is now included as a part of *Canacona* taluka.

The area of Goa is 3806 sq. km. with 131 km. long coast line which is more or less dentate with creeks, inlets, river deltas. The maximum, length is 105 km. and the width 6o km. The area is comprised of 11 administrative units as talukas, (1) Pernem, (2) Bicholim, (3) Satari, (4) Bardez, (5) Tiswadi (Ilhas), (6) Salcete, (7) Marmugao Smallest, (8) Ponda, (9) Sanguem (largest), (10) Quepem, (11) Canacona (with Angidiv) which form the basis for presenting the distribution of species in this Flora (Map-I). Forests though very much degraded during early 60's cover about 1050 sq. km.

The region is drained by the rivers, the Mandovi (61. 6 km. long) and the Zuari (62.4 km. long) which form wide alluvial deltas before discharging into Agoada Bay and Marmugao Bay respectively. They are navigable throughout the year. The other small rivers are Sinquerim, Chapora (Colvale), Tiracol (Araundem), Sal, Talpona, Galgibaga, Baga, Mapuca, Bicholim, Sanquelim, Paroda and others, all originating from the Western Ghats, mostly outside Goa limits.

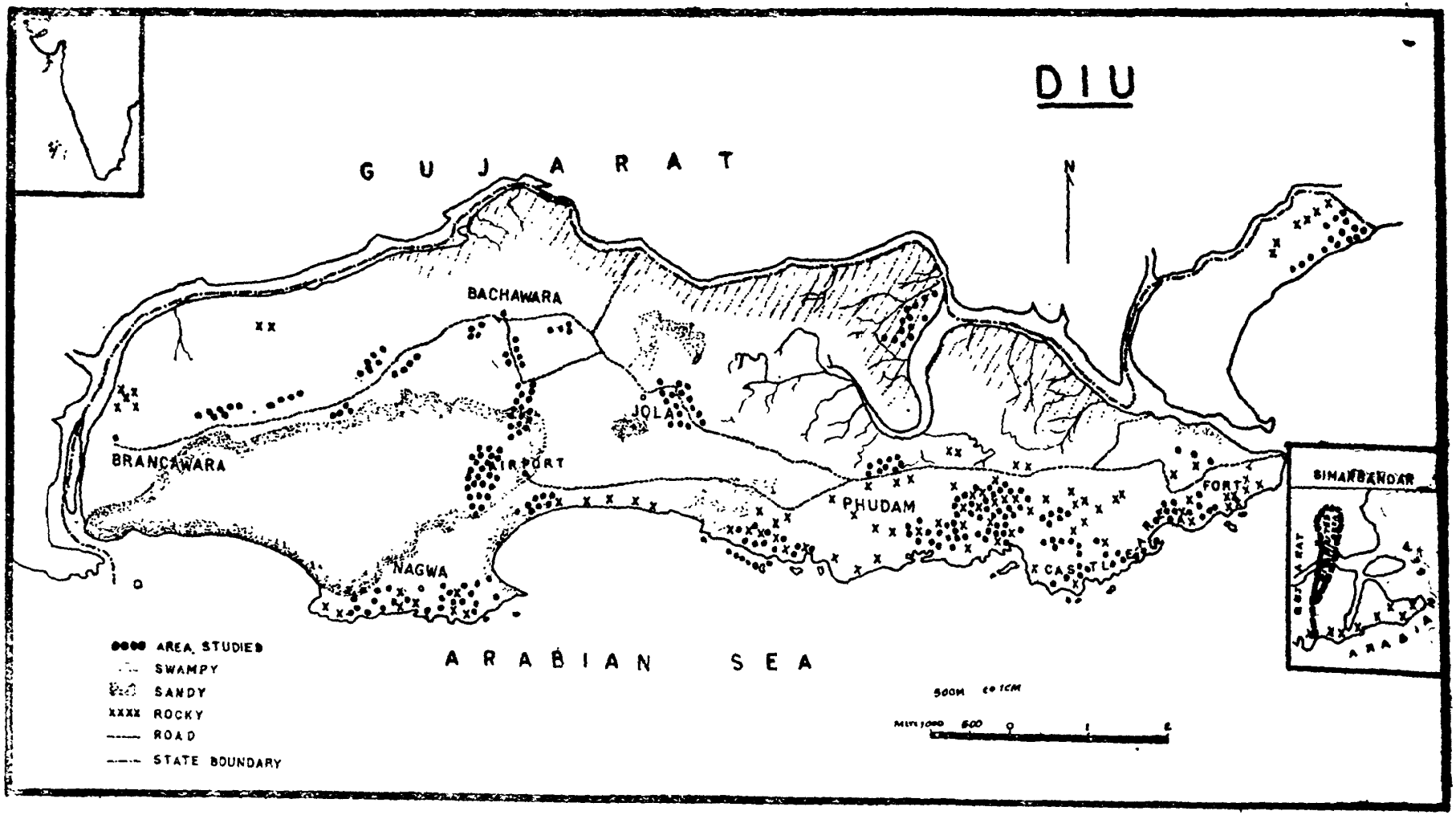
The major portion of the slopes of the Western ghat belt falls within Goa territory and the highest peak is Sonso God (alt. 1022.5 m) in Satari taluka and the other high points range from 350 m to 800 m in different talukas. The Dudhsagar Water falls (Sanguem taluka) with rushing waters of about 600 m below into the far-reaching valleys and luxurient forest, offer a gorgeous panorama, particularly during the rainy season.



MAP I

Diu :

Diu, a small island off Saurashtra coast, with narrow sandy shores and rugged rocky creeks along the south, facing the Arabian sea, is bounded by other sides by narrow swampy Chassi river which separates Gogale, a parf of the main land of Junagadh district of Gujarat State. Gogale together with another tiny Simbor island (Panikota island-situated a few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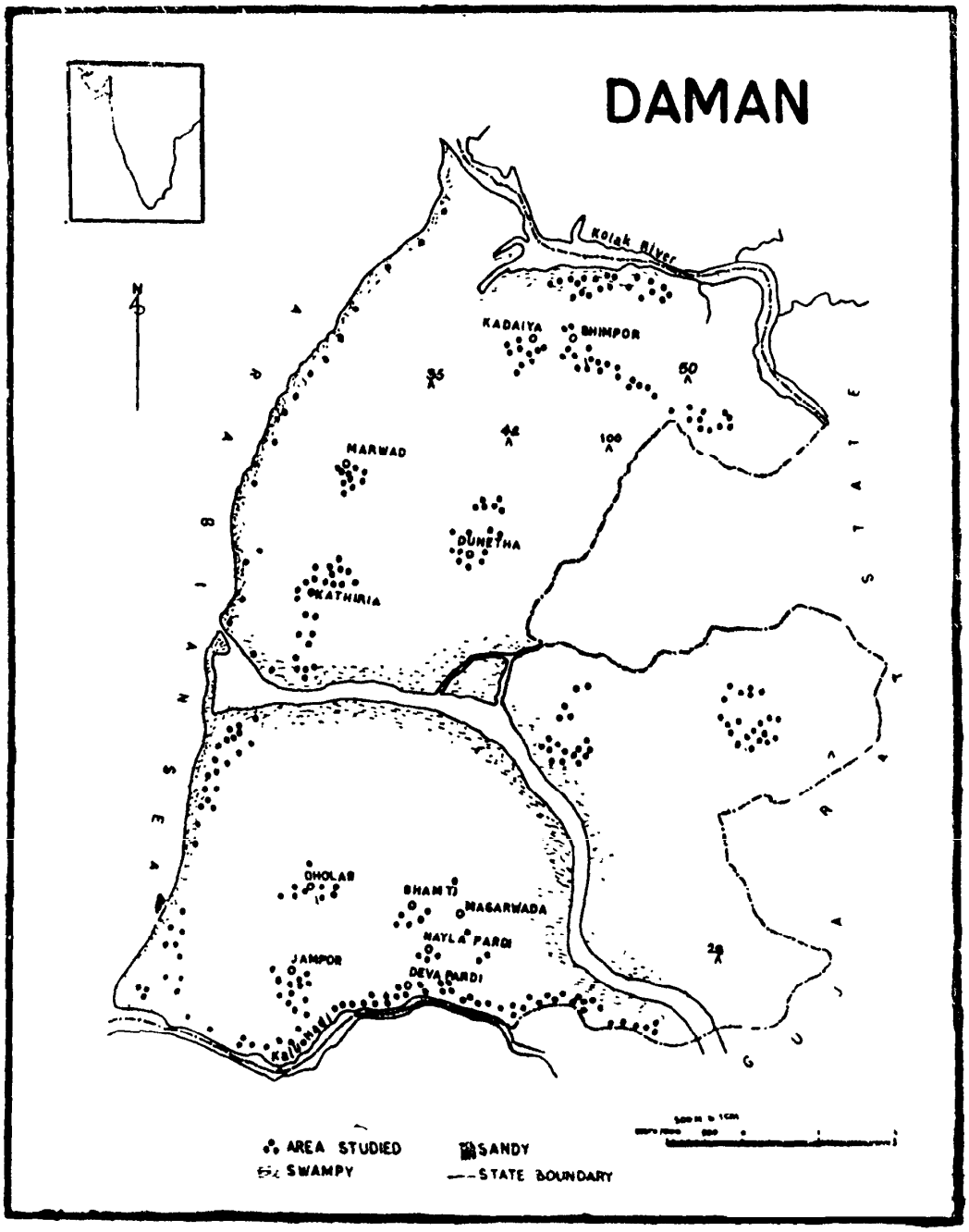
STATE BOUNDARY

MAP II

kilometres away, east of Diu along the coast but not included in the present work) forms a part of Diu district. The location of Diu is 20° 41′54″20° 44′30″N and 70°52′30″-71°0 ′30″E (Map II). The island which was under the Muslim rulers of Cambay, was occupied by the Portuguese in 1534. The area of the is and is about 40 sq. km with its maximum length about 12 km and the breadth about 3 km. There is no forest zone but the sandy area is densely covered by branched palms 'okra' [*Hyphaene dichotoma* (White) Furtado].

Daman :



MAP III

Daman is a small enclave with an area of 57 sq. km., along the West coast within 20°12'-20°28' N and 72°50'-72°54'E is bounded by the Arabian sea on the West and Surat district of Gujarat State on other sides. The only important river, Daman Ganga divides the town into big Daman (Fort area with offices) and small Daman (Nani Daman with shops). The area with its ancient fortress was once under the Muslim rulers of Cambay and later in 1555-'59, was acquired by the Portuguese Governor, Francisco Earetto, in exchange of half the revenue derived from Diu. The small township is associated with villages like Bimpor, Dundorta, Dabel, Thana Paidi, Jampor etc., some of them along the swampy banks of the two small rivers, the Coileque on the north and the Cale on the south and on the sandy beach along sea coast. Thorny scrub type of vegetation is quite limited (Map III).

Dadra and Nagarhaveli :

Dadra is a small, town along the Daman-Vapi-Nagarhaveli road, about 8 km north-west of Nagarhaveli. Nagarhaveli is, however, a wide hilly tract with good forest zones. This region is situated between 20°03'-20°22' N and 72°55'-73°13' E. Nagarhaveli was under the Maratha rulers almost during the whole of 18th century and in 1781 they granted Nagarhaveli including Dadra to the Portuguese for the various favours rendered to the rulers. The area, being extremely inaccessible with mostly "Girijans" living in various groups of hamlets on different hill tops, the development even in minor projects was practically negligible during the Portuguese regime. Subsequently by the movement and uprising of the local people, liberation of Dadra was effected in July, 1954 and of Nagarhaveli in August, 1954.

The area of the region is 490 sq. km. Though it was a part of Daman district during the Portuguese regime, due to its earlier liberation, it is now administered as a separate Union territory with Silvassa as the headquarters to the Government. Forests of the area with Saily, Khanvel, Dolora etc. as forest administration centres though very much disturbed earlier, have good potential to improve their productivitiy. Daman Ganga which joins the Arabian sea at Daman is the only important river flowing across the region. The hilly ranges which represent the northern extreme of the Western ghats have high tops with altitudes ranging from 250 m to 432 m. Ghambir ghad, the highest point along the range with 684 m altitude is just outside Nagarhaveli border (Map IV).

GEOLOGY AND SOIL

Following the general pattern of the Western ghats and the west coast of the southern Maharashtra State, the Goa region can be divided into three physiographic units ; (1) Hills and valleys along the ghat zone

with old crystalline rocks of Granite-gneiss mainly of biotic type belonging to Archean age traversed by schists and quartzites. (2) Narrow coast line with sandy soils and alluvium along river banks. (3) Undulating plateau or mainland between the hills and the coast with residual laterite of the detrital type. The most interesting aspect of Goa's position is its location

MAP IV

along the transition zone between the Deccan trap and the Archean rocks. In fact, such transition actually begins from the narrow strip of the Phonda Ambolighat-Ramghat belt of south Ratnagiri district which has a definite bearing on the change in nature of vegetation and its components as observed during the author's studies. The escarpment of the ghats in

Goa mostly consists of Dharwarian Quartzites and granitegneiss which form a part of the extensive southern Archean system, thus presenting the rugged view of hills quite distinct from the terraced formation of Trappean hills of Maharashtra State [For more details on Geology and Soil of Goa, P.D. Dhepe's (1956) publications may be consulted].

The soils in Goa may be broadly classified into three main types : (1) Laterites of high and low level type formed by natural metamorphosis and degeneration of underlying rocks along the ghats. (2) Red gravelly soils derived from micaceous granite gneiss, covering the undulating plateau mixed with medium black soils adjoining river banks. (3) Alluvial soils including coastal alluvium along the coastal belt and in low lying situations.

General data on the geology of the Western India coast north of Bombay, covering the gulf of Cambay and Saurashtra coast (south) are applicable to the region under study, Diu, Daman, Dadra and Nagarhaveli. Cambay gulf basin, being now an important centre on the west coast for oil and gas exploration, is under intensive geological study. It is an intra-cratenic basin formed by the sinking of Deccan Trap in the form of Graben. There are a few major faults and several subsidiary faults. Along Diu, Gogale coast as in Saurashtra coast, ossiferous conglomerates are found, resting upon thick blue clay. The hills of Nagarhaveli of the Deccan Trap zone have basaltic (amygdaloidal or prophyritic) underlying rocks intersected by dykes of fine-grained basalt and red quartz.

Soils of Diu and Daman mostly belong to coastal alluvium mixed with sand and medium black soil derived from the Trap and rocky creeks of Trap origin. They vary from fine sands (which occupy a wide zone west of the air port area in Diu) to heavy clays. The soils in Dadra and Nagarhaveli area are mostly formed by disintegration of the Deccan Trap rocks, occurring as thin finely broken, well-aerated mantle mixed up with decayed organic matter.

CLIMATE

The climate of Goa region though moist and relaxing, is generally healthy with four seasons, the summer from March to May, the south-west monsoon season from June to September, the post-monsoon October and November and the winter December to February, with a distinct dry period of 6-7 months (November-May) when the rainfall is less than 100 mm in a month.

(a) Rainfall :

The onset of the south-west monsoon is no where so sudden and marked in the whole of India as on the Goa and Ratnagiri coast round

about June 7th where heavy downpours follow the poor rains of hot weather season. The record of rainfall abruptly rising from about 90 mm to 900 mm from May to June year after year, is very indicative of this phenomenon. The average annual rainfall for the Goa region as a whole which is almost continuous from June to middle of October, is 2500 mm. Considerable variation in rainfall from the coastal belt to the ghat ranges is seen from 2600 mm to 3300 mm in the former (Pernem taluka) and from 4000 mm to 5000 mm in the latter (Canacona taluka) (Marmugao 2600 mm; Sanguem 4100 mm; Colem 5000 mm). The rainiest month is July when nearly a third of the annual rainfall is received. The variation from year to year in the rainfall is not large. On the average on 154 days in the year, the Goa region gets rain of 2.5 mm or more per day. The climatic diagram of Goa gives at one sight the impression of the climate as a whole, showing distinctly the duration and the intensity of the average of dry and humid seasons during a year (Figs. 2 & 3).

(b) **Temperature :**

In the hot season, temperature rises slowly from March and later part of April, and May forms the hottest period with 35°-37°C. With the onset of monsoon, temperature drops by four to six degrees. Day temperatures during monsoon are lower than those in the cold season. In the post-monsoon months of October and November, day temperatures increase and days in November are considerably very hot. Night temperatures are the lowest in January, ranging 15°-16°C. Areas within 20-25 km from the coast are the most pleasant, particularly in hot months with sea breeze blowing, nearly throughout the day, but along the inland both days and nights can be oppressive during hot season and more so in the foot hill area.

(c) **Humidity :**

The region on the whole is very humid being very close to the sea with the percentage of humidity varying from 70-90 along the coast and from 80-95 along the ghat zone. Even during the winter and summer months, the relative humidity seldom goes below 70%.

(d) **Winds :**

Winds are very strong and are mainly westerly or south-westerly during the monsoon months. In the rest of the year, winds blow from directions between north and east in the mornings and between west and north-west in the afternoons.

(e) **Special Weather phenomena :**

During the pre-and post-monsoon months, the region experiences very strong winds sometimes reaching gale force, particularly very near the

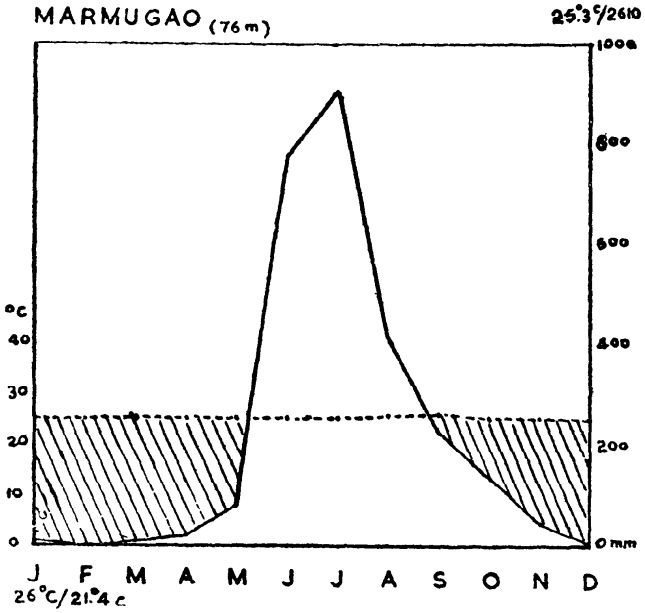


Fig. 2

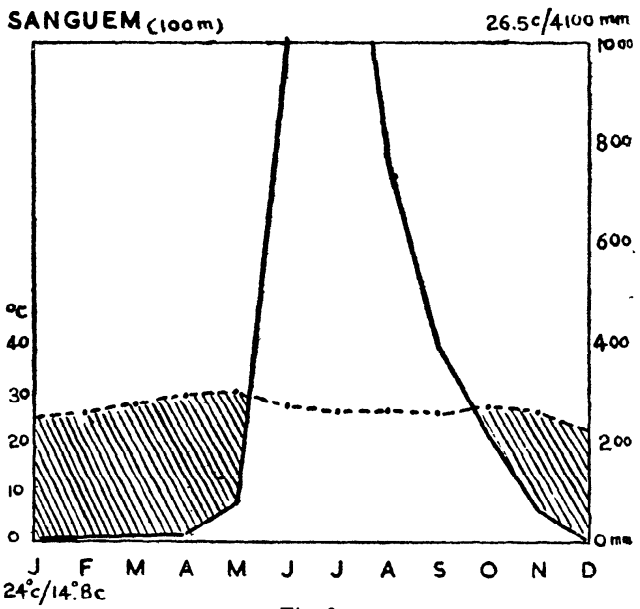


Fig. 3

Fig 2 & 3 : Climatic diagrams of Marmugao (Coastal) and Sanguem (inland) with altitude in meters, mean annual temperature in °C and mean annual rainfall in mm (given at the top of the diagram) and mean daily temperature of coldest month and absolute minimum temperature in °C (given at the bottom of the diagram), indicating temperature curve (dotedline), rainfall curve (thick line) and drought period (shaded space) and proving the drought period as practically constant irrespective of considerable variation in rainfall from coast to inland in Goa.

coast and heavy rain in association with cyclonic storms which develop in the Arabian sea and move in close proximity to the coast. Thunderstorms are common in the post-monsoon months and the latter part of the hot season.

The climatic condition of Diu, Daman, Dadra and Nagarhaveli are similar to the broad pattern characteristic of Gujarat coast and its interior. The area is dry for greater part of the year except for about 3-4 months when it receives precipitation under the influence of south-west monsoon. The post-monsoon period till the end of winter season is quite pleasant. Generally, the rainfall starts from the month of June and lasts till the middle of September, July being normally the month which receives sub stantial rain during the season. The annual average rainfall varies from 584.6 mm (in Diu) to over 2000 mm (in Daman and Nagarhaveli).

Soon after the rains, dry period sets in from October onwards followed by winter season, December-February. The temperature for the coastal places does not go below 16°C while in the hilly tract of Nagarhaveli it touches down nearly 10.5°C. With the onset of summer from March onwards, the weather becomes quite hot with temperature rising upto 37°C.

The data as available for Diu and Daman only indicate that relative humidity in the atmosphere is high during rainy season and low during summer, the percentage varying from 55 to 87 throughout the year.

VEGETATION AND ANALYSIS

The vegetation can be broadly classified into the following types :

(i) Estuarine vegetation consisting of mangrove species along the narrow muddy banks of rivers ; (ii) Strand vegetation along the few coastal belts; (iii) Plateau vegetation comprising of low deciduous as well as moist deciduous species confined especially to the lower elevations of the ghats ; (iv) Semi-evergreen and evergreen forests limited to patches along the upper elevation of the ghats.

Altitudinally, the estuarine and strand vegetation range from sea level to 50 m, the low deciduous and moist deciduous species fall within 50-500 m and the semi-evergreen and evergreen forests occur from about 500 m onwards. Besides, the area abounds in many hydrophytes and grassl-ands which occur at all elevations. The composition of the various types of vegetation has been briefly analysed below :

(i) *Estuarine vegetation of mangroves along swampy river banks :*

Climate has no appreciable influence on its composition and the depth of the mangroves varies with the local condition. Botanically this

zone is characterised by the peculiar root formations (stilt roots of *Rhizophora*, pneumatophores in *Avicennia*, knee roots in *Bruguiera* etc.) and viviparous fruits for seed dispersal. Selected estuarine areas along the banks of river Chapora at Colvale, along the river Zuari at Borim, and river Goa at Amona and river Tiracol at Conad have been studied in great detail but the vegetation is monotonous and uniform in all these areas with members of Rhizophoraceae being predominant.

Thickets of *Rhizophora conjugata*, *R. mucronata*, *Bruguiera gymnorrhiza*, *Kandelia candel*, *Lumnitzera racemosa*, *Sonneratia caseolaris*, *Avicennia officinalis* and *A. marina* readily strike the eye while *Cerbera manghas*, *Excoecaria agallocha* and *Aegiceras corniculatum* are rather scattered. Undergrowth is scarce being mostly confined to *Acanthus ilicifolius*, *Derris trifoliata*, *D. scandens*, *Clerodendrum inerme*, *Caesalpinia crista*, *Cyperus compactus*, *Vitex trifolia* and members of Poaceae. Often *Acanthus ilicifolius* presents pure formations and near the hightide mark, *Excoecaria agallocha* and *Clerodendrum inerme* are conspicuous together with such drought-loving species as *Crotalaria lutescens*, *Aristolochia indica*, *Boerhavia trianthema* etc.

(ii) *Strand and creek vegetation along coastal belt* :

Much of the coastal region of Goa is rocky with projecting ridges as well as rocky boulders and consequently the strand vegetation is limited to a few patches of narrow strip bordering the Arabian sea. The vegetation along the south bank of river Mandovi near Panaji belong to this category. Tree species as *Pongamia pinnata*, *Thespesia populnea*, *Cerbera manghas*, *Calophyllum inophyllum* and *Pandanus tectorius* some of which are exotics but naturalised, growing wild, whereas *Cocos nucifera* and *Casuarina equisetifolia* are extensively cultivated affording a picturesque view. The other associates include such shrubs as *Derris trifoliata*, *Caesalpinia crista* *Flagellaria indica* and *Scaveola taccada* intermixed with *Sesuvium portulacastrum*, *Arthrocnemum indicum*, *Melanthera biflora*, *Fimbristylis schoenoides*, *Cyperus arenarius*, *Phyla nodiflora* and *Spinifex littoreus*. Along the coastal sands *Urginea indica* and *Launea fallax* flourish luxuriently with *Ipomoea pescaprae* effectively serving as a sand binder at many points especially near the river deltas the strand vegetation abruptly merges with the mangroves with the components of both the types getting intermixed.

Along the rocky creeks and projecting ridges facing the coast, could be seen many herbaceous species as *Neanotis rheedei*, *N. lancifolia*, *Iphigenia indica*, *Scilla hyacinthina*, *Cyperus squarrosus*, *Naregamia alata*, *Begonia crenata*, *Mitreola oldenlandioides*, *Habenaria grandifloriformis*, *Tricholepis glaberrima*, *Adiantum philippense* and *Trichodesma* sp. together with other members of Scrophulariaceae, Asteraceae, Acanthaceae,

Rubiaceae and Euphorbiaceae. *Cassia absus*, *Neuracanthus sphaerostachyus* and *Lepidagathis cuspidata* are common associates with such climbers as *Mucuna prurita*, *Asparagus racemosus*, *Cocculus hirsutus* and *Gloriosa superba*.

(iii) *Plateau vegetation along undulating terrain and foot hills* :

A major portion of Goa belongs to this category with the scrub jungles extending from 50-200 m and the deciduous forests confined to 200-500 m altitude.

(a) **Open scrub jungle** : Undulating rocky plateaus with scant vegetation are met with along Panaji to Cortalim, Panaji to Colvale, Cortalim to Margao and from Bicholim to Sanquelim, to mention a few which are due to manganese ore mining "Kumri" cultivation, overgrazing and other biotic factors. *Anacardium occidentale* is cultivated on an extensive scale. Severely eroded waste lands sustain patchy vegetation composed of dry deciduous elements as *Carissa congesta*, *Holarrhena antidysenterica*, *Lantana camara* var. *aculeata*, *Calicopteris floribunda*, *Woodfordia fruticosa*, *Mictocos paniculata*, *Grewia abutilifolia*, *Vitex negundo* and species of *Breynia*, *Calotropis*, *Zizyphus*, *Cassia*, *Ixora*, *Sesbania*, *Acacia*, *Albizia*, *Terminalia*, and *Crotalaria*. In the wastelands abound *Girardinia zeylanica*, *Scoparia dulcis*, *Leonotis nepetaefolia*, *Borreria stricta*, *Phyllanthus asperulatus*, *Elephantopus scaber*, *Euphorbia fusiformis* and species of *Corchorus*, *Sida*, *Leucas*, *Justicia*, *Smithia*, *Ocimum* etc. The majority of climbers are confined to Menispermaceae (*Cocculus*, *Cissampelos*), Vitaceae (*Ampelocissus*, *Cissus*), Asclepiadaceae (*Gymnema*, *Dregea*, *Pergularia*), Liliaceae (*Asparagus*, *Gloriosa*) and Dioscoreaceae (*Dioscorea bulbifera*, *D. hispida*). The herbaceous vegetation is seen at the best only immediately after the monsoon and by November-December except for members of Poaceae and Asteraceae the ground flora is negligible.

(b) **Moist deciduous forests :** Forests around Tudal, Ordofond, Butpal, Molem, Kodal, Ambiche Gol near Valpoi and Anmode ghat are essentially moist deciduous and much of the forest area in Goa fall under the above type. The important components of the deciduous forests belong to species of *Terminalia*, *Anogeissus*, *Xylia*, *Dalbergia*, *Dillenia*, *Phyllanthus*, *Careya*, *Hymenodictyon*, *Wrightia*, *Xeromphis*, *Grewia*, *Lannea*, *Sapium* etc. mixed with *Dendrocalamus* and *Bambusa*. The dominant families represented by density of population are Rubiaceae (*Ixora*, *Mitragyna*, *Morinda*, *Adina*), Bignoniaceae (*Heterophragma*, *Oroxylum*, *Radermachera*, *Stereospermum*), Euphorbiaceae (*Glochidion*, *Macaranga*, *Sapium*, *Antidesma*, *Bridelia*, *Mallotus*), Anacardiaceae, (*Spondias*, *Buchanania*, *Linnea*), Sapindaceae (*Schleichera*, *Sapindus*, *Allophyllus*, *Lepisanthes*) and Leguminosae (*Dalbergia*, *Pterocarpus*, *Acacia*, *Albiza*, *Xylia*). The tallest arboreal members include *Lagerstroemia lanceolaia*, *Terminalia crenulata*, *Albizia* sp. *Xylia xylocarpa*, *Kydia calycina*, *Schleichera*

oleosa, Lepisanthes sp., *Alstonia scholaris* and *Dalbergia latifolia.* The moderately tall trees comprising the second tier of species include species of *Grewia, Canthium* and *Morinda, Xantolis tomentosa, Sapindus emarginata, Garuga pinnata, Careya arborea, Xeromphis spinosa, Flacourtia indica, Ixora* sp., *Macaranga peltata, Buchanania lanzan, Strychnos nux-vomica, Meyna laxiflora, Antidesma diandrum, Wrightia* sp. to cite a few. The third tier is composed of shrubs or small trees such as *Callicarpa tomentosa, Ventilago maderaspatana, Zizyphus xylopyrus, Z. glaberrima,Leea latifolia, L. indica* species of *Moghania, Clerodendrum* and *Psychotria, Tarenna asiatica, Murraya paniculata, Chasalia ophioxyloides* etc.

The ground flora in forest clearings and exposed situations comprise members of Fabaceae (*Geissaspis, Crotalaria, Indigofera, Alysicarpus, Desmodium*), Acanthaceae (*Justicia, Rungia, Lepidagathis*), Rubiaceae (*Exallage, Oldenlandia, Borreria*), Scrophulariaceae (*Scoparia, Lindernia, Bacopa, Torenia, Rhamphicarpa*), Euphorbiaceae (*Phyllanthus, Euphorbia*), Asteraceae (*Eclipta, Blumea, Spilanthus, Elephantopus, Senecio, Adenostemma*) and Lamiaceae (*Ocimum, Leucas, Leonotis, Pogostemon, Orthosiphon*). Also *Pteris vittata, Selaginella tenera, S. pronifera* and *Ophioglossum fibrosum* are seen in th · moist forest floor. In addition to the climbers met with in the scrub forests, members of Cucurbitaceae, Ranunculaceae, Smilacaceae, Fabaceae, Oleaceae, Convolvulaceae etc. are represented in large numbers.

(iv) *Semi-evergreen and evergreen vegetation along the upper ghats.*

(a) Semi-evergreen forests :

These forests are seen only as patches along the upper elevations of the ghats mostly above 500 m and bordering the contiguous forests of Ratnagiri district on the north and North Kanara district in the south. In this belt, the moist deciduous forests gradually change into semi-evergreen formation and isolated patches of typical evergreen species are seen scattered in the sheltered ravines and valleys. Such forests are seen at Amboche gol, Molem, Butpal and Nadquem. Arboreal growth is luxurient and the tree trunks are partially laden with lianas, epiphytes and mosses. These forests are ideally suited for ferns which thrive well in humid conditions. *Angiopteris evecta* is the only tree fern recorded from this forest.

The tallest trees are composed of *Michelia champaca, Myristica malabarica, Cryptocarya wightiana, Actinodaphne angustifolia, Ficus talbotii, Lagerstroemia lanceolata, Pterospermum diversifolium, Zanthoxylum limonella, Sapindus laurifolius,* species of *Holigarna, Garcinia talbotii* and *Canthium dicoccum.* Next in order are seen trees such as *Alseodaphne semicarpifolia, Glochidion hohenackeri, Ixora nigricans, Bischofia*

javanica, Macaranga peltata, Hopea wightiana, Clausena dentata, Linociera malabarica and *Olea dioica.* Along the forest outskirts, *Leea edgeworthii, Gomphandra polymorpha* and *Wendlandia thyrsoidea, Glochidion velutinum, Ficus asperrima, Celtis cinnamomea, Blachia denudata, Cinnamomum* sp., *Ligustrum perrottetii, Ervatamia heyneana* and *Meyna laxiflora* are frequent. The third tier composed of shrubs include *Chasalia ophioxyloides, Psychotria dalzellii, Maesa indica, Gymnosporia rothiana, Paramignya monophylla, Glycosmis mauritiana, Leea indica, L. edgeworthii, Chomelia asiatica* etc. associated with other scandent shrubs, *Lavanga sarmentosa, Ancistrocladus heyneanus, Sarcostigma kleinii, Connarus wightii, Strychnos colubrina, Rourea santaloides, Salacia oblonga, Erycibe paniculata* etc. In the disturbed forest areas *Dillenia pentagyna, Careya arborea, Xeromphis spinosa* are common together with climbers such as species of *Argyreia & Jasminum, Anodendron paniculatum, Ichnocarpus frutescens, Smilax zeylanica, Mussaenda glabra, Rubia cordifolia* and members of Asclepiadaceae and Dioscoreaceae.

(b) **Evergreen forests :**

The evergreen forests never reach the climax as seen at North Kanara in Karnataka but represents a good transitional zone which actually starts from Phonda-Amboli-Ramghat belt of the south Ratnagiri district. The density is much less, often much patchy purely due to biotic interference. The transition from the semi-evergreen forests to the evergreen is gradual and almost imperciptible. The tree components are selected and few limited to such families as Clusiaceae, Ebenaceae, Lauraceae, Moraceae, Euphorbiaceae, Sapotaceae and Burseraceae. The lofty trees belong to *Calophyllum elatum, C. apetalum, Garcinia cambogia, Canarium strictum, Lophopetalum wightianum, Chroisophyllum roxburghii, Palaquium ellipticum, Artocarpus gomezianus, Diospyros ebenum* and *Knema attenuata* whereas the medium sized trees are composed of *Litsea wightiana, L. coriacea, Ficus asperrima, Aporusa lindleyana, Antidesma menasu, Carallia brachiata, Evodia lunuankenda* and *Mallotus philippensis.* Near the streams, *Hydnocarpus laurifolia, Syzygium cumini, Ficus tsjakela, F. talbotii* and *Mammea suriga* are frequent. These forests abound in lianas, such as *Butea parviflora, Entada pursaetha, Schefflera venulosa, Chonemorpha fragrans, Gnetum ula, Derris bakeri* and *Combretum latifolium.* The undergrowth is composed of such shrubs as *Ixora coccinea, Dracaena terniflora, Rauvolfia serpentina,* species of *Nilgirianthus, Thelepaepale, Mackenziea* etc. in addition to those common in semi-evergreen forests. The ground vegetation is sparse and poor limited to members of Zingiberaceae, Araceae, Urticaceae, Cyperaceae and Asteraceae, positively due to frequent cutting and grazing.

As compared to the evergreen forests of North Kanara the epiphytes are comparatively poor, limited mostly to Orchidaceae (*Dendrobium,*

Cymbidium, *Eria*, *Bulbophyllum*, *Vanda*, *Aerides* etc.), Asclepiadaceae (*Hoya pendula*) & Araceae (*Remusatia vivipara*) but a few species such as *Utricularia striatula*, *Argostemma courtallense*, *Habenaria crinifera*, *Begonia crenata* etc. are seen in the crevices of tree bark wherever there is a little soil and moisture thus superficially appearing as epiphytes. *Drynaria quericifolia*, *Microsorium membranaceum*, *Pyrrosia adnascens* are some of the common epiphytic ferns that abound in these forests. The root parasites belong to Scrophulariaceae, (*Striga*, *Sopubia*, *Rhamphicarpa*, *Centrathera*), Santalaceae (*Santalum album*) and Orobanchaceae (*Aeginetia indica*). The stem parasites are predominantly composed of members of Loranthaceae (*Viscum*, *Helixanthera*, *Helicanthes*, *Dendrophthoe*, *Taxillus* etc.), though *Cassytha filiformis* and *Cuscuta reflexa* are also frequent. The terrestrial orchids include *Platanthera susannae*, *Nervilia aragoana*, *Malaxis versicolor*, together with species of *Habenaria* and *Peristylus*. The composition of the parasitic, epiphytic and ground vegetation area is more or less similar in both the evergreen and semi-evergreen forests.

The herbaceous vegetation in these forests include *Geophila reniformis*, *Adenostemma lavenia*, *Costus speciosus*, *Curcuma decipiens*, *Ageratum conyzoides*, species of *Blumea*, *Smithia* and *Torenia*, *Emilia sonchifolia*, *Spilanthes paniculata* etc. along with members of Cyperaceae and Eriocaulaceae. Along moist rocky slopes occur species of *Neanotis*, *Canscora*, *Senecio*, *Impatiens*, *Utricularia*, *Arthraxon*, *Begonia*, *Centratherum*, *Lindernia* and *Oldenlandia* together with *Cheilanthes tenuifolia* and *Adiantum philippense*. Many of the herbaceous species that occur in the moist deciduous forests equally thrive well in these areas.

Hydrophytes :

Under hydrophytes, the free floating as well as the marshy plants have been included irrespective of the forest classifications. The vegetation is monotonous containing many ubiquists and are independent of the macroclimate. The rooting marsh plants include *Nelumbo nucifera*, *Nymphaea pubescens*, *N. nouchali*, *Monochoria vaginalis* and species of *Eriocaulon*, *Polygonum*, *Cryptocoryne* etc. besides many sedges and grasses. *Acrostichum aureum*, the littoral fern grows along back waters near Tirem (Satari taluka) and is rather rare. The submerged aquatics are composed of *Ceratophyllum demersum*, *Najas minor*, *Blyxa echinosperma*, *Hydrilla verticillata*, *Ottelia alismoides* and *Vallisneria spiralis* to cite a few. Among the hydrophytes that extensively cover the surface of water are *Ipomoea aquatica*, *Utricularia flexuosa*, *Myriophyllum intermedium*, *Neptunia oleracea*, *Cyperus cephalotes*, *Pistia stratiotes*, *Hygrorhyza aristata* etc. besides species of *Nymphoides* and *Nymphaea*. Free floating hydrophytes like *Pistia stratiotes*, *Nymphoides* sp. and *Utricularia flexuosa* grow gregariously-

in such dense patches that vast areas of the pond are completely covered by them. The rare species, *Eriocaulon rivulare* is an interesting collection from these areas.

In the fast flowing streams attached to the rocks are seen members of Podostemaceae, belonging to such species as *Dicraea stylosa*, *Griffithella hookeriana*, *Hydrobryopsis sessile* and *Terniola zeylanica* associated with *Eriocaulon rivulare* and *Homonoia riparia*. In moist or drying mud near ponds and streams are seen species of *Drosera*, *Bacopa*, *Xyris*, *Utricularia*, *Limnophila*, *Saccolepis*, *Eriocaulon*, *Cyperus*, *Salomonia*, *Phyla*, *Dysophylla*, *Burmannia* in profusion. Along the banks of streams with calm water are seen *Lagenandra ovata*, *Cryptocoryne spiralis*, *Homonoia riparia*, *Crinum asiaticum*, *C. latifolium* and *Rotula aquatica*. In inundated rice fields and shallow waters of the lake *Ceratopteris thalictroides* is frequent.

The account will be incomplete without mention of rheophytes that are confined to banks of streams. *Pandanus tectorius* is conspicuous forming dense thickets with *Lygodium flexuosum* climbing over them. The other tree species that may be included under this category are *Syzygium cumini*, *Ardisia solanacea*, *Cinnamomum zeylanicum*, *Barringtonia racemosa*, *Madhuca longifolia*, species of *Ficus* and *Polygonum*, *Homonoia riparia*, *Hydnocarpus laurifolia* and *Diospyros embryopteris*. The best adopted rheophytes are members of Podostemaceae, that have already been mentioned earlier.

GRASSLANDS

Patches of grassland occur in the plains of Goa especially in low lying areas along the undulating plateau and tall grasses dominate practically suppressing other herbaceous vegetation. The region near Onda is one such fertile area. In such swampy regions, *Isachne miliacea*, *Jansenella griffithiana*, *Pseudoraphis spinescens*, *Saccharum spontaneum*, *Sacciolepis interrupta*, *Hygrorhyza aristata* and *Paspalidium geminatum* dominate. In shady parts *Ischaemum semisagittatum*, *Oplismenus compositus*, *O. burmanni*, *Sporobolus diander*, *Garnotia stricta* and *Cyrtococcum oxyphyllum* are very common. Along rocky slopes *Manisuris acuminata*, *Themeda triandra*, species of *Eragrostis* and *Digitaria stricta* occur. In cultivated fields *Centotheca lappacea*, *Cynodon dactylon*, *Digitaria adscendens*, *Echinochloa colonum*, *E. frumentacea*. *Isachne miliacea*, *Jansenella griffithiana*, *Panicum notatum* as well as species of *Paspalidium* and *Setaria* grow as weeds. *Manisuris talbotii* seems to be restricted in distribution in Goa and possibly to adjoining zones and a new species, namely *Manisuris goaensis* has been described by us from this region.

ECONOMIC AND MEDICINAL PLANTS

In Goa a wide range of wild plant material grows well and with proper planning and systematic cultivation some of the species can be developed into plants of considerable economic importance. Plants like *Cocos nucifera*, *Anacardium occidentale*, *Mangifera indica*, *Ananas comosus*, *Areca catechu*, *Piper nigrum*, *Artocarpus heterophyllus*, species of *Musa* and *Citrus*, *Psidium guyava* and their cultivation and further development on a commercial basis are quite well known. Species of *Garcinia indica*, *Cinnamomum zeylanicum*, *Myristica fragrans*, *Murraya koenigii* as condiments deserve a mention for their utility. A few other species like *Flacourtia jangomas*, *Averrhoa bilimbi*, *A. carambola*, *Litchi chinensis*, *Phyllanthus emblica* are also grown for their edible fruits.

As for the timber, variety of woods are in demand with the developing industrialisation and some of the species suggested here are known for their quality of wood. With proper management of deciduous and semi-evergreen forests, most of the species can be brought into the approved range of species required for woodbased industries. Besides the wellknown timber species of *Terminalia*, *Tectona*, *Lannea*, *Dalbergia*, *Xylia*, *Lagerstroemia* etc. trees like *Saccopetalum tomentosum*, *Hopea wightiana*, *Sterculia foetida*, *Pterocarpus marsupium*, *Pongamia pinnata*, *Bridelia retusa*, *Dillenia pentagyna*, *Holigarna arnottiana*, *Syzygium cumini* *Mitragyna parvifolia*, *Madhuca longifolia* also deserve special attention. Though *Tectona grandis*, the teak, does not occur wild it can possibly be introduced and cultivated as seen from the forty year old teak plantations at Valpoi which is somewhat satisfactory. Several useful exotics like *Eucalyptus*, *Casuarina* etc. grow well.

For extraction of fibres, oils, gums etc. several species are known to yield suitable material. Species like *Sarcostigma kleinii*, *Blumea eriantha*, *Guizotia abyssinica*, *Carthamus tinctorius*, *Mimusops elengi*, *Origanum vulgure*, *Thymus vulgaris*, *Santalum album*, *Croton tiglium*, *Hitchenia caulina*, *Vetiveria zizanioides*, *Cymbopogon* sp. etc. are quite important as oil producing plants. *Corchorus capsularis*, *Crotalaria juncea*, *Calamus pseudo-tenuis*, *Caryota urens* are some of the fibre yielding plants where as *Sterculia urens* is a good source of "Karaya" gum used as a food preservative.

The grasslands of Goa harbour many economic fodder grasses which could be profitably utilised through proper farm mangement. The highly palatable fodder grasses include *Centotheca lappacea*, *Cynodon dactylon*, *Echinochloa frumentacea*, *Hygroryza aristata*, *Isachne globosa*, *Paspalidium geminatum*, *Digitaria adscendens*, species of *Setaria*, *Themeda cymbaria*, *T. tremula* and *T. triandra*. A few species as *Alloteropsis cimicina*, *Apluda mutica*, *Chloris barbata*, *Coix lacryma-jobi*, *Garnotia stricta* etc. though not

upto the mark, are still browsed by cattle when other sources of fodder are scarce. However, care should be taken to avoid some grasses like *Dactyloctenium aegyptium* and *Paspalum scrobiculatum* which develop poisonous cyanogenetic principles especially on wilting. In addition, many forage legumes are found growing wild in these grasslands and these legumes due to their high protein content, richness in calcium and phosphorus add considerably to the nutritive value of the forage grasses if they form at least 20% of the fodder. The common legumes that occur in this region are *Desmodium triflorum, Geissaspis cristata, G. tenella, Goniogyna hirta,* species of *Alysicarpus & Indigofera, Phaseolus radiatus, P. trilobus, Sesbania sesban, Smithia sensitiva, S. conferta* and species of *Cassia, Vigna, Zornia & Tephrosia* etc. which are well known for their forage value but in nature these do not occur in proper proportion. By selecting such of the indigenous rich legumes that are common in Goa and by broadcasting the seeds during the early monsoon, the nutritive value of the fodder grass can be considerably enhanced.

The area is quite rich in medicinal plants. There is a good possibility of introduction and cultivation of several useful species required by the Pharmaceutical firms of Bombay who have already been planning for cultivation and propagation of specific medicinal plants. To mention a few, species like *Salacia chinensis, Rubia cordifolia, Spilanthes paniculata, Plumbago indica, Holarrhena antidysenterica, Rauvolfia serpentina, Gymnema sylvestre, Tylophora indica, Hemidesmus indicus, Strychnos nux-vomica, Solanum nigrum, Withania somnifera, Adhatoda vasica, Hygrophila auriculata, Ocimum basilicum, Coleus amboinicus, Zingiber officinale, Ensete superbum, Curculigo orchioides, Iphigenia indica, Aloe barbadensis, Asparagus racemosus* var. *Javanicus* and *Gloriosa superba,* well known for their medicinal value, grow under natural conditions in Goa forests.

PLANTS OF BOTANICAL VALUE

The flora of the region abounds in interesting species of botanical value both from the taxonomic as well as academic point of view especially for student community. Quite a few species have been found to be new to the science like *Manisuris goaensis, Arthraxon lancifolius* var. *hindustanicus* and species of *Fimbristylis* etc. *Ceropegia fantastica,* a rare plant has been collected again after a lapse of over 50 years. *Drosera indica* species of *Utricularia* members of Podostemaceae like *Dicraea stylosa, Griffithella hookeriana, Hydrobryopsis sessile, Terniola zeylanica* and prasites like *Aeginetia indica, Dendrophthoe, Helixanthera, Helicanthes, Loranthus, Macrosolen* and *Viscum* are quite interesting enough. Orchids both terrestrial and epiphytic like species of *Platanthera, Habenaria, Liparis, Eulophia* and species of *Pholidota, Cymbidium, Dendrobium, Vanda* etc. deserve special mention. The Pteridophyte flora is equally rich with species of

Selaginella, Ophioglossum fibrosum, Angiopateris evecta, Acrostichum aureum, Schizoloma heterophyllum and several others.

Many species of considerable values and interest along Baranzong iron ore mine area, are disturbed and eliminated. It is very necessary to level the mine areas and provide the suitable environment for the natural regeneration of the species of the surrounding forest.

Diu :

The vegetation on the island is confined to various habitats such as rocky creeks, sandy sea shore, sand stone pits, swampy backwater area, salt pans and fallow fields and roadsides. Tree species are practically absent except for *Hyphaene dichotoma* together with plants like *Borassus flabellifer, Cocos nucifera, Pongamia pinnata, Tamarindus indica, Pithecellobium dulce, Thespesia populnea* etc. most of which are exotics.

On the eroded projected rocky creeks along sea shore, a number of herbaceous species like *Statice stocksii, Portulaca quadrifida, Glinus, oppositifolius, Goniogyna hirta, Tephrosia uniflora* ssp. *petrosa, Kickxia ramosissima, Trichodesma indicum, Dipteracanthus patulus, Euphorbia parviflora, Phyllanthus debilis, Atriplex stocksii* etc. together with a climbing and trailing plants such as *Cocculus hirsutus, Clitoria ternatea, Cayratia carnosa, Mukia maderaspatana, Ipomoea maxima* etc. are common. The most common grasses met with are *Apluda mutica, Chloris montana, Cymbopogon parkeri* and a few others. At Nagoa, a small area of gravel and rock, adjoining the rocky creek, stunted bushes of *Commiphora wightii* form a dominant community mixed with *Barleria prionites. Striga gesnerioides* var. *minor* a root parasite on *Andrographis echioides* and *Lepidagathis trinervis* is rather frequent along this area.

It is quite curious to note that some of the above mentioned herbaceous taxa and *Commelina albescens*, an interesting species, so far known from Rajasthan only, grow sparsely or sometimes singly in the small shallow pits on the rocks covered by a thin layer of sand. Further some of the rocks deeply projected into the sea are heavily laden with marine algae of a wide range of species of which are considered to be of economic value, (These species are not included in the present work).

Along sea shore on the southern face of the island, sand binders like *Ipomoea pes-tigridis, Cyperus arenarius, Aeluropus lagopoides* grow luxuriantly. The other herbaceous associates are *Polycarpaea spicata, Digera alternifolia, Hydrophylax maritima, Borreria articularis, Evolvulus alsinoides, Phyla nodiflora, Indigofera cordifolia, Eragrostis ciliaris* etc.

Very near to the undisturbed sand stone ditches and excavations particularly in castle area a number of perennials such as *Abutilon indicum, Pupalia lappacea, Lantana camara* var. *aculeata, L. indica, Cassia italica, Boerhavia verticillata, B. diffusa, Triumfetta rotundifolia, Plumbago zeylanica* and annuals like *Bidens biternata, Trianthema decandra, Andrographis echioides, Trichodesma indicum, Vernonia cinerea, Pulicaria wightiana* together with trailing and twining plants like *Cardiospermum halicacabum, Cucumis prophetarum, Mukia maderaspatana, Ipomoea obscura, Rhynchosia minima* var. *laxiflora* and grasses, *Sporobolus marginatus, Cenchrus setigerus, Chloris montana, Apluda mutica, Arthraxon lancifolius, A. prionodes* are of common ocurrence.

The muddy flats along the northern edge of the island with a thin layer of alluvium harbour only one mangrove species, *Avicennia marina* var. *acutissima.* Even the mature plants are very stunted, hardly 30 50 cm high, and such growth may possibly due to regular picking up of tender leaves by local people, for cattle fodder. *Aeluropus lagopoides* and *Urochondra setulosa* which resist brackish and marshy conditions, grow in this area.

Near about salt pans, a little away from the marshy tract, halophytes represented by *Suaeda* and *Arthocnemum* together with the usual grasses and sedges *Aeluropus lagopoides, Urochondra setulosa, Fimbristylis polytrichoides* are met with. Colonies of *Cressa cretica, Arthocnemum indicum* and *Salicornia* sp. are quite predominant.

In the fallow fields covered with sandy soil mixed with gravel and rock, stunted *Xerophytes* and mesophytes are common represented by *Euphorbia nivulia, E. tirucalli, Gymnosporia emarginata, Caesalpinia crista, Leptadenia pyrotechnica, Barleria prionites, Lantana indica, Calotropis procera, Jatropha gossypifolia, Hibiscus micranthus, Cordia rothii* together with some climbers like *Pergularia daemia, Rivea hypocrateriformis, Asperagus racemosus, Ipomoea obscura* etc. In and around fields where *Setaria italica* is cultivated, annuals such as *Commelina forskalaei, Corchorus aestuans, Celosia argentea, Striga densiflora* and a few grasses like *Cenchrus setigerus, Apluda mutica, Chrysopogon fulvus, Sorghum halepense* etc. grow sparsely.

The common roadside weeds in Diu town are *Cleome viscosa, Cassia tora, Indigofera linnaei, Glinus oppositifolius, Acanthospermum hispidum, Pedalium murex, Sesamum mulayanum, Acalypha indica* etc.

The luxuriant growth of the branching palm, *Hyphaene indica* in several hundreds along the extensive sandy bed of the air field area and also the adjoining regions outside Diu boundary is really remarkable and has

no parallel anywhere in India, either along coastal or desert areas.

Daman :

Major part of the area is under cultivation either for food crops or cash crops. The sandy or strand vegetation appears all along the narrow sandy beach mixed with undulating gravelly mounds or small hillocks, practically barren or with low scrubby vegetation. The narrow strips of muddy flats present a poor mangrove vegetation.

Along the sandy belt *Aloe barbadensis, Sericostoma pauciflorum Ipomoea pescaprae, Solanum surattense, Jatropha gossypifolia, Thespesia populnea, Acacia nilotica,* ssp. *indica, Lantana* sp. etc. are found to be common. *Hyphaene dichotoma* grows singly or in groups along the southern coastal belt but not in such large numbers as seen in Diu and surroundings. The northern sandy belt is mostly with coconut plantations. Along the shore and a little interior, *Phoenix sylvestris* and *Borassus flabellifer* are common.

The undulating terrain and hillocks are devoid of tree growth. A few shrubs and mostly, grasses dominate such habitat. The open grassy areas and the slopes of the hillocks are dominated by species of *Themeda-Pseudanthistiria* community, commonly associated with *Ischaemum indicum, I. semisagittatum, Iseilema laxum, Heteropogon contortus, Eragrostis viscosa, Digitaria* sp., *Setaria glauca, Chloris barbata* mixed with a few legumes like *Geissaspis cristata, Alysicarpus bupleurifolius, Sopubia delphinifolia, Evolvulus alsinoides, Celosia argentea* and species of *Smithia, Desmodium, Lepidagathis, Borreria* etc. Among the shrubs, *Lantana* sp., *Adhatoda vasica. Euphorbia tirucalli, E. neriifolia, Vitex negundo, Grewia tiliaefolia, Woodfordia fruticosa, Zizyphus mauritiana* are found to be common along the plains.

The ruderal vegetation commonly consists of *Leucas lavandulaefolia, Martynia annua, Leonotis nepetaefolia, Justicia simplex, Alysicarpus hamosus, Xanthium strumarium, Malachra capitata, Cassia occidentalis, Achyranthes aspera, Tridax procumbens, Argemon mexicana* and such other weeds. Along the moist situations species of *Cyperus, Fimbristylis, Scirpus, Eriocaulon* and *Dopatrium junceum* etc. appear frequently.

The mangrove vegetation occurring on muddy flats along the river banks of Daman Ganga. Coileque and Kalei consists of mostly *Avicennia marina* var. *acutissima,* associated with *Aegiceras corniculatus, Acanthus ilicifolius, Sonneratia apetata, Salicornia* sp. and a few members of Cyperaceae and Poaceae.

Dadra :

The area is generally under cultivation with a few open grassy fields and wastelands.

The grasslands are generally dominated by species of *Pseudanthistiria-Themeda - Iseilema* community. The common associates in the grasslands are *Ischaemum indicum, Setaria glauca, Aeschynomene indica, Alysicarpus vaginalis, Desmodium triflorum, Smithia salsuginea, Rhamphicarpa longiflora, Merremia emarginata, Phyllanthus simplex, Aneilema* sp., *Enicostema hyssopifolium, Triumfetta rotundifolia* and a few others.

The ruderal vegetation is very similar to that of Daman with species of *Leucas, Martynia, Xanthium, Cassia, Achyranthes, Malachra, Argemone* and others. Various species of *Cyperus, Fimbristylis, Eriocaulan, Dopatrium* and *Phyla* cover moist habitat. Associated with these are the palms, *Borassus flabellifer* and *Phoenix sylvestris.*

Nagarhaveli :

The vegetation in general is that of moist deciduous type. In lower plains and valleys, cultivation of food crops is common. Small patches of open grassy fields intersperse the forest zones. The forests though quite disturbed by the nomadic "Girijans" and their shifting cultivative, have a high capacity for production with a good range of species composition. During the dry period, much of the valuable forest litters are swept-off and burnt in groups to serve as nutrient ash for their crops, a privilege followed as a right since the days of Portuguese rule.

The general pattern of the floristic composition of these forests is mostly uniform except in the frequency of a few species. The common tree species are *Tectona grandis, Terminalia crenulata, T. bellirica, Adina cordifolia, Garuga pinnata, Phyllanthus emblice, Mitragyna parvifolia, Butea monosperma, Diospyros melanoxylon, Anogeissus latifolia, Cassine glauca, Heterophragma quadriloculara, Morinda tinctoria, Careya arborea, Ficus* sp., *Dillenia indica, Bridelia squamosa, Trevia polycarpa, Dalbergia latifolia, Ougeinia oojeinensis, Lagerstroemia parviflora* and others. White stemmed trees of *Sterculia urens* are more conspicuous in the northern zone forests. *Dendrocalamus strictus* and *Bambusa bambos* are fairly common.

The shrubby layer is generally dominated by *Carissa congesta.* The other common associates are *Holerrhena antidysenterica, Wrightia tinctoria, Grewia tiliaefolia* var. *leptopetala, Helicteres isora, Woodfordia fruticosa, Leea indica, L. macrophylla, Baliospermum axillare. Thespesia lampas, Meyna laxiflora* etc.

The herbal undergrowth is rather poorly represented on account of the sweeping and clearing of forest floor and such other biotic interferences. However, species like *Scilla hyacinthina*, *Curculigo orchioides*, species of *Curcuma*, *Arisaema*, *Heliotropium*, *Iphigenia*, *Dentella repens*, *Cyanotis cristata*, *Murdannia scapiflora*, *Chlorophytum laxum*, *Lindernia crustacea*, *Impatiens kleinii*, *Pimpinella* species and other geophytes (in the early monsoon period) associated with *Neuracanthus sphaerostachyus*, *Rungia elegans*, *Blepharis asperrima*, *Barleria prattensis*, species of *Abelmoschus*, *Desmodium*, *Teramnus labialis*, *Rhynchosia rothii*, *Hemidesmus indicus*, *Corchorus aestuans*, *Trichodesma* sp., *Blainvillea acmella* and various grasses such as species of *Oplismenus* and *Ischaemum*, *Spodiopogon rhizophorus*, *Arundinella pumila* are the common components of the ground flora.

Calycopteris floribunda and *Combretum ovalifolium* are fairly common climbers of the forest, whereas species of *Aerides*, *Oberonia*, *Dendrobium* are a few of the epiphytic orchids. *Viscum articulatum* is the most common stem parasite.

The riverian vegetation on the gravelly beds and along the banks of Daman Ganga river and its tributories consist of *Homonoia riparia*, *Tamarix ericoides*, *Polygonum glabrum*, *Cyperus rotundus*, *Rotala aquatica*, *R. tenuis*, *Hygrophila serpyllum*, *Bacopa monnieri*, *Cyathocline purpurea*, *Ammania baccifera* and *Canscora diffusa* mixed with sedges and grasses as species of *Fimbristylis*, *Eleocharis*, *Isachne*, *Arundinella* and others.

ECONOMIC AND MEDICINAL PLANTS

The richness of economic and medicinal plants depends upon the richness and diversity of the flora of the region which in turn depend upon the geographical position of that region. The development of local "Small Scale Industries" depends solely upon the availability and existence of such natural resources.

Trees like *Tectona grandis*, *Terminalia crenulata*, *T. bellirica*, *Anogeissus latifolia*, *Dalbergia latifolia*, *Adina cordifolia*, *Butea monosperma*, *Mallotus philippensis*, *Lagerstroemia parviflora* etc. yield valuable timber. *Sterculia urens* is a good source of "karaya" gum used as food preservative and is being exported. The epicarp of ripe fruits of the indigenous Doum palm, *Hyphaene dichotoma* ("Okra" or "Makamberu") is edible and is consumed by local people, whereas its mature, hard endosperm is utilised in making very attractive small scent and snuff containers, thus serving as a good source for cottage industry. *Phoenix sylvestris*, *Borassus flabellifer* are often tapped for preparing liquor. *Diospyros*

melanoxylon provides "beedi leaf" which is a good source of revenue as a minor forest product.

Species like *Alhagi pseudalhagi, Asparagus recemosus, Tribulus terrestris, Sida cordata, Thevetia peruviana, Ocimum sanctum, O. gratissimum, Clitoria ternatea, Eclipta prostrata, Tridax procumbens, Holarrhena antidysenterica, Hemidesmus indicus, Solanum surattense, Salvadora persica, Adhatoda vasica, Boerhavia diffusa, Gloriosa superba, Aloe barbadensis, Commiphora wightii, Ensete superbum* are some of useful medicinal plants from these regions and a few of them are well-known for their medicinal properties.

PLANTS OF BOTANICAL VALUE

Hyphaene dichotoma (=*H. indica* Becc.) an interesting palm which has been often confused with the introduced Egyptian species *Hyphaene thebaica* (in various gardens) has been clarified by me together with its distribution along the west coast of India (1963, 1964). Record of *Moghania tuberosa*, a rare plant, poorly represented in herbaria and Rajasthan desert plants, *Cordia crenata* and *Commelina albescens* (now collected from Diu) and *Murdannia scapiflora* in Nagarhaveli, is of considerable interest.

DISCUSSION

During the studies on the flora of Goa region 1115 species of Angiosperms belonging to 657 genera arranged into 146 families have been collected. Of these 891 species under 538 genera classified under 124 families belong to Dicotyledons and 224 species under 119 genera presented under 22 families are Monocotyledons. A few Pteridophytes numbering to 27 species representing 25 genera arranged under 11 families have, however, been collected wherever available. *Gnetum ula* is the only Gymnosperm that grows wild in these forests. While analysing the number of wild species represented by each family, it is evident that there are 21 families which present more than 15 species and each such number together with the number of genera within brackets are given below against each family following the order of dominance :

I. Fabaceae-79(40) ; II. Poaceae-68(44) ; III. Euphorbiaceae-51(28) ; IV. Cyperaceae-48(9) ; V. Rubiaceae-46(28) ; VI. Acanthaceae-42(27) ; VII. Asteraceae-41(31) ; VIII. Convolvulaceae-33(12) ; IX. Malvaceae-26(11) ; X. Lamiaceae-22(14) ; XI. Mimosaceae-22(9) ; XII. Orchidaceae-21(16) ; XIII. Scrophulariaceae-20(10) ; XIV. Caesalpiniaceae-20(8) ; XV. Moraceae 19(4) ; XVI. Verbenaceae-18(11) ; XVII. Commelinaceae 18(5) ; XVIII. Vitaceae-18(5) ; XIX. Asclepiadaceae-17(13) ; XX. Cucurbitaceae-17(12) ; XXI. Apocynaceae-16(14).

Further scrutiny of the data on dominant families based on the number of species with reference to those as observed in the neighbouring zones of Goa region, namely Khandala ghats in the north and North Kanara ghats in the south besides general comparison with the peninsular India flora as given in Gamble's Flora of Madras province and as analysed by Hooker and also the India flora as presented by Hooker. f. reveals interesting points. The following table gives dominant families of Goa in regular order and the position occupied by such families in other floras.

Table

No. of species	Family	Order of dominance in Goa Flora	Santapau's Khandala Flora	North Kanara Flora	Gamble's Flora of Madras province	Hooker's order for Western peninsula	Hooker f's order for India
121	Leguminosae*	I	II	I	I	II	II
68	Poaceae	II	I	II	II	I	III
51	Euphorbiaceae	III	VI	III	V	VI	V
48	Cyperaceae	IV	V	V	VIII	V	VIII
46	Rubiaceae	V	IX	VI	III	VII	IV
42	Acanthaceae	VI	IV	IV	IV	III	VI
41	Asteraceae	VII	III	VII	VII	VIII	VII
33	Convolvulaceae	VIII	X	X	—	—	—
26	Malvaceae	IX	XV	—	—	—	—
22	Lamiaceae	X	XII	—	IX	IX	IX
21	Orchidaceae	XI	VII	VIII	VI	IV	I

*Leguminosae (*sensu lato*) is considered in this estimation.

The data as shown above indicates that the flora of North Kanara with its order of dominant families looks closer in its pattern to the flora of Goa than that of Khandala. In general the peninsular India flora as represented by Gamble's work and that of Hooker f. and the flora of India mostly signify the contrast in comparison to the floras on either side of Goa region. This observation confirms my opinion about the closer affinity of Goa flora with the evergreen forests of the Mysore ghats.

While carrying out the floristic studies of the areas Diu, Daman, Dadra and Nagarhaveli, 607 species of Angiosperms belonging to 358 genera have been collected and sorted out into 89 families. Of these, 442 species grouped into 272 genera belong to Dicot families numbering 74 and 165 species of 86 genera come under 15 Monocot families. The analysis indicating the dominance of a few families based on representatiAe

species from the region under study, as presented in the table below, is prepared by putting together all the components available from the shore lands of Diu and Daman and the interior hills of Nagarhaveli. This is no doubt an incongruous combination when compared to the composite unit of Goa flora, but at the moment such combined data is worked out only for general comparison with the dominant families of surrounding regional floras like Pavagadh hill (near Baroda) Flora (1966) and Saurashtra check list (1967) and those as suggested by Hooker f. for Indus plains and India as a whole.

Table

No. of species (No. of genera)	Family	Order of dominance in Diu-Nagar-haveli Flora	Pavagadh Flora	Saurashtra checklist	Hooker f's order for Indus plains	Hooker f's order for India
86 (49)	Poaceae	I	II	II	I	III
80 (41)	Leguminosae	II	I	I	II	II
37 (7)	Cyperaceae	III	—	VIII	IV	VIII
27 (23)	Asteraceae	IV	III	III	III	VII
25 (9)	Euphorbiaceae	V	V	VII	IX	V
21 (13)	Acanthaceae	VI	IV	VI	—	VI
18 (13)	Scrophulariaceae	VII	XI	XIV	V	—
17 (12)	Rubiaceae	VIII	—	X	—	IV
16 (8)	Malvaceae	IX	VII	IV	VIII	—
14 (6)	Convolvulaceae	X	VI	V	X	—
13 (3)	Commelinaceae	XI	—	—	—	—

A general comparison of the gradation in the dominance of family from different regions reveals that families Poaceae, Leguminosae, Cyperaceae and Asteraceae maintain almost identical positions both in the present flora and in Hooker's data on Indus plains flora. Further, irrespective of the slight exchange, the positions of Poaceae and Leguminosae are equally dominating compared to the rest of the families in other floras and even in Flora of India as a whole. But there is one snag about this comparison between the two families. Leguminosae (*sensu lato*) according to present understanding, actually comprised three families Fabaceae, Caesalpiniaceae and Mimosaceae. Hence, if the two later families are excluded and the more prominent family Fabaceae which include highly economical species as well as good herbaceous legumes that grow as very useful components in grass lands, is treated in par with the composite grass family, even then Poaceae comes out always as the most dominant in all the drier parts, surrounding the region under study.

Further, good sandy zone of Diu and Daman where the family Poaceae is well represented may also be developed into possible grassland

areas. Before undertaking a small project even on experimental basis, proper understanding of the adaptability of grass on sandy soils and subsequently developing into good grasslands, is essential. The typical grasses have a very high transpiration rate which is not checked even by an incipient lack of water in the soil. At the moment when nearly all the water has been lost, the osmotic value of the cell sap of the leaves rises abruptly and the leaf tissue dies. After a short time, the whole grassland turns yellow. Only the growing points of the shoots at the soil surface surrounded by the dead leaf sheaths and protected by them against water loss, remain alive as do the roots in the soil. Generally the cortex of the root dies and only the central part remains loosely surrounded by the dead rhizodermis with sand particles ("root trousers"). The high transpiration rate of living grasses can be maintained because the grasses have a so called "intensive root system" with good water absorbing capacity; a comparable small soil volume is very densely permeated by fine roots. Such a root system is only appropriate, if the available water content of the soil during the growing season is high. Therefore the grassland grows best in region with summer rainfall and on fine sandy soils. Grasses are able to endure long drought periods in a "dormant" state and they do not need water for transpiration, since the leaves are dead. With the type of sandy environment, as seen in Diu, a few experiments for the grassland development on a small scale to begin with are worth the trial.

In Daman, particularly in the inland undulating plateau area, grazing of cattle and sheep is quite heavy. With this the leaf surface of the grasses is decreased by grazing, less water is therefore used by grasses and more is left in the soil during the dry season. This benefits the shrubs and trees but even their growth is stunted due to careless wood cutting for fuel etc., with the result, the small hillocks in Daman are seen covered by thorny bushes developing a scrub, thus resulting neither a forest or a grassland. It may, therefore, be advisable to carry out a few experiments by way of fencing the hillocks completely to protect them from grazing and make the necessary observations whether useful grasslands could be developed in Daman area so that an appropriate rotational system of grazing could be adopted, later. Quality of such grasslands can also be improved further by mixing up useful species of legumes which also grow well in this region and by introducing more palatable species of fodder grasses when the environment is well established for grassland development.

Another interesting observation can be made with reference to the unusually luxuriant growth of branching palms, *Hyphaene dichotoma* (=*H. indica*) in Diu and surrounding areas. The occurrence of climatic

woodland zones along very flat regions, especially on flat water sheds in East Africa, presents a distinct vegetation pattern. The plant cover is a macromosaic of branching strips of grassland amidst endless woodland. The ecological explanation of this pattern is the nearly unobservable micro-relief. During the rainy season the water overflows the slight depressions at the head of the water courses, but the penetration of the water into the soil is not deep due to a clay layer near the soil surface. During the dry season, these soils dry out entirely. No tree species can stand this alternation of inundation and drought except some palms like *Hyphaene* or *Borassus* (Walter, 1964). Therefore, on such alternately humid and arid plains a climatic woodland zone, either edaphic grassland or a palm tree savanna is developed in Africa. The environment with palms, as seen in Diu with extensive growth of *Hyphaene* and *Borassus*, is somewhat comparable to those in Sudan and North Arabia as observed by Walter (1964) who indicates that in the deserts of North Sinai on the Mediteranian coast, Date palms (*Phoenix dactylifera*) grow on the beach in front of high bare sand dunes with sea waves reaching the palm bases during stormy weather and appearing as though the palms are growing in sea water. But a more detailed examination shows that under the baye dunes there is a fresh water table forming a cushion above the saline sea water. The rainfall in this region is 100 mm. The rainwater percolates easily through these bare sand mounds. As there is no vegetation on these mounds, it is not used for transpiration and causes a ground water table. The upper surface of this fresh ground water is higher than the sea level. Therefore, it flows slowly through the sand of the beach into the sea. The roots of the date palms absorbs this fresh water. So if the fresh water table is about 3 m deep, then there is no evaporation. On such places, it is possible to plant date palm suckers so deep that the base of the sucker is in the moist sand above the ground water and only the tips of leaves bound together show above the surface of the sand. After the roots are formed the palm starts to grow and the shoot emerges from the sand. As the conditions existing in Diu are somewhat similar and the luxuriant growth of *Hyphaene* seems to be to some extent indicative of suitable environment for a possible trial cultivation of Date palms, it is worth investigating the soil structure and the availability of any good fresh water table in Diu island zone.

As regards moist deciduous forests of Nagarhaveli, no specific suggestion is required except good forest management. The adjoining Dangs forest zone with almost identical climate geology and soil is a standing example of high productivity, inspite of extreme biotic interference by the "Girijans" of those hills. No doubt, with the 400 years of bad management during the Portuguese regime, the Nagarhaveli forests have suffered considerably ; but with proper forest planning, silviculture and protection,

the forests with their wide range of tree and shrubby species would be able to compete equally well with the neighbouring forest zone including the rich Dangs forests.

During such future developmental planning, the floristic data presented in this work, I hope, would be useful for a better understanding and appreciation of the species, their identity, affinities and distribution in the region under study and also for assisting in the preparation of a major flora of the Gujarat region.

Natural vegetation is often supposed to integrate and express the whole environment (topography, geology, soil and climate). Hence the study of vegetation and its composition form the basis for the preparation of vegetation maps which in turn are useful for the land utilisation studies and for determining appropriate 'land units'. For proper interpretation of the vegetation maps it is essential to know the causative relationship between the plant distribution and the environmental factors together with the floristic composition. Such study would further lead to eco-physiological investigations about which we have a long way to go particularly in our country.

Lauer (1952) indicates that the duration of the dry season is of decisive importance and not the amount of rain for the different vegetation types in the tropics. Walter (1964) argues that this statement is not quite correct. He says that both the total rainfall and the duration of the drought are important ; the former more for the drier vegetation types and the latter more for the humid forest types.

Considering the two aspects noted above, studies on the floristic composition of seven distinct areas with three places for Goa (as noted in the table given below), selected along the Western ghat belt covering regions of Maharashtra, Goa and Mysore are carried out during 1960-68 and the various details are presented in my paper on "Floristic Patterns along the Western ghats of India" [Notes from the Royal Botanic Garden, Edinburgh 37 (1) : 95-111.1979]

Analysis of such studies presents the gradual change from the semi-evergreen type of vegetation to the evergreen type along the Western ghat belt and such change actually begins from the Phonda-Ambolighat area which along with the Goa ghats forms a transitional zone of considerable phytographical significance. The gradual change in the climatic pattern coupled closely with the geology from the Trap to the Archean type has a positive bearing on the vegetation of this interesting zone. The sudden change in the composition of vegetation from Mahabaleshwar to Ambolighat-Goa ghats (Ambechegol-Butpal & Nadquem), irrespective of heavy rainfall,

Table

Area	Altitude m	Mean annual temperature °C	Mean annual rainfall mm	Mean daily temperature of coldest month °C	Absolute minimum temperature. °C	Rainy period in months	Dry period in months
Maharashtra							
Peint (Nasik Dt.)	600	23	2352	18	6	4	8
Khandala (Poona Dt.)	680	24	4900	20	9	4	8
Mahabaleshwar (Satara Dt.)	1420	20	6226	18.6	6	4-5	8-7
Amboli (Ratnagiri Dt.)	664	21	7446	19.5	6	5-6	7-6
Goa							
Colem	200	26.3	4960	24.3	15.7	5-6	7-6
Sanguem	100	26.5	4100	24	14.8	5-6	7-6 (Fig. 2)
Marmugao	76	25.3	2610	26	21.4	5-6	7-6 (Fig. 3)
Mysore							
Agumbe (South Kanara Dt.)	700	21	6602	19.5	9	7-8	5-4
Bagmandala (Coorg Dt.)	900	20.2	6032	19	9	7-8	5-4

is quite conspicuous with a generous sprinkling of such typically tall evergreen species some with buttressed roots, as *calophyllum, Hopea, Mesua, canarium, Garcinia* intermixed with other medium-sized evergreen species belonging to *Holigarna, Hydnocarpus, Symplocos, Diospyros, Syzygium* etc. Such studies confirm that both the rainfall and the period of drought together with the geological aspect are essential in determining floristic composition with the general statement that the more humid the climate is, the more luxuriant the natural vegetation and the poorer are the soils, all the other conditions being equal. Thus this Ambolighat-Goa ghats region marks the turning point of the semi-evergreen forests to the evergreen type, representing perhaps the northern-most limit of the evergreen species along the ghats which was hitherto believed to be along North Kanara ghats.

CONCLUDING REMARKS

Goa region in general and the ghat zone in particular have a high potential for good forest productivity. During the Portuguese period, there was no systematic and scientific approach for the preservation of forest resources and for artificial plantations. As such, the forests are in a poor condition due to shifting cultivation, abuse of user rights, illicit fellings,

lack of access and control and annual fires. Subsequently with the beginning of "ore rush" since 1950, forests of wide areas, were cleared, surface soil containing deposits of iron and manganese were opened up and extremely neglected, exposing the slopes to high erosion. This practice was continued as seen (in 1970) in Baranzongmine area and unless the work of levelling up the deserted mine areas is carefully attended to and closely followed up by soil conservation programme together with proper management of mining with modern machinery, the region would loose some of the valuable forest zones.

In view of the most suitable climate and soil, there is ample scope for successful introduction and production of some selected timber species from Karnataka and Kerala States and also even from Assam Zone. A study on the representative genera and species of the evergreen forests of the Western and Eastern India, and their habitat, carried out by me (1960) reveals the possibility of introduction from those zones species of *Calophyllum*, *Dipterocarpus*, *Hopea*, *Ailanthus*, *Canarium*, *Tetrameles*, *Palaquium*, *Cinnamomum* etc. Similarly several useful medicinal plants can be introduced and successfully cultivated. With the advancement of Pharmaceutical industry in our country, particularly with Bombay as the major centre, Goa region offers a suitable phytoclimatic zone for establishing medicinal plant farms and some firms from Bombay have already progressed in this direction. It is also quite possible to try and introduce *Hevea byaziliensis*, the rubber plant from the Kerala rubber estate and the Goa administration is attempting on this project.

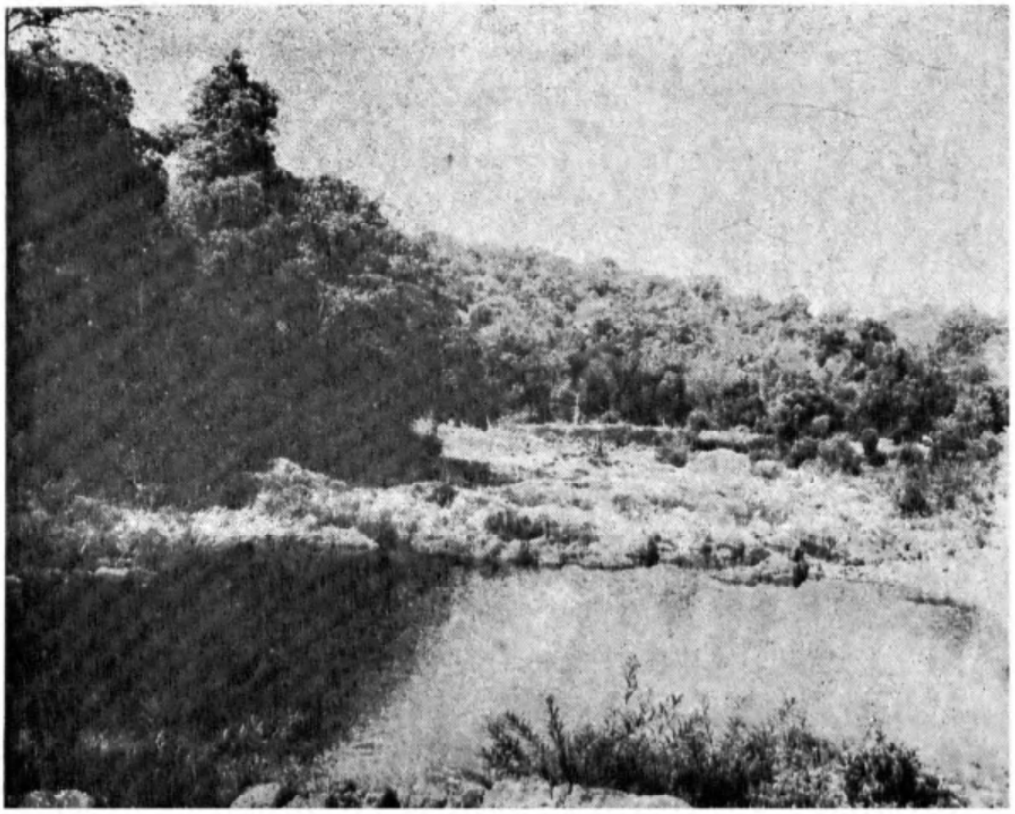
In Goa with its wide range of habitat from sea-shore to ghat zone, different plant communities are formed. Further in a transitional zone of this type, disturbance of natural conditions by man or the formation of new habitats by natural causes such as erosion, recession of glaciers or emergence from water, may provide, suitable habitats for hybrid populations. As suggested by Anderson (1959) the habitat needs "hybridising" before hybrids can survive because in the undisturbed habitat they are unable to compete with individuals of the parent genotype. Inter-specific association of species becomes more pronounced and thus the dependance of one species upon another within the general framework of the environment increases as well. As such, the botany of Goa provides ample scope by way of possible location of interesting species some of them even new to science, particularly along the ghats of Satari district to Canacona ghats, through borders of castle-rock zone and various plateau slopes. The collection of new species, *Manisuris goaensis* Rolla Rao et Hem. (1968) from the plateau area near Cortalim and Parvorim and location of *Ceropegia fantastica* Sedgewick after a lapse of over half a century in Canacona forests beyond Orthofond by Kanodia

(1964) are some of the few examples, besides several new and interesting species described from the Western ghats adjoining to Goa region. Further, the presence of minerals on surface layers of the soil may offer an interesting field of Geobotanical studies on the correlation of the herbs including grasses and low shrubs with the mineral contents of the soil. A few interesting groups like Podostemaceae, ferns and mosses and marine algae along some of the rocky creeks of the shoreland, present good scope of further studies by the academic and scientific institutes of Goa.

There is, in the chronology of taxonomical research, a fairly logical sequence of rather distinct phases characterising phytographic development. I have tried to illustrate this roughly for the Indian zone in fig. 1. Applying this sequence for the progress of Indian Botany, botanical exploration and publication since Garcia da Orta's *Colloquios* (1563) and after a gap of more than a century, Rheede's *Hortus Malabaricus* (1680-1703), have passed through various phases as shown in fig. 1 which were, however, intervened by "long vacuumes" With this background, after filling up the various "lacunae" in Indian Flora even in a broad pattern, it emanates clearly that further definite progress can only be derived from thorough revisions of the various families embracing the whole of India. In my critical studies and revision work of a few genera and families, following a biosystematic approach, based on extensive collections both living and preserved, it is evident that we are still in need of better understanding of the species concept and the various populations. Species which were considered by earlier workers as "rare" and later frequently redescribed in regional floras as "endemics" have turned out to be "false endemics" as their range of distribution is now found to be much wider. Plants like *Nanothamnus sericeus* Thoms., *Cyathocline lutea* Law ex Wt., *Senecio hewrensis* (Dalz.) Hook. f., *Rotala ritchiei* (C.B.Cl.) Kochne, *Commelina subulata* Roth, *Cyanotis concanensis* Hassk., *Indochloa clarkei* (Hack.) Bor., *Ischaemum kingii* Hook. f., *Dimeria hohenackeri* Hochst. ex Miq. are a few of the several examples from the Western ghat belt whose so called endemism is scattered to several hundreds of kilometres in different directions of the country.

Neither pure nor applied science is now served by provisional results and the knowledge and use of vegetable products are positively dependent on exact specific identification, be it for aims of scientific botany (speciation, population study distribution) or for medical botany, horticulture, silviculture or agricultural crops, for fodders or for any profit, mankind can derive from the plant world.

Semi-evergreen forest near Butpal (Canacona taluka) with *Xylia*, *Calophyllum* (Buttressed roots), *Terminalia*, *Cinnamomum*, undergrowth with *Psychotria*, *Eranthemum* and *Arundinella*



Evergreen forest at Nandore (Satari taluka) along Mahadevi river with *Syzygium*, *Diospyros*, *Knema*, *Litsea* mixed with *Dendrocalamus*.

Evergreen forest near Codal (Satari taluka) with *Hopea wightiana*, *Litsea coriacea* and *Murrava koenigii* etc. as dominant components.

A patch of *Murdannia* and *Eriocaulon* with *Drosera* on moist habitat along Verna plateau (Salcete taluka).

Grassland plateau near Onda (Bicholim taluka) with *Themeda*, *Ischaemum* and bushes of *Zizyphus*, *Ixora* etc.

Cultivated fields and Coconut groves near Novem hills Mudgao (Marmugao taluka).