PLANT LIFE OF SOUTH ASIA

Edited by

S.I. Ali and A. Ghaffar

Dedicated to

Dr. R.R. Stewart

on his Centennial

Proceedings of the International Symposium held at the Department of Botany, University of Karachi, Karachi-75270, Pakistan. 24-27 February, 1990

Prof. Dr. S.I. Ali,
Sitara-i-Imtiaz
Vice Chancellor,
University of Karachi,
Karachi-75270, Pakistan

Prof. Dr. A. Ghaffar,
Chairman,
Department of Botany,
University of Karachi,
Karachi-75270, Pakistan

Plant Life of South Asia / edited by S.I. Ali and A. Ghaffar

"Proceedings of the International Symposium on Plant Life of South Asia" 24-27 February, 1990, Karachi, Pakistan.

Includes bibliograph and Index.

1. Plant Life — South Asia — Congresses. I. Ali, S.I. 1930 — II. Ghaffar, A. 1932 — III Title.

1991 581. 0954

ISBN 969-470-001-9

Printed in Pakistan by Shamim Printing Press

Dr. R.R. Stewart

PREFACE

Since the publication of the Flora of British India by Sir Joseph Hooker and his collaborators which was begun in 1872 and completed in 1897, thousands of additional plant specimens have since been collected and described by plant scientists. In the prepartition days there were no large herbaria in the region which is now Pakistan. The plants collected were deposited in herbaria specially in Calcutta, Dehra Dun, Bombay or at the British Museum (Natural History), London and at Kew or at Edinburgh in Britain. Dr. R.R. Stewart arrived in India in 1911 and at the Gordon College, Rawalpindi started collection of plants from the Pubjab, Chamba and Kashmir and thus the Stewart Herbarium was set up. When Pakistan was created in 1947, Dr. Stewart's herbarium was the main vascular plant herbarium and in 1960 when Dr. Stewart retired it contained 50,000 specimens which has now increased to 70,000. The credit for this rich heritage goes to the genius and love of Dr. R.R. Stewart.

It took at least 23 years when the first fasicle of the Flora of Pakistan was published in September 1971 under the joint editorship of Nasir and Ali. Descriptions of 193 plant families for the Flora of Pakistan have now been published. This could not have been possible without *'An Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir'* by R.R. Stewart (1972). On the centennial of Dr. R.R. Stewart, the Department of Botany, University of Karachi, therefore, organized the International Symposium on Plant Life of South Asia and after an interval of 30 years Dr. Stewart also paid a visit to Pakistan. Dr. R.R. Stewart alongwith eminent plant scientists like Dr. K.H. Rechinger, Prof. I.C. Hedge, Miss J. Lamond, Prof. Y.C. Ma, Dr. Salar Khan, Dr. S.S. Bir, Dr. I.M. Sulaiman, Dr. S.Z. Husain, Mr. A. Radcliffe-Smith, Dr. James A. Duke, Dr. J.H. Kirkbride, Prof. H. Freitag participated in the symposium and made presentations.

Apart from the inaugural proceedings of the symposium, the book on Plant Life of South Asia gives a comprehensive account of the Chenopdiaceae, Euphorbiaceae, medicinal plants and threatened plants of Pakistan, Flora Iranica, vegetation of Bangla Desh, ferns of the Indian subcontinent, genesis and results of South West Asiatic Flora, floristic comparison between Inner Mangolia and Mangolia etc. The symposium provided an opportunity to exchange ideas and make strategies for the future.

We are grateful to the foreign delegates and local participants for the deliberation and active participation in the discussion. We are thankful to the University of Karachi and to the P.I.A., Dr. A.Q. Khan Research Laboratories Kahuta, The British Council, the Third World Academy of Sciences, Trieste-Italy and other agencies for necessary assistance for holding the symposium and the publication of the book on Plant Life of South Asia.

December, 1991

S.I. Ali
A. Ghaffar

CONTENTS

Page

Reproductive Biology

INAUGURATION

Plant Life of South Asia, 3–6, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

INTRODUCTORY REMARKS

S.I. ALI

Dean, Faculty of Science,
University of Karachi, Karachi-75270, Pakistan.

Your Excellency, Mr. Fakhruddin G. Ebrahim the Governor of Sindh, Dr. R.R. Stewart, Dr. Manzooruddin Ahmed the Vice-Chancellor, Dr. G.M. Khattak, Dr. Joseph H. Kirkbride, Mr. I.C. Hedge, Mrs. Ellen Stewart Daniels, distinguished guests, delegates, ladies and gentlemen.

On behalf of the Organizing Committee of the International Symposium on Plant Life of South Asia, it is a matter of great privilege and pleasure for me to thank you, Your Excellency for kindly gracing the occasion. I would like to take this opportunity and extend a very warm welcome to various delegates also who have come all the way from far and near to participate in the symposium.

Ladies and Gentlemen! We have assembled here this morning to pay tributes to Dr. R.R. Stewart on the occasion of his 100th birthday. Though his birthday actually falls on 15th April, nonetheless we have taken the liberty of organizing the Symposium in the last week of February, so that Dr. Stewart and other participants are not unnecessarily exposed to the hot and humid weather of Karachi.

Dr. Stewart joined the staff of Gordon College, Rawalpindi, in 1911 as Lecturer in Biology and retired as President Emeritus in 1962. After retirement he continued to work as Research Associate at the University of Michigan till 1981.

For about 50 years, Dr. Stewart collected plants in Pakistan and Kashmir. He left his herbarium, containing more than 60,000 specimens in Gordon College, Rawalpindi. Subsequently this herbarium was presented to Pakistan Agricultural Research Council, Islamabad, where, it is now part of the National Herbarium. The Pakistani Nation is certainly indebted to Dr. Stewart for this heritage, without which any progress in the evaluation of Plant Wealth of Pakistan would not have been possible or at least it would have been greatly hampered.

Not having studied at Gordon College, Rawalpindi, though I cannot claim to be a student of Dr. Stewart, nonetheless, I have had the pleasure of spending many summers in his herbarium and probably I am one of those persons who has benefitted most by his openheartedness, helpful and generous nature, his magnanimity and his kindness. All his manuscripts, notes and other materials, were always available to anyone who could be interested in such activities.

Ladies and gentlemen! One is really amazed to find out that Dr. Stewart published his first scientific paper in 1915 and his last paper was published in 1985. I understand that some of his recent manuscripts are yet to be published. Thus he had a long and productive career for about 75 years. But from the point of view of the Flora of Pakistan, 'An Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir', is the most important publication. The editors of the Flora of Pakistan had free access to it in the manuscript form from the early days and it has been used as a Check List for Flora of Pakistan.

I think that the work that has been done on flora of Pakistan, should be looked upon as an extension of the work of Dr. R.R. Stewart. In view of this, a brief resume of the work done on Flora of Pakistan, seems appropriate.

Ladies and Gentlemen! It may not be out of place to point out that the importance of the historical collections in taxonomic research can hardly be over emphasized. Unfortunately, the most important historical collections from our country are present either in India (Calcutta, Dehra Dun and Bombay) or in various European Herbaria: Kew, British Museum (Natural History) London and Edinburgh, being more important. Except for some odd duplicates no historical collections are in Pakistan. The conditions for writing a Flora of Pakistan could, therefore, scarcely be said to be encouraging.

Nonetheless, proposals for writing a Flora of West Pakistan were submitted in 1966-67 through the Agricultural Research Council to the United States Department of Agriculture under Public Law 480. These projects were separately awarded to Gordon College, Rawalpindi under the supervision of Prof. E. Nasir and to the Department of Botany, University of Karachi, under the supervision of Dr. S.I. Ali with the understanding that the 2 groups will work in collaboration with each other.

The editors have frequently visited European Herbaria in the course of editing the manuscripts. In addition we have tried to send draft copies of manuscripts to various experts all over the world. Many authorities and friends have responded to our requests and pointed out short comings and offered suggestions for improvements. Over the years, one such group, stationed at the Edinburgh Herbarium, comprising of Mr. B.L. Burtt (who now spends most of his time in S. Africa), Mr. I.C. Hedge and Ms. J. Lamond, has almost become a part of our own team. Almost all our manuscripts have been read and, from time to time, improved by them. It is a matter of pleasure to express our gratitude to them. Likewise we are grateful to the Directors and Curators of all such institutions which have helped us by sending the loan of herbarium specimens and other relevant materials to facilitate our study. I would specially like to express my indebtedness to Prof. Dr. K.H. Rechinger, former Director of Natural History Museum, Vienna, the Editor of the monumental Flora Iranica for helping us from time to time.

For the Flora of Pakistan the account of the first family was published in 1970. About twenty years later accounts of 190 families, involving 1129 genera, and 3480 species, spread over 4542 pages and accompanied by 832 plates, depicting 2048 species have been published. In all, 43 taxonomists belonging to 6 different countries and 16 artists (including 2 from England) have contributed. Including Pteridophytes, the accounts of families, involving 479 genera and 3029 species have yet to be completed.

Our present research project, which is funded by United States Department of Agriculture, through Agricultural Research Council, Government of Pakistan, will come to an end on 30 September, 1991. As this source of funding has now dried up, we do not know what will happen in future after 1991.

The Flora of Pakistan is a work of fundamental nature, concerned with the evaluation of the Plant Wealth of the country. As this type of information is extremely important for proper economic planning, it is logical to expect that fund would be made available, so that it may be possible for us to carry this work forward to its logical conclusion.

At the Department of Botany, University of Karachi, we have also tried to extend our work on the Chromosome Numbers of Vascular Plants of Pakistan, in collaboration with Dr. Peter Raven of Missouri Botanical Garden, through a research project awarded to us by National Science Foundation, Washington. Likewise our facilities for Chemotaxonomy, Electron Microscopy, Palynology and Numerical Taxonomy have been strengthened further in view of the linkage of our Department with the Department of Botany of the University of Reading. This linkage programme is being funded by O.D.A. through the British Council.

God has blessed Pakisan with unlimited natural wealth, mineral as well as biological. Unlike mineral wealth, which cannot be augmented along with time, the biological wealth, if nurtured properly, can certainly be augmented and improved. Carefully planned coordinated national policy for the protection and improvement of our natural biological wealth is the need of the hour. Protection of all the species is necessary because each species presents a unique genetic combination and a genetic resource once lost can never be reclaimed. Presently 90% of the total plant productivity is obtained from 12 species only and even now there is greater dependence on 4 cereals. In case we are going to adopt a futuristic approach, this base will have to be broadened. Under-utilized plants will have to be indicated, untapped genetic resources, so richly available in our country in the form of wild relatives of cultivated plants will have to be utilized. Along with the conventional methods, the modern technologies should be applied to reap the rich dividends. The economic aspects of the whole exercise should be highlighted so that the scientific researches are translated for the good of the common man. Thus further researches on various aspects of economic botany are clearly indicated.

In the end, I would like to express my gratitude to Dr. Stewart, who has taken the trouble of travelling all the way across three continents to be here with us this morning. We wish him a very pleasant stay in Pakisan. I am grateful to various other delegates also, who are representing very eminent organizations and who are known the world over for their scientific contributions, for participating in the symposium.

I thank you, Your Excellency for finding time to grace the occasion.

Proceedings of the International Symposium on Plant Life of South Asia held at the Department of Botany, University of Karachi, Karachi-75270, Pakistan. 24-27 February, 1991

Plant Life of South Asia, 7–9, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

WELCOME ADDRESS

MANZOORUDDIN AHMED

Vice-Chancellor,
University of Karachi, Karachi-75270, Pakistan.

Your Excellency the Governor of Sindh and the Chancellor, University of Karachi, Dr. R.R. Stewart, Professor S.I. Ali, Distinguished delegates, Ladies and Gentlemen.

I have great pleasure in welcoming you all to the International Symposium on Plant Life of South Asia. The symposium is being organized by our Department of Botany on the occasion of the Centennial of Dr. R.R. Stewart.

Our Department of Botany is one of the better staffed and most active departments of the Faculty of Science. It is certainly the best Department of Botany in Pakistan. Out of 22 members of the staff 17 have Ph.D. degrees to their credit. They have earned research projects which are funded by United States Department of Agriculture, National Science Foundation, Washington, Pakistan Atomic Energy Commission, Pakistan Agricultural Research Council, Pakistan Science Foundation, University Grants Commission and National Scientific Research & Development Board etc., involving a total annual grant of about Rs. 2.2 million and thus are contributing their share to the scientific progress and development of Pakistan.

The Department is academically linked with the Department of Plant Sciences of the University of Reading, U.K. Facilities for specialization are available in 6 different branches of Botany. More than 500 scientific research papers have already been published in journals of international repute by the staff and students of the Department.

Apart from other reasons, the Department of Botany has earned an international recognition for working upon the Flora of Pakistan edited by Professor E. Nasir of PARC, Islamabad and Prof. S.I. Ali. Taxonomic accounts of 190 plant families have been published, which have now become a standard source of reference on the Plant Wealth of Pakistan. The departmental herbarium has a collection of over 70,000 plant specimens collected from different regions of Pakistan for over 3 decades.The Plant Taxonomy Section has built up a unique collection of scientific literature on plants, which coupled with the herbarium has now become one of the best institutions for teaching of Systematic Botany in the country. In this section, facilities for advanced research are available in all the advanced disciplines of Systematic Botany, including Chemotaxonomy, Numerical Taxonomy, Cytotaxonomy, Biosystematics and Reproductuve Biology.

The Plant Taxonomists of Pakistan are fortunate to have had the guidance of Dr. R.R. Stewart, who has kindly left a rich heritage of more than 60,000 specimens that he collected between 1911-1962, for the benefit of posterity. This Stewart Collection is now housed in the National herbarium, PARC, Islamabad. The International Symposium on Plant Life of South Asia has therefore been organized to pay tributes to Dr. Stewart who, along with his daughter, has taken the trouble of travelling, more than 8000 miles in order to be with us today. It is a matter of great pleasure and privilege for me to extend a very warm welcome to him. I hope he has a very pleasant stay in Pakistan.

Your Excellency, we are specially grateful to you for kindly sparing some of your precious time for us this morning. I am well aware of the commitment of the present Government of Pakistan for removing the hunger and poverty from our midst and for improving the lot of the common man. In order to achieve this objective, it is imperative that we realise the importance of Science and Technology. Every segment of our existence, be it agriculture or industry, rural uplift or urban development, over-all improvement of our health, living and economic standards, all are contingents on advances in Science and Technology. The present Government, realising the key role that science and technology can play in national development, has committed itself to give a high priority to science and technology in the national scheme of things. We do sincerely hope that the Government would be able to spend at least 1% of GNP on Science and Technology sectors as recommended by UN agencies so that Pakistan may be able to march on the road to progress.

Sir, it is with some pride that I would like to inform you that the number of research projects which have been assigned to us or completed by us for various national and international agencies far exceeds all the efforts in this field by sister universities. This speaks of the calibre and potential of our research scholars. The number of M. Phil./Ph.D., produced by this University so far stands at over 600, which is far above the total of all the other Universities of Pakistan.

I am very happy that, apart from the Pakistani participants, about 30 delegates from 13 different countries are also participating in the Symposium. I am sure scientific deliberations at the Symposium will be mutually beneficial for all the participants and the seeds for further collaborative research so very essential for fruiting of new ideas will certainly take root. I hope the distinguished botanists will enjoy their stay in Pakistan and if possible, they may also like to visit various parts of our country, which, being biologically so variable and culturally so rich offers many unique attractions.

In the end I would like to thank you, Your Excellency, once again for kindly gracing the occasion. I think that Professor S.I. Ali and other members of the Organizing Committee should be warmly commended for the excellent job that they have done. Likewise I would like to congratulate Dr. Stewart on the occasion of his 100th birthday with all the good wishes for continued health and happiness.

Welcoming all of you Ladies & Gentlemen, I thank you.

Plant Life of South Asia, 11–13, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

INAUGURAL ADDRESS

FAKHRUDDIN G. EBRAHIM

Governor of Sindh,
Sindh Secretariat, Karachi, Pakistan.

Dr. R.R. Stewart, Dr. Manzooruddin Ahmad the Vice-Chancellor, Dr. S.I. Ali the Dean Faculty of Science, distinguished delegates, ladies and gentlemen.

I am glad to know that the International Symposium on Plant Life of South Asia has been organized on the occasion of the Centennial of Dr. R. R. Stewart. I understand that Dr. Stewart came to our country in 1911 and worked here for about 50 years as an educationist, botanist and a social worker. He started teaching Biology to the students of Gordon College, Rawalpindi in 1911 and in 1962 he retired as President Emeritus of the College. Thousands of his former students still remember him for his love and for his willingness to discuss and solve the problems of his students. Dr. Stewart headed many social organizations during this period and came to the rescue of people of all walks of life, particularly immediately after the creation of Pakistan when his services were probably needed most.

The services of Dr. Stewart as a Professor and plant explorer are no less outstanding. For about 50 years he collected more than 60,000 samples of the plants growing in various parts of Pakistan and Kashmir. This rich collection of plants, housed in Gordon College, Rawalpindi, has now been shifted to Pakistan Agricultural Research Council, Islamabad, as part of the National Herbarium. Pakistani Nation is grateful to Dr. R.R. Stewart for this valuable donation.

Though over the years he has published many books and research papers in reputable journals, his most outstanding contribution, which took him more than 10 years to complete, is 'An Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir' (1972). His last paper was published in 1985, indicating that Dr. Stewart is still actively engaged in research. I would like to congratulate him for his outstanding achievements and wish him continued health and happiness.

It is indeed gratifying to know that the foundation laid by Dr. Stewart has been used to good advantage by Professor E. Nasir at Islam-abad and Professor S.I. Ali at Karachi, the editors of the Flora of Pakis-tan. This magnus opus, which is spread over 4524 pages, is a publication of lasting value and will be referred to for several centuries. It is certainly a very important achievement for the country itself, being a basic tool for botanical, environmental, agri-silvicultural investigations in Pakistan. This major scientific and technical achievement, to a very large extent a national undertaking, carried out by Pakistani botanists, deserves our unrestricted admiration. I would therefore like to congratulate Professor Nasir and Prof. Ali for their concerted achievement. I hope that the work on Flora of Pakistan and other related projects at the University of Karachi will continue so that an authenticated account of our Plant Wealth is available for proper utilization of our natural resource.

I am conscious of the fact that modern scientific education and research has become very cost intensive and our universities and research organizations need greater inputs in order to upgrade their laboratories. Though the National Commission for Science & Technology was created in 1984 according to the approved Science Policy, but the former Government kept it in cold storage for 5 long years. The first meeting of the Commission for Science & Technology was held in March 1989. We are also following a liberal policy by sending scholars every year for higher studies in frontier sciences. Efforts are also being made to launch a revitalised Science Policy that is in conformity with the aspirations of the intelligentia of Pakistan. The present peoples Government has adopted a liberal policy for the promotion of science and technology within our limited resources. Nonetheless, in a country like Pakistan where democracy is still taking roots, we are faced with many cons-traints. In this connection, two things seem necessary. We must use our national resources as judiciously and profitably as possible, avoiding unnecessary wastage. Secondly, the private sector should also come forward to share the responsibility, so that the Pakistani Nation is able to reap the harvest of modern technological advancements.

Ladies and Gentlemen! The other day I had the privilege of presiding over the University Convocation. I know that the Faculty of Science is fairly active, inspite of various obvious constraints, in the field of research, as exemplified by the research degrees earned by the students. It is also gratifying to know that the Faculty Members are participating in various nation building and constructive activities by tackling various research projects, that they earn in open competition, from various international and national agencies. The Department of Botany, in this connection, deserves special praise for having done some excellent work under the guidance of the Dean, Dr. Ali and the Chairman, Dr. A. Ghaffar.

I am glad to know that about 30 plant scientists from 13 different countries are also participating in the Symposium on Plant Life of South Asia. As a result of interaction between the botanists from different countries many new ideas will be generated and many new strategies will be evolved in order to expand the frontiers of knowledge further. I would like to assure you that my Government will give serious consi-deration to the Recommendations and Suggestions that you may like to put forward at the end of the Symposium.

In the end I would like to congratulate Dr. Stewart on the occasion of his 100th birthday and wish him continued health and happiness. I wish the participants of the symposium every success in their deliberations.

With these words, Ladies and Gentlemen, I am pleased to inaugurate the Symposium.

Dr. R.R. Stewart with Prof. Dr. S.I. Ali
at the International Symposium on Plant Life of South Asia

Plant Life of South Asia, 17–23, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

REMINISCENCES

R.R. STEWART

*1420 Santo Domingo Ave;
Duaste, Calf., 91010, USA.*

I consider myself to be very fortunate person not only because I have had a long life and at 100 am still able to read and write all day and am as interested as I ever was in what goes on in the world. I have a wide correspondence and am not lonely. I only had two daughters, Jean Macmillan Stewart Andrews 1919-1970, born at Sialkot and Ellen Reid Stewart Daniels 1921-????, born at Jhelum, so I do not have any Stewarts to follow me but I have six grandchildren and 6 great grand children.

I am fortunate in that I have had opportunities that none of my forebears have had. I am the first in my line to have gone to college, travel and become a scientist. My father's older brother was the first to become a minister and missionary. My father had to go to work at 18 and did not go to a State Teachers college until he was 31 and never had a degree, only a certificate. I grew up on Manhattan Island, New York City and could live at home and go to Columbia University. My father grew up where there were only primary schools with a three or six month term each winter.

The various honours and distinctions I have received while abroad were largely because I was in the right place at the right time and because I was a layman and not a clergyman. My "call" to the Mission field was for a specific job. The young Gordon Mission College of the U.P. Church in 1911 needed some one to teach elementary Botany and Zoology to Pre-med students. I at that time only had a Bachelor's degree and the Punjab University did not require a masters degree for that post.

At this time the flora of this part of India and the Western Himalayas was not well known so the opportunities for Plant research were limitless. Kashmir was only 200 miles away, Western Tibet was only 400 miles away across the main Himalayan Range. Europeans had to spend large sums to get to Kashmir to start their exploration. The first three times I went to Kashmir on a push bike though the third time a British officer gave me a lift part way. I went as far as the capital of Kashmir on my push bike and crossed into Western Tibet on foot at a cost of two or three dollars a day in 1912-13 and 1917.

I collected plants every summer I was in Gordon College between 1912-1959 without grants from any one, only supplementing my regular salary by occasionally selling duplicate plant specimens at 10 cents a specimen. In 1962 after retirement I returned to Pakistan to collect plants for six months at the expense of the U.S. National Science Foundation.

My academic career before going to college was undistinguished. Athletically at Columbia I was also very ordinary only getting a few medals for running but failing to get the coveted "C" to wear on my sweater. In class work, however, I did not find it difficult to get and take more courses than required each semester so that I could graduate in three years. Not wanting to graduate with our rivals, the class of 1910, I finished 1910 with 120 points instead of the 124 required for graduation. In 1910 I was the only one of the class of 1911 to be elected both to Phi Beta Kappa, the Arts, and sigma Xi, the Science Honorary Society. I was chosen the most faithful and deserving student in the class and given $50.00 as prize.

In 1910-1911 I took a course to obtain four more credits to graduate and also took all of the courses required for an M.A. degree, but I did not get the sheepskin until 1915 after returning from India after three years of teaching. In summer of 1916 I obtained my Ph.D.

My wife Isabelle Caroline Darrow M.Sc. and I were appointed to be full members of the United Presbyterian Mission in India and I was given a Cutting Travelling Fellowship. Post doctoral students usually used a fellowship to go to Europe, but I requested permission to use it to travel, collecting plants in India.

This was during World War 1 before the U.S. had become directly involved and the Mediterranean was a war zone. The Foreign Board could not send the 1916 party back early enough for me to get to Gordon College for the September opening of college so they had to appoint another to teach for the year 1916-17 making it possible for me to use my Cutting Fellowship to collect plants. Belle and I were able to collect industriously in the plains in the winter, and then in the lower hills. We went higher as the Spring progressed. This does not appear like a preparation for missionary college work now but my idea was to know my subject so well that I would be an expert along my line and fitted for research work. It turned out that before long, little Gordon College had a better plant collection than the Punjab University Lahore. After some years the Punjab University gave me an honorary D.Sc. The first foreigner to be given the degree.

The Punjab at this period was still in India and about 1938, in their annual honours awards I was given a Kaisar-i-Hind (Emperor of India) gold medal. These medals were given for medical and other forms of civilian activities. The governor distributed the medals to those of us living in the Punjab. (My father was given three tickets, and mother and I were able to go. It was a very grand affair. Everyone else was in dress uniform and the ladies wore colourful evening gowns. Father stood out in his black academic gown. I was proud of him. Ellen).

This research work in plant taxonomy which I started is still being carried on vigorously in two centers. One in Islamabad, the new Pakistan capital and the other in Karachi in Sindh. My work would probably have died in 1960 when I retired at 70 but Prof. E. Nasir a student who studied botany for four years in Gordon, got an M.Sc. in Allahabad, came back to Gordon as lecturer and in 1960 when I left took over my work in biology and I gave him the 50,000 or so specimens which I had accumulated since 1912 by collection and gift. Over the years I had done a great deal of collecting and Nasir was on his own and when I left, it all became his responsibility to look after what is now called the Stewart Collection. It looks as though the good Lord knew that he needed help quickly for at that juncture somebody at the U.S. National Science Foundation thought up something more remarkable than anything we could have dreamed up. The U.S. Govt's had a lot of blocked funds in Pakistan that could only be used in Pakistan. Someone thought that it would be good for U.S. agriculture, business and medicine to bring as much plant material as possible to Beltsville, Md., where it could be studied and if found promising in anyway, more could be imported for testing. I do not know who advised the Americans appointed to implement the scheme in Pakistan but they decided that the best taxonomists in Pakistan to collect Pakistani plant materials and send out collectors were Prof. E. Nasir in the north and S.I. Ali in Karachi in the southwest. Money was given to buy each one a jeep, and other necessary materials plus travel expenses. Annual reports were sent to the U.S. along with specimens which had a reputation for usefulness, until, Beltsville found out that the law of diminishing returns indicated that the collecting should stop. This was I think in 1970.

The Department of Agriculture then decided that Pakistan needed a Flora, which I had realized in 1911 when I was 21 and my collecting from that date and that of Prof. Nasir when he joined me was to gather specimens which would be necessary for a flora. A flora is an inventory or census of the plants of a region which is a pre-requisite for plant geographers who need to know the distribution of plants. Many people also need to know where supplies of useful plants are available.

Profs. Nasir and Ali had done such good work for ten years that they were selected to be Joint Editors of the proposed flora. That was 20 years ago and they are still at work on it. They have had endless difficulties chiefly because most assistants they employed have left Pakistan to get better pay in oil rich countries. So far about 190 fascicles have been printed and distributed to the botanical libraries of the world. Prof. Nasir's son Yasin got his Ph.D. in Karachi and has worked with his father and succeeded him as Director at Islamabad.

My share has been the publication of two general volumes. The first being published in 1972 and the second in 1982. The work has gone slowly because, unlike India, Pakistan has few capable botanists. India has hundreds but they choose fields which are too narrow. India needs a flora for the whole country but Indian botanists are working on 40 local floras. It is more efficient for a good botanist to write a monograph of the rose family, let us say, for the whole country than to study all of the families for a local flora. If the rose family for the whole country is completed the local flora people can modify it easily for use in their local floras.

The flora which Nasir and Ali are preparing will provide Pakistan with a National Flora long before India will have one.

After I retired from Pakistan the Government gave me in 1962 a Sitara-i-Imtiaz, (Star of Distinction) for my educational and botanical work.

In 1963 Alma College, The Presbyterian College in Michigan gave me an Honorary L.L.D. the citation is as follows:

"As a token of our esteem for your long and distinguished career as a scholar and teacher of botany and for the significant contributions which you have made to man's greater understanding of the world of Nature;

In grateful recognition of your pioneering missionary work in India which you so faithfully performed for over more than half a century.

As a symbol of our respect for your achievements as the Principal of Gordon College of Pakistan and for your unfailing devotion to the mission of the Church in higher education among our fellowmen in distant lands;

Now, therefore, the Board of Trustees of Alma College confers upon you, Ralph Randles Stewart, the Honorary Degree, Doctor of Laws, 'honoris causa'".

In 1984 the American Association for the Advancement of Science asked me to become a member but as I think there are 200,000 more with this honour I should not go out and get a new that though I was pleased. The new Indian Fern Society of 50 members asked me to be a honorary foreign member. The Pakistan Academy of Sciences also made me a member about the same time.

Most of us like to be recognized and honoured for some little triumph. We like to have a place in a book of records, to have hit more home runs, to have run faster or made more points in a single game than any one else. Botany has a way of honouring many thousands of us devotees. The early bees find the honey and are distinguished in several ways. The commonest way is by having a plant named after you. The first Englishman to collect plants in Western Tibet was a Veterinary surgeon named Moorcroft. He collected about 28 dried specimens of plants in 1820, made a little bundle and sent them to Wallich in Calcutta. A number of his specimens were new and are named after him e.g., *Gentiana moorcroftiana*. Botanists who are the first to collect in a region may have a large number of plants named for them. It is not quite the thing to find a new species and to call it after yourself, but it is alright to let a friendly botanist draw up the description of the plant and name it for you. The first botanist to prepare the description of a new species and publish the new name with a Latin description places his name after the name of the plant. If you see in a list of names *Rosa alba* L., or Linn., it means that Linnaeus was the first to describe it. Some pioneers in a country who are professionals and describe new plants year in and year out have their names after hundreds or thousands of plants. Some pioneers do not leave many plants for later botanists to name.

I had the advantage of being first or one of the first in some areas and have a good many species named *stewartii* or *stewartiana*. The author often names his plant for the place where it was found or for some peculiarity of the plant, *alba, purpurea, gigantea, tenuis* etc. If you should today discover a new species in Scotland or New York State it would be a noteworthy event but there are still tropical areas where there are many underscribed species waiting to be discovered. Some groups of plants are much better known than others. If you want to find a new fern it is much more difficult than to find a new moss or fungus. If instead of collecting flowering plants diligently in Kashmir I had spent my time in looking for mosses, plant diseases like rusts or fleshy fungi I could have found more new species, but I felt that it was much more important for the pioneer collector to learn the trees, shrubs, vines and flowering herbs first. Still knowing that they might be new I did collect a great many mosses, rusts and smuts. I don't think that I collected any new smuts but did find a good many new rusts and mosses because they took little room in a plant press.

I sent my rusts to Drs. Arthur and Cummins at Purdue University and they published the names in Mycologia. What is the use of such collecting? One never knows. I can show that it may be very important. One day I got a letter from an Indian mycologist. He wrote that he had read in Mycologia that I had found a rust in Gulmarg on a gooseberry. "Can you tell me exactly where you found it"? I told him and he sent some one to gather fresh material. He injected the spores into the blue pine, and the rust which was damaging the blue pines developed. He solved his problem with a little help from me. He had been trying to work out the life history of the fungus damaging these Himalayan pines and had read that the alternate host of the rust damaging the American white pine came from a gooseberry. I remembered that many years ago people from Cornell were eradicating the wild gooseberries in Northern New York where I was living to save the pines. The Indian knew this American discovery and my finding diseased gooseberries in Gulmarg may have been of economic as well as biological importance by proving that spores from gooseberry rust infect pines as barberries develop the spores causing wheat rust.

I did not have such good fortune with my mosses. Mosses are not of much economic importance but are of some value as soil builders, causing rocks on which they grow to decay. They are small and often numerous in moist areas. Few grow in dry areas. There are thousands of kinds and those who specialise in them are called Bryologists. Mr. H.N. Dixon was the English expert on Indian mosses. About 60 years ago I met him at Kew and he said that he would name my mosses. I kept my eyes open and from time to time sent him packets of fruiting mosses. He kept part of each packet and returned duplicates named and quite a few species were reported to be new genera. I felt pleased.

After retiring I went to work at the Herbarium of the University of Michigan and as they have a great deal of moss literature I thought I would look up Dixon's papers. I could not find them. I asked a Bryologist for help and he found that only one of my "new" species had actually been published. I asked Prof. Nasir to send the duplicates to a new expert to have him see if some one had found these mosses in the last 50 years and do what is necessary if they are really new.

Being able to add to scientific knowledge and discover new species brings satisfaction and I think that what Prof. Nasir and I have done in making a national collection without any effort on the part of Pakistan must be unique. India inherited the Botanical Survey of India which started 200 years ago near Calcutta. It is supposed to have the largest plant collection in Asia. It has a large staff and a publishing department which has been active over the years. Pakistan does not yet have a Botanical Survey.

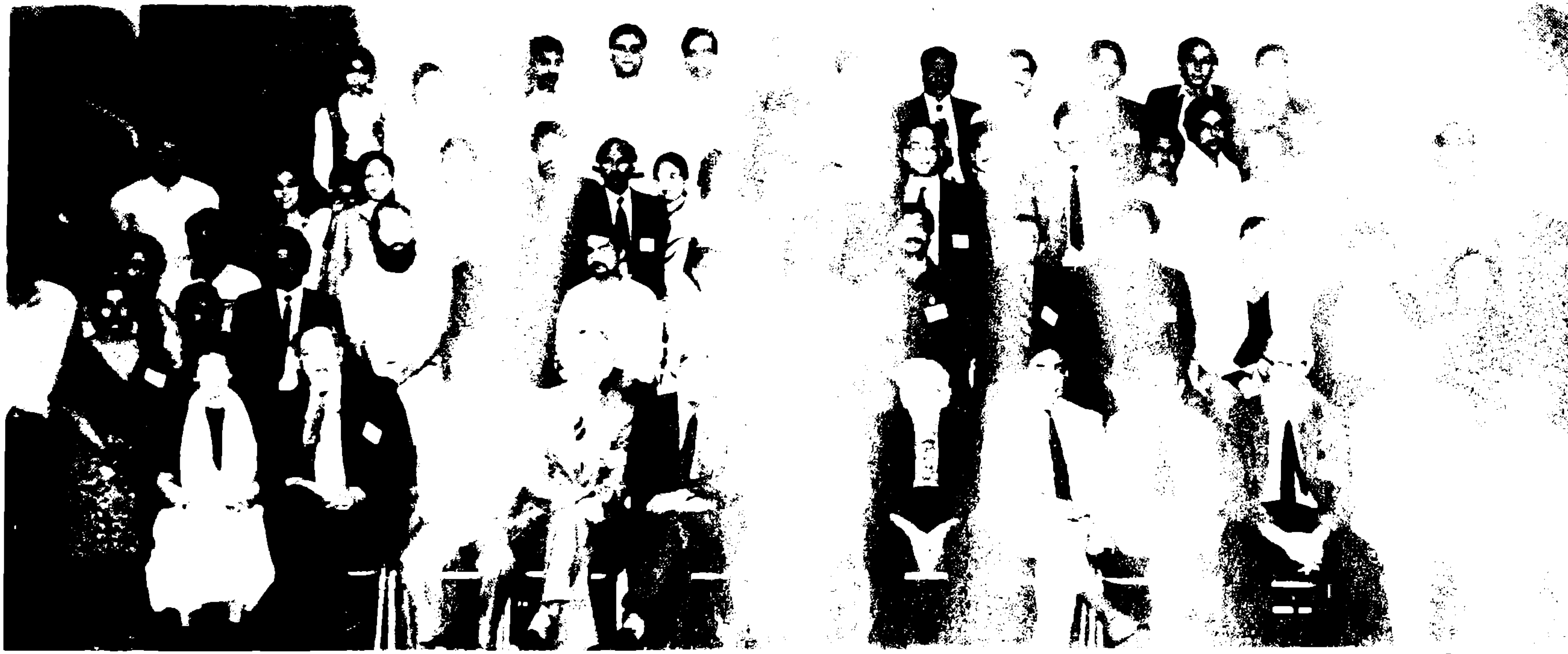
How did Prof. Nasir and I came to give this herbarium to the Government of Pakistan? It is a long story which I will try to condense. It was started for my own use in 1912. A tiny college with less than 100 students does not need a herbarium. A forestry or agricultural college and a University with graduate students needs one but the Punjab University in Lahore has never had a good herbarium. I started mine in a dressing room off my office in one cupboard. I knew so little about the names of Rawalpindi plants that I kept a specimen of each plant I named so that months later I would not have to look it up all over again.

Collecting every year hundreds of specimens added up and needed more room than the dressing room so I took the specimens to my Botany department office and years later that became too small and part of the collection was put in the Biology Museum and adjacent laboratory where it was when I retired in 1960.

I was the Principal or Vice Principal from 1934-1960. The question of who owned it was never raised though it was called the Gordon College Herbarium because it was there and it was used by the staff. When I left I gave a paper to Prof. Nasir stating that it was his and he continued to use it. When Pakistan nationalized the Christian colleges and it was getting near Prof. Nasir's time to retire there were new problems. In 1970 Prof. Nasir began to work on the Pakistan flora financed by the U.S. National Science Foundation using what had been my specimens as a foundation.

There was an unfinished Mission building near the college athletic field and Prof. Nasir moved the specimens to this building away from the bustle and noise of the college labs. Then we began to wonder about the future of the collection. The new Principal, Prof. Masud wanted the collection left at the college for reasons of prestige. The Christian who succeeded Nasir as head of the Botany Department at Gordon would have liked, no doubt, to be given charge of the collection but Nasir and Ali needed it for their preparation of the Pakistan flora which was being financed with U.S. money. After consulting with Dr. Tebbe of the U.S. Mission we decided to offer the Herbarium to the Pakistan Government and they accepted it. Prof. Nasir and his son have now been working away for 20 years on the flora and E. Nasir and I have the distinction of giving a National Herbarium to a sovereign nation.

In[illegible]atic[illegible]al Symposi[illegible]nt Life of [illegible]outh Asia



1st Row L-R: Mrs. Ellen-Stewart Daniels, Dr. J. Duke, Prof. Dr. Y.C[illegible] Dr. H. [illegible] Prof. Dr. S.S. Bir, [illegible] Dr. S.I. Ali, Prof. [illegible] Dr. S.Z. Husain, Prof. Dr. M.S. Khan, Mr. A. Radcliffe-Smith, Prof. Dr. K.H[illegible] Mrs. W. [illegible]

2nd Row L-R: Mr. L. Ahmed, Miss. Z. Zia, Dr. K. Khatoon, Dr. K[illegible] Raza, [illegible] Hussain, Dr. S. [illegible], Dr. J.H. Kir[illegible] Suleman, Dr. Mrs. A.S. Seneviratne, Dr. Imtiazul Haq, Dr. Ansar-ul-Kar[illegible] M.R. Sidd[illegible] S.R.A. Shamsi, Prof. T.C. Hedge, Mrs. [illegible] Khatoon.

3rd Row L-R: Mr. G.R. Sarwar, Mr. S.I. Jafri, Miss F. Agha, Mis[illegible] Miss Z.A. Razzaq, Mr. T. Ali, Prof [illegible] Jalal, Mrs. A. Jahan, Mrs. W. Anjum, Dr. A.R. Beg, Prof. Dr. M. Qa[illegible] Ahmad, Mr. Manzoor Ahmed Malik, [illegible] Khan. Mr. R.Y. Hashmi, Mr. S.R. Zaidi, Mr. A. Ghafoor, Prof. Dr. J. Ahmed

4th Row L-R: Miss R. Ansari, Mrs. T.H. Siddiqui, Miss B. Jah[illegible] Khan [illegible], Mr. A. Shahzad, Mr. A. Rashe[illegible] Dr. Y.J. Nasir, Mr. Sadruddin, Mr. S. Omer, Mr. M. Ahmed, Mr. M. Habib.

OVERVIEW

Plant Life of South Asia, 29–38, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

THE GENESIS AND RESULTS OF SOME SW ASIATIC FLORAS

I.C. HEDGE

Royal Botanic Garden,
Edinburgh EH3 5LR, Scotland, UK.

ABSTRACT

The tremendous activity of Flora writers throughout the world from the middle of the 20th century onwards is, in a historical context, one of the main features of whole-plant botany at the present time. The earliest Floras historically were little more than lists of plant names within a given area. Today the best of modern Floras are sub-monographic in content. Several major SW Asiatic Flora projects were initiated in the 1950s and 1960s. The progress of some of these Floras is reviewed, including that of Pakistan. Comments are made about the necessity for local botanists to build on and develop the basic information that Floras provide. The importance of a good Flora for all aspects of botany cannot be over-emphasised, but it always has to be regarded as a stage in botanical knowledge, not an end-point in itself.

THE FIRST FLORAS

Before starting to talk about some of the SW Asiatic Floras of the present time, it is relevant to say a little about the origins of Flora writing in general and to mention some of the earliest known Floras, whether or not they were designated by the term Flora. It is difficult to specify the earliest known Flora, and by that I mean a scholarly botanical guide, of one kind or another, to the plants that grow in a particular area. But two of the earliest date from the 16th century. They were by the Dutchman Carolus Clusius: one was the first Flora of Spain and Portugal published in 1576 as a 'result of his travels there in 1563-65'; the other deals with the flora of Austria and adjacent parts of what we know today as Hungary. It was published in 1583 and dealt not only with native species, but also with such ornamentals as Tulips, Lilies, Fritillaries, even some American introductions such as *Solanum* and *Mirabilis*. Stafleu (1967) suggests that this remarkable work of Clusius set a standard for many years to come because of the accuracy of its descriptions and in the precise indication of localities. Clusius did not use the word Flora in the title of these two books but there is no doubt that they are Floras as we understand them today and that the origins of Flora writing go back more than 400 years.

Just as it is difficult to pin-point the earliest known botanical guide to the plants of an area, so too is it difficult to specify who first used the term Flora for such a guide. One strong candidate is Simon Paulli who published *Flora Danica* in 1648. From then on till Linnaeus's time there were a number of Floras produced such as Ruppius, *Flora Jenensis* (1718) — the area of Jena in E Germany; there was also Breyne's *Flora Capensis*, S. Africa — of 1724, but this was a collection of paintings, not a botanical treatise. So although one tends to think of Linnaeus as the initiator of most aspects of modern botany, including Floras, in fact he was just one botanist, certainly a most excellent one, in the ever-continuing progress of botanical knowledge. But it is true to regard Linnaeus's *Flora Lapponica* of 1737 as an important landmark in Flora writing. The nomenclature here, being pre-*Species Plantarum*, is of polynomials, but otherwise its contents are relatively modern. Synonyms are given, as are details of habitat; cryptogams are also dealt with.

At this point it is worth mentioning that it is very helpful for present day botanists to differentiate between a published (book) Flora and the general term for the vegetation of an area by using a capital "F" for the book and a small "f" for the vegetation. Because the term Flora derives from the name of the Roman goddess of flowers, it is understandable that the earliest botanists considered all the plants growing in an area and did not differentiate, as we do today, between native and cultivated plants. To them, both were a natural part of what they were describing. Thornton's beautiful *The Temple of the Flora* (1799) is a rather later post-Linnaean example being "Picturesque botanical plates of the New illustration of the sexual system of Linnaeus". During and after Linnaeus's time the number of Floras (with a capital 'F') published greatly increased. And most of the basic or initial Floras of Europe date from this time, such as the earliest British Floras. I'll come back later to the fact that although the first British Floras go back 200 years and more, throughout those 200 years new and improved Floras have been, and still are, being written. The last word on British flora has certainly not been written. New information always has to be incorporated.

Although it is bad taxonomy to attempt to classify Floras into historical 'taxa' — they all intergrade — it is useful for the purposes of this short talk to recognise three main eras: that of pre-Linnaean and Linnaean Floras, already dealt with; the Victorian era covering the mid 1850s to the end of the century; and the era of the present time from the mid to the end of the current century where the relevant modern Floras of SW Asia are considered.

THE VICTORIAN ERA

So turning to the 19th century and the Victorian era, this was a time of numerous Flora productions. These Floras dealt mainly with comparative morphology and little attention paid to such present-day facets as nomenclature, typification, citation of specimens, ecology or cytology. George Bentham was one of the great botanists, polymaths and writers of that time and two of his Floras, *Flora Hongkongensis* (1861) and the massive 7-volume *Flora Australiensis* (1863-78) set the standard for many of the subsequent Floras, especially those emanating from Kew. Bentham (1874) made several very pertinent comments about Flora writing, which are just as relevant today as they were in his time. For him "The principal object of a Flora is to enable the user to determine any plant in the area dealt with"; and, "any tyro can draw up a long description of specimens, but selecting the characters necessary to give a good idea of a species in a short description requires a thorough knowledge of the subject and a methodical mind". Simplistic maybe but very true and honest. Well, I'm not sure how Bentham would assess our present-day Floras — certainly our descriptions have got very much longer — but he undoubtedly set a very high standard of description in all his works both as sole author and those he co-authored with Hooker, especially *Genera Plantarum* (1862-83) of which he (Bentham) wrote the greater part. An interesting side-light on Bentham's dedication to botany is provided by the following contemporary account of his working habits when he was over 80 years old — "after more than a year's constant uninterrupted work on the orchids [for *Genera Plantarum*], he concluded his revision of that difficult order late one Saturday afternoon; but without pause, knowing that the grasses, a still more arduous task, remained to be undertaken, he simply bade an attendant bring him the material for commencing this last great portion of his work and immediately began"! Kew at his time was, as it is today, one of the main world centres of taxonomic research, but at Geneva Edmond Boissier was laying the foundation of a work that was to so greatly influence the progress of botanical knowledge in SW Asia: the monumental *Flora Orientalis*. The first volume was published in 1867, the final fifth volume in 1884; and a posthumous supplement in 1888. Boissier in his lifetime described almost 6000 new species (Burdet, 1985), a high proportion from the *Flora Orientalis* area, and it is a tribute to his excellence as a botanist that so many of these species are still maintained today. In almost all human activities, progress in any subject mainly results from improving on what has gone before — whether it is political economy, motor cars, football or washing machines. This generalisation is, I think, especially true in taxonomic botany. Linnaeus, De Candolle, Bentham, Boissier and the Hookers provided the solid and accurate framework that their successors could build on. The process still, of course, goes on. As far as SW Asia is concerned, I think all workers on the flora (with a small "f") have been particularly fortunate that Boissier's *Flora Orientalis* covered such a wide, relatively natural area, that is was such an accurate work and, not least, that the *Flora Orientalis* specimens at Geneva have been, and are, so well curated. The fact that there is so much compatibility in taxonomic concepts in the various modern Floras of SW Asia owes more than a little to the concepts of Boissier. Truly, he was a giant.

THE SW ASIATIC FLORAS OF TODAY

In moving on to the third of my Flora eras we come up to the present day. It is probably true that the period from about the middle of the 20th century onwards has been the greatest, or at least most productive, of the three eras as far as floristic activity is concerned. Throughout the world a huge number of Flora projects have been under way — whether in Europe, Asia, Africa or the New World. And if in a few hundred years time, there are still botanists around, I would have thought that a botanical historian would regard the present Flora-writing activity as one of the main features of whole-plant botany in the 20th century. Some of these Flora projects have been, or are, enormous. *Flora URSS* completed in 1964 deals with over 17,000 species of flowering plants of which about 1500, or 10%, were described as species new to science during the 30 or so years of the project (Shetler, 1967). The main Flora of China (*Flora Reipublicae Popularis Sinicae*) will, it is estimated, treat c. 28,000 species of vascular plants. It involves over 200 Chinese botanists and the intention is that, with the first volume published in 1959, the project will be completed in 80 volumes before the end of the century. It is interesting to ponder the fact that these two colossal Flora projects have been financially supported by communist-socialist governments. And in comparison, most Flora projects elsewhere in the world are under continual financial stress and have to look to many varied sources for funding. More specifically, 2 of the richest countries in the world, America and Saudi Arabia, have no Floras — nor have their governments shown any inclination to finance such projects. An interesting comparison between East and West. Send a man to the moon, or invest x-millions in a new oil well — but why spend money on understanding plants?

Turning now more specifically to SW Asia Floras of the present time, there are three that I would like to consider briefly — *Flora of Turkey*, *Flora Iranica* and *Flora Pakistan*. For me, the genesis of any Flora is always an interesting topic. And the genesis of these three particularly so in that all of them owe their inception and development to an individual — not to a government, or an institute or an advisory committee. The names of Peter Davis, Karl Heinz Rechinger and Ralph Stewart are almost synonymous with *Flora Turkey*, *Flora Iranica* and *Flora Pakistan*. In a similar way, Komarov is synonymous with *Flora URSS*, even though it was completed long after his death; as is Father Mouterde with *Nouvelle Flore du Liban et de la Syrie*.

Peter Davis once said that "the idea of of writing a Flora of Turkey arose fortuitously as a personal and optimistic vision". When he was 20, he botanized in 1938 in mountains of W Turkey where a century earlier Boissier had botanized. From that first visit was born his fascination with the plants and vegetation of Turkey. After the war he took his degree at Edinburgh, acquiring various gold medals on the way, was appointed a lecturer in the Botany Department of the University in 1950, and soon thereafter started on the first of his ten major plant collecting trips to Turkey; these yielded c. 27,000 specimens, frequently collected in triplicate or even quintuplicate (Davis & Hedge, 1975). Some of these expeditions were very long. In 1957, I travelled with him for almost 7 months; he was not the easiest and relaxed of travelling companions, but certainly was an outstanding collector. By the late 1950s, sufficient herbarium material had been assembled to make writing a Flora a realistic goal. Both at Edinburgh and Basel, where Dr. A. Huber-Morath had independently built up another major Turkish collection from his many journeys in Turkey. In 1961, with the aid of financial support from the then Department of Scientific & Industrial Research, Davis was able to set up a small team of 2 full-time research assistants based at the Royal Botanic Garden, Edinburgh. There was much close co-operation with the Garden, at that time a government department, and without that support it is doubtful if progress on the Flora of Turkey would have been so fast and so smooth. Throughout the whole project this mutually beneficial and happy relationship continued. The first volume of the Flora was published in 1965 by Edinburgh University press, the last volume, vol. 9, in 1985. A supplement vol. 10, dated 1988, was largely prepared and edited by Davis's last two research assistants, Robert Mill and Kit Tan. The bare statistics are that c. 8800 species were treated in 9 volumes published in a 20-year period — i.e., over 400 species each year. Although Boissier's *Flora Orientalis* was the skeletal framework from which the Turkish Flora was built, the *Flora of Turkey* was, as *Flora Iranica*, an original piece of research; it is very far from being merely a compilation of what was previously published. Dr. Mill has recently estimated that in the period 1945 to now the total number of new species described from Turkey was 1332; that is 15.5%. Even allowing for c. 150 names that have subsequently been reduced either to synonomy or changed in status the percentage is still as high as c. 13.5%. Endemism is very high.

Well, so much for the genesis of the *Flora of Turkey* and its neat almost metronomic progress to completion. What about the results? Was the enormous amount of time, labour and money expended worth it? One result of paramount importance is that scientifically we know incomparably more about Turkish plants than we did 25 years ago. Another is that Turkey now has a large number of competent local botanists at Universities throughout the country who are the next generation of research workers on the Turkish flora. I remember how in the late 1950s Turkish taxonomic botanists were very thin on the ground. Then as the Flora progressed more and more young Turkish botanists came to work at Edinburgh and make use of our facilities. Contacts and friendships that still continue. Whole-plant botany in Turkey is certainly alive and well. Not just in taxonomy, but in forest botany, conservation, cytology, biosystematics, phytosociology and phytochemistry. But although there is now such a solid core of botanical expertise in Turkey, there is still no national herbarium which, with associated laboratory and library facilities, should be the main focal point for reference and associated research. Such a national herbarium should be an integral part of botanical research in any part of the world.

The main reason I've said quite a lot about the Turkish project is not just because it is historically interesting, but because several aspects of it are relevant to taxonomic botany in general and Flora writing in particular. I may be biased, I probably am, but I think the Flora project was in many ways a model and the Flora itself a model of what a modern scientific Flora should be. It has a succinct format, it is easy to use, the observations about species are informative and, importantly, the Flora was completed within the estimated time-scale. In some other parts of the world, admittedly with larger numbers of taxa to deal with, there are Floras that seem destined to be completed, at worst or best, by our great-great-grandchildren-by which time a lot more of their species will be extinct. *Flora of southern Africa*, *Flora Malesiana* with its monographic but unrealistic format, *Flora tropical East Africa* (started almost 40 year ago), *Flora Thailand* are some examples. And when is Hooker's *Flora of British India* going to be superseded by the completed *Fascicles of Flora of India?*

I am only going to say a little about *Flora Iranica* because Professor Rechinger has already talked about it. But I would like to emphasise just how much a 1-man 1-woman (his wife Wilhelmina) Flora this is, and has been. Since the first very slender fascicle appeared in 1963, *Flora Iranica* has developed into another of the truly major Floras of our time. One of the most recently published families the Caryophyllaceae (No. 163) is a case in point. It deals with over 450 species, probably about 1/4 of the global species total and is a major contribution to our knowledge of the family; endemism in some genera, e.g., *Silene*, is as high as 40-60%. Considering that Rechinger would have been an important historical figure if he had stopped publishing 1/4 century ago, it is astonishing that he started on the first of his major Flora Iranica collecting trips when he was over 50 (Rechinger, 1989) and embarked on a Flora which covers about 10,000 species when he was in his mid-fifties! Of course, he has had much co-operation from botanists throughout the world who have written accounts. Already in 1990 over 8,000 species have been treated. One criticism that can be made of the *Flora of Turkey* is that it is inadequately illustrated. This is certainly not a criticism that can be levelled at *Flora Iranica*; it is very well illustrated with photographs, line drawings and, in recent fascicles, scanning electron micrographs. But this very desirable adjunct to the text inevitably pushes the price up. And consequently less copies get bought and used. It is a sad fact that the costs of publishing scientific works with limited print-runs in Europe are disturbingly high. To buy a set of *Flora Turkey* would set you back about £500; a set of *Flora Iranica* several times that total! The last point that I want to make about *Flora Iranica* is that the general botanical community should be duly appreciative of the fact that, as with Boissier's *Flora Orientalis* , the boundaries of his Flora were not based just on political frontiers but were drawn to cover a more natural area — even though it is inevitable that as soon as you draw a line on a map, you are bound to create some artificial boundaries.

The last of the three Floras to comment on is that of Pakistan itself. It differs from the previous two Floras in one very major point. It is home-produced and has had 2 autonomous editors, one in Karachi, Professor Ali, the other Professor E. Nasir in the north at Rawalpindi. The great majority of the family accounts have been prepared by local botanists, the artwork entirely by local artists. Although the Flora project was started in the late 1960s (with United States Department of Agriculture funding) by its two editors, the real genesis of the Flora goes much further back. Our respected guest of honour at this Symposium, Dr. R.R. Stewart started plant-collecting almost 80 years ago when in 1911 he was in Ladak (Stewart, 1982). For the next 50 or so years he was at the core of botany, training and encouraging students, and plant collecting in all parts of what today is Pakistan. Throughout these years he published a variety of papers dealing with the floras of different areas. His activities were the real genesis of the *Flora of Pakistan*. In 1972 he published his *Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir*. Although this was a couple of years after the first small fascicle of the Flora appeared, the Catalogue is really the basic reference work for anybody preparing accounts for the Flora. I know from practical experience, while recently writing up the Labiatae (Hedge, 1991), just how important and accurate a framework it is; remarkably little is missing from it. Earlier, Ali (1978) said of the *Catalogue* — "we had free access to it in mss form from early days in the Flora project and it has been the basis of all our humble efforts".

In assessing the *Flora of Pakistan* it is very important to remember the difficulties the contributors and editors faced. They did not have the facilities of library, herbarium, and garden that, for example, Edinburgh has. They had in Pakistan little access to type specimens. They had frequent uncertainties about continuing financial support. Without wishing to be too critical, I think it is true to say that the more recent fascicles of the Flora are better than some of the earlier ones. There was in the earlier fascicles a tendency to create too many new taxa and give formal rank to variation that would have been better treated informally in discussion. Although there is often an inherent desire in taxonomists to create new species and new taxa — they feel they are demonstrating their taxonomic prowess — the self — effacing altruistic taxonomist (as we all should be!) knows that he or she is contributing just as much to botany by reducing a species to synonymy as by creating a new species. But my slight criticism of the earlier parts of *Flora Pakistan* would also apply to the earlier parts of both *Flora Turkey* and *Flora Iranica*. Sometimes this is because the material for study was inadequate at the time of writing the accounts; an example of this is the *Flora Turkey* Chenopodiaceae account. Published in vol. 2 in 1966 it is in need of a major re-write to incorporate the evidence provided by material collected in the subsequent 25 years.

Although the *Flora of Pakistan* still has some way to go before completion, I do think that Profs. Ali and Nasir deserve sincere congratulations for what they have achieved-as do the numerous authors of accounts and the botanical artists. It is a very well-illustrated Flora.

CONCLUDING REMARKS AND THE WAY AHEAD

By their very nature, the first scientific Floras of an area are imperfect. They can never be definitive. I mentioned earlier that Flora writing in Britain, including innumerable district or county Floras, has been actively going on for 200 years. And still is going on. We can only hope that, assuming there are still botanists and plants around in another 200 years in SW Asia, that the flora of the region will then be as well-known as Britain is today-hopefully long before a couple of centuries. Regional Floras can only have limited objectives and classifications based on herbarium material alone should not be pushed too far. In this respect, it is very important that authors should always be completely honest about their classification. This may seem very obvious, but it is very relevant If for example an author is uncertain about the differences between two species or conversely that two species are clearly different, it is his/her duty to indicate this quite clearly. Although it is probably true to classify many Flora-writers as self-indulgent (i.e., they do it because they enjoy doing it and write 'for themselves'), the ideal or paragon of a Flora-writer has, in addition to being competent at his work, always to be thinking of the person that is going to use his keys, descriptions and discussions. The worst kind of Flora writer is one whose accounts nobody else can use! I will not cite any examples!

In the not too distant future, almost all the Floras of SW Asia should be completed. So it is relevant to ask "what next — where do we go from here"?

Undoubtedly, there has to be a real development of field studies, the plant and its environment, and this should be done by local botanists using the basic information provided by the Floras of their areas. The importance of a good modern Flora can scarcely be over-emphasised, but it must always be regarded as a stage in improving botanical knowledge, not a definitive end-point in itself.

When I was preparing, for example, the accounts of genera of Labiatae for *Flora of Pakistan*, and again during the same with Chenopodiaceae for *Flora Iranica*, I was struck by the number of taxonomic problems involving 'pairs' of species. That is, 2 species, certainly closely related and yet distinct from related species, which differed from each other in few characters, sometimes ill-defined, and occupying very similar or identical habitats and with almost identical distributions. Young species not fully differentiated? This situation is just an example of clear-cut problems that should be pointed out in Flora accounts as future research projects.

In an earlier paper (Davis & Hedge, 1975), we discussed some of the several facets of modern botany that can be developed and researched by local botanists. There is no need to emphasise here the extreme importance of realistic conservation projects that would ensure the preservation of the natural vegetation of SW Asia for the future.

In conclusion SW Asia has always been very fortunate in the botanists that it has attracted — from Boissier of the last century to Davis, Rechinger and Stewart. And, of course, such local botanists as Professors Ali and Nasir.

The future for the next generation of botanists is still challenging and bright!

REFERENCES

Ali, S.I. (1978). The Flora of Pakistan: some general and analytical remarks. *Notes Roy. Bot. Gard. Edinb.*, 36: 427-439.

Bentham, G. (1874). On the recent progress and present state of systematic Botany. *Rep. Brit. Assoc. Advanc. Science*, [1874] 27-54.

Burdet, H.M. ed. (1985). Edmond Boissier, botaniste genevois, 1810-1885-1985. Genève: editions des Conservatoire et Jardin botaniques de la Ville Genève; sér. doc. 17.

Davis, P.H. & Hedge, I.C. (1975). The flora of Turkey: past, present and future. *Candollea*, 30: 331-351.

Hedge, I.C. (1990). Labiatae in Ali, S.I. & Nasir, Y. (eds.) *Flora Pakistan*, 192.

Rechinger, K.H. (1989). Fifty years of botanical research in the Flora Iranica area (1937-1987). In: Davis & Hedge Festschrift, ed Kit Tan, 301-349. Edinburgh University Press.

Shetler, S.G. (1967). *The Komarov Botanical institute*. Smithsonian Institution Press, Washington.

Stafleu, F.A. (1967). Carolus Clusius' Austrian Flora. *Taxon*, 16: 535-537.

Stewart, R.R. (1982). *History and exploration of Plants in Pakistan and adjoining areas. Flora Pakistan*. Islamabad/Karachi.

Plant Life of South Asia, 39–46, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

REPORT ON FLORA IRANICA

K.H. RECHINGER

Beckgasse 22, A-1130 Wien, Austria.

ABSTRACT

Uptil 1989 at least 164 parts of Flora Iranica have been published, beginning in 1963. Most parts contain a single plant family, either large or small. Rosaceae and Caryophyllaceae contain two parts. Of Liliaceae and Scrophulariaceae one part each has been published, the second is due. The Compositae have been published in seven parts. Of Papilionaceae two parts have been published, three parts dealing with the estimated ± 1200 species of *Astragalus* — the largest genus in Flora Iranica — are due. Up to and including part 164 (Compositate VII) 8355 species belonging to 1326 genera have been treated. Liliaceae II, Dipsacaceae and Violaceae and two small families together with 290 species are in press and due to be published in 1991. Altogether 8645 species have been treated so far. The manuscript of Pteridophyta is under preparation for the press. The manuscripts of the remaining families: Chenopodiaceae, Cyperaceae, Ranunculaceae are under preparation. At the moment the amount of species which still remains to be written is diffcult to estimate. When ready, Flora Iranica will comprise more than 10,000 species. Thus the original estimate of ± 9,000 species was too low. In comparison Flora Europaea has 11,557 species, Flora of Turkey just under 8,800 with 8,576 native. Up to and including part 164 seventy seven collaborators representing 21 nations have contributed to Flora Iranica: 13 Austrian, 13 British, 8 German (BRD), 6 Swedish, 6 URSS, 5 Dutch, 4 Swiss, 3 each Czechoslovakian, German (DDR), Israel and USA; 2 Polish and one Bulgarian, Cypriotic, Danish, Egyptian, Finnish, French, Norwegian, Pakistanian. At least 55 family treatments were prepared by myself; 28 families with the help of collaborators. The author has undertaken ten expeditions in the years 1937, 1948, 1956/57, 1962, 1965, 1967, 1971, 1974, 1975 and 1977 during which nearly 50,000 numbers were collected.

DEVELOPMENT AND STYLE OF FLORA IRANICA

In comparing the first parts of *Flora Iranica* issued in 1963 with the current ones, it is clear that only the general frame work has remained the same. The six initial volumes viz., *Convolvulaceae, Ephedraceae, Araceae, Tamaricaceae, Orobanchaceae* and *Euphorbiaceae*, had keys only with no species descriptions. From part 7 on specific descriptions are given.

At the beginning only a limited selection of species of each genus was illustrated. Now habit photographs of all species of which representative material is available, are presented. This is meant as a help for users with no or an incomplete knowledge of the latin and german languages.

The herbarium material on which the Flora is based has multiplied enormously during the past 25 years. The coverage of the area by the network of the various collectors is now much denser and less uneven. The policy of enumerating all known localities has been maintained in order to show the numerous characteristic patterns of distribution. It is remarkable how very few widely spread species are in fact distributed over the whole of the Flora Iranica area.

The editorial frame-work is kept flexible: genera having their centre of speciation within the Flora Iranica area are treated almost monographically. Genera having their evolutionary centres outside the area are treated in a more superficial way. By sticking to a certain amount of flexibility the personal style of the individual contributors is expressed instead of the traditional over-editing or "streamlining".

An inevitable shortcoming of the earlier parts of *Flora Iranica* is, that my own as well my collaborators' approach was from the West the area of Boissier's *Flora Orientalis*. *Flora URSS* was still in progress and *Flora Kavkaza* and the Floras of Turcomania, Tadjikistan, Uzbekistan and the *Conspectus Florae Asiae Mediae* as well the *Flora of Turkey* were still in their earlier stages of publication; *Flora of Pakistan* had not yet started.

One of the permanent problems of writing *Flora Iranica* is the necessity to balance the very narrow species concept of most of the Soviet authors with the cummulative one of Hooker's *Flora of British India*, and, at the same time, trying to bring *Flora Iranica* in line with the well balanced concept of Boissier's *Flora Orientalis*. In the case of Boissier again, it is apparent that on the basis of recent more ample material one has, in many cases, to return to the original narrower concept of Boissier's *Diagnoses Plant. Or. Nov.* in comparison with *Flora Orientalis*.

DELIMITATION AND SUBDIVISION

Flora Iranica was conceived from the beginning to include as far as possible a territory with natural physico-geographical boundaries. Disregarding political delimitation this is expressed by the subtitle: "Flora of the Iranian highlands and the bordering mountain ranges". Iran and Afghanistan are included entirely. In the northwest in the absence of natural boundaries, the political frontier with Turkey has been accepted thus linking up with Peter Davis' *Flora of Tur-*

key which started publication almost simultaneously with *Flora Iranica*. Further east in Transcaucasia the course of the Araxes river was accepted including Talysh, politically belonging to the Soviet Union. East of the Caspian the mountainous part of Turcomania is included with the northern foot of the Kopet Dagh, another slice of Soviet territory. Further east the northern frontier of Afghanistan partly follows the Amu Darya. In the northeast — again in absence of natural boundaries — the Afghanistan political boundary is taken as limit including the narrow Wakhan corridor.

Of all the boundaries of *Flora Iranica* that of the northeast is the most artificial: the flora and vegetation of Wakhan and adjacent areas appears to be virtually identical with that of neighbouring Soviet C. Asia. Similarly, the flora of the Sino-Himalayan region reaches its western limit in this north-east boundary of *Flora Iranica*. Much collation with the floras of Soviet C. Asia and the Himalayas remains to be done. Because the *Flora of Pakistan* had not yet started I accepted the north-south course of the Indus as the eastern boundary of *Flora Iranica*, including Chitral and Swat but excluding Gilgit. The southern boundary is formed by the Arabian Sea and the Persian Gulf and further northwest by the boundaries between Iraq following for hundreds of kilometres the so called "Persian Foothills", the lowest outermost range of the Iranian Highlands. Any subdivision of the *Flora Iranica* area is more problematical than its overall delimitation.

As to *Iran:*

Names of provinces and their boundaries have changed 4 to 5 times during the past 50 years, and the same is true for their capitals and other place names. Basically the *Times Atlas* is used for provinces and place names and their transcriptions. Gradually volumes of Adametz' *Gazetteer* became available and this forms a useful tool for localisation. But exact localisation and identification of place names remains a very time consuming task, the more so on older labels, where common names occurring all over Iran like Abbassabad, Safed Rud etc., are given without any hint to their situation. Another serious problem is the extremely divergent transcription of place names depending on the nationality of the writer using English, German, French, Russian or indigenous versions of the same word. Over the years of Flora Iranica a card index for most of the localities and a collection of itineraries of the more important collectors has been built up by my wife Wilhelmina.

Subdivision of Iran is a compromise between the traditional provinces (as indicated e.g., on the Times Atlas) and phytogeographical facts.

The *North* of Iran covers mainly the Caspian Lowlands and the humid north facing slopes of the Elburz Range covering the provinces of Gilan, Mazanderan and Gorgan as far as the Caspian forest extends. In cases of doubt, the watershed between the Caspian and the dry interior is followed.

The *West* of Iran covers the eastern section of the Armenian mountain knot and the northwestern sections of the Zagros range with the adjacent Khuzistan plains. It includes Persian Azerbaijan, Khamseh, Kurdistan, Hamadan, Kermanshah, Arak, Esfahan as well as the not precisely limited tribal territories of Qashqai, Bakhtiari and Luristan.

The *South* comprises the southeastern section of the Zagros Range, the huge mountains of Kerman, the Lut desert - and the Jaz Murian basins including the provinces Fars, Kerman, Lar and Balochistan.

The *East* comprises mainly Khorasan with the Kopet Dagh and the southern mountain range parallel to it and the eastern border of the Kavir desert basin.

The *centre* is the main western part of the Kavir desert basin and the interior slopes of the bordering mountain ranges comprising the provinces or territories of Tehran, Qazvin, Semnan-Damghan, Shahrud-Bustan, Qom and Yazd.

This subdivision of Iran coincides roughly with some of the main plant geographical features as I had anticipated them.

As to ***Afghanistan:***

Initially I had to adopt the delimitations proposed by M. Køie and Rechinger (1954) because at the time the country was much less known than Persia and completely unknown to me. While gradually getting acquainted with Afghanistan, publication of *Flora Iranica* had already started and I found it impractical to change the subdivisions. Only slight amendments to Koeie's delimitations have been introduced.

As to *Pakistan:*

The enumeration begins in the north and progresses to the south roughly like *Flora of Pakistan*. The eastern limit is about the north-south course of the Indus River.

As to *Iraq:*

In Iraq the mountainous minor section of the country roughly covering Iraqi Kurdistan is included in *Flora Iranica*. Enumeration of localities is according to districts from north to south. The lower Persian Foothills are included. For localisation of villages and cities the gazetteers compiled by Mr. E. Guest in the first and other volumes of *Flora of Iraq* are of great help.

Two sections politically forming part of the Soviet territory are dealt with in *Flora Iranica* in order to include mountain ranges bordering the Iranian Highlands. These are in the north: the mountainous southern part of Turkmenistan (abbreviated Mt. Turkmen, in Fl. URSS.) mainly the Kopet Dagh north slopes, and in the northwest Talysh, the mountainous part South of the Araxes River forming part of Southern Transcaucasia.

SPECIES AND SUBSPECIES CONCEPT

Every botanist who has gained a more intimate knowledge of the plants growing in a certain country comes to the conclusion that in nature there are "good" or "strong" and "poor" or "weak" species. In other words, some species differ from each other by several salient characters, others by few characters difficult to grasp. When starting to write a "Flora" the author must try to present to the user of his book as clear as possible a picture of the manifold phenomena he is faced with.

The author is faced with two contrasting dangers: either to over simplify in order to make the way for the user short and easy; or else to try and give a true picture of the complete polymorphism and get lost in the jungle. In the first case he will be called a "lumper", in the second a "splitter".

One of the possibilities to come closer to the solution of the problem is the introduction and strict application of the category of subspecies for geographical races: that is for members of polymorphic groups replacing each other in different areas (or altitudinal belts), but still morphologically not so completely separated from each other that they could be accepted as species. The use of the term subspecies is, of course, not new. It has gradually crystallized during the past century. By some authors it was, however, unequivocally applied for species groups difficult to distinguish but not considering geographical or ecological divergence.

Application of the subspecies concept has also practical advantages. Incomplete specimens can still be identified as to specific level and thus be used by foresters, ecologists or plant sociologists.

The category of subspecies should, however, only be used after extensive field work and intensive studies of the whole polymorphic group in the field as well as in the herbarium. Uncritical application of the term would only add to confusion and to the burden of synonymy.

STATISTICS

Until 1989, 164 parts of *Flora Iranica* have been published, beginning in 1963. Most parts contain a single plant family, either large or small. *Rosaceae* and *Caryophyllaceae* contain two parts. Of *Liliaceae* and *Scrophulariaceae* one part each is published, the second is due. The *Compositae* have been published in seven parts. Of *Papilionaceae* two parts have been published; three parts dealing with the estimated ± 1200 species of *Astragalus* — the largest genus in *Flora Iranica* — are due. Up to and including part 164 (*Compositae* VII), 8355 species belonging to 1326 genera have been treated. *Liliaceae* II, *Dipsacaceae* and *Violaceae* and two small families with together 290 species are in press and due to be published in 1991. Altogether 8645 species have been treated so far. The manuscript of *Pteridophyta* is under preparation for the press. At the moment the amount of species which still remains to be written is difficult to estimate. When ready, *Flora Iranica* will comprise more than 10,000 species. Thus the original estimate of ± 9,000 species was too low. In comparison *Flora Europaea* has 11,557 species, *Flora of Turkey* just under 8,800 with 8,576 native.

LARGE FAMILIES AND GENERA

The largest families comprising more than 400 species are:

Compositae	2114	
Papilionaceae	1640	including estimated 1100 *Astragalus*
Gramineae	758	
Labiatae	541	
Umbelliferae	515	
Caryophyllaceae	466	

The largest genera (more than 100 species):

Astragalus	± 1100
Cousinia	378
Acantholimon	164
Silene	140
Allium	139
Oxytropis	115
Nepeta	107

I had no time to figure out the percentage of endemics. It is extremely high in *Compositae, Papilionaceae, Labiatae* and *Umbelliferae*, moderately high in *Caryophyllaceae* but remarkably low in *Gramineae*.

Up to and including part 164, seventy seven collaborators representing 21 nations have contributed to *Flora Iranica*: 13 Austrian, 13 British (9 English — 4 Scottish), 8 German (BRD), 6 Swedish, 6 URSS, 5 Dutch, 4 Swiss, 3 each Czechoslovakian, German (DDR), Israel and USA.; 2 Polish and one Bulgarian, Cypriot, Danish, Egyptian, Finnish, French, Norwegian, Pakistanian. Atleast 49 family treatments were prepared by myself; 25 families with the help of collaborators.

Flora Iranica was from the beginning a private enterprise with its base in the Natural History Museum in Vienna where the complete set of my herbarium specimens and the majority of specimens of other collectors are kept.

The author made ten expeditions in the *Flora Iranica* region in the years 1937, 1948, 1956/57, 1962, 1965, 1967, 1971, 1974, 1975 and 1977 during which nearly 50,000 numbers were collected. For details see The Davis & Hedge Festschrift (Kit Tan ed.) Edinburgh University Press, 1989.

The whole burden of editing and preparing the various accounts fell on the author and his wife Wilhelmina. The thankless task of identifying and arranging tens of thousands of localities into geographical order and of checking the bibliography is hers.

Only moderate grants for a limited number of collaborators from various sources have been available.

Flora Iranica has now reached its final stage. Part 165 (*Liliaceae* II) is due to appear during April 1991 together with 166 (*Rhizophoraceae*) and 167 (*Pontederiaceae*). Parts 168 (*Dipsacaceae*) and 169 (*Violaceae*) are in press.

The manuscripts of 170 (*Pteridophyta*) and 171 (*Cyperaceae*) are in advanced stages of preparation. Work on *Chenopodiaceae*, *Rubiaceae* and *Ranunculaceae* is in progress. The tremendous task of dealing with *Astragalus* is in the hands of Prof. Podlech at Munich; about one fourth of the manuscript is ready for press. So the situation as far as completing the work is promising. It partly depends on the time that can be spent by international co-authors — all working of their own free will and in spite of their other commitments.

PLANS FOR THE FUTURE

Two concluding volumes for *Flora Iranica* are planned. In one the distributional areas of the endemic genera will be shown as well as those of taxa with their distributional limits cutting through the *Flora Iranica* area in order to furnish a solid base for the discussion of the phytogeographical position of the *Flora Iranica* area and its connections with neighbouring ones. The second volume should contain a gazetteer correlating the multilingual localities mentioned in the Flora and showing the itineraries of the more important collectors.

When *Flora Iranica* will be concluded it will form a solid base for the knowledge of one of the old World's richest extratropical centres of plant speciation with its far-reaching influence on the floras of adjacent territories and beyond.

I conclude my lecture with my sincerest thanks to all who have helped me during the past half century and last not least to my wife Wilhelmina who has assisted me as a driver and collector in the field as well as an untiring and skillful secretary at home and in the herbarium.

REFERENCE

Køie, M. and Rechinger, K.H. *Symbolae Afghanicae. Dan, Biol, Skr.*, 8: 1-80, Copenhagen.

Plant Life of South Asia, 47–54, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

A FLORISTIC COMPARISON BETWEEN INNER MONGOLIA AND MONGOLIA

MA YU-CHUAN (MA YU-QUAN)

Biology Department,
Inner Mongolia University, Hohhot, P.R. China

ABSTRACT

In the Mongolian Plateau and its neighbouring areas there are 137 families, 792 genera and 3374 species of vascular plants. There are ten large families, viz., Compositae (87 genera/444 species), Gramineae (73/316), Leguminosae (27/313), Cyperaceae (11/186), Ranunculaceae (21/150), Rosaceae (28/145), Cruciferae (53/133), Chenopodiaceae (27/119), Caryophyllaceae (21/109) and Scrophulariaceae (22/106). There are ten large genera in this region, viz., *Carex* (131 species), *Astragalus* (94), *Oxytropis* (93), *Artemisia* (90), *Salix* (61), *Saussurea* (56), *Polygonum* (51), *Potentilla* (46), *Pedicularis* (39), *Allium* (38). There are three endemic genera: *Tetraena*, *Potaninia*, *Tugarinovia* and three subendemic genera: *Pugionum*, *Ammopiptanthus* and *Stilpnolepis*.

INTRODUCTION

Since the independence of the People's Republic of Mongolia in 1921, the Mongolian Plateau had been divided into two different countries. Therefore it is rather difficult to study the Mongolian Plateau as a whole. I have tried to make a floristic comparison between Inner Mongolia and Mongolia, and the floristic analysis of Mongolian Plateau and its neighbouring areas. The range that this paper deals with contains the administrative area of Inner Mongolia Autonomous Region of the People's Republic of China (abbreviated as Inner Mongolia) and the People's Republic of Mongolia (abbreviated as Mongolia). From the geographic point of view this means the Mongolian Plateau and its neighbouring areas (abbreviated as Mongolian Plateau). The taxa of vascular plants cited in this paper are mainly based on the two books: viz., "Key to vascular plants of Mongolia" by I.V. Grubov and "Flora Intramongolica" edited by me. The author analyzed and compared the flora of Inner Mongolia and Mongolia family by family, and determined the number of similar genera and species. By adding the number of genera and species of Inner Mongolia and Mongolia, then subtracting the number of similar genera and species, we have the number of genera and species of the Mongolian Plateau and its neighbouring areas. In addition, the author determined the coefficient of similarities between taxa of these two countries. In the Mongolian Plateau there are 137 families, 792 genera and 3374 species of vascular plants. Among them there are 17 families, 28 genera and 73 species of Pteridophyta; 3 families, 8 genera and 31 species of Gymnospermae; 117 families, 756 genera and 3270 species of Angiospermae.

FLORISTIC ANALYSIS OF FAMILIES

There are 108 families in Mongolia, 133 families in Inner Mongolia. The number of similar families is 104; thus, there are 137 families in the Mongolian Plateau. The families that differ between them are 31, and among these are 3 families, Scheuchzeriaceae, Aizoaceae and Capparaceae, distributed only in Mongolia. The twenty-seven families are distributed only in Inner Mongolia. They are: Juglandaceae, Fagaceae, Aceraceae, Cistaceae, Onocleaceae, Salviniaceae, Loranthaceae, Drynariaceae, Cucurbitaceae, Pontederiaceae, Aristolochiaceae, Magnoliaceae, Vitaceae, Elatinaceae, Araliaceae, Oleaceae, Dioscoreaceae, Chloranthaceae, Simarubaceae, Sapindaceae, Tiliaceae, Trapaceae, Loganiaceae, Pedaliaceae, Phrymaceae, Eriocaulaceae, Commelinaceae. Ten large families contain more than 100 species, viz., Compositae, Gramineae, Leguminosae, Cyperaceae, Ranunculaceae, Cruciferae, Chenopodiaceae, Caryophyllaceae, and Scrophulariaceae (Table 1). These 10 families include 370 genera and 2021 species, making up 46.71% of the total genera and 60% of the total species respectively. Twenty nine families contain only one species, making up

Table 1. Comparative and statistical table of 10 large families in the Mongolian Plateau and its neighbouring area.

Family name	Mongolia		Inner Mongolia		Common in both		Coefficient of similarity		Mongolian Plateau	
	Gen.	Spp.	Gen.	Spp.	Gen.	Spp.	Gen.	Spp.(%)	Gen.	Spp.
Compositae	68	303	73	286	44	145	45.36	32.66	87	444
Gramineae	57	205	66	200	50	89	68.5	28.16	73	316
Leguminosae	23	232	26	160	23	79	88.46	25.24	27	313
Cyperaceae	10	109	11	120	10	43	90.9	23.12	11	186
Ranunculaceae	21	93	18	110	18	53	81.71	35.33	21	150
Rosaceae	28	101	23	104	23	60	82.14	41.38	28	145
Cruciferae	53	115	32	72	32	54	60.38	40.30	53	133
Chenopodiaceae	25	86	19	82	17	49	62.96	41.18	27	119
Caryophyllaceae	16	75	19	65	14	31	66.66	28.44	21	109
Scrophulariaceae	13	68	21	61	11	23	47.82	21.69	22	106
Total	314	1387	308	1260	242	626			370	2021

21.16% of the total families; sixty-two families contain 2-9 species, making up 45.25% of the total families. These two categories amount to 66.41%. In the Mongolian Plateau sixty-one families contain only one genus, making up 44.5% of the total number of families; fifty-two families contain 2-5 genera, making up 38%; thirteen families contain 6-19 genera, making up 9.5%; eleven families contain more than 20 genera, making up 8%. In the floristic composition of the Mongolian Plateau, the families containing more than 100 species are 10, making up 7.3% of total families; the families containing 40-99 species are 7, making up 5.1%; the families containing 20-39 species are 10, making up 7.3%; the families containing 10-19 species are 19, making up 13.87%; the families containing 2-9 species are 62, making up 45.25%; and the families containing one species are 29, making up 21.16%.

FLORISTIC ANALYSIS OF GENERA

There are 599 genera in Mongolia, 667 genera in Inner Mongolia and 792 genera in Mongolian Plateau and its neighbouring areas. The number of similar genera of Mongolia to Inner Mongolia is 482 and the number of differt genera is 205 (92 genera in Mongolia and 113 genera in Inner Mongolia).

Ninety-two genera are distributed only in Mongolia. They are: *Cryptogramma* of Sinopteridaceae, *Abies* of Pinaceae; *Scheuchzeria* of Scheuchzeriaceae; *Anthoxanthum, Piptatherum, Arctagrostis, Schismus, Schizachne, Nardus, Paracolpodium, Eremopyrum* of Gramineae; *Tofieldia* of Liliaceae; *Lysiella* of Orchidaceae; *Koenigia, Oxyria* of Polygonaceae; *Ceratocarpus, Camphorosma, Londesia, Climacoptera, Nanophyton, Petrosimonia* of Chenopodiaceae; *Claytonia* of Portulaceae; *Herniaria, Acanthophyllum* of Carophyllaceae; *Oxygraphis, Callianthemum* of Ranunculaceae; *Glaucium* of Papaveraceae; *Cleome* of Capparaceae; *Macropodium, Conringia, Subularia, Megacarpaea, Carpoccras, Galitzkya, Pachyneurum, Parrya, Tetracme, Strigosella, Syrenia, Taphrospermum, Eutrema, Aphragmus, Braya, Arabidopsis* of Cruciferae; *Drosera* of Drosraceae; *Bergenia* of Saxifragaceae; *Coluria, Dryas, Alchemilla* of Rosaceae; *Onobrychis* of Leguminosae; *Biebersteinia* of Oxalidaceae; *Middendorfia* of Lythraceae; *Eryngium, Scaligeria, Aulacospermum, Stenocoelium, Schultzia, Pachypleurum, Cenolophium, Conioselimum* of Umbelliferae; *Phlox* of Polemoniaceae; *Heliotropium, Nonea, Anoplocaryum, Treetocarya, Crniospermum, Rochelia, Lindelofia, Rindera, Onosm* of Boraginaceae, *Eremostachas, Perovskia, Ziziphora, Hyssopus, Origanum* of Labiatae; *Lancea, Lagotis* of Scrophulariaceae; *Asperula* of Rubiaceae; *Krylovia, Filago, Helichrysum, Pulicaria, Pyrethrum, Waldheimia, Kaschgaria, Nardosmia, Arnica, Cousinia, Centaurea, Ancathia, Cichorium, Chondrilla* of Compositae.

There are 113 genera which are distributed only in Inner Mongolia. They are as follows: *Ophioglossum* of Ophioglossaceae; *Gymnopteris* of Hemionitidaceae; *Allantodia* of Athyriaceae; *Camptosorus* of Aspleniaceae; *Lepisorus, Pyrrosia* of Polypodiaceae; *Leptolepidium* of Sinopteridaceae; *Salvinia* of Salviniaceae; *Platycladus* of Cupressaceae; *Arthraxon, Bothriochloa, Digitaria, Elytrigia, Eriochloa, Hemarthria, Imperata, Leucopa, Miscanthus, Oryzopsis, Timouria* of Gramineae; *Arisaema, Calla, Pinelia, Typhonium* of Araceae; *Clintonia, Disporum, Fritillaria, Scilla, Smillacina, Smilax* of Liliaceae; *Corylus, Ostryopsis* of Betulaceae; *Hemiptelea, Celtis* of Ulmaceae; *Pilea, Girardinia* of Urticaceae; *Aristolochia* of Aristolochiaceae; *Cornulaca* of Chenopodiaceae; *Cucubalus, Sagina* of Caryophyllaceae; *Yinshania* of Cruciferae; *Astilbe, Deutzia, Hydramgea, Philadelphus* of Saxifragaceae; *Prinsepia, Sibiraea* of Rosaceae; *Indigofera, Amphicarpea, Kummerowia* of Leguminosae; *Tetraena* of Zygopyllaceae; *Celastrus* of Celastraceae; *Ziziphus* of Rhamnaceae; *Xanthoceras* of Sapindaceae; *Vitis, Ampelopsis* of Vitaceae; *Tilia* of Tiliaceae; *Lythrum* of Lythraceae; *Trapa* of Trapaceae; *Eleutherococcus* of Araliaceae; *Sanicula, Torillis, Eriocycla, Notopterygium* of Umbelliferae; *Orthilia* of Pyrolaceae; *Pterygocalyx* of Gentianaceae; *Fraxinus, Syringa* of Oleaceae; *Buddleja* of Loganiaceae; *Periploca, Meteplexis* of Asclepiadaceae; *Trigonotis* of Boraginaceae; *Agastache, Ajuga, Clinopodium* of Labiatae; *Physalis* of Solanaceae; *Limnophila, Lindernia, Mazus, Melampyrum, Mimulus, Omphalothrix,*

Table 2. Comparative and statistical table of 10 large genera in Mongolian Plateau and its Neighbouring Areas.

Genus name	Mongolia no. of spp.	Inner Mongolia no. of spp.	Same no. of both no. of spp.	Coefficient of similarity (%)	Mongol. Plat, Neighb. Areas no. of spp.
Carex	80	81	30	22.90	131
Artemisia	65	63	38	42.22	90
Astragalus	68	41	15	15.95	94
Oxytropis	78	28	13	11.50	93
Saussurea	42	30	16	28.57	55
Salix	40	30	9	14.75	61
Polygonum	24	41	14	27.45	51
Potentilla	35	30	19	41.30	46
Allium	30	24	16	42.10	38
Pedicularis	30	18	9	23.07	39
Total	492	386	179		699

Phteirospermum, Rehmannia, Siphonostegia of Scrophulariaceae; *Boschniakia* of Orobanchaceae; *Leptodermis* of Rubiaceae; *Abelia, Weigela* of Caprifoliaceae; *Dipsacus* of Dipsacaceae; *Actinostemma, Thladiantha* of Cucurbitaceae; *Codonopsis, Lobelia, Platycodon* of Campanulaceae; *Eupatorium, Kalimeris, Callistephus, Doellingeria, Conyza, Anaphalis, Siegesbeckia, Stilpnolepis, Tussilago, Doronicum, Atractylodes, Arctium, Rhaponticum, Myripnois* of Compositae.

The families containing above ten different genera are: Compositae 28 genera in Mongolian Plateau (14 in Mongolia, 14 in Inner Mongolia); Gramineae 18 (11, 7); Cruciferae 17 (1, 16); Umbelliferae 12 (8, 4); Scrophulariceae 11 (2, 9); Boraginaceae 10 (9, 1).

Ten large genera each of which contains 38 — 131 species, are: *Carex* (131 species), *Astragalus* (94), *Oxytropis* (93), *Artemisia* (90), *Salix* (61), *Saussurea* (56), *Polygonum* (51), *Potentilla* (46), *Pedicularis* (39), *Allium* (38) (see Table 2). These ten genera include 699 species, making up 20.71% of the total species.

ENDEMIC AND SUBENDEMIC GENERA

(1) Endemic genera — There are no endemic genera in Mongolia but there is one endemic genus (*Tetraena*) in Inner Mongolia. When the above two regions are combined together, two endemic genera (*Potaninia* and *Tugarinovia*) happen. Therefore, Mongolian Plateau has three endemic genera.

1. *Tetraena* Maxim., of Zygophyllaceae, which contains only one species — *T. mongolica* distributed in narrow area of East Alashan of Inner Mongolia. It is a relict species of Tertiary Period.
2. *Potaninia* Maxim., of Rosaceae, containing single species — *P. mongolica* Maxim., distributed in East and West Alashan of Inner Mongolia; East Gobi, Gobi-Altai and Valley of Lakes of Mongolia.
3. *Tugarinovia* Iljin of Compositae, also containing one species — *T. mongolica* Iljin, distributional area same as *Potaninia*.

(2) Subendemic genera — there are three genera in this region.

1. *Pugionum* Gaertn., of Cruciferae contains 5 species, 4 species widely distributed in the sand dune of the south part of Mongolian Plateau, and its neighbouring regions (North boundary of Shaanxi, Ningxia and Gansu); one species — *P. pterocarpum* Kom., distributed in Depression of Great Lakes of Mongolia.

2. *Ammopiptanthus* Cheng f. of Leguminosae contains 2 species. *A. mongolicus* (Maxim.) Cheng f. distributed in East and West Alashan of Inner Mongolia; Alashan Gobi of Mongolia; North part of Ningxia and NE corner of Gansu. And *A. nanus* (M. Pop.) Cheng f. distributed in the narrow area of the west part of Xingjiang.
3. *Stilpnolepis* Krasch. of Compositae, which contains single species — *S. centiflora* (Maxim.) Krasch., distributed in the sand desert of Ordos and East Alashan of Inner Mongolia, North boundary of Shaanxi, and NE corner of Gansu.

APPENDIX—"FLORA INTRAMONGOLICA" PROJECT

FLORA INTRAMONGOLICA is the Flora of vascular plants of Inner Mongolia Autonomous Region. It is the result of a cooperative research by sixteen higher universities, colleges and institutes in Inner Mongolia. This set of books are based on successive research efforts by botanists for more than fifty years.

FLORA INTRAMONGOLICA contains descriptions of the families, genera and species of all known native plants and some of introduced and cultivated plants found in Inner Mongolia. For each species botanical name, scientific name, mongolian name, essential citation, morphological description, habit, locality, distribution and economic uses are described. Keys have been prepared to make identification of these plants as simple as possible. Illustrations have been given to every native species.

FLORA INTRAMONGOLICA first edition volume 1-8 were published successively from 1977 to 1985.

Volume 1 contains introduction, conspectus of the flora and treatments of Pteridophytes, Gymnosperms and 11 families of Angiosperms (from Chloranthaceae to Aristolochiaceae), 1985. There are 294 pages and 83 line drawings. Price U.S. $12.00.

Volume 2 ranges from Polygonaceae to Cruciferae. It has 390 pages and 195 line drawings, 1978, sold out.

Volume 3 covers the families from Crassulaceae to Leguminosae. It comprises 309 pages and 142 line drawings, 1977, sold out.

Volume 4 begins with Oxalidaceae and goes through Umbelliferae. There are 223 pages and 95 line drawings, 1979, Price U.S. $10.00.

Volume 5 contains Pyrolaceae to Campanulaceae. It has 442 pages and 169 line drawings, 1980, sold out.

Volume 6 contains only one family, Compositae. There are 355 pages 127 line drawings, 1982, sold out.

Volume 7 begins with Typhaceae and goes through Gramineae. It has 282 pages and 96 line drawings 1983, price U.S. $12.00.

Volume 8 ranges from Cyperaceae to Orchidaceae. There are 372 pages and 153 line drawings, 1985, sold out.

As a result of the change of administrative areas in our country, vols. 2, 3 and 4 can not include many species of 4 Eastern Leagues and 1 Western League. Simultaneously these 3 volumes are short of scientific literature citations. There are also a number of species, which are missing and not perfect enough. It is necessary to revise and republish a more complete and consistent FLORA INTRAMONGOLICA, Second Edition.

FLORA INTRAMONGOLICA, Second Edition will be published in 5 volumes. We firstly publish Volume 3 and the rest are in preparation.

Volume 1 contains introduction, conspectus of flora and descriptions of Pteridophytes and Gymnosperms, in preparation.

Volume 2 ranges from Chloranthaceae to Cruciferae.

Volume 3 (2nd. ed.) contains 40 families (from Crassulaceae to Umbelliferae, including the large families—Rosaceae and Leguminosae) 165 genera and 541 species. It has 716 pages and 268 line drawings, hardbound, 1989. Price U.S. $30.00.

Volume 4 covers the families from Pyrolaceae to Compositae.

Volume 5 is about Monocotyledons.

Vol. 1, 4, 7 of 1st ed. and Vol. 3 of 2nd ed. can be obtained from: The secretary, The Editorial Committee of Flora Intramongolica, Biology Department, Inner Mongolia University, Hohhot, P.R. China.

CLASSICAL TAXONOMY

Plant Life of South Asia, 57–72, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

THE EUPHORBIACEAE OF PAKISTAN

A. RADCLIFFE-SMITH

The Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, Great Britain.

ABSTRACT

The family Euphorbiaceae is represented in Pakistan by 24 genera. Of these by far the largest genus is ***Euphorbia*** with 52 species, followed by ***Phyllanthus*** with 10, ***Acalypha*** with 5, ***Chrozophora*** with 4, ***Andrachne, Breynia*** and ***Jatropha*** with 3 each, ***Bridelia*** and ***Flueggea*** with 2 each, and the remaining 15 genera with one each, thus making a total of 99 species in all. Of these only 68 — i.e, just over two thirds — are truly native. The native species are distributed among only 13 of the genera, which means that 11 of, i.e, nearly half, the genera are introduced, either accidentally or deliberately. Of the introductions, 10 species in 6 genera have become subsequently naturalized, whilst 21 species in 15 genera are only known in cultivation. By far the largest number of cultivated species are ornamentals, but some are cultivated for their edible fruits (e.g., *Phyllanthus acidus*) or roots (i.e., *Manihot esculenta*), some for their oilseeds (e.g., *Aleurites moluccana, Vernicia fordii, Ricinus communis*), with the oils having many industrial uses, or for seeds with medicinal properties as, e.g., the Physic Nut *Jatropha curcas*, whilst others are cultivated as hedgeplants (e.g., *Euphorbia neriifolia* and *E. tirucalli*). On Webster's system of classificaiton of the family (1975, revised 1989, unpublished), all the Subfamilies are represented in the Pakistan flora except one, the Oldfieldioideae. Unfortunately the treatment of the Family in the Flora reflects Pax's system, which has now been shown to be inadequate in many ways, especially palynologically, whereas Webster's system better reflects information now available from the newer disciplines. The genera represented in Pakistan are discussed.

The Family Euphorbiaceae the 6th largest family of Flowering Plants in the world, is represented in Pakistan by 24 genera (Radcliffe-Smith, 1986b). Of these, by far the largest genus in terms of numbers of species is *Euphorbia* itself with 52 species, followed by *Phyllanthus* with 10, then *Acalypha* with 5, *Chrozophora* with 4, *Andrachne, Breynia* and *Jatropha* with 3 each, *Bridelia* and *Flueggea* with 2 each, and the remaining 15 genera being represented by one species each, making a total of 99 species for the family in all. This is portrayed here in histogram-form (Fig. 1).

Of these 99 species, only 68, i.e., just over two-thirds, are native to Pakistan. These indigenous species are distributed among only 13 of the genera, i.e.,

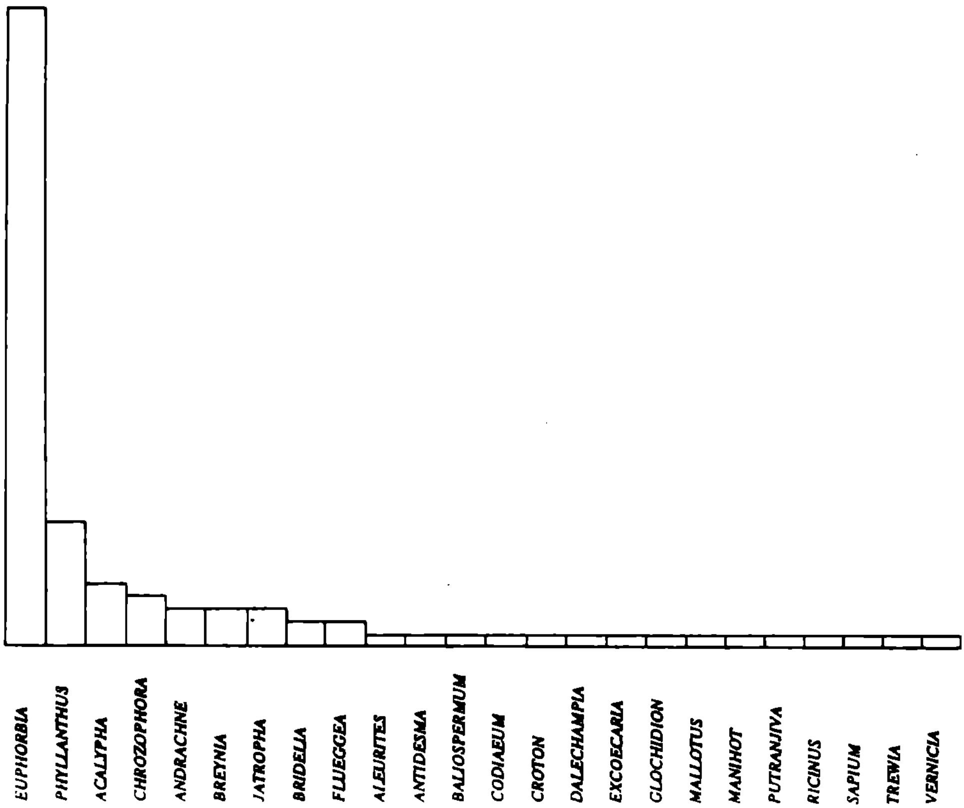


Fig. 1. Representation of Indigenous and Introduced Geneera of Euphorbiaceae in the Flora of Pakistan.

just over half. Forty-one of the indigenous species belong to the genus *Euphorbia*, i.e., nearly two-thirds, which genus is found to occur in a wide variety of habitat-types ranging from sea-level to up to over 15,000′ (4700 m.) in altitude. None of the indigenous species belonging to the other 12 genera is recorded from above 8,000′ (2440 m.), but as shown in Fig. 2, the altitudinal ranges in the genus *Euphorbia*, nine species either reach or surpass the 10,000′ (3050 m.) mark.

Pakistan has four endemic taxa of Euphorbiaceae, all of them in the genus *Euphorbia*. These are *E. jacquemontii* Boiss. var. *lasiocarpa* Boiss., from Baltistan, Punch, Vale of Kashmir and Riasi, *E. micractina* Boiss., from Punch, Muzaffarabad, Gilgit, Vale of Kashmir and Baltistan, *E. thyrsoidea* Boiss., from Swat, Gilgit, Vale of Kashmir and Punch, and *E. talaina*, which I described in Kew Bulletin in 1986 (Radcliffe-Smith, 1986a), and which is found in Waziristan, Quetta-Pishin and Kalat. This was the only species which had to be described as new for the Flora account, an illustration of which is given in Fig 3. It appears to be most closely related to *E. leptocaula* Boiss., which occurs in the

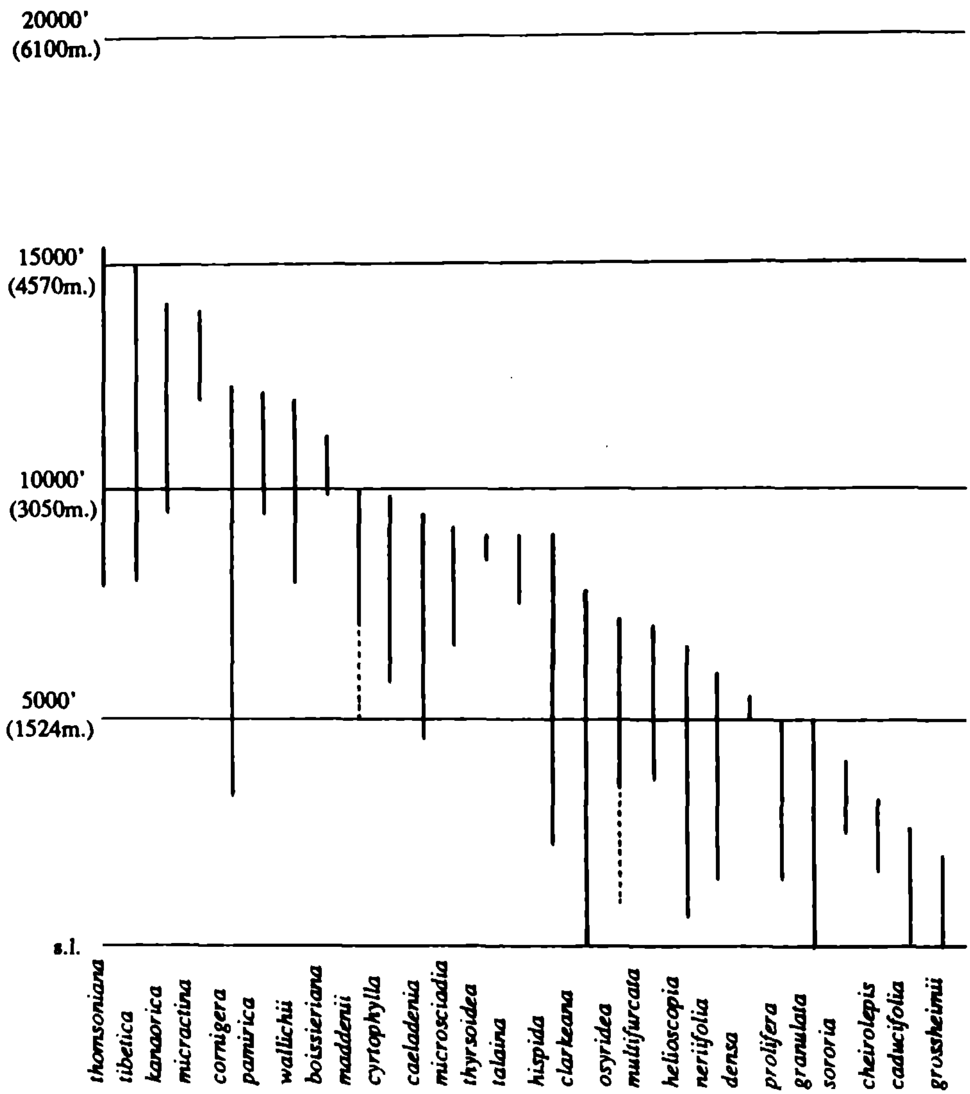


Fig. 2. Altitudinal ranges of some Pakistani *Euphorbia* species.

Ukraine, the Crimea and the Caucasus. It differs from this species chiefly in the form of its stem- and ray-leaves, as well as in its distribution. It may be expected to turn up across the border in Afghanistan, but, so far as I am aware, it has not as yet been recorded from there. The name *'talaina'* refers to the generally rather depauperate appearance of the somewhat minimal plant-body in this species. It appears to be locally common in moist habitats from around 7,500′ (2290 m.) to 9,000′ (2740 m.), being found, for example, by freshwater springs. It had been confused in the literature and on herbarium labels with a number of other species both within and outside Pakistan, in addition to the SW Russian *E. lep-*

Fig. 3. *Euphorbia talaina*. A, habit x 1 (*H. Crookshank* 157, K); B, plant showing underground part x 2/3; C, cyathium x 8; D, fruit x 6 (*Harsukh* 20651, K); E, seed x 10 (*Zaffar Ali & Yasin Nasir* 5823, RAW).

tocaula already mentioned. Thus, it had been determined as *E. retusa* Forssk. (syns. *E. kahirensis* Raeusch., *E. cornuta* Pers.), which ranges from Macaronesia to the Upper Persian Gulf, but in that species the leaves are serrate and the caruncles are very large; the same goes for *E. caeladenia* Boiss. (Syn. *E. stocksiana* Boiss.) with which it has also been compared, but with which it is, however, sympatric. It has also been confused with *E. dracunculoides* Lam., and *E. taurinensis* All., but both of these are annuals, whereas *E. talaina* is a perennial, and both have either ornamented or sculptured seeds, whereas in *E. talaina* the seeds are smooth. Another suggestion as to its identity was *E. variabilis* Ces., but, despite some morphological similarities, this would appear to be a phytogeographical improbability since that species is endemic to the Italian Alps! Other postulated identities have been *E. boissieriana* (Woron.) Prokh., but this is a much more robust species in which the pseudopleiochasial leaves are shorter and broader; the Himalayan *E. cornigera* Boiss., but since this has both rounded glands and warty fruits as opposed to cornute glands and smooth fruits, it occupies a different Section of the genus; *E. osyridea* Boiss., but this species is unique amongst SW Asiatic spurges of the Subgenus *Esula* in having lateral inflorescences instead of terminal ones; and finally *E. cyrtophylla* Prokh., a Pamir species which, however, is provided with densely-leafy sterile axillary branches which are quite absent from *E. talaina*. The fact that ten different suggestions had been made as to the plant's identity, some of them admittedly much nearer the mark than others, but none of them wholly satisfactory, led me to consider that this must be a new species, and so I accordingly described it as such.

As to the other endemic species, *E. thyrsoidea* Boiss., is clearly closely-related to what has been variously referred to as the leafy spurge complex or the *E. waldsteinii* (*E. virgata*)-aggregate, but differs chiefly from the other Pakistani members of this group in its thyrsiform inflorescence of inflorescences, in the more broadly lanceolate stem-leaves, the ovate-deltate as opposed to transversely elliptic or suborbicular ray- or pseudopleiochasial leaves and in having truncate and 2-horned instead of crescentic cyathial glands.

E. micractina Boiss., belongs to a different complex, the *E. pilosa*-complex, which has representatives throughout Eurasia, and apart from its smaller stature, and fewer rays to the pseudopleiochasium, it is very similar to *E. cornigera* Boiss. Since the altitudinal range of the latter is a very wide one, namely from 3,300′ (1000 m.) to 12,300′ (370 m.), whereas the altitudinal range of *E. micractina* is much narrower and lies above it with a few hundred feet of overlap, i.e., 12,000′ (3660 m.) to 14,000′ (4270 m), it could be that the latter is simply a high-altitude form of the former. It was certainly not easy to assign some specimens from around the 12,000′ (3660 m.)-mark to one or other of the two, so although the traditional distinction between them was maintained for the Flora, perhaps they should have been merged together as one species.

The other endemic taxon, namely *E. jacquemontii* Boiss., var. *lasiocarpa* Boiss., on the other hand, is a member of the *E. wallichii*-complex, a group with greater representation in the Eastern than in the Western Himalaya, and with a particularly critical assemblage of species in East Nepal, Sikkim and Bhutan. *E. jacquemontii* is one of the poorest-known Himalayan species, being represented in herbaria only by a very few rather old collections, and its variety *lasiocarpa* is only known from three gatherings. Further material would be of value in order to assess correctly the true status of this taxon, which appears to differ from *E. wallichii* Hook. f. chiefly in having a less robust rootstock, shorter somewhat reddish-tinged stem-leaves, a more compact pseudopleiochasium and smaller fruits, which are only about half the diameter of those of *wallichii*.

The phytogeographical affinities of the rest of the indigenous Pakistani Euphorbiaceae are many and varied, and it may truly be said of them that here is a country where east meets west, and to some extent where north meets south.

Pakistan is at the extreme eastern end of the range, for example, of two of its *Andrachne* species, namely *A. telephioides* L., and *A. aspera* Spreng., both of these extend westwards as far as the Cape Verde Islands; in Pakistan, the former is only found to the west of the Indus, whereas the latter occurs on both sides of it. *Chrozophora oblongifolia* (Del.) Adr. Juss. ex Spreng., occuring here in southern Balochistan, has its western limit in Egypt and the Sudan; *Euphorbia densa* Schrenk, also in Balochistan, extends westwards as far as Israel; and *E. boissieriana* (Woron.) Prokh., in the North West Frontier Province, ranges westwards to Turkey.

Furthermore, Pakistan is disjunctly at the eastern end of the range of such species as *E. petiolata* Banks & Sol., which occurs in Algeria, Cyprus, Turkey east to Turkmenistan and south to Sinai, then here up in Chitral, but not in the rest of North Africa nor in Afghanistan; as *E. sororia* Schrenk, known from Soviet Central Asia, NW Iran and here in Balochistan, but so far not recorded from SE Iran or Afghanistan; and as *E. grossheimii* Prokh., which occurs in Egypt, Sinai, Israel, Jordan, Iraq, Saudi Arabia and the southern U.S.S.R., and also here in Balochistan, but which appears to be absent from both Iran and Afghanistan. *E. peplus* L., which ranges from Macaronesia to Turkmenistan, may well have been introduced into Pakistan, where it is scattered more or less throughout the country, as it has been into SE & E Asia, Australia and N & C America.

Then again, Pakistan is also at the eastern or southeastern end of the range of species of much more restricted overall distribution, such as *E. cheirolepis* Fisch. & Mey., in western Balochistan, and also from Turkmenistan, Uzbekistan, Iran and Afghanistan; *E. azerbajdzhanica* Bordz., in Swat, and also in southern Transcaucasia, Turkmenistan and Afghanistan; *E. osyridea* Boiss., *E. caeladenia* Boiss. and *E. microsciadia* Boiss., the former from the Northwest Frontier Province and Balochistan, the two latter from Balochistan, and all three also in Iran and Afghanistan; *E. multifurcata* Rech. f., Aell. & Esfand., from southern Balochistan, and also from southern Iran; *E. cognata* (Klotzsch & Garcke) Boiss., from North West Frontier Province, and also from Afghanistan; *E. aucheri* Boiss., from Balochistan, and also from NE Iraq, Iran, Turkmenistan and Afghanistan; *E. cyrtophylla* Prokh., from North West Frontier Province, and also from Afghanistan and Tadzhikistan; and *E. pamirica* Prokh., from Chitral and Gilgit, and also from Tadzhikistan.

Pakistan is near, but not quite at the eastern end of the range of several species of differing phytogeographical affinity, such as *Phyllanthus rotundifolius* Klein ex Willd., which only occurs in the south of the country, and which ranges from Tropical Africa to Sri Lanka; *Chrozophora tinctoria* (L.) Raf., more or less throughout the country, which ranges from Spain and NW Africa across to NW India; *Acalypha ciliata* Forssk., from NE Pakistan and southern Kashmir, i.e., E of the Indus, which ranges from Bourkina Faso and Namibia across to Orissa and Sri Lanka; *Dalechampia scandens* L. var. *cordofana* (Hochst. ex Webb) Muell. Arg., from Sind, which ranges from the Cape Verde Islands and Angola across to Gujarat; *Euphorbia granulata* Forssk., which is found more or less throughout Pakistan except for the southeast, and which ranges all the way from the Canaries to Kirghizistan and northern India; *E. inderiensis* Less. ex Kar. & Kir., from Chitral, and also in Iran, Afghanistan, Turkmenistan, Kazakhstan, Uzbekistan, Tadzhikistan, Kirghizistan and Dzhungaristan; *E. dracunculoides* Lam., more or less scattered throughout the country, which ranges from southern Spain and NW Africa across to India; and *E. falcata* L., in northern Pakistan and Balochistan, which ranges from Central Europe and North Africa accross to Kirghizistan.

Then again, Pakistan is situated at about the middle of the range of such wide-ranging species as the two *Flueggeas*, the north Pakistani and south Kashmiri *F. virosa* (Roxb. ex Willd.) Voigt and the SE Pakistani *F. leucopyrus* Willd., which range from Tropical Africa to Japan and Timor and from NE Tropical Africa to Burma and Thailand respectively; *Phyllanthus maderaspatensis* L., in central and eastern Pakistan, ranging from Tropical Africa to Australia; *Chrozophora sabulosa* Kar. & Kir., in Balochistan, which ranges from Oman to western China; *C. plicata* (Vahl) Adr. Juss. ex Spreng., in SE. Pakistan, which ranges from Tropical Africa to Burma; *Acalypha brachystachya* Hornem., in Kashmir S & E of the Indus, ranging from Central Africa to Java; *A. indica* L., in southern Pakistan, ranging from Central Africa to the Ryu Kyu Islands; and *Euphorbia indica* Lam., fairly widespread in Pakistan, which ranges from Tropical Africa to China, although part of the western distribution of this species may be due to accidental introduction.

The distribution within Pakistan of such tropical species as *Acalypha ciliata* and *A. brachystachya* is of interest since neither of them has ever been recorded from west of the Indus. Such basically Sudano-Deccanian species as these seem still to be restricted to the Plate upon which they were rafted following the breakup of Gondwana, and which brought them into direct contact with the main Asian land-mass.

Pakistan is also at the mid-point of the range of distribution of species of much more restricted occurrence such as *Euphorbia clarkeana* Hook.f., fairly widespread in the country, but only ranging from Afghanistan to northern India; *E. hispida* Boiss., in northern Pakistan and Kashmir, also from Afghanistan to northren India; and the very restricted and subendemic *E. kanaorica* Boiss., again in northern Pakistan and Kashmir, but otherwise only in Nuristan and, as the name implies, Kinnaur.

Pakistan lies at the southern end of the range of distribution of comparatively few species, such as *E. thomsoniana* Boiss., in northern Pakistan and Kashmir, and elsewhere in northern Afghanistan, the Tien Shan, W Tibet and NW India; *E. seguieriana* Neck., in the Northwest Frontier Province, which occurs from Central Europe across to Siberia; and *E. lathyris* L., in Pakistan known only from Swat, which occurs more or less throughout the Palaearctic Zone.

Furthermore it is at the southwest end of the range of *E. tibetica* Boiss., which is in Kashmir, and which extends into the Tien Shan and across Tibet to western China, but only just getting into NW India.

On the other hand, Pakistan is at the western end of the range of distribution of such species as *Bridelia verrucosa* Haines, *Glochidion velutinum* Wt., *Phyllanthus parvifolius* Ham., and *Andrachne cordifolia* (Wall. ex Decne.) Muell. Arg. These all occur in north or NE Pakistan and south Kashmir, and extend eastwards to Bhutan & Bengal, Burma, Bhutan & Khasia and to Nepal respectively; *Euphorbia nivulia* Ham., from the Punjab, also extends eastwards to Burma, whilst *E. prolifera* Buch.-Ham., also in NE Pakistan and southern Kashmir, extends east to SW China. Different parts of Pakistan also form the western limit of species of more restricted distribution such as *Phyllanthus fraternus* Webster, which, although is only indigenous to NE Pakistan, S Kashmir and NW India, has nevertheless become subsequently introduced into Arabia, Africa and the West Indies; *Euphorbia caducifolia* Haines from Balochistan and Sind, also in Central India; and *E. cornigera* Boiss., and *E. maddenii* Boiss., from N. Pakistan and Kashmir, and also in NW India. Furthermore, Pakistan is nearly, but not quite, at the western end of the range of distribution of *E. wallichii* Hook. f., from the Northwest Frontier Province and south Kashmir, which ranges from Afghanistan to Assam.

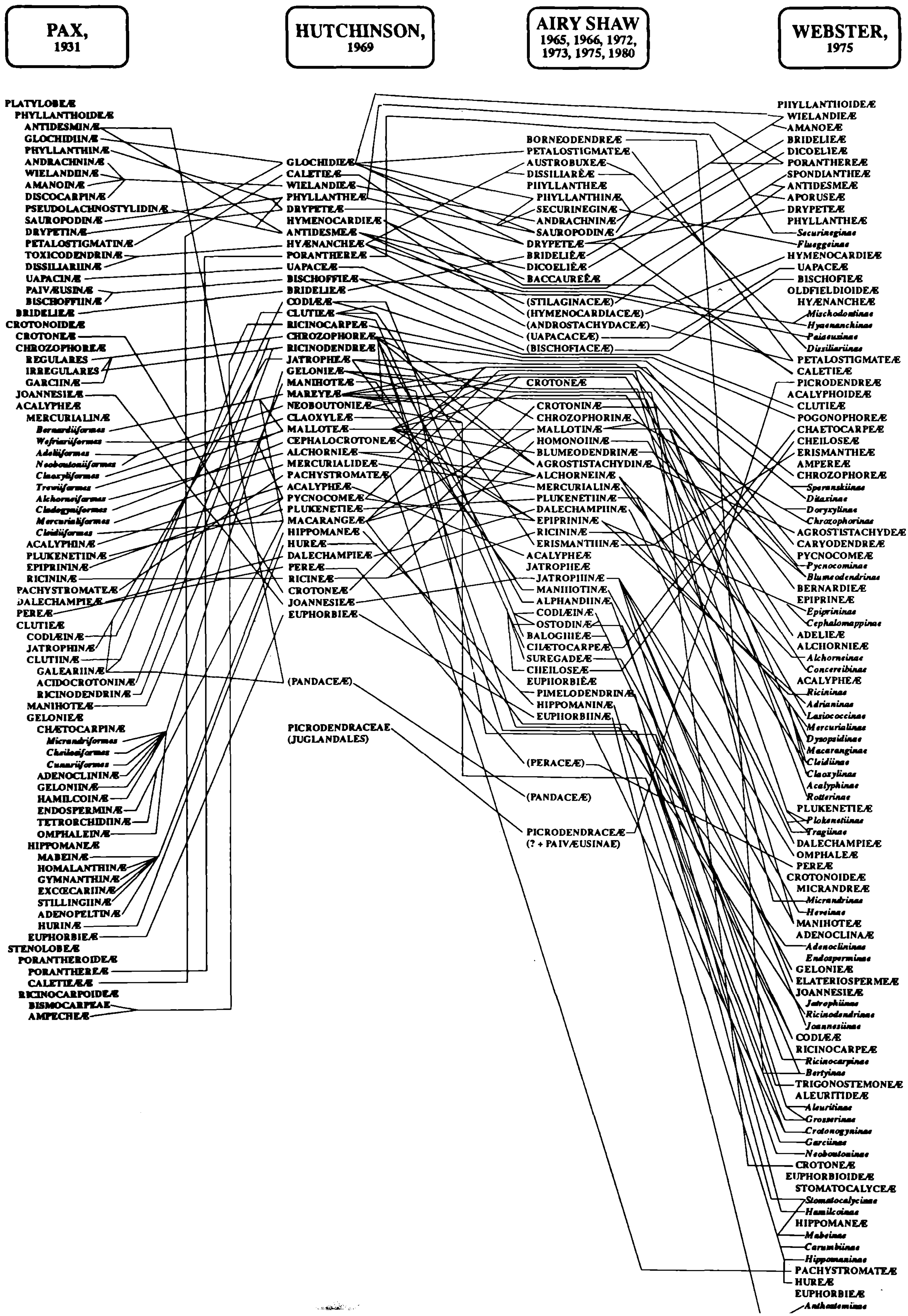
Then again, Pakistan is at the extreme northwestern end of the range of distribution of a number of southeast Asiatic species, such as *Bridelia retusa* (L.) Spreng., in south Kashmir, which extends to Sumatra; *Antidesma acidum* Retz., also in south Kashmir, and extending to Java; *Putranjiva roxburghii* Wall., which, although cultivated as an ornamental at lower altitudes, is nevertheless indigenous in northeast Pakistan at around 1,000′ (300 m.), and extends southeastwards to New Guinea; *Phyllanthus virgatus* Forst. f., in Kashmir and NE Pakistan, extending to Polynesia; *P. emblica* L., the Emblic Myrobalan or Amla, wild in the hills of Kashmir and NE Pakistan, but cultivated in the plains: it extends to West Malesia, and has a special claim to fame in that its fruits are probably the richest-known source of Vitamin C — they are often used in making pickles, preserves and jellies; *Mallotus philippensis* (Lam.) Muell. Arg., the Kamila, in NE Pakistan, which extends to Melanesia and Eastern Australia, whose fruits yield a red dye as well as various medicinal preparations; and *Baliospermum montanum* (Willd.) Muell. Arg., from S. Kashmir, which extends to West Malesia.

Pakistan also plays host to some Euphorbiaceae which are panpalaearctic, i.e., *Euphorbia helioscopia* L., panpalaeotropical, i.e., *Phyllanthus reticulatus* Poir., or pantropical, namely *P. urinaria* L., *Euphorbia hirta* L., and *E. thymifolia* L.

So much for the indigenous or probably indigenous species. There remain some 31, or nearly one-third, of the Pakistani species of Euphorbiaceae, distributed among 11, or nearly half, the genera, which are introduced, either accidentally or deliberately. Of these introductions, some ten species in six genera have become subsequently naturalized, whilst 21 species in 15 genera are only known in cultivation.

By far the largest number of cultivated species are exotic ornamentals, such as *Breynia disticha* J.R. & G. Forst. var. *disticha* f.*nivosa* (Bull) Croizat ex A.R. Smith, the "Snow Bush" from Vanuatu, in which the leaves are commonly blotched with creamy-white; *Acalypha hispida* Burm. f., the "Red-Hot Cat's-Tail", probably originating from the Bismarck Archipelago, with its densely-flowered female inflorescences up to 30 cm. long, bright or dark red on account of the masses of much-branched styles; *A. wilkesiana* Muell. Arg., originating from Fiji but now widely-cultivated in the tropics generally, and exhibiting considerable variation with regard to leaf-size, shape, coloration and variegation-patterning; *Codiaeum variegatum* (L.) A.H.L. Juss., the so-called "Crotons" of horticulture, in which the variation of the foliage is even greater in all these respects; *Jatropha integerrima* Jacq., from the Greater Antilles, cultivated for its showy bright red flowers, and the widespread neotropical *J. gossypiifolia* L., grown for its dark reddish-purple foliage (incidentally, no species of *Jatropha* is indigenous to Pakistan, and in fact the number of indigenous species of this genus is surprisingly few in Tropical Asia generally, numbering not more than half-a-dozen or so in all, and all of them from the southern Deccan Peninsula, considering that the genus is so well represented in Tropical America and Africa); *Sapium sebiferum* (L.) Roxb., the "Chinese Tallow Tree", cultivated in Pakistan not so much for the wax which surrounds the seeds as for the ornamental quality of its red and yellow autumn tints; and *Excoecaria cochinchinensis* Lour., cultivated for its two-tone foliage, olive-green above and purple to crimson beneath. In the genus *Euphorbia* itself are several well-known ornamentals, and those recorded as having been cultivated in Pakistan are: *E. marginata* Pursh, the "Snow-on-the-Mountain Spurge" from North America; *E. cyathophora* Murr., the "Painted Spurge" from Mexico; *E. pulcherrima* Willd. ex Klotzsch, the "Poinsettia" from Central America and *E. milii* des Moul. var. *milii*, the "Crown-of-thorns Spurge" from Madagascar.

Some, but not many, Euphorbiaceae are cultivated in Pakistan as food-plants, as, for example the "Otaheite Gooseberry", *Phyllanthus acidus* (L.) Skeels, widely grown at low altitudes for its edible fruits. Webster, who has monographed West Indian *Phyllanthus*, does not consider this species to have had a palaeotropical origin, counter to prior opinion, but since its closest congeners hail from South America, he feels that to have been its continent of origin too. *Manihot esculenta* Crantz, the "Manioc" or "Cassava" is of course widely cultivated in the tropics of both hemispheres for its tuberous roots which form a staple food in many areas. According to Rogers and Appan, who monographed *Manihot* in 1973 for the "Flora Neotropica" series, *M. esculenta* is a cultigen which is not known in the wild state, but its closest wild relative is *M. aesculifolia* (Humboldt, Bonpland & Kunth) Pohl which ranges more or less throughout Central America from northern Mexico to Panama.


PAX, 1931
HUTCHINSON, 1969
AIRY SHAW 1965, 1966, 1972, 1973, 1975, 1980
WEBSTER, 1975
PLATYLOBEÆ
PHYLLANTHOIDEÆ
ANTIDESMINÆ
GLOCHIDIINÆ
PHYLLANTHINÆ
ANDRACHNINÆ
WIELANDIINÆ
AMANOINÆ
DISCOCARPINÆ
PSEUDOLACHNOSTYLIDINÆ
SAUROPODINÆ
DRYPETINÆ
PETALOSTIGMATINÆ
TOXICODENDRINÆ
DISSILIARIINÆ
UAPACINÆ
PAIVÆUSINÆ
BISCHOFFIINÆ
BRIDELIEÆ
CROTONOIDEÆ
CROTONEÆ
CHROZOPHOREÆ
REGULARES
IRREGULARES
GARCIINÆ
JOANNESIEÆ
ACALYPHEÆ
MERCURIALINÆ
Bernardiiformes
Wetriariiformes
Adeliiformes
Neoboutoniiformes
Claoxyliformes
Trewiiformes
Alchorneiformes
Cladogyniformes
Mercurialiformes
Cleidiiformes
ACALYPHINÆ
PLUKENETIINÆ
EPIPRININÆ
RICININÆ
PACHYSTROMATEÆ
DALECHAMPIEÆ
PEREÆ
CLUTIEÆ
CODIÆINÆ
JATROPHINÆ
CLUTIINÆ
GALEARIINÆ
ACIDOCROTONINÆ
RICINODENDRINÆ
MANIHOTEÆ
GELONIEÆ
CHÆTOCARPINÆ
Micrandriformes
Cheiloseiformes
Cunuriiformes
ADENOCLININÆ
GELONIINÆ
HAMILCOINÆ
ENDOSPERMINÆ
TETRORCHIDIINÆ
OMPHALEINÆ
HIPPOMANEÆ
MABEINÆ
HOMALANTHINÆ
GYMNANTHINÆ
EXCŒCARIINÆ
STILLINGIINÆ
ADENOPELTINÆ
HURINÆ
EUPHORBIEÆ
STENOLOBEÆ
PORANTHEROIDEÆ
PORANTHEREÆ
CALETIEÆ
RICINOCARPOIDEÆ
BISMOCARPEÆ
AMPERÆ
GLOCHIDIEÆ
CALETIEÆ
WIELANDIEÆ
PHYLLANTHEÆ
DRYPETEÆ
HYMENOCARDIEÆ
ANTIDESMEÆ
HYÆNANCHEÆ
PORANTHEREÆ
UAPACEÆ
BISCHOFFIEÆ
BRIDELIEÆ
CODIÆEÆ
CLUTIEÆ
RICINOCARPEÆ
CHROZOPHOREÆ
RICINODENDREÆ
JATROPHEÆ
GELONIEÆ
MANIHOTEÆ
MAREYEÆ
NEOBOUTONIEÆ
CLAOXYLEÆ
MALLOTEÆ
CEPHALOCROTONEÆ
ALCHORNIEÆ
MERCURIALIDEÆ
PACHYSTROMATEÆ
ACALYPHEÆ
PYCNOCOMEÆ
PLUKENETIEÆ
MACARANGEÆ
HIPPOMANEÆ
HUREÆ
DALECHAMPIEÆ
PEREÆ
RICINEÆ
CROTONEÆ
JOANNESIEÆ
EUPHORBIEÆ
(PANDACEÆ)
PICRODENDRACEAE (JUGLANDALES)
BORNEODENDREÆ
PETALOSTIGMATEÆ
AUSTROBUXEÆ
DISSILIAREÆ
PHYLLANTHEÆ
PHYLLANTHINÆ
SECURINEGINÆ
ANDRACHNINÆ
SAUROPODINÆ
DRYPETEÆ
BRIDELIEÆ
DICOELIEÆ
BACCAUREÆ
(STILAGINACEÆ)
(HYMENOCARDIACEÆ)
(ANDROSTACHYDACEÆ)
(UAPACACEÆ)
(BISCHOFIACEÆ)
CROTONEÆ
CROTONINÆ
CHROZOPHORINÆ
MALLOTINÆ
HOMONOIINÆ
BLUMEODENDRINÆ
AGROSTISTACHYDINÆ
ALCHORNEINÆ
MERCURIALINÆ
PLUKENETIINÆ
DALECHAMPIINÆ
EPIPRININÆ
RICININÆ
ERISMANTHINÆ
ACALYPHEÆ
JATROPHEÆ
JATROPHINÆ
MANIHOTINÆ
ALPHANDIINÆ
CODIÆINÆ
OSTODINÆ
BALOGHIEÆ
CHÆTOCARPEÆ
SUREGADEÆ
CHEILOSEÆ
EUPHORBIEÆ
PIMELODENDRINÆ
HIPPOMANINÆ
EUPHORBIINÆ
(PERACEÆ)
(PANDACEÆ)
PICRODENDRACEÆ (? + PAIVÆUSINAE)
PHYLLANTHOIDEÆ
WIELANDIEÆ
AMANOEÆ
BRIDELIEÆ
DICOELIEÆ
PORANTHEREÆ
SPONDIANTHEÆ
ANTIDESMEÆ
APORUSEÆ
DRYPETEÆ
PHYLLANTHEÆ
Securineginae
Flueggeinae
HYMENOCARDIEÆ
UAPACEÆ
BISCHOFIEÆ
OLDFIELDIOIDEÆ
HYÆNANCHEÆ
Mischodontinae
Hyaenanchinae
Paiaeusinae
Dissiliariinae
PETALOSTIGMATEÆ
CALETIEÆ
PICRODENDREÆ
ACALYPHOIDEÆ
CLUTIEÆ
POGONOPHOREÆ
CHAETOCARPEÆ
CHEILOSEÆ
ERISMANTHEÆ
AMPEREÆ
CHROZOPHOREÆ
Speranskiinae
Ditaxinae
Doryxylinae
Chrozophorinae
AGROSTISTACHYDEÆ
CARYODENDREÆ
PYCNOCOMEÆ
Pycnocominae
Blumeodendrinae
BERNARDIEÆ
EPIPRINEÆ
Epiprininae
Cephalomappinae
ADELIEÆ
ALCHORNIEÆ
Alchorneinae
Conceveibinae
ACALYPHEÆ
Ricininae
Adrianinae
Lasiococcinae
Mercurialinae
Dysopsidinae
Macaranginae
Cleidiinae
Claoxylinae
Acalyphinae
Rotterinae
PLUKENETIEÆ
Plukenetiinae
Tragiinae
DALECHAMPIEÆ
OMPHALEÆ
PEREÆ
CROTONOIDEÆ
MICRANDREÆ
Micrandrinae
Heveinae
MANIHOTEÆ
ADENOCLINAÆ
Adenoclininae
Endospermineae
GELONIEÆ
ELATERIOSPERMEÆ
JOANNESIEÆ
Jatrophiinae
Ricinodendrinae
Joannesiinae
CODIÆEÆ
RICINOCARPEÆ
Ricinocarpinae
Bertyinae
TRIGONOSTEMONEÆ
ALEURITIDEÆ
Aleuritinae
Grosserinae
Crotonogyninae
Garciinae
Neoboutoninae
CROTONEÆ
EUPHORBIOIDEÆ
STOMATOCALYCEÆ
Stomatocalycinae
Hamilcoinae
HIPPOMANEÆ
Mabeinae
Carumbiinae
Hippomaninae
PACHYSTROMATEÆ
HUREÆ
EUPHORBIEÆ
Anthosteminae

Other species cultivated in Pakistan are sources of vegetable oils, as, for example, *Aleurites moluccana* (L.) Willd., the "Candlenut Tree", which is widely distributed throughout the Indo-Pacific region. It produces a drying oil in the seeds which is used in paint manufacture; furthermore, the seeds are also edible. A rapid drying oil is also obtained from the seed-kernels of *Vernicia fordii* (Hemsl.) Airy Shaw, indigenous to S. China, S. Burma and N. Vietnam, which is used in varnish-manufacture. In Pakistan, these are recorded as having been cultivated in Lahore and Abbotabad respectively. The oil from the seeds of the widespread "Castor Oil Plant", *Ricinus communis* L., has many uses:- as an illuminant, in medicine as a purgative, in tanning as a leather preservative, and in industry as a lubricant, especially for delicate machinery; furthermore, the oil-cake is used both for fertilizer and for fuel. The oil from the seeds of the neotropical *Jatropha curcas* L., the "Physic Nut", has a violently purgative action; this species is furthermore widely-cultivated as a hedge-plant, since it is not eaten by goats. Other euphorbiaceous hedge-plants in Pakistan are two species of *Euphorbia* itself, namely the Indian species *E. neriifolia* L., and the Angolan *E. tirucalli* L.

Pantropical weeds of known origin which occur in Pakistan are *Phyllanthus amarus* Schum. & Thonn., from Tropical America, and not originally from Tropical Africa as the authorities might seem to indicate; *Croton bonplandianus* Baill., better known in Asia perhaps as *C. sparsiflorus* Morong, from S Bolivia, Paraguay, SW Brazil and northern Argentina; the first record of its introduction into Tropical Asia was Bangladesh in 1897/8, from where it has since spread more or less throughout the palaeotropics (Bruhl, 1908); *Euphorbia hypericifolia* L., which hails from the New World Tropics; *E. serpens* Kunth, also indigenous to the Americas; *E. prostrata* Ait., again neotropical, and finally the more widespread New World species *E. heterophylla* L., sometimes also known as *E. geniculata* Orteg., which is in fact a weedy poor relation of the Poinsettia.

The classification of the Family Euphorbiaceae has been in a more or less continual state of flux since the earliest natural systems of classification of flowering plants were proposed. Every worker over nearly two centuries who has animadverted to the problem has come up with his own solution, very often very different from those of his predecessors &/or contemporaries. Fig. 4 shows, the relationships between the systems of Pax (1931), Hutchinson (1969), Airy Shaw (1965-1980) and Webster (1975). I have not as yet built into this chart the systems of Adrien de Jussieu (1824), Baillon (1858), Mueller Argoviensis (1866), Bentham (1880) or Hurusawa (1954) or the recently-revised and as yet unpublished system of Webster which was issued in broadsheet form only for the purposes of the St. Louis, Missouri Euphorbiaceae Symposium in 1989.

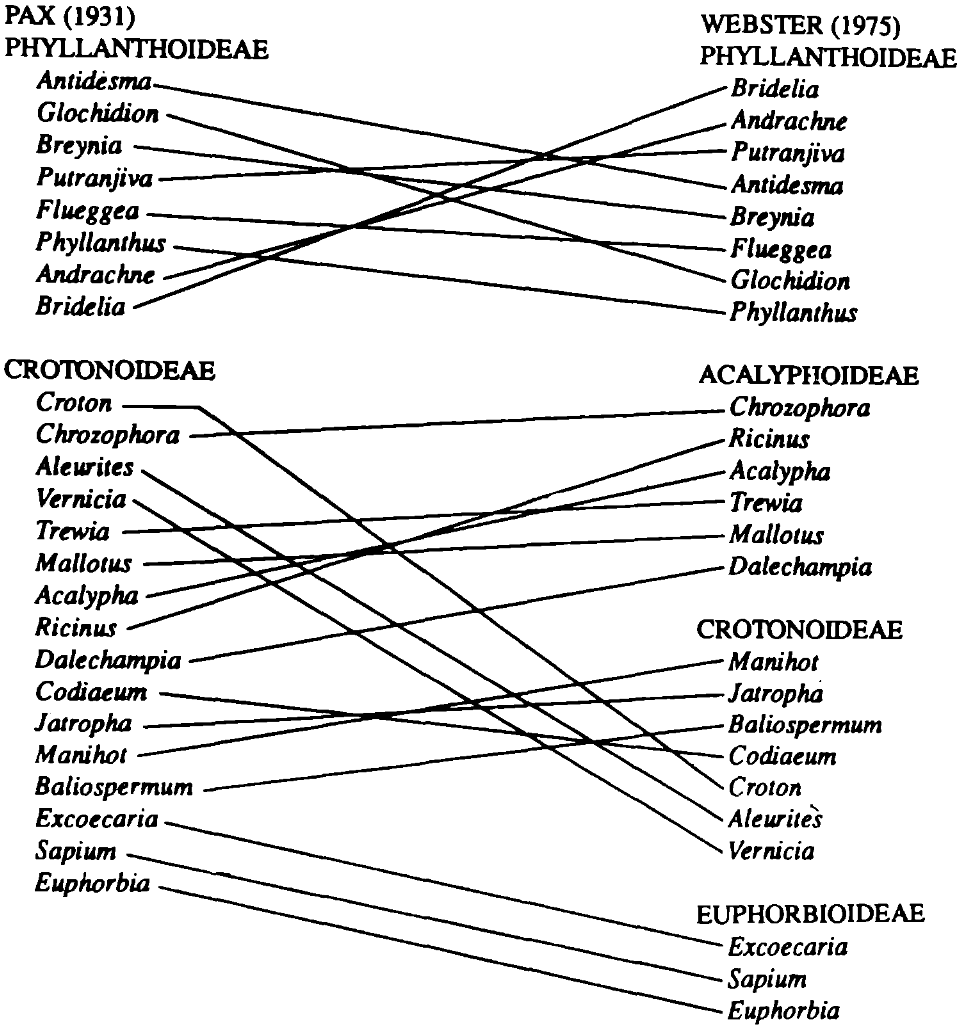


Fig. 5. A. comparison of the systems of Pax (1931) & Webster (1975) with reference to the genera represented in Pakistan.

In his paper, 'Notes on the Euphorbiaceae', published in the Botanical Journal of the Linnaean Society in 1878, Bentham, referring to the works of Baillon and Mueller said: "two men, both indeed of high standing in the science, and with comparatively ample materials at their command, have recently worked up the family with great care and attention independently of each other, and I would have readily followed the lead of either of them, but that the two have so frequently come to conclusions diametrically opposed to each other, that I have been compelled to steer a course of my own through a labyrinth of tribes, subtribes, genera, sections or vaguely-indicated affinities". However, as the chart shows the systems of this century are scarcely any more in harmony with each other then those of the last.

When I came to prepare the account of the family for the Flora of Pakistan, which was published in 1986, I opted for a slightly modified version of Pax's treatment for the arrangement of the genera, since my then mentor, Mr. H.K. Airy Shaw, had always preferred it to any other one, had not yet fully worked out his own — indeed, as it turned out, he never did, since he died in 1985 — and was strongly opposed to the systems of Hutchinson and Webster.

However, following the conferences of specialists on the Order Euphorbiales at Kew in April 1986, and on the Family Euphorbiaceae in St. Louis in August 1989 already referred to, it is becoming apparent that a modified version of Webster's treatment is likely to turn out to be the most natural treatment so far proposed as far as information from the newer disciplines is concerned.

Had I adopted Webster's instead of Pax's system for the classification of the family for the "Flora of Pakistan", Fig. 5 shows that a considerable amount of re-shuffling of the genera would have been needed:

i) In the Subfamily Phyllanthoideae, the eight genera would have been re-arranged: I had already brought *Bridelia* to the first position on account of its valvate perianth, all the others being imbricate.
ii) It is however, the Subfamily Crotonoideae of Pax which would have been the most affected, since Webster now has this split up into three subfamilies, the Acalyphoideae, the Crotonoideae *sensu stricto* and the Euphorbioideae. The latter stands out in Pax's system as the last three genera of his Crotonoideae, but the other two of Webster's subfamilies are not quite as evident.

ACKNOWLEDGEMENTS

I wish to place on record my indebtedness to Professor S.I. Ali and Prof. E. Nasir for their encouragement, interest and help with the Flora account.

REFERENCES

Airy Shaw, H.K. (1965). Diagnoses of new families etc. for the 7th edition of Wills' Dictionary, *Kew Bull.*, 18: 249-273.

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

Airy Shaw, H.K. (1975). The Euphorbiaceae of Borneo. *Kew Bull.*, Add. Ser. IV.

Airy Shaw, H.K. (1980). The Euphorbiaceae of New Guinea. *Kew Bull.*, Add. Ser. VIII.

Baillon, H. (1858). Étude Générale du Groupe des Euphorbiacées. Paris.

Bentham. G. (1878). Notes on Euphorbiaceae. Bot. J. Linn. Soc., 17: 185-267.

Bentham, G. & Hooker, J.D. (1880). *Genera Plantarum*, 3: 239-340.

Bruhl, P. (1908). Recent plant immigrants. I. *Croton sparsiflorus* Morong. *J. Proc. As. Soc. Beng.* II, 4: 603-607.

Hurusawa, I. (1954). Eine nochmalige Durchsicht de herkömmlichen systems der Euphorbiaceen in Weiteren Sinne. *J. Fac. Sci. Tok. III (Bot.)*, 6: 209-342.

Hutchinson, J. (1969). Tribalism in the family Euphorbiaceae. *Am. J. Bot.*, 56: 738-758.

Jussieu, A. de (1824). *De Euphorbiacearum Generibus ... Tentamen*. Paris.

Mueller, J. (1866). Euphorbiaceae. In: A.P. deCandolle (Ed.), *Prodr. Syst. Nat.*, 15: 89-1286.

Pax, F. & Hoffmann, K. (1931). Euphorbiaceae. In: A. Engler & H. Harms. (Eds.), *Die Natürlichen Pflanzenfamilien*, 19C, 2nd ed., 11-233, Leipzig.

Radcliffe-Smith, A. (1986a). A new spurge for the Flora of Baluchistan. *Kew Bull.*, 41: 319-32.

Radcliffe-Smith, A. (1986b). Euphorbiaceae. In: E. Nasir and S.I. Ali (Eds.), Flora of Pakistan. 172, Karachi.

Webster, G.L. (1975). Conspectus of a new classification of the Euphorbiaceae. *Taxon*, 24: 593-600.

Webster, G.L. 1975. Revised conspectus of the Euphorbiaceae. *Euphorbiaceae Newsletter*, 2: 5.

Plant Life of South Asia, 73–93, (1991)
S.J. Ali and *A. Ghaffar* (Eds.)

THE CHENOPODIACEAE OF PAKISTAN — AN ASSESMENT OF PRESENT KNOWLEDGE*

H. FREITAG

Morphologie u. Systematik der Pflanzen, Fachbereich Biologie/Chemie, Universität Kassel, Heinrich Plett Str. 40, D-3500 Kassel, Germany.

ABSTRACT

During the last two centuries a considerable amount of informations on the *Chenopodiaceae* of Pakistan has accumulated. Nevertheless, that included rather many uncertainties and large gaps, caused by peculiar biological, ecological, geographical and taxonomical reasons, which are discussed in detail. Based on the collections made on a joint expedition of the Botanical Institutes of Kassel and Karachi from 18 IX 1986-26 X 1986 and the evaluation of other herbarium material, 17 species are recorded for the first time from the Flora of Pakistan (including a few which were hitherto erroneously cited). Some more species will certainly come out from continuing work with critical groups and several older collections. Many species considered until now as being rare have much wider distribution and density in the desert and semi-desert areas of Pakistan. Some species of both groups are dominating plants in widespread plant communities. Despite many additions, the total number of *Chenopodiaceae* remains more or less stable from Stewart (1972) with 102 species to Jafri (1986) with c. 100 sp. and to the actual estimate of again c. 100, because many species reported in literature proved to be misidentifications. The largest genus is undoutbly *Salsola* with about 25 species, followed up by the genera *Chenopodium, Atriplex, Suaeda* and *Haloxylon* with 10-5 species each.

INTRODUCTION

Although the *Chenopodiaceae* do not belong to the really large families in the Flora of Pakistan, the respective account has not yet been published. This might require an explanation, all the more as the late Dr. S.M.H. Jafri left a manuscript on *Chenopodiaceae* behind in 1987.

Like in other families, the catalogue of our honoured Dr. R.R. Stewart (1972) provided the starting point and the basic reference. He was very well

* This article differs somewhat from the paper presented at the sympsium. It includes additional data obtained during the post-congress stay in the herbaria of Peshawar and Karachi, and new results gained by continuing laboratory work.

aware of the peculiar case of the Pakistani chenopods, and in his introductory statement (p. 216) he listed the reason why in his opinion the family has been "Neglected by collectors" and is so "poorly represented in many collections". It might be of general interest to discuss his points here shortly.

(1) "Most of the members of this family are weedy". — This is very true for a number of annual species, particularly in the genera *Chenopodium, Atriplex, Halocharis, Axyris and Salsola.*
(2) "Few of them can be called beautiful". — There is no doubt about this, but fortunately that has no serious impact upon trained collectors.
(3) "Most of them grow in deserts and waste places". — Indeed, and most of the desert areas are in remote parts of the country, and difficult to reach even nowadays.

According to my experience, at least one most important point should be added:

(4) Most *Chenopodiaceae* produce flower and fruits in autumn, when most other flowering plants have dried up and therefore collecting is not considered to be worthwhile by normal standards.

Consequently, Dr. Stewart ended up with the claim: "More attention should be paid to this family which furnishes much of the food for desert animals".

In his scrupulous enumeration he then listed about 102 species with their respective date. He fully recognized the many problems in identification of the Pakistani chenopods, both encountered by himself and suspected in the relevant literature.

CRITICAL APPRAISAL OF DR. JAFRI'S MANUSCRIPT

After the publication of the *Chenopodiaceae* -account for the Flora of Libya (Jafri & Rateeb, 1976), in his last years the late Dr. Jafri concentrated on the *Chenopodiaceae* of Pakistan. His efforts resulted in a draft for the Flora of Pakistan, which evidently was not fully revised when he unexpectedly died in 1987. In his deserving paper he accumulated a lot of new data and cited c. 100 species. This number equals that of Stewart, but he added some species and sacked others considered as misidentifications or synonyms. As the manuscript probably never will be published, its most important merits are mentioned here, followed by its shortcomings:

First records for the Flora of Pakistan

Bienertia cycloptera Bunge

G-1: Jiwani, 17. XI. 84 (KUH).

We recollected the Irano-Turanian species there in 1986 (F. 18541, Gh. 1843). It covered vast expanses of salty clay on dry ground in different plant communities, even entering into fallow fields and limestone slopes near the village Ganz. Perhaps there are no other localities in Pakistan. The nearest localities known to me are in S Afghanistan, C Iran and on the Arabian Peninsula.

Halocnemum strobilaceum (Pall.) M. Bieb.

G-3: Lasbelas 5 mi. from Kund Malir on way to Agore camp, Kamal *et al.*, 2069 (KUH).

Today we can confirm the guess of Jafri that the species might be probably undercollected (Jafri, 1987).

Halopeplis perfoliata (Forssk.) Schweinf. & Ascherson

G-1: Jiwani Marine base, Qaiser & D. Khan 7139, 7143 (KUH).

We have seen the S. Mediterranean/Saharo-Sindian species in the lagoon area 12 km N of Jiwani, here it forms a salt-marsh community of its own between belts of *Arthrocnemum* and *Halocnemum* (F. 18546, Gh. 1849). Probably, the species is restricted to this westernmost corner of the Makran coast which is close to the known localities in S Iran and Oman.

Salsola tomentosa (Moq.) Spach

E-2: Koh-e-Sultan near Nokkundi, Qaiser 58 (KUH); ibid. Qaiser & Ghafoor 4417 (KUH).

We found this Irano-Turanian element growing profusely and sometimes as codominant in the same area (F. 18699/13, Gh. 1981) from about 1800 m onwards in an open semi-desert community with *Zygophyllum eurypterum, Anabasis setifera, Cornulaca monacantha* and *Artemisia* cf *sieberi*. It is very likely that the species will be found also in other mountains close to the Afghan border, at least in the Chagai hills.

Reconsideration of misunderstood taxa

Salsola drummondii Ulbr.

The species was cited by Stewart from the type area in Mianwali distr. (C-6) only. Later Botschantzev (1976) considered it as a synonym of *S. schweinfurthii* Solms-Laub. Based on 2 specimens from the Makran coast (Qaiser 7067, 7071, both in KUH) and on a living collection at the Botanical Institute in Karachi, with good arguments and even without having seen the type, Jafri put the species back into its rights, but under the questionable new combination *Seidlitzia drummondii* (Ulbr.) Jafri (1987).

Misidentifications

Anabasis annua Bunge

The sterile specimen cited from D-4, Spin Karez, 18 VII 57 Nasir (RAW) is a young individual of *Seidlitzia florida* (M. Bieb.) Boiss., which can be detected by the different stem anatomy (absence of a multilayered epidermis). From the same locality also flowering material of the latter species has been seen: 17 x 50 A.H. Khan (PPFI-B).

Anabasis aphylla L.

The specimen from E-4, near the road Nushki-Quetta, Qaiser & Ghafoor 4381 (KUH) belongs to *A. Haussknechtii Bunge* ex Boiss., instead. We collected it there as well in 1986 (F. 18775, 18776, Gh. 2058).

Arthrocnemum indicum (Willd.) Moq.

All specimens cited in literature and identified by Jafri proved to belong to *A. macrostachyum* (Moric.) K. Koch. Although sterile specimens of the perennial *Salicornioideae* look very similar to each other, they can be easily distinguished by their specific cortex structure. In this regard, *A. macrostachyum* is unique in having the radially arranged cortex parenchyma interspersed with long sclereids (Jafri, 1987).

Halocharis div. spec.

From 9 species cited in the manuscript, 3 are very doubtfully described as new. The specimens are under investigation by I. Hedge.

Hammada scoparia (Pomel) Iljin = *Haloxylon tamariscifolium* (L.) Pall.

The only specimen from F-4, 2 mi. from Loki Shah Saddar on way to Sehwan, Malik & al. 2228 (KUH), is a meagre individual of *Haloxylon salicor-*

nicum. The S Mediterranean species has its easternmost localities in Syria (see Freitag, 1989).

Salsola arbuscula Pall.

The 2 specimens cited from the Koh-e-Sultan N of Nokkundi (E-3) belong to *Halothamnus subaphyllus* (= *Aellenia subaphylla*), (Jafri, 1987).

Salsola micranthera Botsch.

All specimens cited belong to *S. nitraria* Pall., instead (Jafri, 1987).

Salsola montana Litv.

The very young specimen Jafri & Akbar 2047 (KUH) from between Quetta and Ziarat rather belongs to *S. arbuscula*, as can be judged from the papillose indument on leaf and stem surfaces. However, *S. montana* might occur in N Balochistan and in Waziristan, since I collected it in arid mountain areas of the neighbouring Paktya Province in Afghanistan. A likewise sterile specimen from Ziarat (6 VII 59 A.H. Khan, in PPFI-B) matches *S. montana* much better, but also its identity remains questionable.

NARROW FACTUAL BASE

Probably the most serious disadvantage of Dr. Jafri's manuscript is its narrow factual base. Even the material of some important herbaria in Pakistan has not been included (ISL, PPFI, RAW only partly), and none of the herbaria abroad has been seen.

The somewhat fragmentary character results also from the fact, that large desert areas, especially from Balochistan, remained virtually unexplored with regard to the occurence and distribution of *Chenopodiaceae*, but this of course is not a fault of the author.

PRESENT SITUATION

New data sources

During the last years the situation has improved considerably in several respect. New and important collections were made due to the increased activities of the botanical centres in Pakistan. A most rewarding collecting trip was undertaken from 18-9 to 26-10-1986 as a joint expedition of the Botanical Institutes of the Universities of Kassel (H. Freitag, G. Kothe) and Karachi (A. Ghafoor, S. Omer) to the desert areas of Balochistan. The season and the route (see Fig. 1) were chosen specifically to fill the gaps in our knowledge of the chenopod flora. Of course, other late flowering or otherwise interesting plants were collected as well. Altogether 250 specimens of *Chenopodiaceae* out of a total of c. 1000 have been collected by our group, and similar numbers by the Karachi group. More localities have been noticed in the field. The expedition yielded several new species for the Flora of Pakistan, added many records for species considered hitherto as being rare, and delivered a wealth of informations about the ecology and the phytocenological affinities of the chenopod species of the area. In the following chapters, the specimens collected by Freitag & Kothe, which

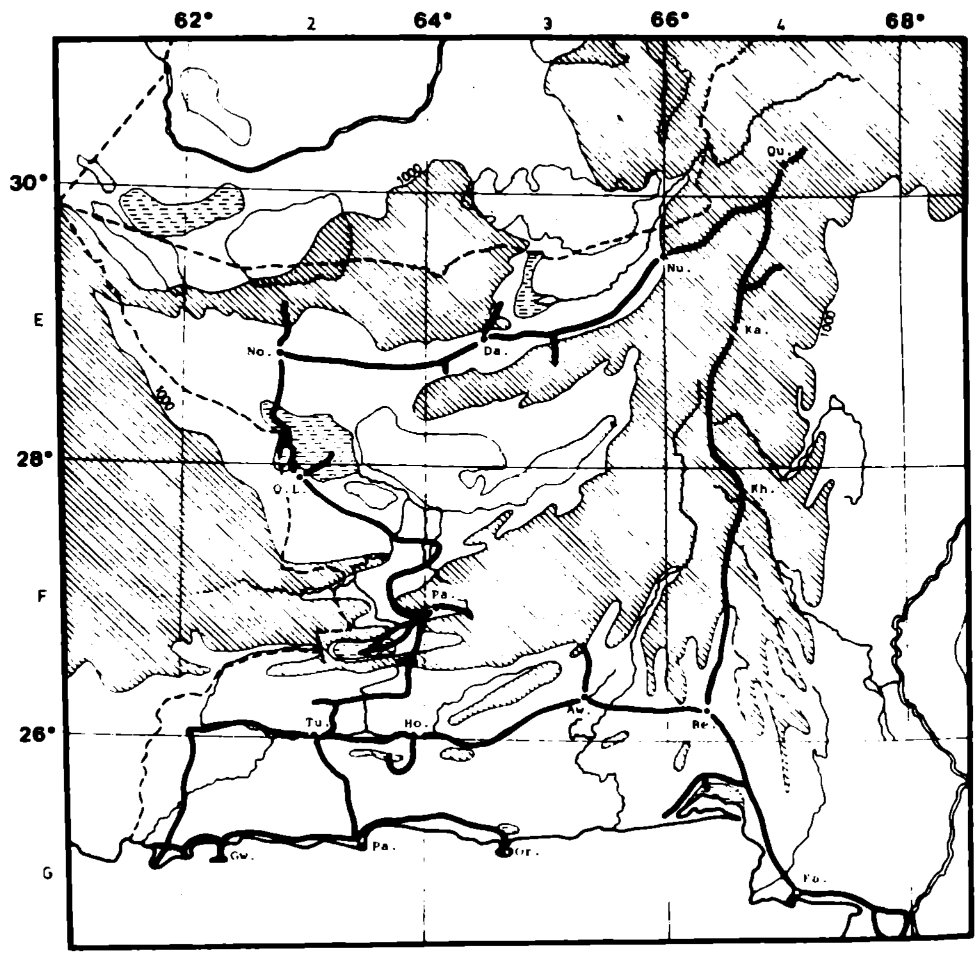


Fig. 1. Route of the expedition to desert areas of Balochistan, jointly undertaken from 18.9-26.10.1986 by botanists from Kassel and Karachi.

are preserved in the University herbarium in Kassel (KAS) are simply abbreviated as F., and those ones collected by Ghafoor & Omer as Gh. The latter ones are kept in KUH.

Furthermore, the collections of more herbaria have been evaluated or are under study: BM, E, ISL, K, PMNH, PPFI-B, RAW, W. New revisions of critical groups (Halothamnus, different sections of *Salsola*) are underway in Kassel, and field studies have been carried out in the variation of critical species along salt-and moisture gradients.

In this paper, only a first, still provisional report of some of the more spectacular results which are already obtained is given. The work is still in progress, in particular in the genera *Halocharis* (by I. Hedge), *Chenopodium* (by P. Uotila), certain groups of *Suaeda*, and in the species groups of *Salsola kali* and *S. lanata*.

NEW SPECIES FOR PAKISTAN

Tropical species

Halosarcia indica (Willd.) Wilson (= *Arthrocnemum indicum* (Willd.) Moq.)
G-4: Gadani (between Sonmiani and mouth of Hab river) salt marshes, 26 VI 89 D. Khan (KUH).

At the symposium I had to state, that I still had not seen any specimen from Pakistan (Jafri, 1987). But a few days later, while running through the new collections in KUH, I detected a recent gathering. *Halosarcia indica* can be distinguished from the somewhat similar *Arthrocnemum macrostachyum* by its strictly prostrate habit, the very compact spikes, the much thicker and more succulent branches and its cortex structure. It is the only member of the *Salicornioideae* with an unmistakable Kranz syndrome and with very peculiar clear "passage cells" in the palisade layer of the chlorenchyma, as it has been seen in the type from S India and stated already by Wilson (1980). I have seen specimens from the coast of E Africa and S India, but it is very likely that it is also distributed all along the Western coast of India.

SAHARO-SINDIAN SPECIES

Agathophora alopecuroides (Del.) Bunge

F-2: 20 km SW of Panjgur at road to Hoshab, 970 m, F. 18621. 93 km S of Panjgur near road to Hoshab, 850 m, F. 18585.

F-3: 35-40 km from Gichak on way to Panjgur, Omer & al. 2080 (KUH).

This is one of the most unexpected discoveries, as until yet the easternmost stands of that distinct species have been known from the Arabian Peninsula. The species is rather common in the Central Makran Range, from the foothills at 900 m up to the highest slopes of the Mihta Sing at 1450 m. The distinct dwarf shrub looks rather similar to *Salsola kerneri*, but the succulent leaves are equipped with a long terminal bristle. It is a regular component of rather rich semidesert communities on sloping hillsides in weak, schist-like limestone. In drier habitats it is associated with *Gymnocarpus*, *Anabasis setifera*, *Salsola cyclophylla*, *S. rubescens* and *Haloxylon salicornicum*. Higher up it grows with *Salsola kerneri* and *Zygophyllum eurypterum*.

Anabasis lachnantha Aellen & Rech. f.

F-2: 93 km S of Panjgur near road to Hoshab, 850 m, F. 18586.
G-2: near Pishukan, W Gwadar bay, edge of salt gardens, 3 m, F. 18534.
G-3: 170 km E of Pasni at road to Ormara, 50 m, F. 18439, Gh. 1752.
G-4: foothills of Haro Rge. at edge of Bela plain c. 15 km N of Kandewari, 40 m, F. 18233, Gh. 1672.

Until now the species has been only known from SE Iraq. The new findings in Balochistan and in the Eastern province of Saudi Arabia (Mandaville 7600) give proof of a much wider zonal distribution in the Eastern sector of the Saharo-Sindian region. Certainly, in future more localities will be discovered, and the species might be found also in the driest edges along the Indus plain. Perhaps the record of *A.* cf. *phyllophora* (Aitch. 411) from the Jhelum district (in Stewart, 1972) belongs here.

The species is restricted to extreme xerohaline habitats, usually on marl rich in gypsum and some sodium chloride. There it grows with *Suaeda fruticosa*, *Halothamnus iranicus* and sometimes also with *Haloxylon recurvum* or *Indigofera oblonga*.

The specimens were collected several weeks before the flowering period, but they agree in many respect with the type. They differ from *A. articulata*, which reaches its eastern boundary in Saudi Arabia, by much coarser and more succulent branches. In habit it approaches also *Arthrocnemum* and *Halosarcia*, but by its multilayered epidermis and absence of sclereids, confusion can be avoided.

Salsola cyclophylla Baker

More than 20 numbers have been collected by us in E-2, 3, F-2, 3, 4 and G-1, 2, 3, 4, and in some more places the species has been noticed. Therefore only a map is given here (see Fig. 2). A few specimens have also been found in older collections, e.g., Lamond 328 (E, KUH), Rechinger 27850 (W), XI 1880 Pierce (K) and Popov 146 (BM), but they have been misidentified as S. *baryosma*. Hitherto the species was known from S Yemen and Egypt up to S Iran only (Botschantzev, 1974; Chaudary & Akram, 1986). In Pakistan, *S. cyclophylla* usually inhabits gypsiferous serosems rich in fine sand and silt. It is an associate and often codominant of very open semi-desert communities, together with *Haloxylon salicornicum*, *Anabasis setifera* or *Salsola drummondii*. The intricately

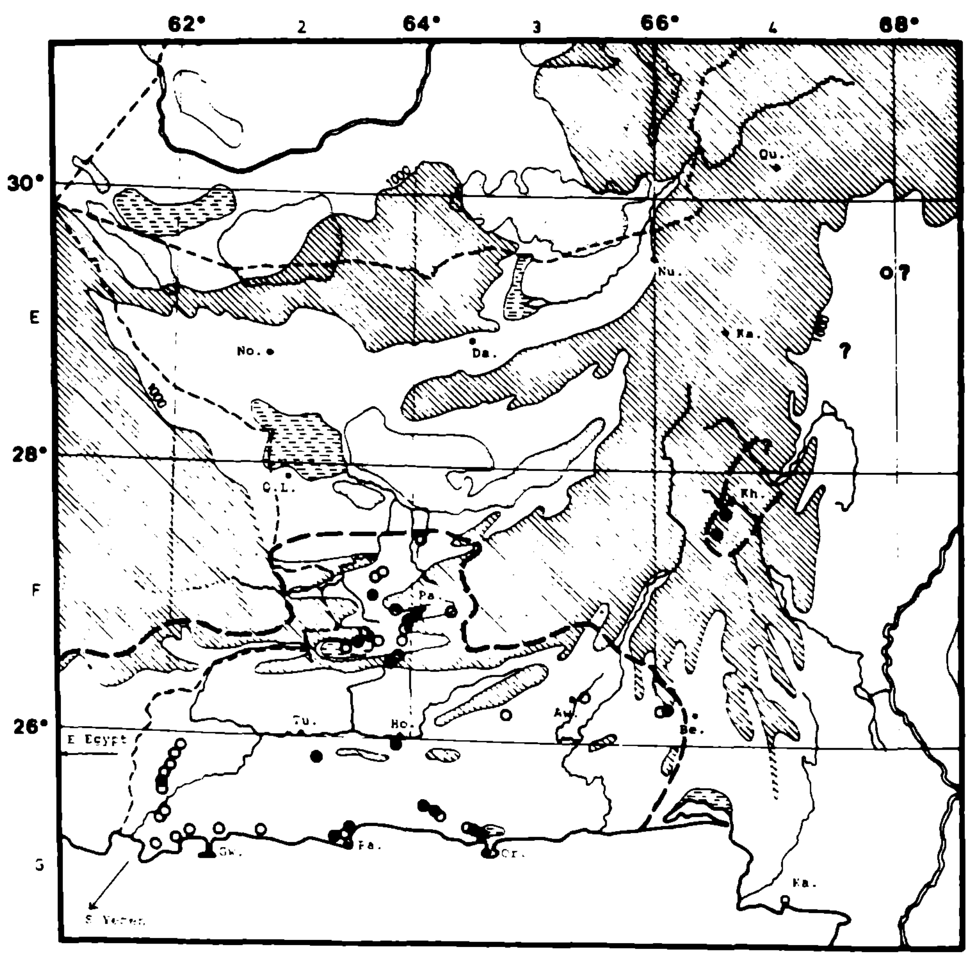


Fig. 2. Distribution of *Salsola cyclophylla* Baker in Balochistan (black circles — herbarium specimens; open circles — field notes). The E Saharo-Sindian species was not known before from Pakistan.

branched small shrub reaches a height of 30-60 cm and a diameter of 40-100 cm. Beside some differences in the flowers and fruits, *S. cyclophylla* differs from *S. baryosma* by its shining white silvery appearance which is caused by the very dense, appressed indument of the scale-like clasping leaves (for details see Freitag, 1989).

Salsola rubescens Franch.

F-2: 20 km SW of Panjgur at road to Hoshab, 970 m, F 18620, Gh. 1900. 40 km NW of Panjgur at new road to Palantak, 1100 m, F. 18679; ibid. 80 km NNW of Panjgur, 950 m, F. 18683.

The discovery of that species of sect. *Belanthera* was a surprise. It resembles *S. tomentosa*, but differs by the semi-amplexicaulous leaves which are arranged in a strictly distichous manner at the shortened ultimate branches. The plants from Balochistan agree completely with the type from Hadramaut, which hitherto was known only up to Oman. Curiously enough, the species has not been seen at the Makran coast. In C Balochistan it has been observed in a wide altidudinal range from c. 900-1450 m. Ecologically and phytocenologically it is similar to *Agathophora alopecuroides*, and often both have been found growing together.

IRANO-TURANIAN SPECIES

Cornulaca leucacantha Charif & Aellen*

E-20: 30 km s of Nokkundi, 630 m, F. 18672, Gh. 1954.

A few individuals have been collected from gypsiferous soil at the roadside in the almost barren northwestern corner of Balochistan. At first the almost globular and extremely spiny annual bushes of about 50 cm have been mistaken for *Horaninovia pungens* (Gilli) Botsch., an endemic of the S Afghanistan deserts. Due to a personal note of I. Hedge ("This lacks the characteristic scabrid papillae of *Horaninovia*-rather *Cornulaca*"), the identification has been reconsidered. *C. leucacantha* occurs scattered in the driest desert areas of C Iran, Iraq and the Northern parts of the Arabian Peninsula. The next locality known to me is the plateau S of Kerman (Freitag & Kuhle, 1980).

*According to Hedge (in litt.) this species comes into the synonymy to *C. aucheri* Moq.

Gamanthus gamocarpus (Moq.) Bunge

D-4: 37 mi. E of Quetta at road to Ziarat, 6 VII 59 59 A.H. Khan (PPFI-B). Since I have collected and noticed the species also in the higher semi-desert areas of SE Afghanistan, it is justified to expect it also in other parts of N Balochistan. It preferably inhabits highly eroded slopes and tolerates comparatively high salt concentrations.

Halothamnus subaphyllus (C. Meyer) Botsch. (=*Aellenia subaphylla* (C. Meyer) Aellen)

E-2: Koh-e-Sultan 40 km N of Nokkundi, 1900 m, F. 18699/17, Gh. 1991; ibid. 39 km N of Nokkundi, 1800 m, F. 18699/22, Gh. 1938; ibid. Qaiser & Ghafoor 4413, 4419, 4421 (all KUH); c. 25 km N of Nokkundi in foothills of Koh-e-Sultan, Gh. 1978.

The species had been recorded already for Pakistan on base of Jafri 2043 from Ziarat/Quetta by Stewart (1972), but that sterile plant probably belongs to *Salsola arbuscula* Pall. Inversely, true *H. subaphyllus* had been collected already 1971 by Qaiser & Ghafoor, but was mistaken for *Salsola arbuscula*. We collected and noticed the species in the Koh-e-Sultan in altitudes from 1600-1900 m from dry river beds, where it occurs scattered in a semi-desert community dominated by *Cornulaca monacantha*, *Haloxylon salicornicum* and *Artemisia* cf. *sieberi*. Very likely the species will be found in similar habitats at least in the neighbouring Chagai hills, as it is rather common over S and SE Afghanistan. It should be mentioned that according to Botschantzev (1981) the populations from NW Balochistan belong to *H. subaphylloides* Botsch., which is considered by him a southern vicariant of the Turkmenian *H. subaphyllus*. His weighting of the very small differential characters (longer and denser axillary hairs) is under reconsideration.

Noaea major Bunge

D-4: Hindubagh, 1800 m, 13, VIII 68 Shariq (PPFI-M)

The species is not rare in different semi-desert and seral plant communities in the adjacent provinces of Paktya, Ghazni and Zabul in Afghanistan, from 1900-3200 m. It is certainly underrepresented in the collections form N Balochistan.

Panderia pilosa Fischer & C. Meyer

E-4: Màstung, southern border of the city, roadside, 1700 m, F. 18835. Kalat, roadside near gas station, c. 2100 m, F. 18894.

The small annual grows gregariously in heavily disturbed waste places and is certainly common im many settlements in N Balochistan, like in most areas with similar climate from Anatolia to Middle Asia. With their winged fruits the plants look much like a small *Salsola*, but the tepals are united in lower part to a distinct cup, and the leaf anatomy is clearly "kochoid" in the sense of Carolin *et al.*, (1975).

Salsola chorasanica Botsch.

D-3: Ahmadwal, Datta 12 (RAW).
D-4: Pishin, 1500 m, 8 IX 67 Shariq (PPFI-M)

According to the literature the species is known from the type locality in E Iran only. Meanwhile it has been collected from several more places in E Iran and S Afghanistan. The new records from Upper Balochistan add considerably to the geographical range of the species. The divaricately branched annual inhabits salty clay flats with a sparse halophytic vegetation. It belongs to section *Cardiandra* and can be recognized by the dense "mealy" indument of bladder-like hairs and the long tepals, which form a characteristic narrow cone after the flowering period.

Salsola griffithii (Bunge) Freitag & Khani

E-3: 14 km SW of Nushki at road to Dalbandin, 900 m, F. 18749.
F-2: 60 km SSW of Panjgur near road to Hoshab, 1000 m, F. 18595; ibid. 40 km S of Panjgur, 1000 m, F. 18597, Gh. 1916.

The rediscovery of *Noaea griffithii* Bunge near the type locality SE of Kandahar in SE Afghanistan and the transfer of that shrubby species with spine-tipped leaves to the genus *Salsola* has been dealt with elsewhere (Freitag & Khani, 1987). There also a map of the total distribution of the species is given including the localities cited above. The strictly psammophytic species is a regular component of semi-stabilized sand fields. It grows in association with *Salsola richteri*, *Pennisetum divisum*, *Panicum turgidum*, *Cyperus conglomeratus* and *Haloxylon salicornicum*. To the south and southwest of Panjgur we noticed it in many sand fields. But we did not see it in the extremely arid sand dune areas of inner Kharan. The sands near Nushki evidently receive slightly more precipitation due to its position near to the higher mountain systems.

Salsola implicata Botsch.

F-2: Zangiabad near Nushki, Shah & Rehman 2592 (ISL).

The delicate psammophytic desert annual until recently has been known only from the sand deserts of Russian Middle Asia. Like so many other species of the Irano-Turanian sand deserts, I have found it in the respective habitats also in N and S Afghanistan, in C Iran and identified it in collections from S Iran (Léonard, 1987). Most often it grows in a plant community dominated by *Haloxylon persicum* and *Salsola richteri*.

Salsola kerneri (Wol.) Botsch. (=*Hypocylix kerneri* Wol.)

F-2: 40 km NW of Panjgur at new road to Palantak, 1100m, F. 18680, Gh. 1941. 60 km WSW of Panjgur at road to Parom, 910 m, F. 11652, Gh. 1926. 93 km S of Panjgur near road to Hoshab, 850 m, F. 18584.
F-3: Mihta Sing Mts. c. 30 km E of Panjgur, Gh. 1935. Koh-e-Sabz, 1350 m, Shah & Nisar 434 (ISL).

The species belongs to section *Coccosalsola*. It grows as a dwarf shrub, has conspicuously shining white stems and looks much like *S. montana* Litv., or small individuals of *S. arbuscula* Pall. In contrast to the latter species, the flowers are arranged in axillary clusters instead of being solitary. At least in the western section of the Central Makran Range the species is rather common from c. 850-1400 m on semi-desertic slopes in the predominant weak limestone and on pediment plains. In higher altitudes it is often codominant in plant communities with *Zygopghyllum eurypterum*. In lower altitudes it goes together with *Agathophora*, *Salsola cyclophylla*, *S. rubescens* and *Anabasis setifera*.

Salsola leptoclada Gand.

E-2: 20 km N of Nokkundi, Gh. 1962. Koh-e-Sultan, c. 40 km N of Nokkundi, around sulphur mines, 1900 m, in obs., Gh. 1990.
E-3: 14 km SW of Nushki at road to Dalbandin, 900 m, F. 18755.

This is a delicate annual of sect. *Cardiandra*, which grows in rather different natural or semi-natural, more or less disturbed habitats. In Pakistan it has been collected from dry river beds, eroded slopes and semi-stabilized sand fields. Probably it has a wider distribution in Upper Balochistan close to Afghanistan where it is a common species.

Salsola nitraria Pall

D-4: Quetta, 1900 m, 29 V 68 Beg (PPFI-B)
D-5: Loralai, 1410 m, Jafri & Akbar 2323A (KUH).
E-2: Koh-e-Sultan 39 km N of Nokkundi, 1900 m, F. 18699/24, 18699/27, Gh. 1986, 1988.
E-3: Nushki, V 66 M. Khan (PPFI-B)
E-4: 5 km E of Nushki at road to Quetta, Gh. 2047. 10 km E of Nushki at road to Quetta, Ghafoor & Yusuf (KUH). 52 km NE of Nushki, 1500 m, F. 18768, Gh. 2062. Dune area 7 km of Mastung, 1680 m, F. 188833.
F-2: Parom village, 96 km W of Panjgur, 895 m, F. 18649, 18650, Gh. 1921.
F-3: Panjgur, garden of guesthouse, F. 18640. 30 km WSW of Awaran at road to Hoshab, T. Ali 1457 (KUH).
G-2: 9 km S of Mand at road to Suntsar, Ghafoor & Qaiser 273 (KUH).

This very widely distributed weedy annual of section *Caroxylon* has so far been mistaken for young individuals of *S. baryosma* or for *S. micranthera*. The leaves have the same fishy smell like the first, but the plant is strictly annual and has much larger and usually smoke-coloured fruits. The specimen Jafri & Akbar 2323A has been named *S. micranthera* by Botschantzev and the name has been overtaken by Jafri (1987). *S. micranthera* ought to differ from *S. nitraria* mainly by smaller anthers (0,5-0,7 mm versus 0,8-1,3 mm), but with more material at hand the populations from Pakistan come into the variation of the common *S. nitraria*. The species has no distinct habitat preference. It grows in natural semi-desert communities on eroded slopes, on sand fields, but more often in highly disturbed places in settlements, on fallow fields and along ditches, on any type of soil.

Salsola richteri (Moq.) Kar. ex Litv.

E-1: 20 km NE of Qila Ladgasht, edge of Hamun-e-Maskhel, 500 m, F. 18688, Gh. 1948.
E-3: 14 km SW of Nushki at road to Dalbandin 900 m, F. 18751, 18752, Gh. 1948.
F-1: 51 km SW of Panjgur, 1 km W of road to Hoshab, 1000 m, F. 18628. 20 km S of Panjgur, Gh. 1907. Panjgur, 900 m, Popov 181 (BM).

This is another highly characteristic species of the Irano-Turanian desert flora (Freitag, 1986), which penetrates both from S Afghanistan and SE Iran into the sand dune areas of N and C Balochistan. Here it forms a community of its own with *Haloxylon persicum, H. salicornicum, Salosola griffithii, Pennisetum* *divisum* and other species of semi-stabilized dunes. The species of sect. *Cocco-salsola* grows as a shrub of 1-3 m. It can easily be recognized by its up to 7 cm long delicate leaves which at the main branches often become pendant. The local name is "narunk" (Qila Ladgasht).

NEW RECORDS OF "RARE" SPECIES

Here only a few striking examples are given of species, which due to under-collection hitherto are very poorly represented in the herbaria.

Halocnemum strobilaceum (Pall.) M. Bieb.

Stewart did not mention the species, and Jafri cited only 1 specimen from Lasbela district (Jafri, 1987). We can add the following localities:

G-1: Estuary of Dasht river N of Jiwani, in obs.. Gh. 1848.
G-2: Pishukan at W Gwadar Bay, salt gardens, in obs.. 2 km S of Pasni, 3 m, F. 18402, Gh. 1819. 3 km S of Pasni, 2 m, F. 18479, 18480.
G-4: Bela plain, 34 km W of Liari at road to Kandewari, 22 m, F. 18223, Gh. 1655. 4 km SE of "Hassan hotel" between Liari and Kandewari, Gh. 1663. Zikri Goth, N bank of Sonmiani Bay, 11 VII 89 D. Khan (KUH).

The Mediterranean/Irano-Turanian species is rather common along the Makran coast. It grows on salty clay of lagoons and estuaries, and on low sand flats immediately beside the shore. Usually it forms a community of its own and is associated by *Halopyrum mucronatum* (on sand only), *Urochondra setulosa*, *Suaeda fruticosa* and *Cressa cretica*. Often *Halocnemum* causes the formation of regularly shaped mounds, which might reach a height of up to 1.5 m and a diameter of more than 3 m with the emerging branches being only 20-30 cm tall.

Halostachys caspica (M. Bieb.) C. Meyer (= *H. belangerana* (M. Bieb.) Botsch.)

Stewart reported only one locality near Multan cited already in Parker (1918), and Jafri added two localities from near Keti Bunder in S Sind (Abedin 4132, 9401, both in KUH). There we recollected the species (F. 18161), but the following localities can be added:

E-2: 48 km N of Qila Ladgasht near road to Nokkundi, 530 m, F. 18695, Gh. 1951.
G-4: Mouth of Hingol river W of Bela plain, II 89 Beg (PPFI-B). Karachi, Clifton, 25 VIII 86 Husain & Ahmad (KUH).

The tall succulent shrub (0,5-2 m) grows in salty clay in estuaries and at the edge of inland playas, where less saline groundwater is in reach of the roots. In Pakistan the species might have a somewhat wider range, but it is doubtless that it will remain scattered, like in Iran and Afghanistan.

Halothamnus iranicus Botsch.

The species was described by Botschantzev (1981) from S Iran, with the var. *glabra* from Gabd, N of Jiwani, in westernmost Makran.We collected and noticed the species in many other places, and a few specimens of earlier collections have been seen in KUH under different other names. *Halothamnus iranicus* grows in the most extreme desert habitats, preferably on salt-containing weak limestone or on marl, both on slopes and in dry plains. Its xerohalophytic properties are well in line with growth form and morphology: it is an intricately branched, often mat-forming dwarf shrub of 20-50 cm, with small lanceolate, semi-succulent leaves, and a thick wax layer gives the plant a distinct bluish colour. From the presence in Khuzdar district it can be concluded that its distribution reaches much more to the North, in particular in the rain shadow areas in and along the Sulaiman Range.

Haloxylon persicum Bunge ex Boiss. & Buhse

Jafri did not see any specimen from Pakistan and was somewhat sceptical about the rather many records from all parts of Balochistan and Sind which are cited in Stewart. Like him, I did not yet have the opportunity to check all specimens of the classical collections. But from the experience gained in the Balochistan expedition, I doubt very much that *Haloxylon persicum* occurs in S Balochistan or in Sind. There we only saw the common *H. salicornicum* which in sterile herbarium specimens looks very much like *H. persicum.* We collected *H. persicum* at the following localities:

E-3: 42 km W of Dalbandin, 2 km S off the road to Nokkundi, 620 m, F. 18705, Gh. 1996. 13 km W of Nushki, 900 m, in obs.
F-2/3: 15-25 km NE of Qila Ladgasht, 500 m, F. 18687, Gh. 1950.

Near to Nushki, the species is said to be planted in the protected sandy areas near the road, but in the same area Aitchinson (1888) did his classical collections which include *H. persicum.* The first locality is very far from any settlement and all evidence is in favour of an undisturbed site. From the distant road the tall shrubs and small trees could only be seen by the use of binoculars as small dots on the lower part of the huge dunes. The last locality belongs to a part of the Hamun-e-Mashkel which is covered by small sand dunes up to 2 m. Here *H. persicum*, which is called "tagaz" by local people, reaches a height of about 4 m and is sometimes cutted for firewood. Usually *H. persicum* is the dominant species, and as in S Afghanistan it is associated with other psammophytes, preferably with *S. richteri*, *Cyperus conglomeratus*, *Euphorbia cheirolepis*, *Aeluropus macrostachys*, and on underlying clay flats also with *Suaeda fruticosa*. It is very probable that *H. persicum* is a common species in the waste dune areas all over Kharan and Chagai districts.

Krascheninnikovia ceratoides (L.) Guldenst. (= *Ceratoides latens* (J.F. Gmelin) Reveal & Holmgren)

So far only very few collections have been cited from Balochistan. But some more specimens have been seen in PPFI-B from D-4, D-5 and E-4. Furthermore, we met with the species as being really common in the Harboi Hills (F. 18896, Gh. 2190) and in the Koh-e-Maran NNE of Kalat. This observations and the species' distribution in the adjacent mountains of Afghanistan justify to expect it in all higher areas of N Balochistan from about 2000 m onwards.

Salsola drummondii Ulbr.

To the three localities cited in Stewart and Jafri today many more can be added:

C-2: S side of Bahadur Khel pass between Bannu and Kohat, c. 500 m, F. 24532; ibid. c. 600 m, F. 24533; ibid. 26 IV 68 Salim (PPFI-B). Dhok Pathan, Stewart & Nasir 22886 (RAW).
F-2: 38 km WSW of Panjgur, close to edge of Hamun-e-Parom, near "Hotel", 900 m, F. 18644. 50 km W of Panjgur on way to Parom Gh. 1915.
F-3: 14 km WSW of Panjgur near road to Hoshab, 940 m, F. 18619.
G-2: 4 km N of Pishukan at W Gwadar Bay, salt gardens, 3 m F. 18535, Gh. 1838. Gwadar, 7 X 66 s. coll, (KUH). 20 mi. from Pasni on road to Gwadar, Qaiser 7067. 6 km NW of Pasni, 30 m, F. 18397. Between Pasni and Rambra on way to Ormara, Gh. 1834A & B.
G-3: 20 km NW of Ormara, Mor Pati, 20 m, F. 18475, Las Bela, 17 V 65 Beg (PPFI-B); ibid. XI 60 McVean (KUH).
G-4: 15 km W of Liari near road to Kandewari, Gh. 1650. 30 km NW of Uthal at road to Bela, F. 18074, Gh. 1600, 1609.

S. drummondii is another typical element of the eastern section of the Saharo-Sindian region and very widespread in S and C Balochistan, where it forms a distinct plant community on dry salty alluvial plains, both on clay and on sand sheets. Usually it replaces the *Suaeda fruticosa*-community on the drier side. At the Northern edge of the Indus-plain it extends along the branches of the Salt Range from the type locality in Mianwali into Kohat and Attock districts. The species occurs probably in other places along the foothills of the Sulaiman Rge., most likely in Sibi district (Fig. 3).

Suaeda aegyptiaca (Hasselq.) Zoh. (=*S. baccata* Forssk. ex J.F. Gmelin)

Stewart cited only one specimen collected from Pierce somewhere at the

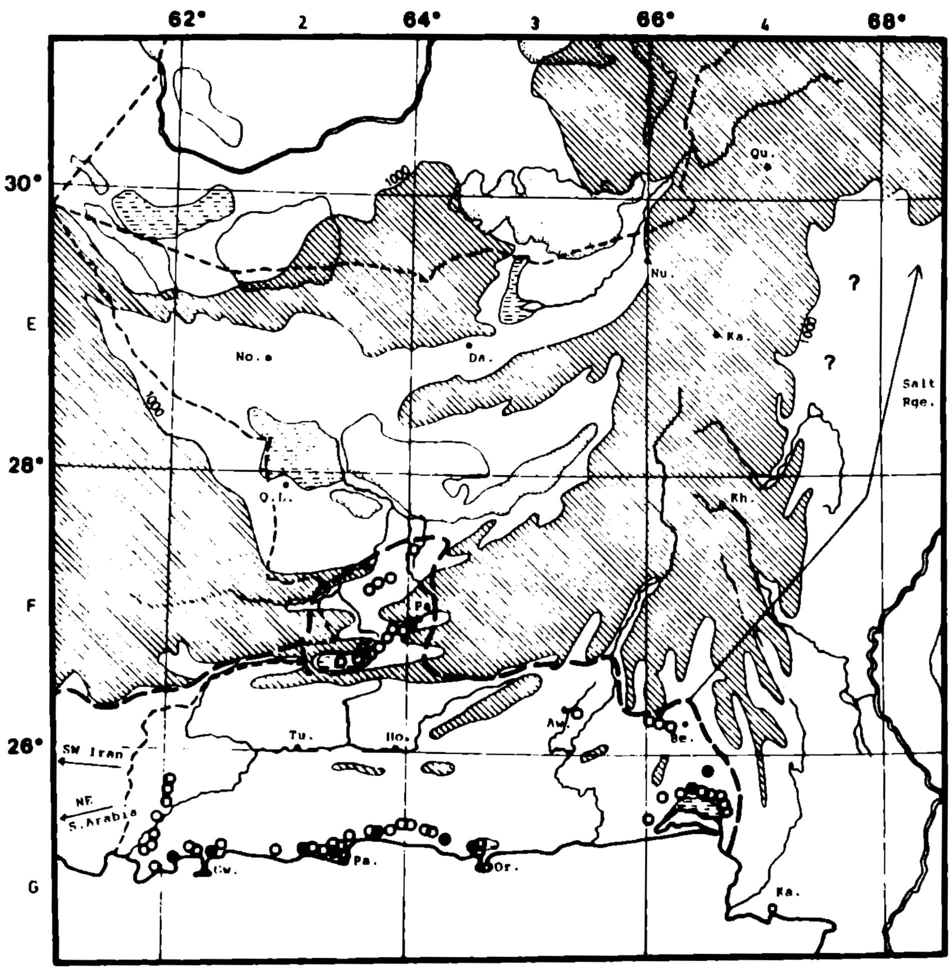


Fig. 3. Distribution of *Salsola drummondii* Ulbr. in Balochistan (black circles — herbarium specimens; open circles — field notes). The E Saharo-Sindian species was known before from 2 localities in Balochistan only.

coast of Balochistan. Jafri added two localities from G-2 (Hoshab, Kamal & Nazim 1146, 1153) and G-4 (Phitti creek near Kankhi, XII 77 Qaiser, all in KUH). We collected and noticed the Saharo-Sindian species in more than 20 localities all over Balochistan, from the coast to the Afghan border and up to altitudes of about 1000 m. As a winter-germinating annual it is confined to areas which receive at least some amount of rain in that season. *Suaeda aegyptiaca* prefers saline habitats and there it produces highly succulent leaves. However, sometimes it has been found growing as a weed in irrigated gardens and fields. Under such conditions it gets a rather different habit with less succulent, flatter leaves, greater height and a more erect branching system. A similar morphological plasticity which might cause confusion has been observed in material from Egypt (Freitag, 1989). Even more puzzling might be the morphological change caused by repeated grazing. The plant can resprout several times, and thereby it might get the appearance of a true perennial. *Suaeda aegyptiaca* joins different plant communities. Most often it has been seen in salt-marshes, in riverain forests of different *Tamarix* -species and in ruderal vegetation along irrigation ditches.

PERSPECTIVES FOR THE FAMILY ACCOUNT

The account of the *Chenopodiaceae* for the Flora of Pakistan is in preparation. It is done in line with the respective work on the family for the Flora Iranica project. To have the manuscript ready in a time-span of about 2-3 years, and to make use of the available expertise, the work has been split up in between I. C. Hedge, Edinburgh, (most genera), H. Freitag, Kassel (*Salsola* and related genera), P. Uotila, Helsinki (*Chenopodium*) and D. Podlech, Munich (*Suaeda*).

After having completed the Balochistan expedition, the work in most Pakistani herbaria, and a short field trip to the Salt Range area after the symposium, it became evident that still some parts of Pakistan are seriously undercollected with regard to chenopods. This is most obvious for the eastern foothills of the Sulaiman Range in N Balochistan. Especially the extremely arid lower tracts of Sibi district is expected to be inhabited by a rather rich chenopod flora, but remains virtually unknown. Another large gap remains in C Balochistan with the area around Kharan which could not be reached by us in 1986. Furthermore, it seems to me that also the arid valleys in N Pakistan, in particular in Gilgit district, are in need of more exploration. Further collecting should be carried out as soon as possible-and preferably in late autumn-to include the material into the *Chenopodiaceae* account for the Flora of Pakistan.

ACKNOWLEDGEMENTS

The author would like to acknowledge the support for the expedition from the Deutsche Forschungsgemeinschaft (DFG). He is deeply indebted to the staff of the Department of Botany at the University of Karachi, in particular to Prof. S.I. Ali for providing all facilities, and to all members of the expedition.

REFERENCES

Aitchison, J.E.T. (1888). The Botany of the Afghan Delimitation Commission. *Transact. Linn. Soc. Bot.* 2, *ser.*, 3: 1-139.

Botschantzev, V.P. (1969). Conspectus specierum sectionis *Cardiandra* Aellen generis Salsola L. *Nov. sist. vyss. rast.*, 6: 53-63.

Botschantzev, V.P. (1974). Species subsectionis *Caroxylon* sectionis *Caroxylon* (Thunb.) Fenzl generis *Salsola* L. *Ibid.*, 11: 110-171.

Botschantzev, V.P. (1976). Conspectus specierum sectionis *Coccosalsola* Fenzl generis *Salsola* L. *Ibid.*, 13: 74-101.

Botschantzev, V.P. (1981). Revisio generis *Halothamnus* Jaub. et Spach (*Chenopodiaceae*). *Ibid.*, 18: 146-176.

Carolin, R.C., Jacobs, S.W.L., & Vesk, M. (1975). Leaf structure in *Chenopodiaceae*. *Bot. Jahrb. Syst.*, 95: 226-255.

Chaudhary, Sh. A. & Akram, M. (1986). The genus *Salsola* in Saudi Arabia. *Proc.Saudi Biol. Soc.*, 9: 57-89.

Freitag, H. (1971 a). Die natürliche Vegetation Afghanistans. *Vegetatio*, 22: 286-344.

Freitag, H. (1971 b). Studies in the natural vegetation of Afghanistan. In: Davis, P.H. (ed.)-*Plant life of South-West Asia*. Edinburgh, p. 89-106.

Freitag, H. (1986). Notes on distribution, climate and flora of the sand deserts in Iran and Afghanistan. *Proc. Roy. Soc. Edinburgh*, 89 B: 135-146.

Freitag, H. (1989). Contributions to the chenopod flora of Egypt. *Flora*, 183: 149-173.

Freitag, H. & Kuhle, M. (1980). A plant list from the Kuh-e-Jupar (S.E. Iran), with some ecological remarks. *Willdenowia*, 10: 161-169.

Freitag, H. & Khani, Kh. (1987). *Salsola griffithii* comb. nov. (*Chenopodiaceae*) — a remarkable species from the sand deserts of SW. Asia. *Pl. Syst. Evol.*, 155: 49-54.

Jafri, S.M.H. (1987). *Chenopodiaceae*. Manuscript (1st draft) Karachi, 122 p.

Jafri, S.M.H. & Rateeb, F.B. (1978): *Chenopodiaceae*. *Fl. Lib.*, 58. 109 p.

Léonard, J. (1987). Contribution a l'étude de la flore et de la végétation des deserts d'Iran. 7. *Louvain*, 125 p.

Parker, R.N. (1918). A forest flora for the Punjab with Hazara and Delhi., Delhi.

577 p.

Stewart, R.R. (1972). An annotated catalogue of the vascular plants of West Pakistan and Kashmir. Karachi. 1028 p.

Wilson, P.G. (1980). A revision of the Australian species of *Salicornieae* (*Chenopodiaceae*). *Nuytsia*, 3: 3-154.

Proceedings of the International Symposium on Plant Life of South Asia held at the Department of Botany, University of Karachi, Karachi-75270, Pakistan. 24-27 February, 1991

BIOSYSTEMATICS

Plant Life of South Asia, 97–108, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

TAXONOMY OF FERNS OF INDIAN SUBCONTINENT: PROBLEMS AND PROSPECTS*

S.S. BIR

Department of Botany,
Punjabi University, Patiala-147002, India.

ABSTRACT

Indian subcontinent is very rich in fern flora with about 500 species on conservative estimate and nearly 25% are endemic mostly to eastern Himalayan region but the taxonomy of the complex genera as *Asplenium*, *Pteris*, *Athyrium*, *Diplazium*, etc., is least understood even today and still the reliance is made on R.H. Beddome's handbook even after a century of its publication. Cytological investigations have indicated nearly 10% of the Himalayan and 15% of the South Indian ferns to be aggregate species with more than one cytotypes included therein. Major taxonomic problems are centred around such species where access to the voucher specimens and type material are problematic. There is no revised flora for any of the countries of the region but Pakistan and Sri Lanka have latest annotated catalogues which give an idea about the richness of the flora.

Preparation of a revised country-wise or region-wise fern flora of the Indian subcontinent needs to be taken up on priority basis since irreparable loss to fern vegetation is taking place with the ever decreasing forest cover. Several of the endangered species may become extinct in not too distant future.

Recent taxonomic revision for *Dryopteris*, *Lepisorus* and *Pyrrosia* has shown that how much little we knew of the richness of our fern flora. The total number of species may exceed 1,000 when flora is fully explored and finally documented. In the process of taxonomic revision, results of morphology, anatomy, cytology and palynology need to be well integrated for circumvention of families, genera and even species because several of the "polymorphic" species are now known to be 'aggregates'. Illustrative examples are given where cytomorphotaxonomy has provided useful clues to the understanding of "species complexes" and the relationship of the component taxa.

INTRODUCTION

The Indian subcontinent with a great variety of climate ranging from tropical to cold temperate supports a very rich flora of vascular plants. These number

*Dedicated to Dr. R.R. Stewart in honour of his 100th birth anniversary on 15th April 1990 for his outstanding contibutions to the systematics of ferns and fern allies of north western Himalayas.

about 15,000 species of monocotyledons and dicotyledons (Santapau & Henri, 1973) and about 600 species of ferns and fern-allies (Bir, 1977) from India alone with many of these being endemic in the country. Including cultivated plants there are about 6,000 taxa of vascular plants in Pakistan and Kashmir with flowering plants numbering 5,632 species (Stewart, 1972).

Himalayas particularly their eastern ranges are very rich in fern flora with nearly 25% of the total for the Indian subcontinent being endemic to the region. The reasons for such a rich flora are not far to seek from. The Himalayas exhibit a great variation in climate and habitat, remained free from catacalysmic changes for a long time (there was little glaciation experience in the eastern part), provided new ecological niches for plants during their evolutionary history and the Himalayan temperate forests accumulate rich biomass which allowed many species to evolve and survive over a long span of time (Bir, 1989). But as we proceed from east to the west in the Himalayas there is a gradual decrease in the prolificity of ferns with the reciprocal decrease in rainfall and in Pakistan part of this mountainous system the ferns are much fewer in number.

In spite of such a rich heritage of plant wealth, no serious efforts have been made in India or Pakistan after attaining their independence for compilation of the revised Pteridophytic flora. Still the classical work of Beddome (1892) on Ferns of British India, Ceylon and Malaya Peninsula forms the basis of any serious endevour on regional flora. Malaya (Holttum, 1955) and Ceylon (for details see Sledge, 1982) have their own fern Floras while India (Dixit, 1984) and Pakistan (Stewart, 1972) are still contented with only annotated catalogues. For Bangladesh there is absolutely a complete lacuna and whatever little informaion is available, it is based on R.H. Beddom's or C.B. Clark's works. As far as fern allies are concerned Baker's (1887) book still forms the basis for the region although a revision of genus *Selaginella* in India has been given by Alston (1945). Obviously, new fern Floras are needed and the present account is aimed at posing problems in 'species circumvention' and as to what has been achieved on this account after these are brought out through cytological studies in India. Many of the species of north western Himalayas are common with Pakistan and concepts, approaches and solutions will naturally be aimed at commonly.

Estimates of Number of Species:

From Pakistan and Kashmir 128 species of ferns and fern allies are listed by Stewart (1972) while from present day political India are listed by R.H. Beddome 466 species of ferns and about 100 fern allies are also known. Dixit (1984) in his Census of Indian Pteridophytes has enumerated more than 1,000 members. The reason for such a wide variance is the fact that in classical fern Floras (Beddome, 1892; Clarke 1880) are included a large number of "aggregate" species (*Dryopteris filix-mas, Athyrium filix-femina, Asplenium unilaterale, Diplazium latifolium*, etc.) whereas in the present day Floras or taxonomic accounts a lot of more splitting is done. But the important point is a common meeting ground of both. Also a number of new records for the region have been made as well as a few more new sepcies/taxa have been described. Thus, so far we are not clear about the exact number of species on the Indian subcontinent, either country wise or on the total.

Chromosomal Analysis:

Such a work on the Pakistan ferns is completely lacking but studies since 1950 on the Indian and Ceylonese members have indicated the existence of a fairly large number of (i) hybrids (both sterile and sexual), (ii) polyploids and (iii) intraspecific cytotypes. Bir (1973, 1983, 1989) has elaborated the speciation processes in Indian fern flora and has given examples of species with more than one "cytotypes or biotypes". According to him intra specific cytotypes are present in 10.31% of the Himalayan and 15% of the south Indian species and these are really the difficult species to deal with taxonomically. These primarily belong to *Dryopteris, Asplenium, Diplazium, Athyrium Lepisorus* and *Pteris*. In view of the present day multicharacter approach to fern taxonomy (Bir, 1972 a) a number of criteria are essentially to be used in defining the taxonomic limits and contents to problematic genera and even 'species' of ferns of Indian subcontinent. The contributions of Chromosomal Analysis of different floras of the region in solving the taxonomic problems has been significant especially in case of 'polymorhic' species. Lists of species with more than one cytotypes have already been given by Bir (1972 b, 1973, 1989) for the Indian Pteridophytes and as a matter of fact the major taxonomic problems are centred around these 'multiple cytotype' species with or without morphological differences.

TAXONOMIC EVALUATION OF INDIAN FERN FLORA

Few illustrative examples of Indian flora with emphasis on species common to other countries of the subcontinent, are as follows:

(a) *Asplenium dalhousiae* complex.

As early as 1963 Bir pointed out the existence of morphotypes intermediate between *Asplenium dalhousiae* Hook. (2x, n = 36) and *Ceterach officinarum* DC. (4x, n = 72). These plants were found to be allopolyploids (6x, n = 108), and described as new species *Asplenium punjabense* (Bir *et al.*, 1985). The three spleenworts are confusingly similar in outline of lamina but can be separated on the basis of venation and the nature of scaliness of the lamina on under surface. All of these ferns have sympatric distribution from Kulu Himalaya to Kashmir and extending to Swat in Pakistan and beyond.

(b) *Asplenium planicaule-laciniatum* complex.

In the north western Himalayas we have got only tetraploid *A. planicaule* Wall. (= *A. yoshinagae* Makino var. *planicaule* Morton) with n = 72 but Garhwal eastwards *A. laciniatum* auct. (= *A. gueinzianum* Mett.), n = 72 has since long been confused with it taxonomicaly but now this species complex is separated into *A. gueinzianum* (var. *gueinzianum* & var. *obtusum*), *A. subintegrifolum* Hook. (= *A. laciniatum* var. *subintegrifolum*), n = 72 and a tetraploid hybrid (2n = 144) between *A. gueinzianum* var. *gueinzianum* (= *A. laciniatum* var. *laciniatum* auct.) and *A. subintegrifolium* (Bir, 1964 b).

(c) *Asplenium dalhousiae-paucivenosum* complex.

Asplenium dalhouisae Hook., is confined to north western Himalayas whereas *A. paucivenosum* (Ching) Bir is found eastwards of Nepal in Darjeeling District and Sikkim State extending to Arunchal Pradesh. Specimens of the later fern in Indian herbaria were named under *dalhousiae* but the two ferns are cytologically very distinct (Bir, 1962) with n = 36 (2x) for *A. dalhousiae* and n = 72 (4x) and 144 (8x) for *A. paucivenosum*. The 4x and 8x plants are very distinct and Bir (1972c) separated these as forma *minus* and forma *majus*, respectively. The latter one was raised to specific status as *Ceterachopsis birii* Love & Love but subsequently Bir *et al.*, (1985) recognising *Ceterachopsis* (J. Smith ex Ching) Bir as a subgenus within *Asplenium* L., this fern was transferred as *A. birii* (Love & Love) Bir, Fraser-Jenkins & Lovis.

(d) The Himalayan *Cystopteris fragilis* complex is segregated into octoploid (n = 168) *Cystopteris sikkimensis* Ching ex Bir (Bir, 1964b) and tetraploid (n = 84) *C. fragilis* (L.) Bernh., group distinguished into formae *fragilis*, *himalayansis* and *granulosa* (Bir & Trikha, 1976), the first two having echinate spores while the last one is characterized by granulose spores.

(e) According to Fraser-Jenkins (1989) *Dryopteris hirtipes* (Bl) Kuntz. subsp. *hirtipes* n = 41, 2x sexual, is South Indian and Sri Lankan plant and its report from the Himalayas is erroneous. The Himalayan samples are referrable partly to *D. darjeelingensis* Fraser-Jenkins, n = '2n' = 123, 3x apogamous but mainly to *D. stenolepis* (Bak.) C. Chr., n = '2n' = 82, 2x apogam. While *D. atrata* (Kunze) Ching recognized as subsp. *atrata* under *D. hirtipes* by Fraser-Jenkins is 4x sexual with n = 82 and is recorded from South India and eastern Himalayas.

(f) *Dryopteris (Nephrodium, Lastrea) filix-mas* has been the most intriguing species complex of the Sino-Himalayan region. R.C. Ching's revision of the Chinese and Sikkim-Himalayan *Dryopteris* is most note-worthy but the recent monograph on *Dryopteris* of Indian subcontinent by Fraser-Jenkins (1989) has explicitly defined the *filix-mas* group of species of Indian subcontinent to consist of: (i) *D. pulcherrima* Ching (= *D. filix-mas* subsp. *patentissima* var. *fibrillosa, D. fibrillosa*) n = '2n' = 82, 2x apogam. (ii) *D. acuto-dentata* Ching (= *Nephrodium kingii, D. filix-max* subsp. *Kingii*), n = '2n' = 123, 3x apogam. (iii) *D. lepidoposa* Hayata (= *Nephrodium filix-mas* var. *khasiana, N. parallelogrammum* forma *khasiana, D. paleacea* var. *khasiana*), n = '2n' = 82, 2x apogam. (iv) *D. wallichiana* (= *Lastrea filix mas* var. *paleacea, D. paleacea, L. patentissima, Nephrodium patentissimum, N. parallelogrammum* forma *patentissimum, D. patentissima, L. filix-mas* var. *parallelogramma, N. parallelogramum*), n = '2n' = 82, 2x apogam. (v) *D. panda* (Clarke) Christ (= *Nephrodium filix-mas* var. *panda, N. pandum*), n = 41, 2x sexual. (vi) *D. serrato-dentata* (Beddome) Hayata (*Lastrea filix-mas* var. *serrato-dentata* Bedd., *Nephrodium serratodentatum*), n = 82, 4x sexual. (vii) *D. odontoloma* (Bedd.) C. Chr*. (= *Nephrodium filix-max* var. *odontoloma* (Bedd.) Bak., *N. odontoloma* (Bedd.) (Clarke), n = '2n' = 123, 3x apogam. and *D. juxtaposita* Christ (= *Nephrodium filix-mas* var. *normalis* Clarke, *Dryopteris odontoloma* auct., *Lastrea odontoloma* T. Moore, *nom. nud.*), n = '2n' = 123, 3x apogam. (viii) *D. nigropaleacea* (Fraser-Jenkins) Fraser-Jenkins (= *D. pallida* subsp. *nigropaleacea, Nephrodium filix-mas* var. *normalis* pro parte, *N. rigidum, Lastrea rigida, D. odotoloma auct.*), n = 41, 2x sexual. (ix) *D. lachoongensis* (Bedd.) Nayar & Kaur (= *Lastrea filix-mas* var. *lachoongensis*). (x) *D. cochleata* (Buch-Ham. ex Don) C. Chr. (= *Nephrodium filix-mas* var. *cochleatum*), n = 41, 2x sexual. (xi) *D. marginata* (Clarke) Christ (= *Nephrodium filix-mas* var. *marginatum, N. marginatum*), n = 41, 2x sexual. *D. subimpressa* Loyal, n = 41, 2x sexual is segregate of the *D. marginata* group. (xii) *D. caroli-hopei* Fraser-Jenkins (= *Apidium marginatum* Wall. pro parte, *D. marginata* auct. Indian: west Himalayan materials, *Neph-*

*This is endemic to South India and the name wrongly applied to the Himalayan materials which really belong to *D. juxtaposita* until now treated as synonym of *D. odontoloma* by C. Christensen and R.C. Ching.

rodium marginatum senu Hope), n = 41, 2x sexual. (xiii) *D. assamensis* (Hope) C. Chr. & Ching (= *D. filix-mas* var. *assamensis*). (xiv) *D. subtriangularis* (Hope) C.Chr. (= *Lastrea filix-mas* var. *subtriangularis*, *D. subassamensis*).

Dryopteris filix-mas (L.) Schott., n = 82, 4x sexual is a species of the open rocky areas and is found in northeast Afghanistan and Pakistan (Himalaya-west and east of Indus) and in India in north west Himalaya-Kashmir: Pir Panjal, Gulmarg, Kishenganga valley, Sonamarg.

(g) The genus *Lepisorus* of the Himalayas is very poorly understood. In classical works its members are described under *Polypodium* and *Pleopellis* and often materials of quite a different species are labelled as *Polypodium lineare* Thunbg., in different herbaria. *Polypodium lineare* complex in the Himalayas was recognised by Bir & Trikha (1972) to consist of as many as 13 species viz., *L. loriformis* (Wall. ex Mett.) Ching, n = 26; *L. clathratus* (Clarke) Ching; *L. nudus* (Hook.) Ching, n = 35; *L. amaurolepidus* (Sladge) Bir & Trkha, n = 35; *L. pseudonudus* Ching; *L. ussuriensis* (Regel & Mack) Ching: *L. angustus* Ching; *L. thunbergianus* (Kaulf.) Ching; *L. contortus* Ching, n = 35; *L. kashyapii* (Mehra) Mehra, n = 36; *L. excavatus* (Bory) Ching, n = 35; *L. kuchensis* (Wu) Ching, n = 37 and *L. bicolor* Ching. On the basis of further examination of herbarium materials from CAL & US *Lepisorus excavatus* complex of the Himalayas was analysed by Bir & Trikha (1974) to be comprised of *L. oligolepidus* (Bak.) Ching. *L. suboligolepidus* Ching, *L. sublineare* (Bak.) Ching, *L. leiopteris* (Kunze) Bir & Trikha (= *L. scolopendrium* (Don) Mehra & Bir) *L. excavatus* (Bory) Ching, n = 35; *L. oosphaerus* (C. Chr.) Ching, *L. sordidus* (C. Chr.) Ching, *L. subconfluens* Ching and *L. amaurolepidus* (Sledge) Bir & Trikha.

With the discovery of aneuploid numbers n = 35, 36, 37 in *L. excavatus* itself, the specific materials were segregated into var. *excavatus* (n = 35), var. *mortonianus* Bir & Trikha (n = 37) and var. *himalayansis* Bir & Trikha (n = 36) whereas *L. amaurolepidus* was found to consist of var. *amaurolepidus* and var. *longifolius* Bir & Trikha (n = 35). Morphologically the infraspecific taxa are very clear. Similarly, according to Bir & Satija (1981) *L. kashyapii* of the western Himalayan region showed infraspecific variations segregated into var. *kashyapii* (n = 36), var. *major* Bir & Trikha (n = 36) and var. *minor* Bir & Trikha (n = 35). Against an earlier record of about 10 species of *Lepisorus* from the Indian region as many as 20/25 species/taxa are now known from the country. Recently, Khullar (1984) has recorded a discordant note. According to him the type of *L. excavatus* (Bory) Ching is from south east Africa characterised by long stipe with lamina of thicker texture and South Indian plants closely agree with African plants but the western Himalayan plants generally known as *L. excavatus* differ from true *excavatus* in having a much shorter stipe and lamina of thinner texture and thus these were referred as *L. scolopendrius* (Ham. ex D. Don) Mehra & Bir (= *L. leiopteris* (Kunze) Bir &Trikha). The whole Indian material of *L. excavatus* group, needs re-examination because I am not inclined to use the name *L. leiopteris* for whole of the *L. excavatus* group. Further, Ching *et al.*, (1983) segregated from *L. clathratus* complex closely resembling but distinct fern *L. jakonense* Ching (*L. clathratus* var. *jakonense* Blanford). This is a very widely distributed fern in western Himalayas between 2,000-3,000 m. In reality, *L. clathratus* is a fern of higher altitudes (3,000 m. and above) and in *L. jakonense* the rhizome scales have fimbriated margin with long projections and in *L. cclathratus* the margin of rhizome scale is more or less dentate and stipe is longer (Khullar, 1984). *L. thunbergianus* (Kaulf.) Ching is a Japanese fern and is not met with in western Himalayas and Bir & Trikha's (1972) *L. thunbergianus* plants need to be referred to *L. tenuipes* Ching & Khullar (Khullar, 1984). Thus, it seems that the *Lepisorus* materials from India are still in the need of taxonomic revision and this should be done with reference to type materials of the total species recorded from the Indian subcontinent.

(h) *Pyrrosia* Mirbel: The genus primarliy is native of wet forests of Darjeeling Sikkim, Assam, Meghalaya, Arunchal and Peninsular Indian mountains of Pulnis and Nilgiris. A few members are found west of Nepal too extending to Mussoorie and Simla but no member is recorded from Kashmir and Pakistan (Stewart, 1972) as well as western and central India while 5 species are known from Ceylon (Sledge, 1982). The main concentration of members on Indian subcontinent is in eastern and central Himalayas (Garhwal to Bhootan) many of which are common to China, Burma and Malaya. The latest account comes from Satija, Bir & Bhardwaja (1983) who in contrast to 13 species by Beddome (1892) under *Niphobolus* Kaulf., have described 22 species from present day political India with two additional doubtful records from South India. Quite a many of the species look alike but can be segregated on the basis of rhizome scales, hairs on the lamina as well as spores, this being particularly true of *P. stictica*, *P. mollis*, *P. manii*, *P. nayariana* and *P. gardneri* group.

(i) In a recent survey of the distribution, ecology and phytogeography of Asplenioid (respresented by *Asplenium* L., alone) ferns of India, Singh & Bir (1989) recorded about 65 species which represent 10-12% of the total ferns recorded from the country even on the basis of liberal estimates (Dixit, 1984). They have listed species found in western Himalayas (27 species), eastern Himalayas (37 species), central India (8 species) and south India (32 species) and also listed species which are exclusive to different floristic regions. Species which find no mention in Beddome's Handbook include *Asplenium aethiopicum*, *A. aitchisonii*, *A. birii*, *A. nesii*, *A. breynii*, *A. khasianum*, *A. obliquissimum*, *A. paucivenosum*, *A. pseudofontanum*, *A. subintegrifolium*, *A. subvarians*, *A. yunnanense*, etc. The listing of species being based on S.S. Bir's examination of Indian materials at CAL, BLATT, K, US, NY, MICH, GH and BM. Indian materials of *Asplenium unilaterale* complex are now known to be comprised of five species as *A. exicism* Presl., *A. obscurum* Bl., *A.unilaterale* Lamk., *A. rivale* (Bedd.) Bir and *A. obliquissimum* (Hayata) Sugimoto & Kurata.

(j) Usefulness of anatomical features for delimitation of confusingly similar species of Dryopterioid and Thelypterioid ferns or Asplenioid and Athyrioid-Diplazioid ferns in the field is now well established. Even at infraspecific level anatomy is a useful criterion in segregating difficult taxa. The point is illustrated by *Diplazium latifolium* Moore *f. latifolium* of the eastern Himalayas. The stelar structure in the rhizome and petiole of this fern is unusual as compared to the species of the group as *D. polypodioides* Bl., *D. asperum* Bl. and *D. maximum* (Don) C. Chr. It has 4-7 leaf trace strands (2 large and 2-5 small) at the base of petiole instead of usual number of two large strands and in the rhizome the structure is complicated with respect to departure of additional leaf strands. According to Bir (1969) on these features *D. latifolium f. latifolium* is distinguishable from *D. maximum* a species with which it has often been confused or even treated as synonym. Further, the presence of single leaf trace at the base of petiole in *A. himalaicum* Ching ex Mehra & Bir and *A. anisopterum* Christ (Bir, 1971) is a specific diagnostic feature as well as several other anatomical features of the Himalayan members of *Athyrium*.

(k) Palynology is another important aspect in taxonomy. Now the descriptions of taxa must have full information on spores, representing such an important feature of reproductive biology. Examples of role of spore morphology in taxonomy of Indian ferns are quite enough for this field to be given important place in fern taxonomy (Bir, 1966-67, 1976).

(l) The importance of morphology of rhizome, dermal appendages, form of petiole/stipes, nature of sporangia, paraphyses, gametophytes, etc., in taxonomy can not be under rated in the event of newly emerging areas of phytochemistry, reproductive biology (antheridrogen) and ecology. Bir (1972a) while advocating the adoption of Synthetic Approach to Taxonomy has brought out the importance of such features in solving taxonomic tangles at specific or generic levels.

In the foregoing pages, I have given few examples of various taxonomic criteria as applied to the solution of taxonomic confusions about Indian ferns. The right approach in compilation of a revised flora should be on the basis of a monographic account incorporating findings of various disciplines of enquiry as are useful in taxonomy. The basis for polymorphicism of species have to be found and emphasised with clear cut demarcation of various biotypes. All this requires a co-ordinated approach which sooner or later has to be adopted.

PROBLEMS

The major problem in compilation of Flora of India or as a matter of fact of the Indian subcontinent is firstly the lack of interest in the field of taxonomy by plant scientists, secondly no interest in field studies for observing various "species" as they grow in nature and above all thirdly, the hesitation on the part of funding agencies in ear-marking grants for 'Flora' studies. Essentially the importance of "Flora compilation" has to be realized at national level and proper scientific temper has to be created for achieving this end.

Significant plant collections of 18th and 19th centuries from Indian subcontinent are housed in European herbaria and any meaningful taxonomic work is possible only with the study of these collections and reference to type materials which are either not easily located or are not easily available for study.

PROSPECTS

Except for Ceylon where Pteridophytic Flora has been revised by W.A. Sledge of Leeds University, the Floras of all other countries of Indian subcontinent are far from completion. In India only 6 major genera as *Selaginella, Dryopteris, Lepisorus, Pyrrosia, Phymatodes, Microsorium* and a double number of small genera have been revised out of a total of over 100 genera. This means hardly one fifth of the total flora is revised. Nepal's fern Flora has by and large been revised by Japanese Expenditionists (see Flora of Eastern Himalayas-First and Second Report by H. Hara in 1966, 1971 and Third Report by H. Ohashi in 1975) together with reference to species met with in adjoining Darjeeling-Sikkim region but I am not aware of any attempt on fern flora of either Bangladesh or Bhootan or Pakistan. Evidently, a lot more remains to be done.

R.E. Holttum's work on Malayasian ferns particularly the Thelypteridaceae and W. A. Sledge's studies on Ceylon ferns are significant in the context of Indian flora because of commonness of South Indian and Ceylon flora and east Indian and Malayan Flora. East Himalayan flora has a large number of common species with China too. So Chinese specimens can not be over looked. Comparison of Indian materials with Ceylonese, Malayan and Chinese materials is of paramount importance in this direction. Any attempt without study of materials of adjoining regions, is not likely to pay rich dividends about the quality or usefulness of the Flora.

Co-ordination and free exchange of materials amongst taxonomists of Bangladesh, Nepal, Bhootan, India, Pakistan and Ceylon is essential for fruitful completion of Flora work. To achieve this end, study of materials especially at Kew and Peking apart from National herbaria is absolutely necessary. Any amount of difficulties need not dampen the enthusiasm regarding preparation of 'Revised Fern Flora of the Indian Subcontinent'.

CONCLUDING REMARKS

Before concluding, I would like to stress the need and the urgency of compilation of 'Pteridophytic Flora of Indian subcontinent' because from this phytogeographically significant region of the World Flora forest cover is fast decreasing year after year with 1,47,000 hectares being deforested every year in India alone. Naturally, this means destruction of the natural habitats of ferns and fern allies because these flourish the maximum in forests either as epiphytes or as growth on the forest ground or rocks or along water courses. Thus, before the vegetation gets completely destroyed and the species get extirpated from specific regions, we must have total assessment of the plant resources with proper inventories so that requisite steps are taken in time for the conservation of the rare and endangered species, particularly the endemic ones. It may interest the readers to note that area or region-wise lists of endemic and endangered species of Pteridophytes of India have already been compiled by the writer (Bir, 1987).

ACKNOWLEDGEMENTS

I express my grateful thanks to Professor S.I. Ali, Dean, Faculty of Science, University of Karachi and Indian National Science Academy for financial assistance for my participation in the International symposium on 'Plant life in South Asia' held at Karachi on February 24-27, 1990 on the Centennial of Dr. R.R. Stewart.

REFERENCES

Alston, A.H.G. (1945). An enumeration of the Indian species of *Selaginella*. *Proc. Nat. Inst. of Sci. of India.*, 11: 211-235.

Baker, J.G. (1887). *Handbook to the Fern-Allies*. George Bell & Son. London.

Beddome, R.H. (1892). *Handbook to the Ferns of British India, Ceylon and Malaya Peninsula*. Thacker Spink & Co. Calcutta.

Bir, S.S. (1962). Taxonomy of Indian members of family Aspleniaceae. *Bull. Bot. Surv. India*, 5: 1-16.

Bir, S.S. (1963). Evolution in the Indian members of genus *Asplenium* L. *Memoirs Indian Bot. Soc.*, 4: pp. 41-50.

Bir, S.S. (1964a). Taxonomic notes on some Himalayan ferns. *J. Indian Bot. Soc.*, 43: 556-572.

Bir, S.S. (1964b). Two new ferns from the eastern Himalayas. *Nova Hedwigia*, 7: 501-506.

Bir, S.S. (1966-67). Role of spore morphology in the Taxonomy of family "Aspleniaceae". *Palynological Bull.*, 2-3: 3-11.

Bir, S.S. (1969). The stelar anatomy of *Diplazium latifolium* Moore. *Amer. Fern. J.*, 59: 23-26.

Bir, S.S. (1971). Anatomy of some Himalayan species of *Athyrium*. *J. Indian Bot. Soc.*, 50: 247-252.

Bir, S.S. (1972a). Synthetic Approach of Fern Taxonomy. In: Puri, V. *et al.*, (Eds) *Biology of Land Plants*. Sarita Prakashan. Meerut. India. pp. 290-299 (Published in 1974).

Bir, S.S. (1972b). Evolutionary status of the Asplenioid and Athyrioid ferns with particular reference to the Himalayan forms. *Cytologia*, 37: 175-169.

Bir, S.S. (1972c). Cytological observations on *Asplenium paucivenosum*. *Amer. Fern J.*, 62: 44-46.

Bir, S.S. (1973). Cytology of Indian Pteridophytes. In: Nair *et al.*, (Eds) *Glimpses in Plant Science Research*. New Delhi. pp. 28-119.

Bir, S.S. (1976). Contributions of spore morphology in the Taxonomy of some taxa of Ferns. *Advances in Pollen-spore Res.*, 2: 1-28.

Bir, S.S. (1977). Pteridophytic Flora of India: A review of achievements and future challenges in the systematics and taxonomy. *Bull. Bot. Surv. India*, 19: 323-329.

Bir, S.S. (1983). Cytogenetics of Pteridophyta. In: Jaiswal *et al.*, (Eds). *Genetical Research in India*. I.C.A.R. New Delhi. pp. 46-60.

Bir, S.S. (1987). Pteridophytic flora of India: Rare and endangered elements and their conservation. *Indian Fern J.*, 4: 95-101.

Bir, S.S. (1989). Evolutionary Trends in the Pteridophytic Flora of India. In: Bir, S.S. and M.I.S. Saggoo (Eds). *Perspectives in Plant Science in India*. Today & Tomorrow's Printers & Publishers, New Delhi. pp. 1-22.

Bir, S.S., C.R. Fraser-Jenkins & Lovis, J.D. (1985). *Asplenium punjabense* sp. nov. and its significance for the status of *Ceterach* and *Ceterachopsis*. *Fern Gaz.*, 13: 53-63.

Bir, S.S. & Satija, C.K. (1981). *Lepisorus kashyapii* in the western Himalayas. *Amer. Fern J.*, 71: 53-56.

Bir, S.S. & Trikha, C.K. (1972). Taxonomic revision of the Polypodiaceous genera of India IV. *Polypodium lineare* complex. *Bull Bot. Surv. India*, 11: 260-276 (1969 Issue).

Bir, S.S. & Trikha, C.K. (1974). Taxonomic revision of the Polypodiaceous genera of India. VI. *Lepisorus excavatus* group. *Amer. Fern J.*, 64: 49-63.

Bir, S.S. & Trikha C.K. (1976). *Cytopteris fragilis* in the western Himalayas. *Amer. Fern. J.*, 66: 109-110.

Ching, R.C., Y.X. Ling & Wu, S. (1983). A taxonomic revision of *Lepisorus clathratus* (Clarke) Ching complex in the Sino-Himalayan region. *Acta Botanica Yunnanica*, 5: 1-23.

Clarke, C.B. (1880). A review of the ferns of northern India. *Trans. Linn. Soc. Lond.* II (Bot.), 1: 425-611.

Dixit, R.D. (1984). *A census of the Indian Pteridophytes.* Flora of India series IV. Botanical survey of India. Howrah.

Fraser-Jenkins, C.R. (1989). A monograph of *Dryopteris* (Pteridophyta: Dryopteridaceae) in the Indian subcontinent. *Bull. Brit. Mus. (Nat. Hist.) Botany Series*, 18: 323-447.

Holttum, R.E. (1955). *A Revised Flora of Malaya.* Vol. 2. Ferns of Malaya. Printing Press. Singapore.

Khullar, S.P. (1984). The ferns of western Himalaya: A few additions, corrections and annotations. *Indian Fern J.*, 1: 89-95.

Santapau, H. & Henri, A.N. (1973). *A dictionary of Flowering Plants in India.* C.S.I.R. New Delhi.

Satija, C.K., Bir, S.S. & Bhardwaja, A.K. (1983). Taxonomic revision of the Polypodiaceous genera of India. *Pyrrosia* Mirbel. *Bull. Bot. Surv. India*, 25: 62-89.

Singh, Y. and S.S. Bir. (1989). Distribution, Ecology and Phytogeography of Asplenioid ferns of India. *Indian Fern J.*, 6: 268-284.

Sledge, W.A. (1982). An Annotated Check-list of the Pteridophytes of Ceylon. *Bot. J. Linn. Soc.*, 84: 1-30.

Stewart, R.R. (1972). *An Annotated Catalogue of Vascular Plants of West Pakistan and Kashmir.* In: Nasir, E. and S.I. Ali (Eds). Flora of W. Pakistan. Fakhri Printing Press, Karachi, Pakistan.

Plant Life of South Asia, 109–126, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

A NUMERICAL PHENETIC ANALYSIS IN THE GENUS *ORIGANUM* L. (LABIATAE)

S.Z. HUSAIN

School of Plant Sciences, Plant Science Laboratories, University of Reading, Whiteknights, P.O. Box 221, Reading, RG 6 2 AS, U.K.

ABSTRACT

In the course of a phytochemical and taxonomical survey of *Origanum* L., and representative species of related genera, data from essential oil studies, flavonoids, palynology, comparative morphology were gathered. All these data were subjected to numerical phenetic analysis. Cluster analysis (using group average, single linkage and complete linkage) were employed. Each cluster analysis was expressed in the form of a dendrogram. The results agreed well in part with the decisions reached by traditional taxonomic methods, especially with regard to the limitation of sections and species.

INTRODUCTION

Origanum L., (Labiatae) is a taxonomically critical genus containing 38 species (Ietswaart, 1980), whose geographical distribution extends from N. Africa and western Europe to central Asia, although most species occur in the Mediterranean region. One species *O. vulgare* L., occurs in Pakistan. It is widespread and common in dry grassland and scrub on calcarious soils. A detailed study of the morphology, features of pollen by S.E.M. and phytochemistry of secondary compounds in the genus has enabled a comparison to be made between taxonomic schemes derived from conventional morphology on the one hand and macromorphology and chemistry on the other.

The history of chemosystematics (chemotaxonomy) has been described by many authors (Bate-Smith & Swain, 1965; Gibbs, 1958, 1965; Hegnauer, 1962, 69). These accounts clearly show the potential value of using chemical evidence in plant taxonomy and systematics. Species of medical, toxicological and economic importance were the only ones, prior to 1945, for which a substantial amount of data was available; many compounds could not be identified, owing to a lack of suitable techniques and in many cases constituents occurred at concentrations below those which could be detected using instruments available at that time. Also, the techniques available were very time consuming and large quantities of plant material were needed to ensure detection and complete identification of new compounds.

However, in the last two decades progress has been very rapid, especially in techniques such as paper and thin-layer chromatography, electrophoresis, gas liquid chromatography and various forms of spectroscopy (e.g., ultraviolet, infra red, mass spectroscopy and nuclear magnetic resonance), all of which have allowed numerous plants to be extensively surveyed for a wide range of natural products. In general, use of the above techniques means that only relatively small quantities (mg amounts) of plant material need be extracted in order to isolate sufficient compound for full structural determination. A number of different classes of chemical constituents are of potential taxonomic value. These include both macromolecules (proteins, nucleic acid derivatives, chlorophylls and polysaccharides) and secondary constituents, non-protein amino acids, betacyanins and betaxanthins, terpenes, flavonoids and alkaloids. These so called secondary compounds are of low molecular weight rarely above 1000, have an irregular distribution in the plant kingdom.

Several reviews considering the impact of secondary chemistry on plant taxonomy have appeared recently covering much of the progress in the field since 1967 (Cronquist, 1977; Harborne *et al.*, 1975; Swain, 1979). While it is relatively easy to obtain chemical data; it is not always so simple to decide upon the proper application of data in a taxonomic context; where the original objective of the investigation is to enable the identity of taxa to be determined. The problem is not too great, provided that a sufficient number of characteristics have been examined in adequate samples of the taxa concerned.

Where the purpose of investigation is more extensive and involving large complexes, lacking in distinctive morphological characters, the problem of integrating chemical data becomes more difficult. This could possibly be overcome by first applying some techniques of relatively low resolving power (e.g., general protein electrophoresis), in order to find diagnostic breakpoints in what at first appears to be continuum of morphological characters. After reassessing the morphological background, when some general groupings are established, it is helpful then to proceed with high resolution techniques (e.g., enzyme electrophoresis or scanning electron microscopy).

Numerical taxonomy is the grouping of entities on the basis of the character states they display. It provides a logical means of expressing the relationships among taxa, is based on the assumption that all characters should be used in classification and aims to give equal weight to each character (Harris & Bisby, 1980). Taxonomists today believe that the method should be regarded as decisions indicating rather than decision making (Stearn, 1968). Here the aim has been to investigate by numerical methods the phenetic relationships between previously recognised taxa, and to determine how these relationships correlate with the conclusions reached on the basis of the empirical methods and to make recommendations as to species grouping.

The taxa used were previously recognised (Ietswaart, 1980). Gross morphological characters used by previous workers were re-investigated and scored for most taxa. Data from other techniques such as micromorpholoy, phytochemistry (Husain & Markham, 1981; Husain *et al.*, 1982) and palynology (Husain & Heywood, 1982), were also obtained. A total of 117 characters were used (Table-1).

Table 1. Sources of information used in numerical phenetic analysis of 42 *Origanum* species.

		No. of Characters
1.	Vegetative morphology	15
2.	Floral morphology	25
3.	Pollen grain morphology (Scanning Electron Microscope)	7
4.	Leaf flavonoid glycosides	20
5.	Leaf essential oils (gas liquid chromatography)	50

MATERIALS AND METHODS

The live material was grown in the Botanic Gardens at Plant Science Laboratories, University of Reading from seeds either collected on field trips to southern Europe or obtained from European Botanic Gardens. Herbarium specimens (over 2000) were borrowed from 14 different herbaria (Husain, 1983).

The main reason for collecting comparative morphological data was to produce a morphological classification by exactly the same methods and on exactly the same herbarium material as was used for other type of data. Forty morphological characters were used. Secondly, it was of interest to compare the result with the existing morphology-based classifications (Ietswaart, 1980; Briquet, 1897; Boissier, 1879).

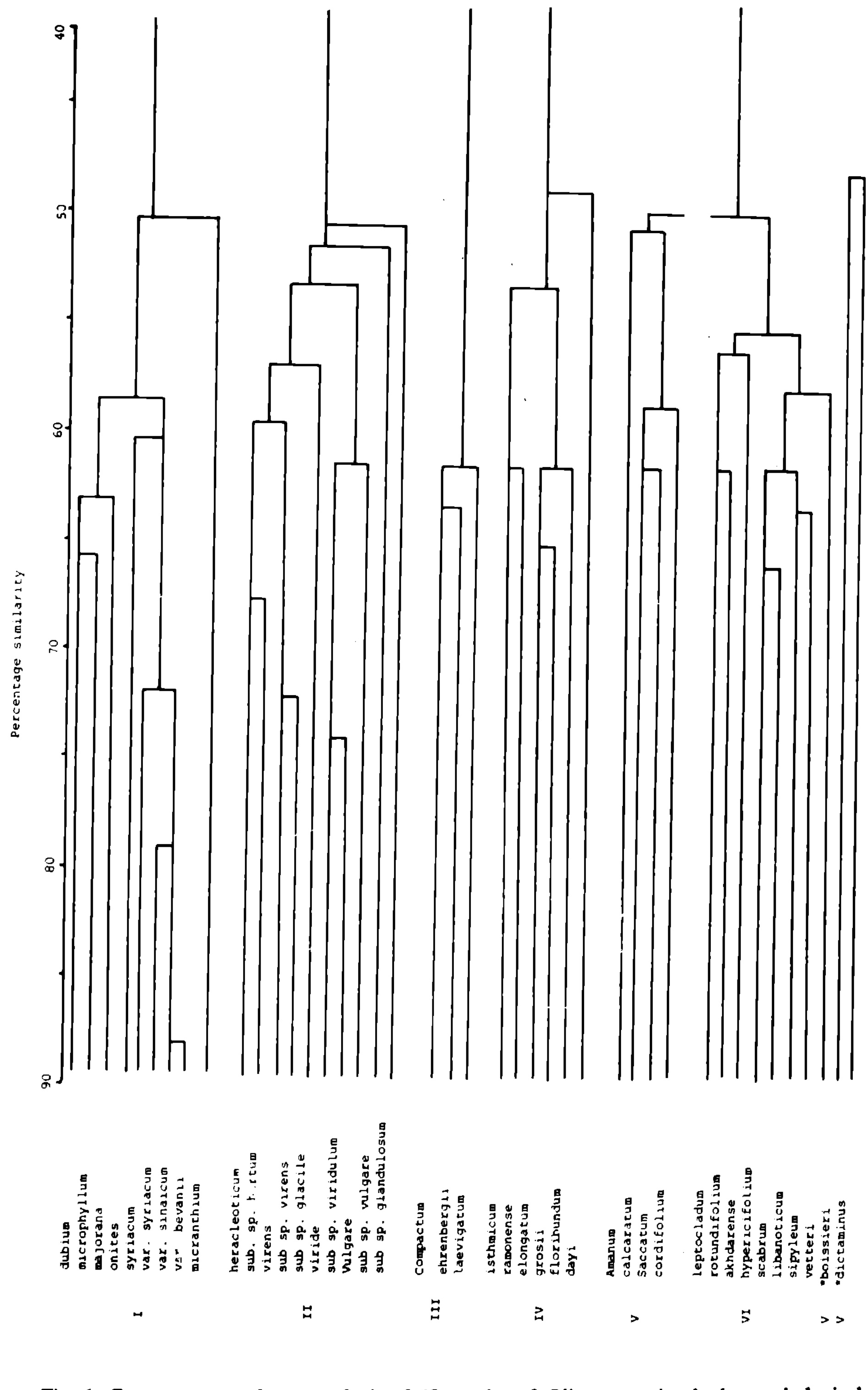


Fig. 1. Group average cluster analysis of 42 species of *Oliganum* using both morphological and chemical characters.

The characters used are of 4 types: binary, multi-state unordered, multi-state ordered and continuous. Binary characters were scored 1 for 1st state and 2 for the other state. Multi-state unordered characters were scored 1, 2, 3, ... up to the number of states recognised in each character; differences between any two states of these characters were regarded as having equal weight. For example, the difference between states 1 and 2 is no greater or less than that between states 3 and 4 or states 1 and 4 (e.g., bract colour whitish = 1, whitish green = 2, green = 3, greenish-yellow = 4, greenish-purple = 5, purple = 6). Multi-state ordered characters are those whose variation is continuous but where the variation is broken up for scoring (e.g., leaf indumentum, which varies continuously, was scored 1 if the leaves were glabrous, 2 if glabrous-pilose, 3 if pilose, 4 if hirsute, 5 if tomentose and 6 if woolly). The classes are selected so that the magnitude of the differences between state 1 and 3 is twice than between 1 and 2. For the characters scored as "continuous characters" it was possible to measure the variation accurately and the actual values could be used (e.g., leaf length), whereas for the multi-state ordered characters, such accuracy was not possible and the continuous character was split into segments for scoring e.g., states of the leaf indumentum (Tables 2-3).

Numerical Analysis

Group average, single linkage (nearest neighbour) and complete linkage (furthest neighbour) phenograms (Sneath & Sokal, 1973) were produced for each data set (Figs. 1-3). All the analyses were made by using the clustering programme ASF 4, prepared by the Applied Statistics Department, University of Reading.

RESULTS

In *Origanum*, group average, single linkage and complete linkage phenograms of combined morphological and chemical characters indicate the possibility of identifying six major groups (Table 4).

The first group contains *O. dubium*, *O. majorana*, *O. micranthium*, *O. microphyllum*, *O. onites*, *O. syriacum* vars *syriacum*, *bevanii* and *sinaicum*. This group is clearly delineated on group average, single linkage and complete linkage analyses. Phenograms using morphological and chemical characters alone also allow clear delimitation of this same group of taxa (Fig. 1-3), with the notable exception of *O. micranthium*, which is distinctly different in single linkage analysis based on chemical characters.

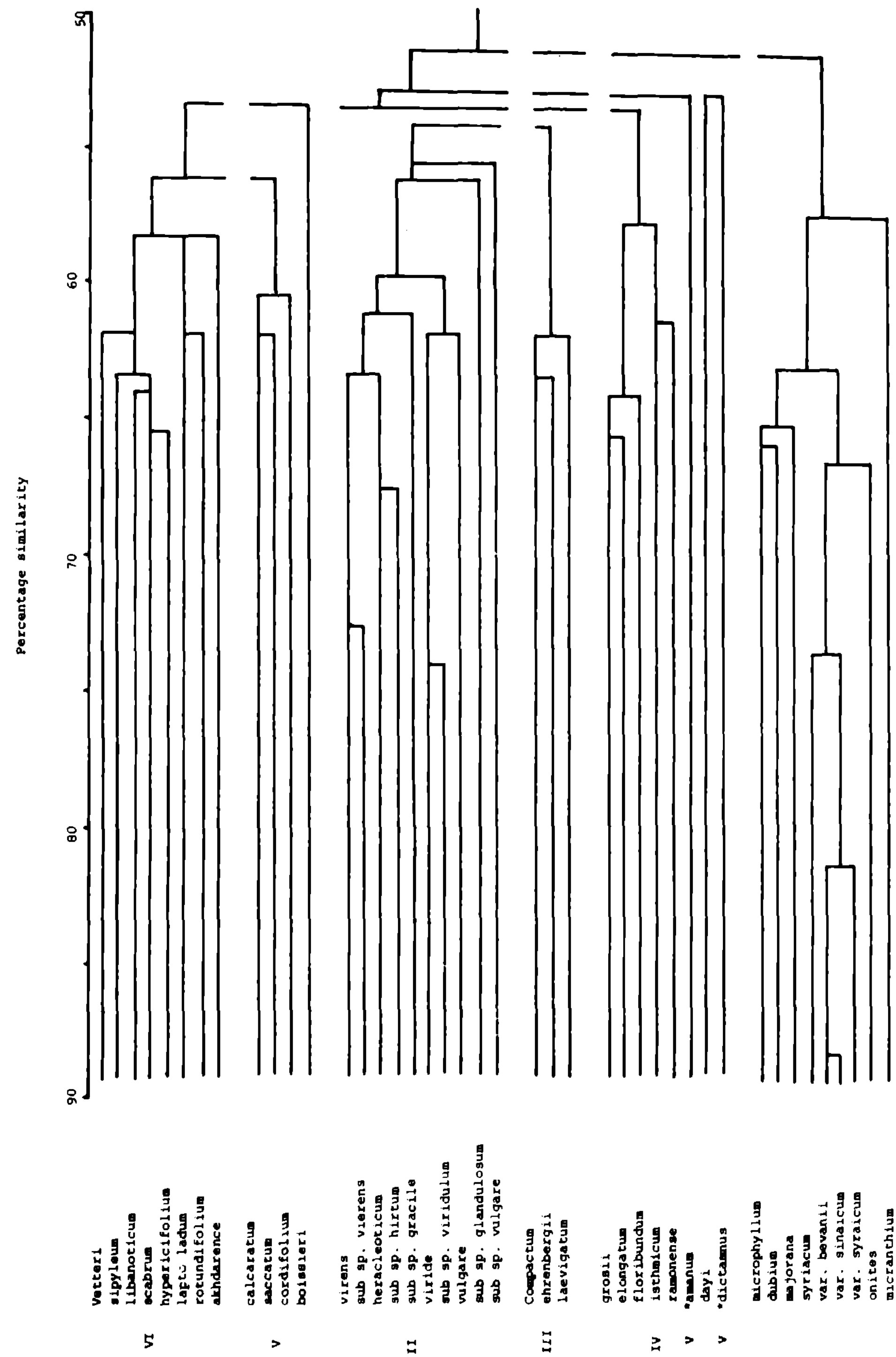


Fig. 2. Single link cluster analysis of 42 species of *Origanum* using morphological and chemical characters.

The second group contains *O. vulgare, O. virens, O. heracleoticum, O. viride* subspp., *hirtum, virens, gracile, viridulum, vulgare* and *glandulosum* (Table 4). The above taxa show a 48% similarity level in group average, clustering in combined morphological and chemical characters (Fig. 1) . The same taxa form a compact group at the 55% similarity level in single linkage (Fig. 2), and at 43% similarity in complete linkage clustering (Fig. 3), indicating general agreement with the delimitation of these taxa by empirical methods.

When a line is drawn at 53% similarity, the group average phenogram (Fig. 1) produces clustering of a third group of taxa: *O. compactum, O. ehrengbergii* and *O. laevigatum* based on combined morphological and chemical characters. *Origanum ehrenbergii* shows 63% similarity with *O. compactum*, which in turn links with *O. laevigatum* at 62% similarity. The same taxa show close clustering at 59% similarity in single linkage and 5% similarity in complete linkage phenograms (Figs. 2-3). Phenograms based on chemical characters alone also agree with clustering arrived at using morphological and chemical characters. On the other hand clusters of the same taxa based on morphological characters alone show combination at various similarity levels with the group two taxa (Table 3).

The fourth group contains *O. isthmicum, O. ramonense, O. dayi, O. elongatum, O. floribundum* and *O. grosii* and shows clustering based on combined morphological and chemical characters. The phenogram of the above taxa divides into two sub-groups on the basis of group average clustering (Fig. 1) at 46% similarity level. These subgroups join with each other at 53% similarity (Table 4). The taxa of this group also show clustering at 42% similarity in complete linkage (Fig. 3), while in single linkage phenogram (Fig. 2) the above two sub-group taxa show 56% similarity, except for *O. dayi* which is clearly separated from the cluster but lies close to the taxa of this group. Phenograms based on the morphological characters show a clustering which is in agreement with the conventional methods of morphological classification.

The fifth group includes *O. amanum, O. calcaratum, O. saccatum, O. cordifolium, O. boissieri* and *O. dictamnus*. The above taxa produce clusters based on combined morphological and chemical characters and show 51% similarity in the group average phenogram (Fig. 1). *Origanum boissieri* and *O. dictamnus*, of this group, do not cluster with the above 4 taxa. Instead they stand somewhat apart, joining with taxa of group six (Table 4). Clusters produced by chemical characters on the same taxa do not entirely agree with sectional delimitation arrived at by conventional methods. The above taxa show clustering and affinities with taxa of the sixth group. *Origanum dictamnus* separates from the main cluster, and *O. boissieri* joins with the taxa of the second group (Table 4).

Table 2. Characters and states used in numerical analysis of *Origanum* species.

(Symbols used for 4 types of characters are: B = Binary; MU = Multistate unordered; MO = Multistate ordered; C = Continuous)

No.	Character	Type of Character	State of Character
VEGETATIVE MORPHOLOGY			
1	Habit	B	Dwarf shrub = 1, Woody at the base = 2
2	Stem	B	Ascending = 1, Erect = 2
3	Stem	B	All branches consisting of spikes = 1, All branches not consisting of spikes = 2
4	Stem	B	Not ramified = 1, ramified = 2
5	Stem	MU	Branches of the first order = 1, Branches of the first and second order = 2, Branches of the first, second and third = 3
6	Leaf shape	MO	Ovate-spatulate = 1, Ovate = 2, Ovate-oblong = 3, Ovate-orbicular = 4, Orbicular = 5
7	Leaf base	MO	Attenuate = 1, Attenuate-orbicular = 2, Cordate = 3, Cordate-orbicular = 4, Sub-cordate-orbicular = 5, Ovate-orbicular = 6
8	Leaf apex	MO	Acute = 1, Acute-obtuse = 2, Obtuse = 3, Obtuse-orbicular = 4
9	Leaf texture	B	Coriaceous = 1, Membranous = 2
10	Leaf margin	MO	Entire = 1, Entire-ciliate = 2, Serrate-ciliate = 3, Entire-serrate-ciliate = 4
11	Leaf length	C	Mean values (cm)
12	Leaf indumentum	MO	Glabrous = 1, Glabrous-pilose = 2, Pilose = 3, Hirsute = 4, Tomentose = 5, Woolly = 6
13	Leaf (veins) abaxial surface	B	Veins raised = 1, Veins not raised = 2

14	Leaf glands (type)	B	Sessile = 1, Punctate = 2
15	Petiole length/Leaf length	C	Ratio
FLORAL MORPHOLOGY			
16	Spike arrangement	MO	Compact = 1, Lax = 2, Corymb = 3
17	Spike shape	MO	Narrow-cylindrical = 1, Cylindrical = 2, Ovate-cylindrical = 3, Ovate = 4, Ellipsoid = 5, Globular-ellipsoid = 6, Globular = 7
18	Spike length	C	Mean values (cm)
19	Bract shape	MO	Lanceolate = 1, Ovate = 2, Ovate-obtuse = 3, Orbicular = 4
20	Bract margin	MO	Entire = 1, Entire-dentate = 2, Entire-ciliate = 3
21	Bract indumentum	MO	Glabrous = 1, Glabrous-pilose = 2, Pilose = 3, Hirsute = 4, Tomentose = 5
22	Bract colour	MU	Whitish = 1, Whitish-green = 2, Green = 3, Greenish-yellow = 4, Greenish-purple = 5, Purple = 6
23	Bract length/Calyx length	C	Ratio
24	Calyx tube indumentum	MO	Glabrous = 1, Glabrous-pilose = 2, Pilose = 3, Hirsute = 4, Tomentose =5
25	Calyx throat indumentum	MO	Glabrous = 1, Pilose = 2, Hirsute = 3, Tomentose = 4
26	Calyx length/total corolla length	C	Ratio
27	Number of lips	C	No lip = 0, One lip = 1, Two lips = 2
28	Number of teeth on the upper lip	C	Number of teeth
29	Upper lip teeth length/upper lip lobe length	C	Ratio
30	Number of teeth on the lower lip	C	Number of teeth
31	Lower lip teeth length/ calyx length	C	Ratio
32	Corolla tube indumentum	MO	Glabrous = 1, Pubescent = 2,

			Pubescent-pilose = 3, Pilose = 4, Hirsute = 5
33	Corolla tube colour	MU	White = 1, White-yellow = 2, White-pink = 3, Pink = 4, Purple = 2
34	Corolla tube shape	B	Saccate = 1, Not saccate = 2
35	Total corolla length	C	Mean values (cm)
36	Upper lip lobe length/ Total corolla length	C	Ratio
37	Lower lip lobe length/ Total corolla length	C	Ratio
38	Stamen filament arrangement	MO	Included = 1, Two included-two protruded = 2, Shortly protruding = 3, Protruding = 4
39	Stamen filament length/ Total corolla length	C	Ratio
40	Style arrangement	MO	Included = 1, Shortly protruding = 2, Protruding =3
41	Style length/ Total corolla length	C	Ratio
PALYNOLOGY			
42	Pollen grain polar length	C	Mean values (µm)
43	Shape of the pollen grain	MO	Oval = 1, Subcircular = 2, Subcircular-circular = 3, Circular = 4
44	Ornamentation of pollen grain	B	Prolate = 1, Reticulate = 2
45	Thickening of ectexine at poles of pollen grain	B	Absent = 1, Present = 2
46	Pollen grain wall thickness	C	Mean values (µm)
47	Length of the colpus expressed as a % of the total pollen grain length	C	Mean % values
48	Number of perforations per lumen of pollen grain	MO	1-3 = 1, 4-6 = 2, 7-9 = 3

The sixth and the final group contains the following taxa: *O. akhdarense*, *O. hypericifolium*, *O. leptocladum*, *O. libanoticum*, *O. rotundifolium*, *O. scabrum*, *O. sipyleum* and *O. vetteri*. At 52% similarity, based on all 117 characters, the above taxa produce clustering in group average phenogram (Fig. 1). In single

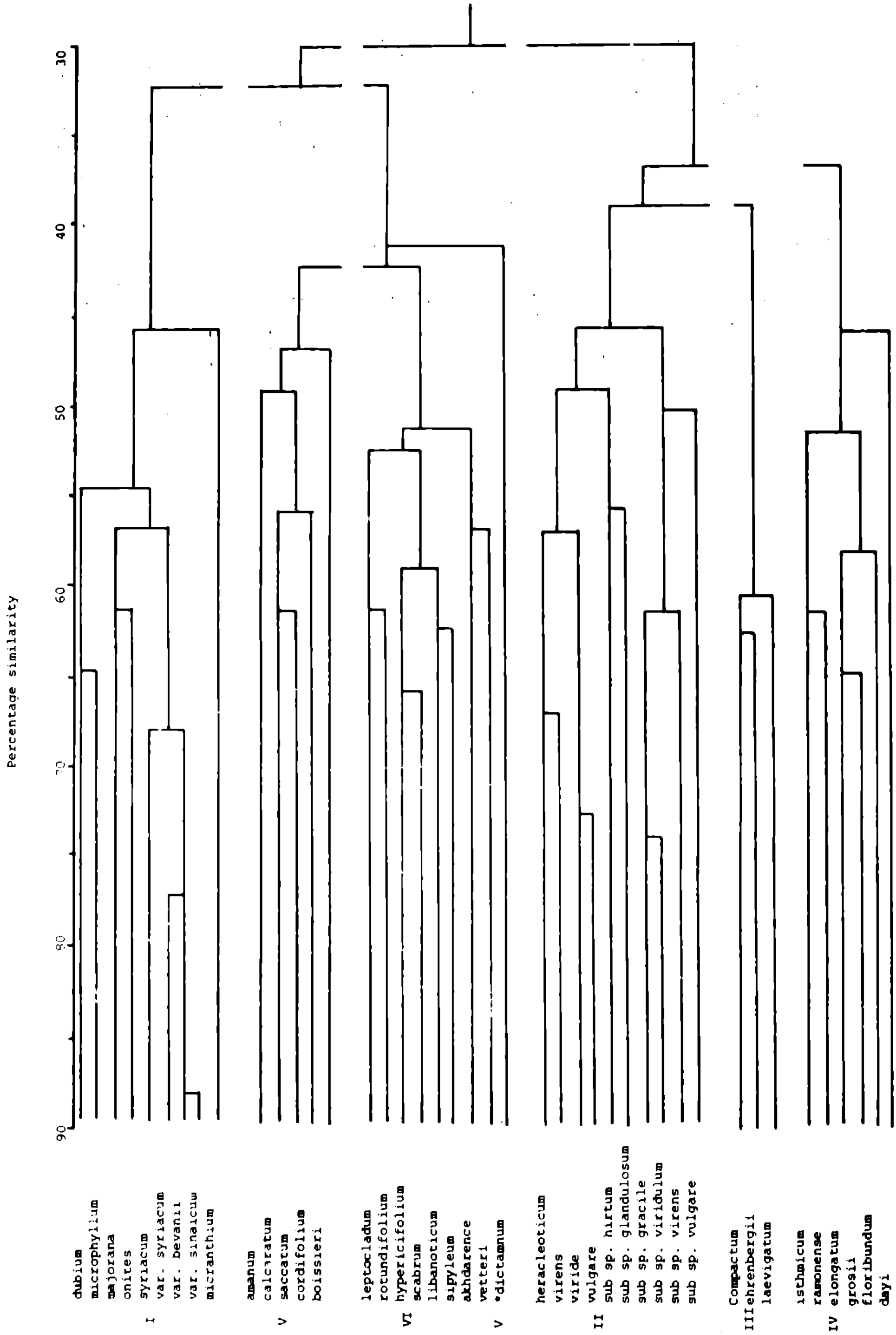


Fig. 3. Complete link cluster analysis of 42 species of *Origanum* using morphological and chemical characters.

Table 3. Chemical characters and types used in numerical analysis of 42 *Origanum* species.

Type of Character	Character number
Leaf flavonoids	
MO (Absent = 0, Trace = 1, Present = 4)	49. 6 hydroxyluteolin
	50. luteolin 7-0-diglucuronide
	51. luteolin 7, 3'-0-diglucuronide or glucoside
	52. luteolin 7, 4'-0-diglucoside
B (Absent = 1, Present = 2)	53. luteolin or apigenin glucuronides
MO (Absent = 0, Trace = 1, Present = 4)	54. luteolin, 7-0-glucoside
	55. luteolin, 7-0-rutinoside
	56. luteolin, 5-0-glucoside
	57. apigenin 7-0-glucuronide
	58. apigenin 7-0-glucoside
B (Absent = 1, Present = 2)	59. apigenin 6, 8-di-c-glucoside
MO (Absent = 0, Trace = 1, Present = 4)	60. scutellarein 6, 4'-dimethyl ether
	61. scutellarein 4'-methyl ether 7-0-glucoside
B (Absent = 1, Present = 2)	61. scutellarein 7-0-glucuronide
MO (Absent = 0, Trace = 1, Present = 4)	63. chrysoeriol 7-0-glucuronide
	64. unidentified flavonoid 15
B (Absent = 0, Present = 2)	65. unidentified flavonoids 16
	66. unidentified flavonoids 17
	67. unidentified flavonoids 19
	68. unidentified flavonoid 20
Leaf essential oils	
MO (Absent = 0, Trace = 1, Present = 4)	69. (+) . (-). α - pinene
	70. α - terpinene
B (Absent = 1, Present = 2)	71. β - Pinene
	72. P-cymene
	73. l-pentanol
	74. unidentified oil 6
	75. unidentified oil 7
MO (Absent = 0, Trace = 1, Present = 4)	76. unidentified oil 8
B (Absent = 1, Present = 2)	77. unidentified oil 9
	78. unidentified oil 10

MO (Absent = 0, Trace = 1, Present = 4)	79. unidentified oil 11
B (Absent = 1, Present = 2)	80. unidentified oil 12
MO (Absent = 0, Trace = 1, Present = 4)	81. linalol
B (Absent = 1, Present = 2)	82. unidentified oil 14
	83. camphor
	84. unidentified oil 16
MO (Absent = 0, Trace = 1, Present = 4)	85. unidentified oil 17
	86. caryophyllene
B (Absent = 1, Present = 2)	87. unidentified oil 19
	88. unidentified oil 20
	89. unidentified oil 21
MO (Absent = 0, Trace = 1, Present = 4)	90. borneol
B (Absent = 1, Present = 2)	91. unidentified oil 23
MO (Absent = 0, Trace = 1, Present = 4)	92. myrcene
B (Absent = 1, Present = 2)	93. unidentified oil 25
MO (Absent = 0, Trace = 1, Present = 4)	94. (—) carvone
B (Absent = 1, Present = 2)	95. (+) carvone
	96. unidentified oil 26
	97. unidentified oil 29
MO (Absent = 0, Trace = 1, Present = 4)	98. unidentified oil 30
	99. unidentified oil 31
	100. unidentified oil 32
	101. unidentified oil 33
	102. unidentified oil 34
	103. unidentified oil 35
	104. unidentified oil 36
	105. unidentified oil 37
MO (Absent = 0, Trace = 1, Present = 4)	106. unidentified oil 38
B (Absent = 1, Present = 2)	107. unidentified oil 39
	108. unidentified oil 40
	109. unidentified oil 41
MO (Absent = 0, Trace = 1, Present = 4)	110. carvacrol
B (Absent = 1, Present = 2)	111. unidentified oil 43
	112. unidentified oil 44
	113. unidentified oil 45
	114. unidentified oil 46
	115. unidentified oil 47
	116. unidentified oil 48
	117. thymol

(Symbols used for 4 types of characters are: B = Binary; MU = Multistate unordered; MO = Multistate ordered; C = Continuous)

Table 4. Group suggested by numerical analysis of chemical and morphological characters within the genus *Origanum*.

	DATA SETS	Morphological + Chemical			Chemical Characters only			Morphological Characters only		
	Taxa	Group Average Analysis	Single Link Analysis	Complete Link Analysis	Group Average Analysis	Single Link Analysis	Complete Link Analysis	Group Average Analysis	Single Link Analysis	Complete Link Analysis
GROUP I	*O. dubium*	—	—	—	—	—	—	—	—	—
	O. majorana	—	—	—	—	—	—	—	—	—
	O. micranthium	—	—	—	—	—	—	—	II	—
	O. microphyllum	—	—	—	—	—	—	—	—	—
	O. onites	—	—	—	—	—	—	—	—	—
	O. syriacum	—	—	—	—	—	—	—	—	—
	var. *syriacum*	—	—	—	—	—	—	—	—	—
	var. *bevanii*	—	—	—	—	—	—	—	—	—
	var. *sinaicum*	—	—	—	—	—	—	—	—	—
GROUP II	*O. heracleoticum*	—	—	—	—	I	—	—	—	—
	O. virens	—	—	—	—	—	—	—	—	—
	O. viride	—	—	—	+	+	+	—	—	—
	O. vulgare	—	—	—	+	+	+	—	—	—
	subsp. *hirtum*	—	—	—	—	I	—	—	—	—
	subsp. *glandulosum*	—	—	—	++	++	IV	—	—	—
	subsp. *gracile*	—	—	—	—	+	IV	—	—	—
	subsp. *viridulum*	—	—	—	+	+	+	—	—	—
	subsp. *virens*	—	—	—	—	—	—	—	—	—
	subsp. *vulgare*	—	—	—	+	++	+	—	—	—

GROUP III	*O. compactum*	—	—	—	—	—	—	II	II	II
	O. ehrenbergii	—	—	—	—	—	—	II	II	II
	O. laevigatum	—	—	—	—	—	—	II	II	II
GROUP IV	*O. dayl*	—	++	—	++	++	I	—	+	+
	O. isthmicum	—	—	—	—	—	I	—	++	+
	O. ramonense	—	—	—	—	—	I	—	+	+
	O. elongatum	—	—	—	—	—	II	—	—	(+)
	O. grosii	—	—	—	—	—	II	—	—	(+)
	O. floribundum	—	—	—	—	—	++	—	—	(+)
GROUP V	*O. amanum*	—	++	—	—	VI	II	VI	++	—
	O. boissieri	++	VI	—	++	++	—	—	VI	—
	O. dictamnus	++	++	VI	++	++	IV	—	—	—
	O. calcaratum	—	—	—	—	VI	—	—	—	—
	O. cordifolium	—	—	—	—	VI	—	—	—	—
	O. saccatum	—	—	—	—	VI	—	—	—	—
GROUP VI	*O. akhdarense*	—	—	—	—	—	—	—	—	—
	O. hypericifolium	—	—	—	—	—	—	—	—	—
	O. leptocladum	—	—	—	—	—	—	—	—	IV
	O. libanoticum	—	—	—	—	—	—	—	—	—
	O. rotundifolium	—	—	—	—	—	—	—	—	—
	O. scabrum	—	—	—	—	—	—	—	—	—
	O. sipyleum	—	—	—	—	—	—	—	—	—
	O. vetteri	—	—	—	—	—	—	—	—	—

KEY: — = clustering together with the other taxa in this group.
I to VI = Indicates the group, the taxa joins in clustering.
(+) or + = clustering together with the other group. (II ⇌ IV)
++ = seprate, showing loose association with more than one group.

linkage analysis the same taxa produce clusters at 57% and 47% similarity levels at incomplete linkage phenograms (Fig. 2-3). Clusters of the above taxa are produced on the basis of 57 chemical characters at high similarity levels except in single linkage, where the clusters produced also include some taxa of the fifth group.

DISCUSSION

Many workers (Lefkovitch, 1980; McNeill, 1972; Small, 1978), using various numerical procedures, have examined the phenetic relationships of groups of wild and domesticated plants supplemented by herbarium material, using as many characters as possible, especially those alleged in literature to have taxonomic importance. They have successfully highlighted the need of either recognition of a taxon as a separate species within the group of morphologically related species or confirm their close relationships.

When all the data on combined characters are considered, Groups I, II, III and VI are neatly delimited on all three clustering methods (Fig. 1-3). Group IV is also clear, except *O. dayi* which separates from the cluster in single linkage. Group V is not as well defined as other groups, in particular *O. dictamnus* shows affinity with group IV and VI and should be considered as separate from all the groups.

At sectional level, numerical taxonomy does not entirely support the results obtained by traditional morphological methods. This may be attributed to the way the characters have been weighted in conventional morphological studies or perhaps we are dealing with a closely related group of plants whose separation into smaller groups may prove to be purely artificial. At species level, with minor variations, classification derived from both morphological and numerical methods appears to be the same. The results from numerical taxonomy therefore essentially confirm decisions reached using conventional morphological techniques. Thus, numerical methods indicate which species should be merged together and which should be retained as separate taxa, but what the results do not specify is at what infraspecific level ranks the reduced species should be maintained.

In general clustering methods used and analysis by single linkage in particular, based on 70 chemical characters only, show a high variability within the taxa, particularly with respect to those of the II and V groups. It should be noted that groups I, II and VI show close clustering and the II, V and VI groups the high order of variability (Table 4).

With all the disadvantages inherent in numerical methods (as in all other forms of taxonomic methods) one should not be led to believe that numerical taxonomy is an excursion to futility. The method makes objective decisions and provides suggestions about phenetic affinities that are helpful in grouping taxa.

REFERENCES

Bate-smith, E.C. & Swain, T. (1965). Recent developments in the chemotaxonomy of flavonoid compounds. *Lloydia*, 28: 313-331.

Boissier, P.E. (1879). *Flora Orientalis*, 4: 779-793.

Briquet, J. 1897. In: Engler, A. and Prantl, K. (Eds.). *Die naturlichen pflanzenfamilien*, 4(3a): 183-380. Leipzig, Wengelmann.

Cronquist, A. (1977). On the taxonomic significance of the structure of secondary metabolites in angiosperms. *Pl. Syst. Evol.*, Suppl. 1: 179-189.

Gibbs, R.D. (1958). Chemical evolution in plants. *J. Linn. Soc. London (Bot.)*, 56: 49-57.

Gibbs, R.D. (1965). A classical taxonomist's view of chemistry in taxonomy of higher plants. *Lloydia*, 26: 279-299.

Harborne, J.B., Mabry, T.J. & Mabry, H. (Eds.). (1975). *The Flavonoids.* Chapman & Hall, London.

Harris, J.A. & Bisby, F.A. (1980). Classification from chemical data, In: Bisby, F.A., Vaughan, J.G., Wright, C.A. (Eds.), *Chemosystematics: Principles and Practice*, Academic Press, London and New York.

Hegnauer, R. (1962-69). *Chemotaxonomie der Pflanzenfamilien.* 1-5. Birkhauser Verlag, Basel, Stuttgart.

Husain, S.Z. (1983). *Chemosystematic studies in the genus Origanum L. , and related genera.* Ph.D. Thesis, University of Reading, Berks., U.K.

Husain, S.Z. & Heywood, V.H. (1982). Pollen morphology of the genus *Origanum* L., and allied genera, In: Margaris, N., Koedam, A. & Vokou, D. (Eds.), *Aromatic Plants: Basic and Applied aspects.* Martinus Nijhoff, Hague, Boston and London.

Husain, S.Z., Heywood, V.H. & Markham, K.R. (1982). Distribution of flavonoids as chemotaxonomic markers in the genus *Origanum* L., and related genera in Labiatae. In: Margaris, N., Koedam, A. & Vokou, D. (Eds.), *Aromatic plants: Basic and Applied Aspects.* Martinus Nijhoff, Hague, Boston and London.

Husain, S.Z. & Markham, K.R. (1981). The glycoflavone vicenin-2 and its distribution in related genera within the Labiatae. *Phytochemistry*, 20: 1171-1173.

Ietswaart, J.H. (1980). A taxonomic revision of the genus *Origanum* (Labiatae). Leiden University Press, The Hague, Boston and London.

Lefkovitch, L.P. (1980). Conditional clustering. *Biometrics*, 36: 43-58.

Mc Neill, J. (1972). The hierarchical ordering of characters as a solution to the character problem in numerical taxonomy. *Taxon*, 21: 71-82.

Small, E. (1978). A numerical taxonomic analysis of the *Daucus carota* complex. *Can. J. Bot.*, 56: 248-276.

Sneath, P.H.A. & Sokal, R.R. (1973). *Numerical Taxonomy*. Freeman & Co., San Francisco.

Stearn, W.T. (1968). Observations on a computer aided survey of the Jamaican species of *Columnea* and *Alloplectus*, In: Heywood, V.H., (Ed.). *Modern Methods in Plant Taxonomy*. Academic Press, London and New York.

Swain, T. (1979). Flavonoids and chemotaxonomic markers in plants. *Photosynthetica*, 11: 330-342.

Proceedings of the International Symposium on Plant Life of South Asia held at the Department of Botany, University of Karachi, Karachi-75270, Pakistan. 24-27 February, 1991

Plant Life of South Asia, 127–147, (1991)
S.J. Ali and *A. Ghaffar* (Eds.)

THE GENUS *EUPHRASIA* L., FROM PAKISTAN AND ITS ADJOINING AREAS

TAHMEENA SIDDIQUI AND M. QAISER

Department of Botany,
University of Karachi, Karachi-75270, Pakistan

ABSTRACT

The genus *Euphrasia* L., is revised from Pakistan and its adjoining areas. Data is utilized from different fields of Botany. Systematic treatment have led to the recognition of 31 taxa, which include 7 new species (described elsewhere) and 3 new records. Seed morphology of 29 species have been studied. Prominent rectangular areolae characterize the surface of the seeds. On the basis of the surface pattern of seeds 4 broad groups are recognized.

Pollen grains of 27 species of *Euphrasia* have been studied. Retipilate type of sculpturing pattern was present. However, 3 broad groups are recognized on the basis of the different fusion pattern of pila heads. Similarly 25 taxa were surveyed for the phenolic constituents, and chemical data has been utilized in the taxonomy of the genus on the basis of presence or absence of a particular compound. Azaleatin 3-galactoside and O-coumaric acid were universally present in all the taxa analyzed and perhaps is characteristic of the genus. Data obtained was numerically analyzed.

INTRODUCTION

Euphrasia L., is a genus of cold, alpine dry climate comprising of c. 450 species (Mabberley, 1987), distributed in both the hemispheres in Europe, Asia, Northern part of America, mountains of Indonesia to Newzealand and Southern parts of South America. In Pakistan and Kashmir, it is distributed in Himalayas (Kashmir, Kurram Agency, Swat and adjoining areas), Karakorums (Baltistan, Ladakh, Gilgit, Hunza, Yasin) and the Hindukush (Chitral, Dir) between an elevation of 3500-15000′ (Fig. 1).

The genus *Euphrasia* L., has been revised from time to time for different floras which included some portion of our region as well (Boissier, 1879; Hooker, 1885; Pennell, 1943; Kitamura, 1960; Yeo, 1980). However most comprehensive work from the area under consideration is that of Pennell (1943), who recognized 18 species including 13 new ones. His work was mainly based

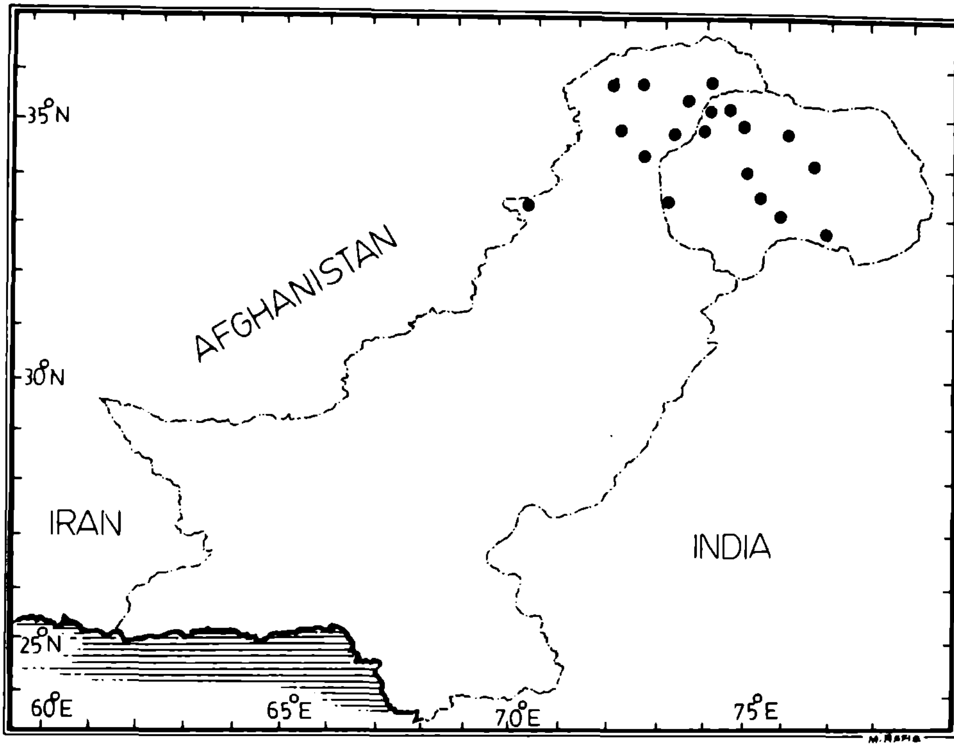


Fig. 1. Distribution of *Euphrasia.*, species in Pakistan and its adjoining areas.

on morphological characters. Since this report, several changes in the taxonomy of the genus have been reported (Yeo, 1978, 1981; Sell & Yeo, 1970). The genus shows little character differences and the specific delimitation based on usual morphological characters is rather unsatisfactory. It was therefore considered necessary to find out additional micromorphological and chemical characters in order to get a clear picture of the genus *Euphrasia* L., in our region.

MATERIAL AND METHODS

Macro and micromorphological characters were investigated and more than 1500 herbarium specimens from various herbaria were studied: AR, BM, CAL, GH, HARV, K, KUH, MICH, NA, NY, O, PH, RAW, US, W, WU (according to Holmgren *et al.*, 1990). An inventory was made for numerical analysis of herbarium specimen.

Pollen and seed morphological studies were carried out. Pollen grains were also collected from at least 2-3 herbarium specimens and were acetolyzed according to the method of Erdtman (1952), prior to light and scanning electron microcopy. Similarly, unruptured capsules were taken and number of seed/capsule were counted. Length and breadth of atleast 25 seeds of one specimen were measured and each species was represented by atleast 2-3 specimens.

For scanning electron microscopy, the acetolyzed material (for pollen grains) was transferred on metallic stub, having a double adhesive tape and coated with gold. For the study of surface pattern of the seeds, the seeds were directly transferred to the stubs and coated. In both the cases, a Jeol scanning microscope (JSM-T200) was used. Chemical analysis for flavanoid pattern was carried out following Harborne (1984). Numerical analysis was carried out using morphological, palynological, seed morphological and chemical data. All the specimens were subjected for numerical analysis using principal component analysis (Orloci & Kenkel, 1985).

RESULT AND DISCUSSION

The Eyebrights (*Euphrasia*) in Pakistan are short lived annuals with two basic types of growth forms, the aestival (early summer form) flowering from June-August, in which the plants are usually short, sparsely or even unbranched, branches are lax, erect short-long and provided with short and 2-3 internodes, whose length at the base vary from 0.25-0.5 cm, is absent at the centre and the floral axis as in *E. kashmiriana* (Fig. 2-B). The corresponding autumnal (late summer form) flowering from late August-mid September, in which the plants are tall, robust, branches are stiff rarely lax, ascending long-short, provided with long and 4-8 internodes whose length at the base vary from 1.0-4.0 cm, at the centre 1.0-2.0 cm and at the floral axis 0.25-0.50 cm as in *E. incisa* (Fig. 2-A).

Foliage:

Two types of leaves are present-cauline and floral, and both of them furnish important diagnostic characters such as general shape, shape of terminal and lateral lobes, and length breadth ratio of the lobes. The cauline leaves in *E. densiflora* are ovate, with aristulate lobes which are longer than broad (Fig. 3-A). In *E. multiflora* cauline leaves are broadly ovate, lobes are acute, which are both longer than broad and as long as broad (Fig. 3-B). In *E. petiolaris* shape is elliptic, lobes are obtuse broader than long (Fig. 3-C). In *E. aristulata* shape is ovate, lobes are acuminate and are as long as broad (Fig. 3-D). In *E. paucifolia* shape of floral leaves is ovate, lobes are acuminate and longer than broad (Fig. 4-A). In *E. laxa* floral leaves are broadly ovate, with aristulate lobes which are longer than broad (Fig. 4-B). In *E. pectinata* shape is elliptic, lobes are acuminate and are as long as broad (Fig. 4-C), while in *E. sevanensis* floral leaves are ovate-broadly ovate in shape, lobes are acute, which are broader than long (Fig. 4-D).

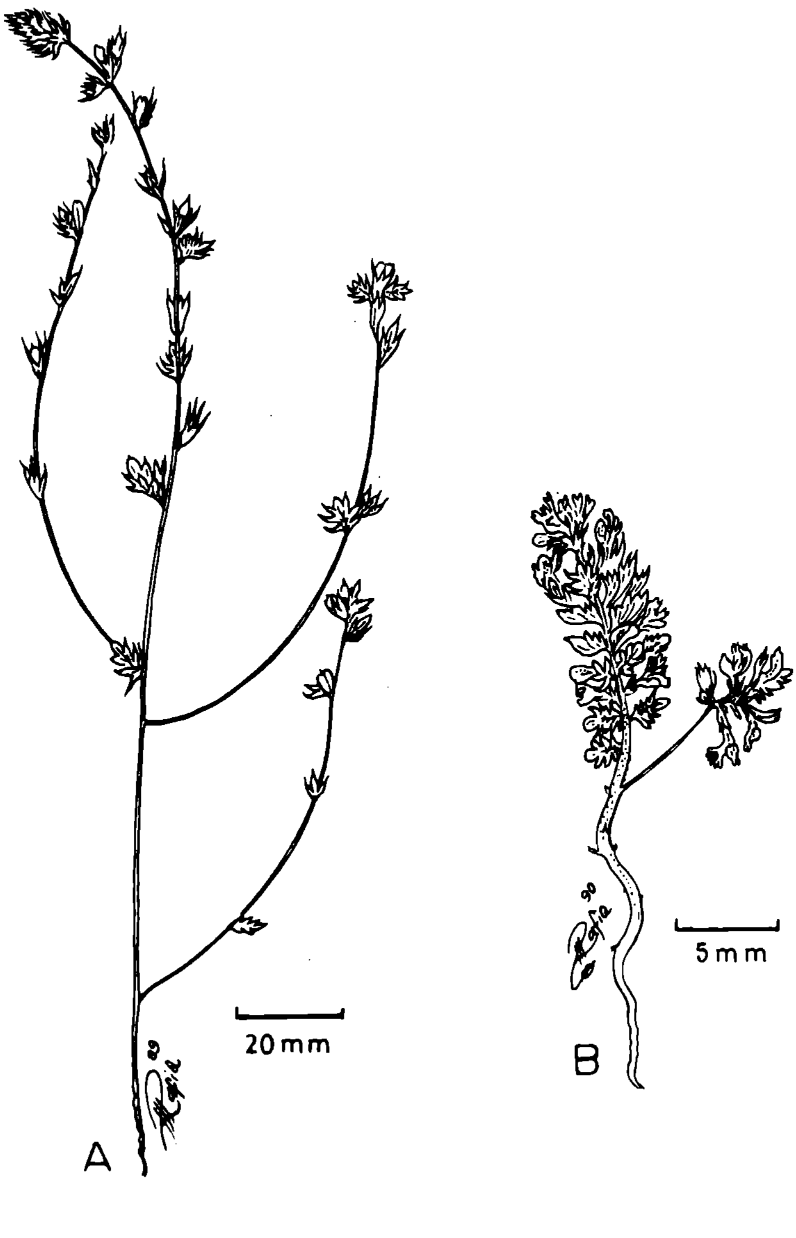


Fig. 2. Growth forms in *Euphrasia*., A. Autumnal form. (*E. incisa*). B. Aestival form (*E. kashmiriana*).

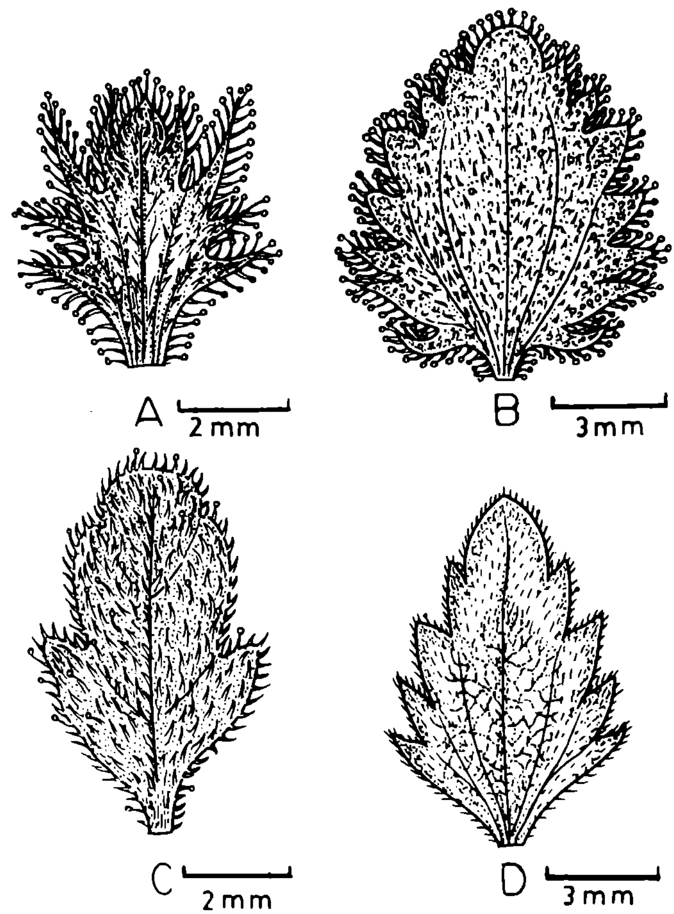


Fig. 3. Different leaf shapes, lobes shape and length breadth ratio of the lobes of cauline leaves in *Euphrasia*., A, leaf ovate, lobes aristulate, longer than broad. (*E. densiflora*). B, leaf broadly ovate, lobes acute, as long as broad and longer than broad, (*E. multiflora*). C, leaf elliptic, lobes obtuse, broader than long. (*E. petiolaris*). D. leaf ovate, lobes acuminate, as long as broad (*E. aristulata*).

Orientation of the leaf lobes, the upper leaf lobes may be antrorse and the lower patent as in *E. aristulata* (Fig. 5-D), or all the lobes may be antrorse as in *E. pectinata* (Fig. 5-C). Regarding curvature of leaf lobes, lobes may be expanded as in *E. incisa* (Fig. 5-B), or they may be medianally incurved as in *E. pseudopaucifolia* (Fig. 5-A).

Indumentum:

The hair clothing of the foliage, corolla and that of the calyx is mostly similar and may consist of only simple hairs or may be a mixture of both glandular

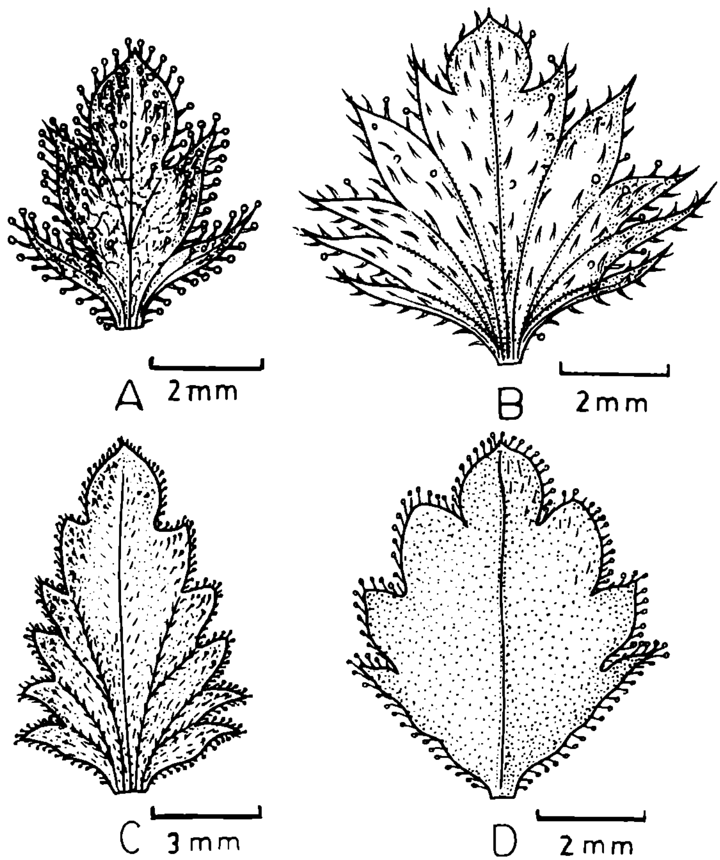


Fig. 4. Different leaf shapes, lobes shape, and length breadth ratio of the lobes of the floral leaves in *Euphrasia.*, A, leaf ovate, lobes acuminate, longer than broad (*E. juzepczukii*) B, leaf broadly ovate, lobes aristulate, longer than broad (*E. laxa*). C, leaf elliptic, lobes acuminate, as long as broad (*E. pectinata*). D, leaf ovate-broadly ovate, lobes acute, broader than long (*E. sevanensis*).

and eglandular hairs, while the indumentum of the capsule and that of the anthers is characterized as being ciliate and pilose, respectively.

The type of hairs, size of the hairs and the density of indumentum are considered important. On the foliage and the calyx two types of hairs are present viz., simple (Fig. 6-A), as in *E. laxa* and hirsute (Fig. 6-B), as in *E. kurramensis*, and the size of the hairs with respect to the glands present on them are classified into two groups. Group one includes taxa whose stalks are < 5 times as long as the glands (Fig. 6-D), as in *E. remota*, and group two comprises of taxa whose stalks are > 5 times as long as the glands (Fig. 6-C), as in *E. pseudopaucifolia*.

On the foliage, hairs may be present all over the surface e.g., *E. aristulata* (Fig. 7-A). Hairs may be present on the lobes and the margins only e.g., *E. pa-*

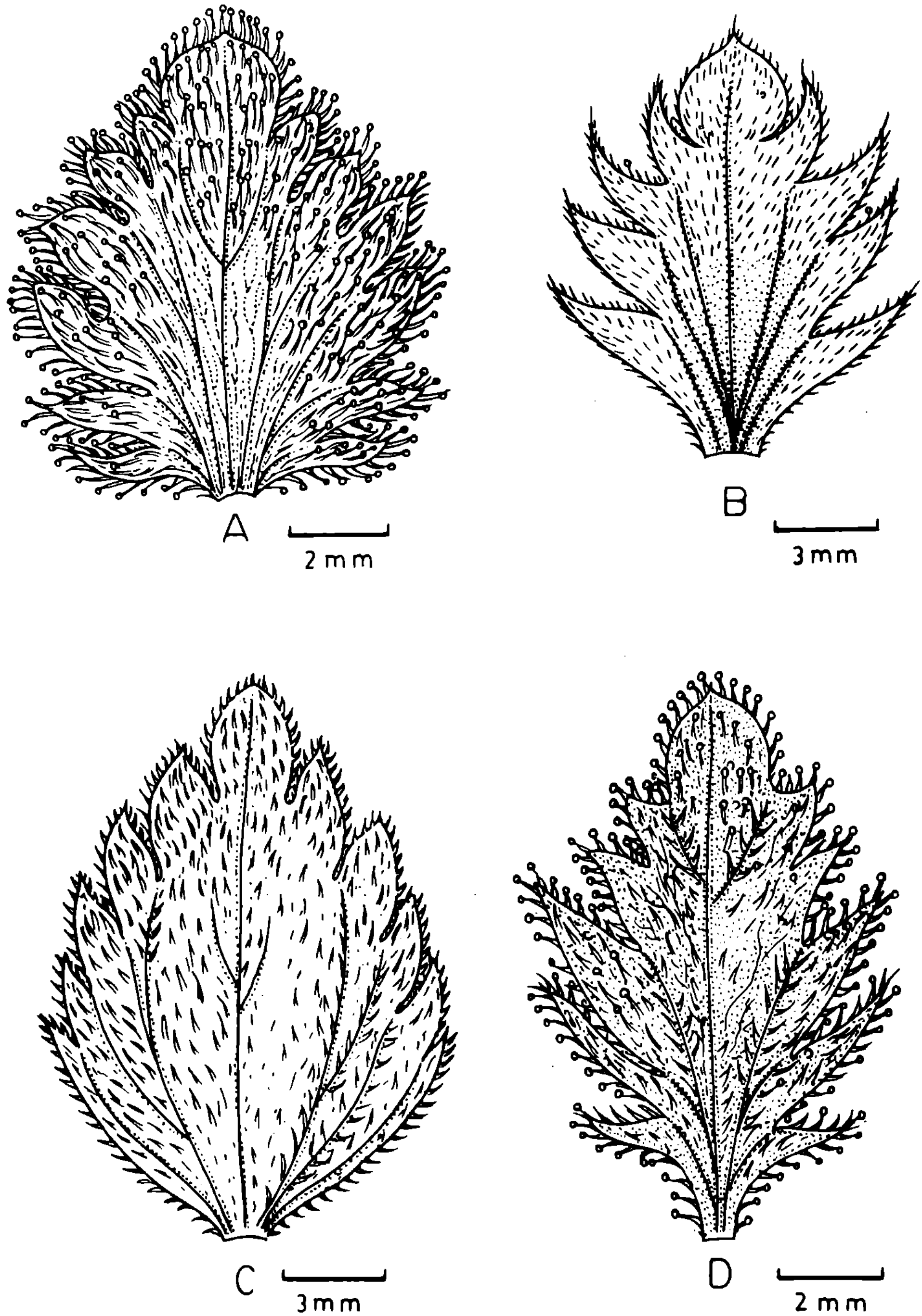


Fig. 5. Orientation and curvature of leaf lobes. A, leaf lobes medianally incurved (*E. pseudopaucifolia*); B, leaf lobes expanded (*E. incisa*): C, all lobes antrorse (*E. pectinata*): D, upper leaf lobes antrorse and lower patent (*E. aristulata*).

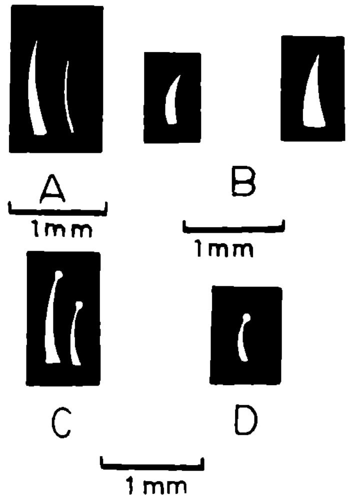


Fig. 6. Different type of hairs in *Euphrasia*., A, Simple hairs (*E. laxa*) B, hirsute hairs (*E. kurramensis*), Different sizes of glandular hairs. C, Hairs > 5-8 times that of the glands (*E. pseudopaucifolia*). D, Hairs < 5-8 times that of glands (*E. remota*).

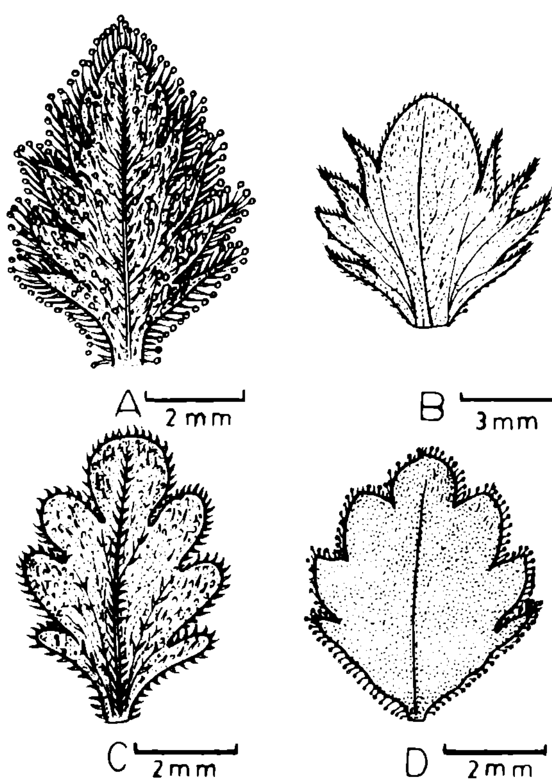


Fig. 7. Density of indumentium on the foliage A, Pubescent all over (*E. aristulata*). B, Pubescent at the margins and lobes (*E. paghmanensis*). C, Pubescent at the margins and veins (*E. kurramensis*). D, Pubescent at the margins only (*E. sevanensis*).

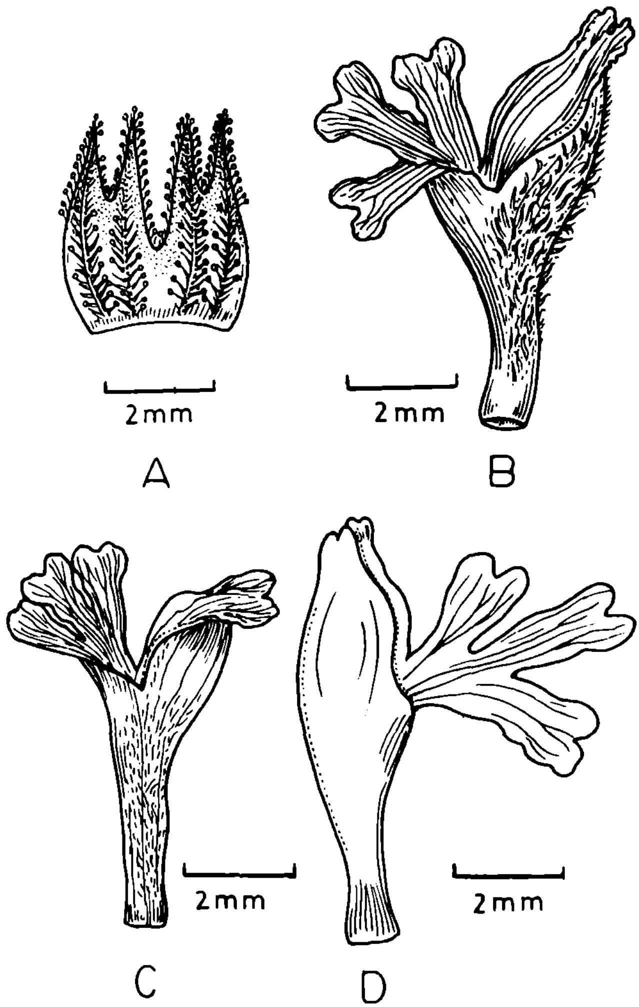


Fig. 8. Different forms of density of indumentum on the corolla in *Euphrasia*., A, Hairs on the calyx present on the nerves and lobes (*E. remota*) B, Corolla pubescent on the tube and upper lip. (*E. multiflora*). C, Corolla pubescent on the tube only (*E. incisa*). D, Corolla glabrous (*E. alba*).

ghmanensis (Fig. 7-B), or at margins and the veins e.g., *E. kurramensis* (Fig. 7-C), or at the margins only e.g., *E. sevanensis* (Fig. 7-D). On the calyx hairs may be present all over the surface of the calyx, or at the margins and the veins e.g., *E. remota* (Fig. 8-A). Hairs on the corolla may be present on the upper lip and the corolla tube e.g., *E. multiflora* (Fig. 8-B), or only on the corolla tube e.g., *E. incisa* (Fig. 8-C), or the corolla may be glabrous e.g., *E. alba* (Fig. 8-D). Moreover capsule may be ciliate all over e.g., in *E. laxa* (Fig. 9-B), or only distally e.g., *E. multiflora* (Fig. 9-A), either with soft or stiff cilia.

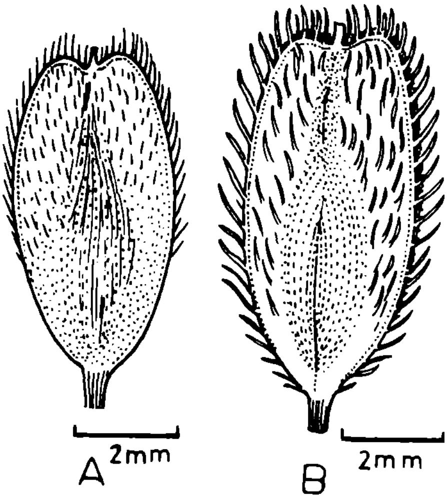


Fig. 9. Density of ciliation of the capsule in *Euphrasia*., A, Capsule ciliate all over (*E. laxa*). B, Capsule distally ciliate (*E. multiflora*).

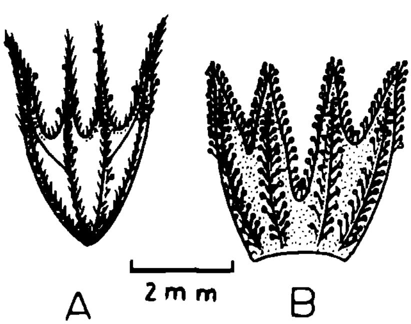


Fig. 10. Types of calyx lobes. A, calyx lobes equal (*E. incisa*). B, calyx lobes unequal (*E. sevanensis*).

Calyx:

The equality and the non equality of the calyx lobes is important. In *E. incisa* all the four lobes are equal (Fig. 10-A), while in *E. sevanensis* calyx lobes are unequal (Fig. 10-B), otherwise it is homogenous in nearly all the characters.

Corolla:

The corolla is typically bilabiate, the upper lip is further two lobed and forms a galea which encloses the anthers. The lower lip is three lobed and is expanded. The size of the corolla as a whole is very important, and measurements are taken from the base of the corolla tube to the apex of the upper lip. Apart

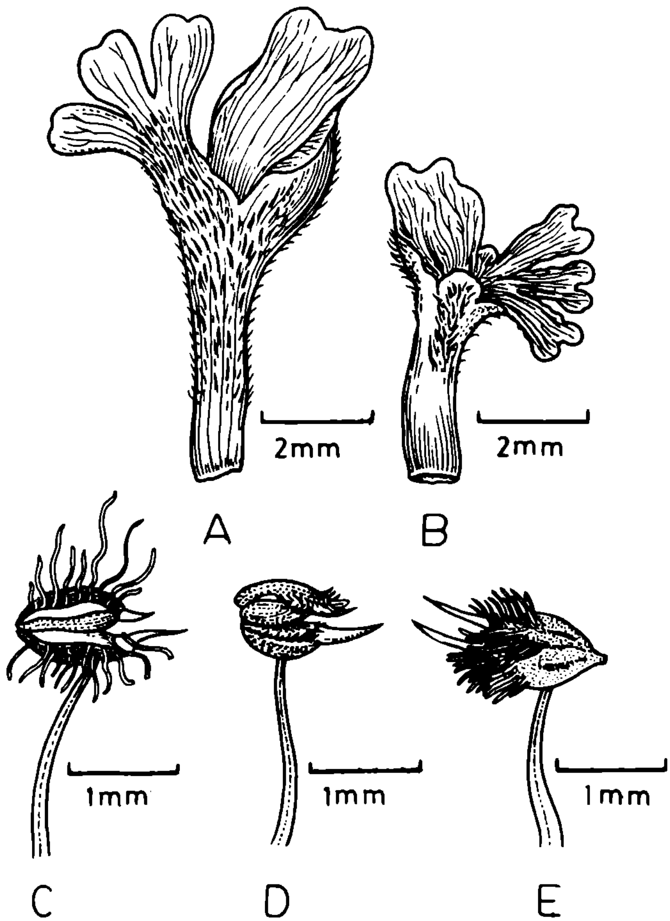


Fig. 11. Shape of the apices of the lobes of the lower lip in *Euphrasia*., A, lobes erose-slightly notched (*E. aristulata*). B, lobes erose-widely notched (*E. densiflora*). Different sizes of hairs present on the awns. C, Hairs twice as long as the longer awn (*E. laxa*). D, Hairs as long as the shorter awn. (*E. kashmiriana*). E, Hairs equalling the longer awn (*E. aristulata*).

from the size of the corolla tube, the size of upper and lower lip and the lobes of the lower lip, their general shape, the shape of their apices and the equality of lobes are of diagnostic value. Apices of the lobes of the lower lip are classified into 2 groups (1) erose-slightly notched, *E. aristulata* (Fig. 11-A), (2) erose-widely notched, *E. densiflora* (Fig. 11-B).

Anthers:

There are 4 anthers per flower. Each anther is pilose and is provided with two unequal awns. The size of the hairs with respect to the size of one of the

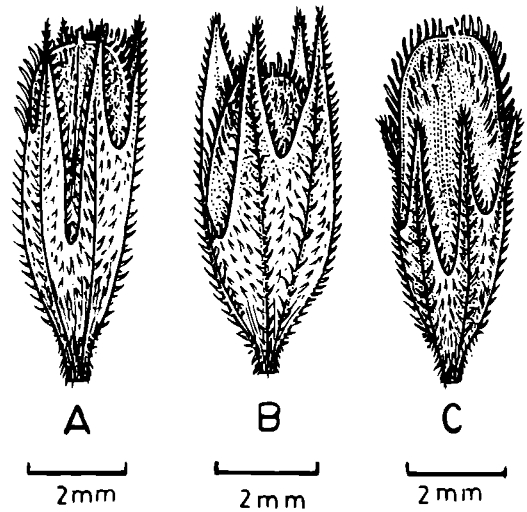


Fig. 12. Types of the capsules with respect to the calyx. A, capsule equalling the calyces (*E. schlagintweitii*); B, capsule shorter than calyces (*E. pectinata*); C, capsules longer than calyces (*E. species* D).

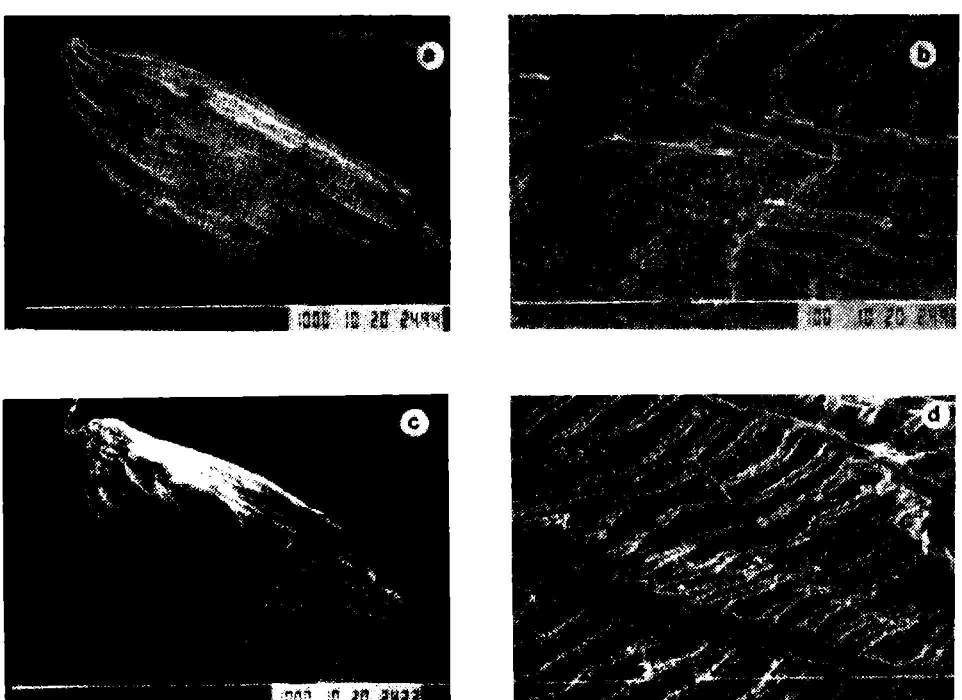


Fig. 13. Shape of seeds in *Euphrasia*. A, elliptic B, oblong. Sculpturing pattern. C, areolae large and shallow, (*E. sevanensis*). D, areolae small and deep (*E. pectinata*).

awn on the anther is considered important. The anther may be provided with the hairs of varying length. The hairs may be twice as long as e.g., *E. laxa* (Fig. 11-C), or equal e.g., *E. aristulata* (Fig. 11-E), or smaller than the larger awn, e.g., *E. kashmiriana* (Fig. 11-D).

Capsule:

The various characters of the capsule are highly diagnostic and have been extensively used as key characters. The important capsule characters include the general shape, shape of their apices and the length/breadth ratio. In *E. densiflora*, capsules are elliptic, 4 times as long as broad with a retuse apex. In *E. sevanensis* shape is oblong, apex is slightly emarginate and is 3 times as long as broad. In *E. foliosa* shape is again oblong, apex is retuse and the capsule is twice as long as broad. In *E. platyphylla* shape is obovate, apex is emarginate and it is 1/2 time as long as broad. The equality of the capsule with respect to the calyces is important and is grouped as capsule equalling the calyces as in *E. schlagintweitii* (Fig. 12-A), capsule shorter than the calyces as in *E. pectinata* (Fig. 12-B), or the capsule may be longer than the calyces as in *E. species D* (Fig. 12-C).

Mature seeds of *Euphrasia* L., are oblong, broadly ovate, carinate, narrowly obovate, oblong-slightly carinate and oblong-broadly ovate with basic brown seed colour. The seed coat pattern is predominantly areolate with prominent transverse ridges traversed by small longitudinal ridges forming rectangular areolae (Fig. 13-A-D). The relative thickness of transverse and longitudinal ridges and shape, size and depth of areolae shows lot of variation. The transverse and longitudinal ridges may be of equal thickness and may be thicker or thinner than the other. The areola may be deep or shallow; large, medium or small in size; regular or irregular in shape. All these characters are diagnostically important.

Palynology:

The pollen grains are subprolate, prolate spheroidal and oblate spheroidal in shape, are tricolpate with acute ended colpi (Fig. 14-A-B). SEM studies indicate the presence of generally retipilate type of sculpturing pattern (Fig. 14-C-E). However, further grouping of this basic type is based primarily on the differences of the surface ornamentation, produced as a result of the fusion and inter connection of the pila heads. The relative thickness of the colpus and the sculpturing pattern of the colpal membrane provides additional support for the delimitation of the taxa.

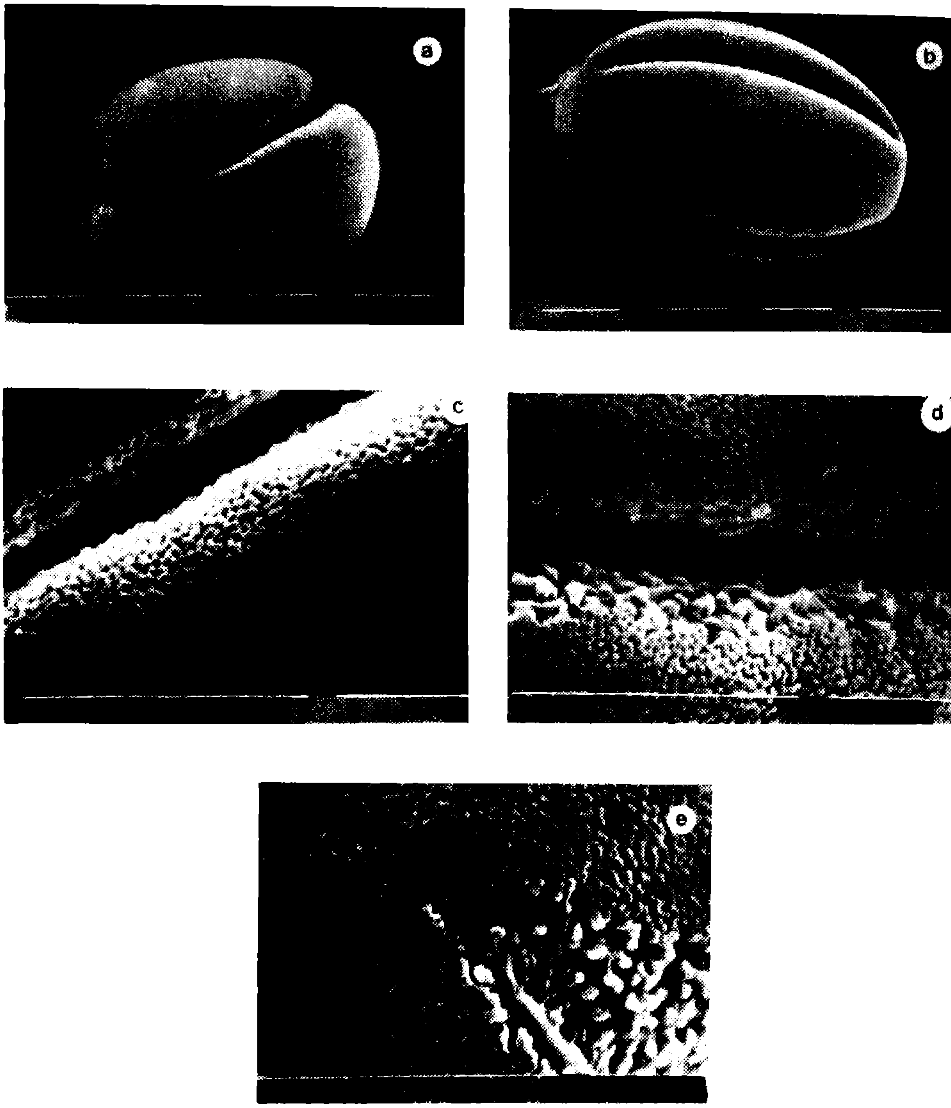


Fig. 14. Shape of pollen in *Euphrasia*. A, Polar view. B, Equatorial view. Basic sculpturing pattern C, retipilate. Sculpturing pattern of the colpus D, rugulate (*E. pectinata*) E, granulate (*E. laxa*).

Flavanoid pattern:

Generally glycosides of flavones (Apigenin, Luteolin and Tricin) and glycosides of flavanols (Kaempferol, Quercetin, Myricetin, Azaleatin) and phenolic acids are present. However, Azaleatin 3-galactoside and *O-coumaric* acid is universally present in the genus. Further confirmation with spectroscopy is in progress and detailed studies on the chemotaxonomy of the genus *Euphrasia* L., will be reported later.

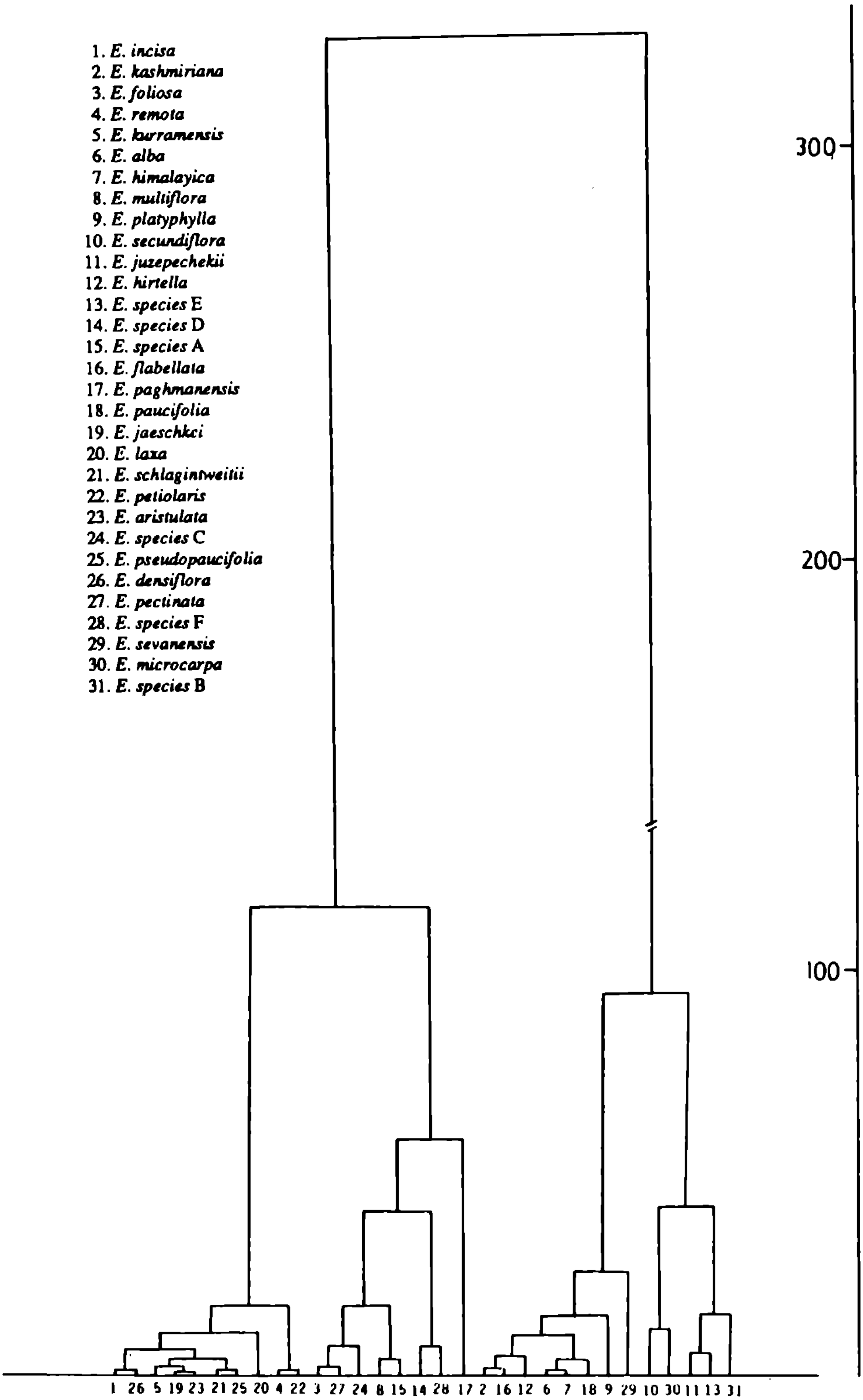


Fig. 15. Dendrogram showing the relationships of species of *Euphrasia*.

As a result of the present studies, 31 species have been recognized which include 7 new species which will be named and described later, 3 new records viz., *E.microcarpa* Pennell, *E. sevanensis* Juz., and *E. juzepechekii* Dev. The dendrogram (Fig. 15) shows the relationship of all the 31 species of *Euphrasia*, L., which are clearly distributed in 4 groups. Group I includes 10 species and is characterized by tall habit of late and mid summer forms, which are finely branched, large number of nodes, flowering nodes much higher, quite a number of leaves which are > 4-lobed and longer than broad. Capsule large, oblong-elliptic, many seeded, seeds large. Group II includes 8 species and is characterized by tall habit of early and late summer forms, finely branched, large number of nodes, flowering nodes much higher, quite a number of leaves which are 3-5 lobed, usually as long as broad or broader than long. Capsule obovate, few seeded, seeds medium sized. Group III includes 8 species which are characterized by short height of early and late summer forms, sparsely branched, few nodes, few leaves which are < 4-lobed, as long as broad. Capsule oblong, few seeded, seeds small. Group IV includes 5 species of short plants which are sparsely or unbranched, few nodes, few leaves 2-3 lobed, as long as broad. Capsule oblong, few seeded, seeds small sized.

A key to all the 31 species is provided, however a detailed taxonomic study dealing individually with all the species will be reported later.

KEY TO THE SPECIES OF *EUPHRASIA*

1.	+	Capsule $2^{1}/_{2}$-4 times as long as broad.	2
	–	Capsule less then $2^{1}/_{2}$-2 times as long as broad.	28
2.	+	Leaf 2-3(-4)-lobed.	3
	–	Leaf 4-10 lobed.	6
3.	+	Calyx lobes unequal.	22. *E. petiolaris*
	–	Calyx lobes equal.	4
4.	+	All leaf lobes antrorse.	5
	-	Upper leaf lobes antrorse, lower patent.	4. *E. remota*
5.	+	Corolla white. Lobes of lower lip erose-slightly notched.	11. *E. juzepechkeii*
	-	Corolla violet. Lobes of lower lip erose-widely notched.	29. *E. sevanensis*

6.	+	Hair on foliage> 5-8 times that of the glands.	7
	-	Hair on foliage < 5-8 times that of the glands.	9
7.	+	Leaf lobes incurved.	25. ***E. pseudopaucifolia***
	-	Leaf lobes expanded.	8
8.	+	Corolla white or pale. Calyx lobes equal, hairy at the margins and viens of the calyx.	5. ***E. kurramensis***
	-	Corolla pink-lavender. Calyx Iobes unequal, hairy only at the distal end of the calyx.	23. ***E. aristulata***
9.	+	Internodal distances large, at the base 5-6 cm, at the floral axis 3-4 cm.	1. ***E. incisa***
	-	Internodal distances short, at the base 1-3 cm, at the floral axis (0) 1-2 cm.	10
10.	+	All leaf lobes antrorse.	11
	-	Upper leaf lobes antrorse lower patent.	14
11.	+	Capsule elliptic.	26. ***E. densiflora***
	-	Capsule oblong.	12
12.	+	Capsule ciliate all over.	13
	-	Capsule distally ciliate.	27. ***E. pectinata***
13.	+	Corolla white tinged purple. Leaf lobes acuminate.	7. ***E. himalayica***
	-	Corolla violet, with dark violet streaks. Leaf lobes acuminate, cuspidate-aristulate with indurated tips.	20. ***E. laxa***
14.	+	Flowers secund. Floral leaves c. 12 x 11 mm.	10. ***E. secundiflora***
	-	Flowers not secund. Floral leaves 4-8 x 3-7 mm.	15

15. + Capsule elliptic. Secondary branches exceeding the length of the plant. — 8. ***E. multiflora***
- Capsule oblong or obovate. Secondary branches not exceeding the length of the plant. — 16

16. + Corolla white, externally glabrous. — 6. ***E. alba***
- Corolla purple or tinged purple, or white with yellow throat, externally pubescent on the upper lip and the tube or only on the upper lip, or only on the tube. — 17

17. + Flowers sessile. — 18
- Flowers pedicellate. — 23

18. + Leaf lobes obtuse. Lips of lower lip erose-widely notched. — 31. ***E. species* B**
- Leaf lobes acuminate or aristulate rarely acute. Lips of lower lip erose-slightly notched. — 19

19. + Right and left lobes of lower lip equal. — 20
- Right and left lobes of lower lip unequal. — 21

20. + Leaf lobes longer then broad, leaf base cuneate. Hairs on anther short, equalling the longer awn. Corolla violet. — 28. ***E. species* F**
- Leaf lobes as long as broad, leaf base truncate. Hairs on anther short equalling the shorter awns. Corolla yellow with violet streaks. — 18. ***E. paucifolia***

21. + Plants short 3-12 (15) cm tall, simple or with (0) 1-4 pairs of erect short lax branches. Two anthers are provided with equal and two with unequal awns. — 22

	-	Plants tall. (15) 18-20 cm tall, 1-7 pairs of short-long ascending stiff branches. Two anthers are provided with equal and two with equal-subequal awns.	19. ***E. jaeschkeii***
22.	+	Corolla white with yellow throat. Capsule emarginate. Anther hairs equalling the longer awn.	9. ***E. platyphylla***
	-	Corolla yellow with violet streaks. Capsule retuse. Hairs on anther short, equalling the shorter awn.	18. ***E. paucifolia***
23.	+	Capsule distally ciliate.	24
	-	Capsule ciliate all over.	
24.	+	Capsule emarginate.	27
	-	Capsule retuse.	25
25.	+	Right and left lobes of lower lip unequal. Middle lobe of lower lip largest.	24. ***E. species* C**
	-	Right and left lobes of lower lip equal. Right lobe of lower lip largest.	15. ***E. species* A**
26.	+	Lobes of the lower lip erose slightly notched.	16. ***E. flabellata***
	-	Lobes of the lower lip erose-widely notched.	21. ***E. schlagintweitii***
27.	+	Leaf lobes as long as broad (very rarely longer than broad). Calyx lobes equal.	7. ***E. himalayica***
	-	Leaf lobes longer than broad. Calyx lobes unequal.	21. ***E. schlagintweitii***
28.	+	Corolla 11-12 mm long.	17. ***E. paghmanensis***
	-	Corolla 5-9 mm long.	29

29. +	Flowers pedicellate.	30
-	Flowers sessile.	14. ***E. species*** **D**
30. +	All leaf lobes antrorse. Lips of lower lip erose-slightly notched.	31
-	Upper leaf lobes antrorse lower patent. Lips of lower lip erose — widely notched.	33
31. +	Left and right lobes of lower lip equal.	13. ***E. species*** **E**
-	Left and right lobes of lower lip unequal.	32
32. +	Lobes of lower lip erose-slightly notched.	30. ***E. microcarpa***
-	Lobes of lower lip erose-deeply notched.	2. ***E. kashmiriana***
33. +	Hair of foliage < 5-8 times than the glands. Corolla white, with yellow throat.	3. ***E. foliosa***
-	Hair of foliage > 5-8 times than the glands. Corolla white, purple tinged, throat not yellow.	12. ***E. hirtella***

ACKNOWLEDGEMENTS

We are grateful to the Directors/Curators of the following herbaria for sending the specimens on loan: AR, BM, CAL, GH, HARV, K, MICH, NA, NY, O, PH, RAW, US, W, WU. We are also thankful to Dr. S.S. Shaukat for his help in numerical analysis. Thanks are also due to Mr. M. Ahmed, for scanning the seeds and pollen, Mr. Rafiquddin for the illustrations and Mr. Bashir Ahmed for typing the manuscript.

REFERENCES

Boissier, E. (1879). *Flora Orientalis*, 4. H. Georg-Bibliopotam Lugduni Genevae et Basilae.

Erdtman, G. (1952). *Pollen morphology and plant taxonomy. Angiospesm* (An introduction to palynology I). Almquist and Wiskell. Stockholm.

Harborne, J.B. (1984). *Phytochemical methods.* A guide to modern techniques of plant analysis. Chapman and Hall. London.

Holmgren, P., Holmren, N.H. & Baruett, L.C. (1990). *Index Herbariorum*, Part I: The Herbaria of the World. New York Botanical Garden, Bronx, New York.

Hooker, J.D. (1885). *Flora of British India*, 4: 304-305. L. Reeve & Co., Ashford, Kent.

Kitamura, S. (1960). *Flora of Afghanistan, the committee of Karakorum and Hindukush*. Kyoto University, Kyoto.

Mabberley, D.J. (1987). *The plant-book*. Cambridge Univ. Press.

Orloci, L. & Kenkel, N.C. (1985). *Data analysis in Biology with examples from population and community ecology*. International Cooperation Publ., Fair land, Maryland.

Pennell, F.W. (1943). *The Scrophulariaceae of the western Himalayas*. Acad. Nat. Sci. Philadelphia Monogr., 5: 99-113.

Sell, P.D. & Yeo, P.F. (1970). A revision of the North American species of *Euphrasia*, *Bot. J. Linn. Soc.*, 63: 189-234.

Yeo, P.F. (1978). A taxonomic revision of *Euphrasia* in Europe. *Bot. J. Linn. Soc.*, 77: 233-334.

Yeo, P.F. (1981). In K.H. Rechinger (Ed.) *Flora Iranica*. 147: 172-184. Akademische Druck-u-Verlagsanstalt, Graz.

Proceedings of the International Symposium on Plant Life of South Asia held at the Department of Botany, University of Karachi, Karachi-75270, Pakistan. 24-27 February, 1991

Plant Life of South Asia, 149–157, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

CYTOLOGICAL STUDIES IN THE ANGIOSPERMS OF PAKISTAN

SURAYYA KHATOON AND S.I. ALI

Department of Botany,
University of Karachi, Karachi-75270, Pakistan.

ABSTRACT

Chromosome numbers of 637 plant specimens comprising 300 genera and 492 species in 66 dicots and 9 monocot families collected from different parts of Pakistan and Kashmir were determined. Maximum number of taxa examined were of the family Compositae (62), followed by Cruciferae (32), Leguminosae (31), Labiatae (25), Scrophulariaceae (24), Boraginaceae (23), and Umbelliferae (19). Thirty families have been cytologically investigated for the first time for the flora of Pakistan. Counts for 406 species are new to flora of Pakistan and counts for 187 species are new to science. New basic numbers are observed in the genera *Cuscuta* (Cuscutaceae) and *Consolida* (Ranunculaceae). B-Chromosomes are observed in five genera for the first time, cytotypes are recorded in eight species. Incidence of polyploidy in the flora is discussed in relation to growth habit and geographic distribution of the taxa.

INTRODUCTION

Floristically and geographically Pakistan is an interesting land. Four phytogeographic regions are known to meet here (Fig. 1). The Saharo-Sindian region occupies the largest area, but represents only 9.1% of the flora; 45.6% of the flora is represented by the Irano-Turanian element (Ali & Qaiser, 1986). The phytogeographic regions are somewhat correlated with the annual rainfall pattern (Fig. 2). The Saharo-Sindian region roughly corresponds to the low rainfall area, and the Sino-Japanese region, which has the richest flora of the northern zone, occupies the highest rainfall area.

Topographically the land varies from sea-level to 8611 m (Ali, 1978). The plains have a long history of agriculture and an extensive irrigation canal system. At the same time, the plains are the most densely populated areas, therefore they represent an extremely disturbed habitat.

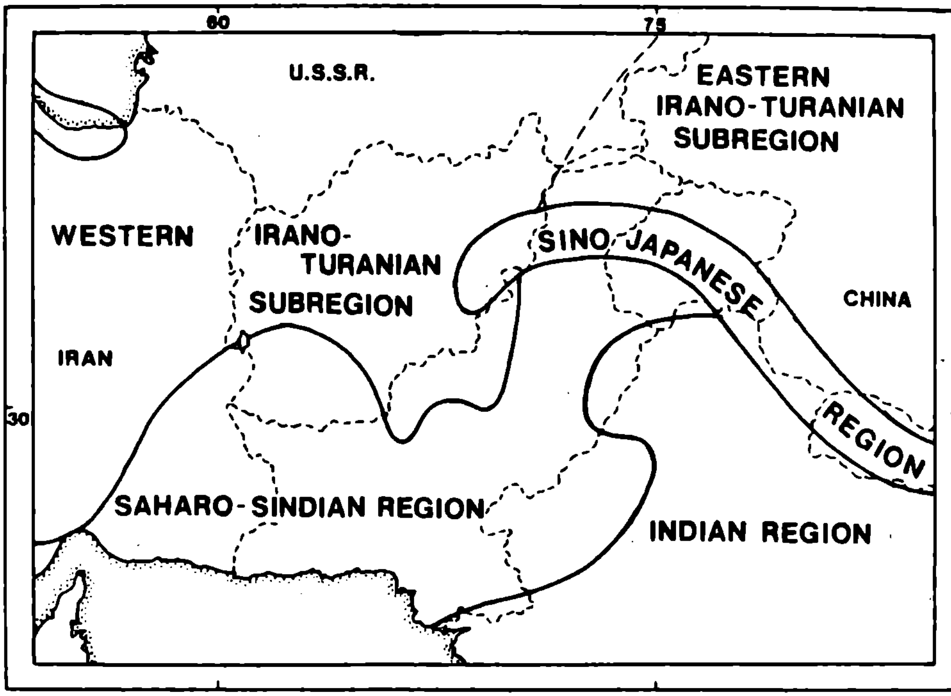


Fig.1. Phytogeographical regions of Pakistan and Kashmir.

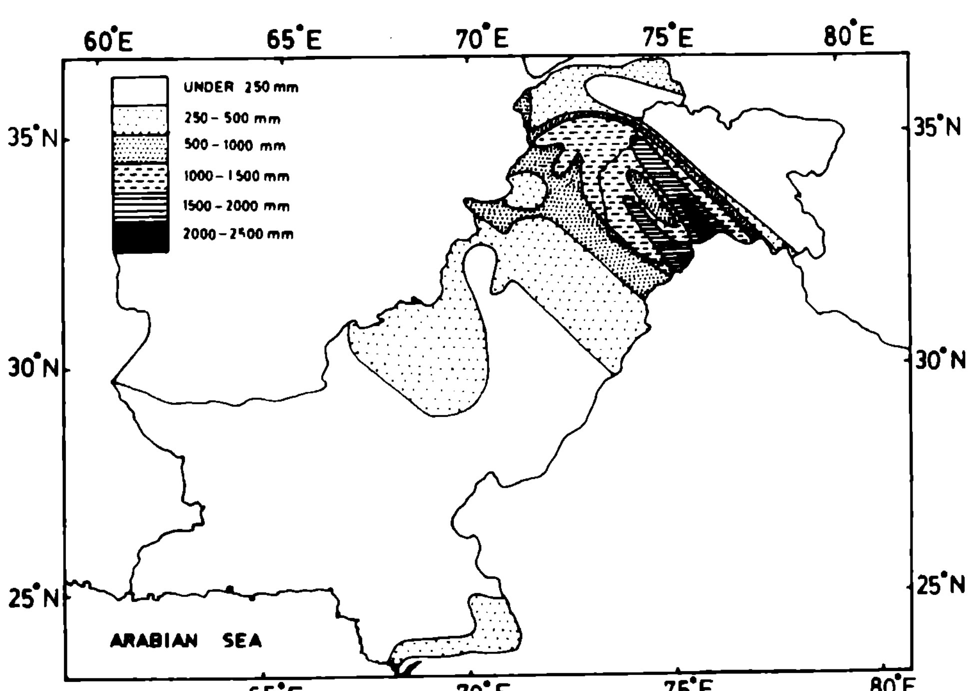


Fig. 2. Mean annual rainfall of Pakistan and Kashmir.

With these diversified geographical and climatological features, it seems very interesting to analyse the flora cytologically. Up to 1982, cytological information was available for less than 6% of flora (Khatoon & Ali, 1982). These studies were based mainly on the collections from the plains and the floras of remote hilly areas remained alsmost unexplored. In the present work, collections were made from all parts of Pakistan and some areas of Kashmir. In addition to the original counts, the data about the local species available from other works done in Pakistan, Kashmir, neighbouring areas of India, Afghanistan and Iran are also incorporated.

MATERIALS AND METHODS

Most of the counts were obtained from pollen mother cell meiosis. Young floral buds were fixed in Carnoy's Solution (a mixture of glacial acetic acid and absolute alcohol, 3:1) and stored at 5°C. Slides were prepared by squashing the anthers in propionic-carmine. For mitotic-studies, root-tips were pretreated in saturated solution of p-dichlorobenzene at room temperature for 3-4 hours, then fixed in Carnoy's Solution. Before squashing, the root-tips were hydrolysed in N HCl at 60°C for 10 minutes. Photographs were taken from temporary mounts, the slides were later made permanent. Voucher specimens are deposited in Karachi University Herbarium (KUH).

RESULTS AND DISCUSSION

i. *Chromosome numbers in the flora of Pakistan*

In the present work, chromoscome numbers are determined for 637 specimens which comprise 300 genera and 492 species in 66 dicot and 9 monocot families. Of these, counts for 187 species are new to science (Table 1), and counts for 406 species are new to flora of Pakistan. Six families have 10 or more new counts, with maximum new counts in Compositae (Table 2). Twelve genera are cytologically investigated for the first time. Most of these genera have a tropical to subtropical distribution, some of them have a restricted distribution up to some neighbouring countries of Pakistan and one genus (*Douepia*) is endemic to Pakistan (Table 3). In eleven larger families, chromosome numbers are

Table 1. New counts in the present study.

Dicots	Monocots	Total
179	8	187
(in 42 families)	(in 6 families)	(in 48 families)

Tabled 2. Families with more than ten new counts.

Family	No. of Taxa
1. Compositae	20
2. Cruciferae	12
3. Scrophulariaceae	14
4. Umbelliferae	10
5. Boraginaceae	12
6. Labiatae	12

now available for more than 25% of their species in our flora. Gramineae comes to be chromosomally the best known family with chromosome numbers available for 45% of its species in the flora, other larger families Compositae and Leguminosae have 38% chromosomally known species (Table 4). By adding the original counts, the counts available from other works done in Pakistan and the counts available in the reports from neighbouring countries, the total number of

Table 3. New generic counts.

Genus	Chr. No.	Geographic distribution of genus
1. *Pseudomertensia* (Boraginaceae)	n = 12	Iran to Himalaya.
2. *Dipterygium* (Capparidaceae)	n = 11	Egypt to Pakistan.
3. *Hochstetteria* (Compositae)	n = 10	Arabia to Pakistan.
4. *Cithareloma* (Cruciferae)	n = 13	Iran, Central Asia.
5. *Douepia* (Cruciferae)	n = 16	Endemic to Pakistan.
6. *Corbichonia* (Molluginaceae)	n = 9	S.W. Africa, Tropical Africa to Asia.
7. *Helinus* (Rhamnaceae)	n = 11	Tropical and S. Africa, Madagascar, N.W. India.
8. *Aitchisonia* (Rubiaceae)	n = 11	Afghanistan, Pakistan.
9. *Gaillonia* (Rubiaceae)	n = 11,22	Central Asia, Afghanistan, Iran, Pakistan to Algeria.
10. *Pseudogaillonia* (Rubiaceae)	n = 11	Arabia, Iran, Pakistan, Afghanistan.
11. *Pterogaillonia* (Rubiaceae)	n = 22	N.E. Africa, Afgh., Pakistan & Iran.
12. *Pycnocycla* (Umbelliferae)	n = 11	Tropical W. Africa to N.W. India.

chromosomally known species in the flora of Pakistan now comes to be 1671, which makes 34% of the total angiospermic flora of Pakistan (Table 5). This means an approximate 6-fold increase in chromosome number information about the flora of Pakistan since 1982.

New basic numbers

In *Consolida stocksiana* (Boiss.) Nevski, we have counted 10 bivalents clearly at diakinesis in several cells (Fig. 3). This count establishes x = 10 as a new basic number in the genus *Consolida*. The most common basic number in this genus is x = 8. The other basic numbers in this genus are x = 7 and x = 9 recently reported by Hong (1986).

In *Cuscuta pulchella* Englem., we found five large bivalents at diakinesis and metaphase I (Fig. 4). The hitherto known basic numbers in the genus *Cuscuta* were x = 7 and x = 15 (Raven, 1975; Lewis, 1980). According to Raven (1975), x = 15 evolved from x = 8 through aneuploid reduction at tetraploid level. Therefore, x = 15 could not be regarded as a multiple of x = 5 and our new count of n = 5 in *C. pulchella* establishes a new basic number in this genus which probably descended from x = 7 through aneuploid reduction.

Table 4. Number of chromosomally known species in some larger families.

Family	No. of species studied in present work	No. of species known from other works	Total (based on works from Pakistan)	Total (including the reports from neighbouring countries)
1. Boraginaceae	23	10	33	42 (31%)
2. Caryophyllaceae	16	1	17	32 (29%)
3. Compositae	62	56	118	230 (38%)
4. Cruciferae	32	4	36	85 (34%)
5. Labiatae	25	2	27	86 (37%)
6. Malvaceae	10	16	26	38 (40%)
7. Leguminosae	31	50	81	162 (38%)
8. Rubiaceae	13	1	14	24 (28%)
9. Scrophulariaceae	24	1	25	51 (28%)
10. Umbelliferae	19	1	20	63 (38%)
11. Gramineae	15	111	126	220 (45%)

Table 5. Present situation of chromosome numbers in Flora of Pakistan.

No. of taxa analysed	No. of taxa known from other works	Total no. of chromosomally known taxa (including the reports from neighbouring countries)	Total no. of species in flora of Pakistan	Percentage of chromosomally known species
492	253	1671	4917	34

B-chromosomes

We have observed B-chromosomes in the following genera for the first time: *Cuscuta* (*C. pulchella* Englem.), *Sporobolus* (*S. kentrophyllus* (K. Schum.) W.D. Clayton), *Hibiscus* (*H. obtusilobus* Garcke), *Asphodelus* (*A. tenuifolius* Cav.) and *Potamogeton* (*P. pectinatus* L.).

Cytotypes

New cytotypes are revealed in the following species:

Dianthus crinitus Sm.: This species was previously reported at hexaploid level by Gentscheff (in Fedorov, 1974). However, our material is found to be diploid with n = 15 and 2n = 30.

Salsola kali L.: The present count of n = 27 is the first report of hexaploid in this widespread species. All previous reports are of tetraploids.

Malva neglecta Wallr.: This is another widespread species. We analysed six specimens of this species. Five of them proved to be diploids with n = 21 but one specimen was tetraploid with n = 42.

Indigofera linnaei Ali: This species is reported at diploid level from India. However, our material is found to be tetraploid with n = 16.

Bupleurum exaltatum M. Bieb.: The earlier report for this species is 2n = 16 (Cauwet-Marc, 1978). But in the present work, all specimen were found to have n = 6.

Conyza albida Willd. ex Spreng.: The present count for this New World species is n = 9, whereas the earlier report from Argentiana is of n = 27 (Bernardello, 1986).

Scorzonera tortuosissima Boiss.: The specimen analysed in the present work proved to be a hexaploid with n = 21, while other report from Pakistan is of tetraploid (Razaq *et al.*, 1991).

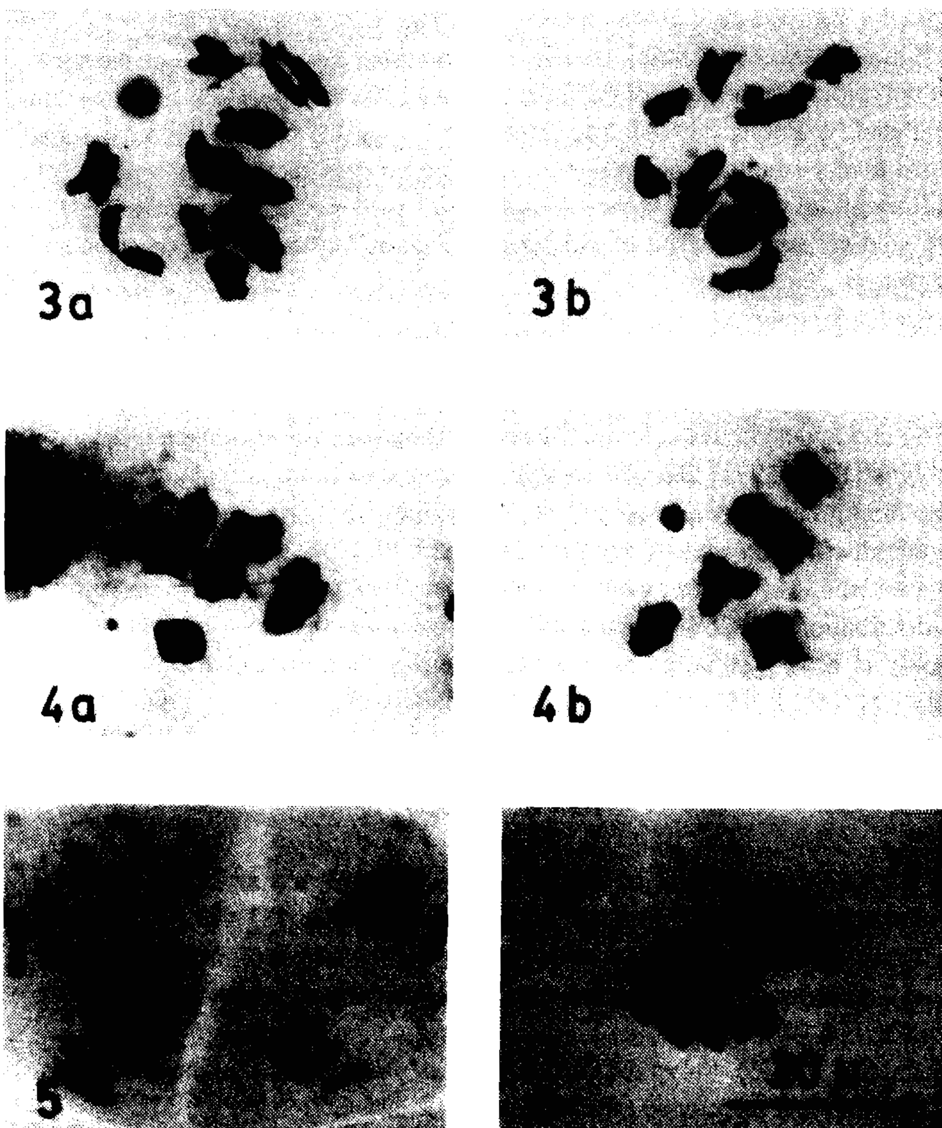


Fig. 3-5. Meiosis in pollen mother cells.

Fig. 6. Root-tip mitosis. 3a,b. *Consolida stocksiana* (diakinesis) n = 10 (*Ghafoor* 1311), 4. *Cuscut pulchella* (diakinesis) a. n = 5, b. n = 5 + 1B (*Ghafoor* 2120), 5. *Dipcada unicolor* (Anaphase-II) n = 4 (*Omer* s.n.), 6. *Dipcade erythraeum* (metaphase) 2n = 22 (*Khatoon* 571).

Dipcade erythraeum Webb & Berth., and *D. unicolor* (Stocks) Baker: *D. unicolor* is generally regarded as a synonym of *D. erythraeum*. Jafri (1966) gave a subspecific rank to *D. unicolor* under *D. erythraeum*. Our finding of n = 4 in the former and 2n = 22 (n = 11) in the latter suggests a specific rank for *D. unicolor* (Figs. 5 and 6). *D. unicolor* is a rare endemic of lower Baluchistan (Pakistan).

ii. *Polyploidy in the flora of Pakistan*

On the basis of presently available information, the percentage of intrageneric polyploidy in the flora of Pakistan is about 32%, which is 10% less than that calculated by Baquar (1976). The difference is evidently due to the reason that he had a very small sample at that time (345 species) which mainly represented the flora of the plains and included larger number of species from those families that have greater incidence of polyploidy, such as Malvaceae, Solanaceae and Gramineae.

In our sample, the highest frequency of intrageneric polyploidy is recorded in perennial herbs (35%), followed by annual herbs (33%), shrubs and subshrubs (23%) and lowest in trees (11%). This is in agreement with the generalization by Stebbins (1938, 1971) that perennial herbs have maximum polyploidy and trees have minium intrageneric polyploidy. Polyploidy is correlated with the geographic distribution also. Among the families with more than 30% intrageneric polyploids, 43% families have a cosmopolitan distribution, 30% have a temperate distribution and 26% families have a tropical distribution. However, as polyploidy is a very complex phenomenon having more than one aspects, more analytical work is needed to understand the pattern of polyploidy in our flora.

REFERENCES

Ali, S.I. (1978). The flora of Pakistan: some general and analytical remarks. *Notes from the Royal Botanic Garden Edinburgh*, 36: 427-439.

Ali, S.I. & Qaiser, M. (1986). A phytogeographical analysis of the phanerogams of Pakistan and Kashmir. *Proceedings of the Royal Society of Edinburgh*, 89B: 89-101.

Baquar, S.R. (1976). Polyploidy in the flora of Pakistan in relation to latitude, life form and taxonomic groups. *Taxon*, 25: 621-627.

Bernardello, L.M. (1986). Numeros Chromosomicos en Asteraceae de Cordoba. *Darwinia*, 27: 169-178.

Cauwet-Marc, A.M. (1978). In IO PB chromosome number reports LXI. *Taxon*, 27: 385-386.

Fedorov, A.A. (ed.) (1974). *Chromosome Numbers of Flowering Plants.* Otto Koelz Science Publishers, W. Germany.

Hong, De-Yuan. (1986). Biosystematic observations on *Consolida* (Ranunculaceae). *Acta Botanica Sinica,* 28: 1-10.

Jafri, S.M.H. (1966). *The Flora of Karachi,* The Book Corporation Karachi, Pakistan.

Khatoon, S. & Ali, S.I. (1982). Chromosome numbers of some plants of Pakistan. *Pakistan Journal of Botany,* 14: 117-129.

Lewis, W.H. (1980). Polyploidy in angiosperms: Dicotyledons. In: *Polyploidy; Biological Relevance,* ed. Lewis, W.H., PP. 241-268. Plenum Press, New York and London.

Raven, P.H. (1975). The bases of angiosperm phylogeny: cytology. *Annals of the Missouri Botanical Garden,* 62: 724-764.

Razaq, Z., Vahidy, A.A. & Ali, S.I. (1991). Chromosome numbers in Compositae from Pakistan. *Annals of the Missouri Botanical Garden* (submitted).

Stebbins, G.L. (1938). Cytological characterstics associated with the different growth habits in the dicotyledons. *American Journal of Botany,* 25: 189-198.

Stebbins, G.L. (1971).*Chromosomal Evolution in Higher Plants.* Edward Arnold (Publishers) Ltd., London.

Proceedings of the International Symposium on Plant Life of South Asia held at the Department of Botany, University of Karachi, Karachi-75270, Pakistan. 24-27 February, 1991

Plant Life of South Asia, 159–168, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

A SURVEY OF CHROMOSOME NUMBERS IN ASTERACEAE FROM PAKISTAN

ZEENAT A. RAZAQ, AHSAN A. VAHIDY* AND S.I. ALI

Department of Botany,
University of Karachi, Karachi-75270, Pakistan.

ABSTRACT

Chromosome counts are reported for 82 taxa of the family Asteraceae from Pakistan. Cumulative analyses of cytological data on indigenous taxa have been carried out. Of about 652 Pakistani taxa, 117 (including present findings) are known cytologically with chromosome numbers ranging from n = 3 to 36. The taxa with n = 9 were the most common (37%) followed by those with n = 10 (13%). Incidence of polyploidy was found to be 15% of the total number of taxa studied.

INTRODUCTION

The family Asteraceae has a cosmopolitan distribution with major concentration in the temperate regions (Mathew & Mathew, 1983). It is the largest dicotyledonous family in the flora of Pakistan including approximately 604 native species belonging to 110 genera (Ali, 1978). In addition to these, 45 species belonging to 24 genera are naturalized or cultivated (Stewart, 1972).

The members of Asteraceae are relatively widely distributed in Pakistan, from the plains up to 10000 meters elevation. Inspite of its wide distribution the family has not been studied well cytologically from Pakistan. So far, the chromosome counts in only 19 per cent of taxa of the family have been reported by different workers (Baquar & Askari, 1970; Khatoon & Ali, 1988, 1991; Razaq *et al.*, 1988, 1992) including present work. Eighty two taxa of the Asteraceae were analysed cytologically and an overview of cytological data accumulated so far is presented here.

* Department of Genetics, University of Karachi, Karachi-75270, Pakistan.

MATERIALS AND METHODS

Materials consisted of young capitula and seeds collected during the period of 3 years, 1987-90 from Karachi, Northern areas of Pakistan, Kashmir, Baltistan, plains of Punjab, etc.

Immature capitula were collected and fixed in Carnoy's solution (3:1 absolute alcohol: acetic acid). The slides were prepared by conventional squashing technique, using 1% propionic carmine. The chromosome counts were made in P.M.Cs. at different stages of meiosis.

For mitotic chromosomes, root-tips collected from germinating seeds, pretreated with 0.002M 8-hydroxyquinoline for 4-6 hours were, fixed in Carnoy's solution for c. 1 hour, then transferred to 1 N HCl to hydrolyse at 60°C for 5 min. Slides were prepared by squash method using 1% aceto orcein. Photomicrographs were taken from temporary mounts but later the slides were made permanent. Voucher specimens were deposited in Karachi University Herbarium (KUH).

Table 1. Chromosome numbers and prevalence of polyploidy in taxa of Asteraceae from Pakistan.

Tribe	Total No. of spp. in Pakistan	No. of chromosomally known taxa	No. of diploid taxa	No. of polyploid taxa
Anthemideae	89	20	18	2
Astereae	49	14	13	1
Calendulae	3	0	—	—
Crepidineae	1	0	—	—
Cynareae	129	9	9	0
Eupatorieae	4	2	1	1
Heliantheae	32	9	8	1
Inuleae	96	21	19	2
Lactuceae	196	29	24	5
Mutiseae	8	2	1	1
Senecioneae	37	7	4	3
Tageteae	4	2	1	1
Vernonieae	4	2	1	1
Total	652	117	99	18

The present analysis includes investigations made on the indigenous material by other workers along with our findings.

RESULTS AND DISCUSSION

In the present study chromosome numbers were determined for 82 taxa. By adding the present counts and counts available in other works carried out in Pakistan (Baquar & Askari, 1970; Khatoon & Ali, 1988, 1991; Razaq *et al.*, 1988, 1992), the total number of chromosomally known species (based on local material) comes to be 117 (18%). Maximum number of cytologically known taxa belong to Lactuceae. No cytological investigation has so far been conducted in tribe Calenduleae and Crepidineae. Of the 117 taxa known chromosomally, 85% were found to be diploid and 15% were polyploid (Table 1).

Polyploid cytotypes are reported in many species (Fedorov, 1974; Moore, 1973, 1974; Goldblatt, 1981, 1984, 1985, 1988) of Asteraceae, which are known to occur at a certain ploidy level in Pakistan. These cytotypes are either euploid or aneuploid variations of the basic chromosome numbers. Euploid cytological races are reported for 18 taxa, while aneuploid cytotypes are known to occur in 8 taxa (Table 2).

Table 2. Gametic and proposed basic chromosome numbers in various tribes of Asteraceae from Pakistan.

Tribe	Observed gametic Chr. no. in different taxa	Proposed* basic no. for the tribes
1. Anthemideae	8, 9	8, 9, 10, 13, 17
2. Astereae	9, 18, 27	4-6, 9
3. Cynareae	12, 14	8-13, 15, 17, 19
4. Eupatorieae	10, 20	4, 5, 9, 10, 12, 15, 17, 19, 20
5. Heliantheae	8, 10, 11, 12, 17, 18, 36	4-19
6. Inuleae	7, 9, 10, 30	5, 7-11, 13
7. Lactuceae	5, 6, 8, 9, 14, 16	3-9
8. Mutiseae	10, 11	6-11, 13, 15, 17, 23, 25
9. Senecioneae	10, 20	5, 9-12, 23, 26, 29
10. Tegeteae	12	7-13, 15
11. Vernonieae	9, 20	7-11, 13, 15, 17

*Source Heywood *et al.*, (1977).
Darlington & Wylie (1955).

In *Coreopsis lanceolata*, 2n = 24 and 48 (Bilquez in Fedorov, 1974) and 2n = 26 (Turner in Fedorov, 1974) are reported. Our finding of n = 10 for this species establishes an additional aneuploid race. Razaq *et al.*, (1992) found chromosomal count of n = 8 for *Artemisia capillaris*, whereas 2n = 18 and 36 were reported earlier (Arano in Fedorov, 1974, and Peng & Hsu in Goldblatt, 1984, respectively). For *Dyssodia tennuiloba*, 2n = 16 and 36 were reported, (Johnston & Turner in Fedorov, 1974), whereas, we have counted 2n = 24 and n = 12 in our material. These counts suggest the presence of aneuploid races or cytotypes in these species.

Table 3 lists the tribes covered in the present analysis, gametic numbers studied and basic numbers proposed by various workers in Heywood *et al.*, (1977) and Darlington & Wylie, (1955) for each tribe. In tribes Eupatorieae and Vernonieae a wide range of basic numbers exists of which n = 10 shows predominance in Eupatorieae and x = 9 and 10 are predominant in the tribe Vernonieae (Mathew & Mathew, 1983).

Raven *et al.*, (1960) suggested 9 as the most frequent basic number for the tribe Astereae. We found all the taxa to be based on x = 9, except *Myriactis wallichii* for which we found n = 18. There are only 3 species of *Myriactis*, of which two are found in Pakistan. The available chromosome data for all 3 species is n = 18 and 2n = 36. On the basis of these informations x = 18 is suspected for this genus.

The members of Inuleae are reported to have x = 5, 7-11, 13 (Merxmuller *et al.*, 1977). Of the 21 taxa covered in the present analysis, 7 were based on x = 7 and 8 on x = 10. Solbrig *et al.*, (1972), commenting on the diversity of morphology and chromosome numbers in Heliantheae, suggested that the basic numbers for this tribe lies within x = 8 to 12. In a few genera lower chromosome numbers (x = 4-7) are represented, which are presumed to be derived through aneuploid reduction (Stuessy, 1977). However, Smith (1975) considered x = 17-19 as the original and other lower basic numbers as derived through aneuploid reduction.

In Tageteae, the most common basic number seems to be x = 12, though x = 7-13 and 15 have been reported as well (Strother, 1977). The most frequent basic most common number in Senecioneae is x = 10 (Nordenstam, 1977). Six out of 7 taxa covered in present analysis also were based on x = 10. In Anthemideae the commonest base number is x = 9, but taxa with x = 8, 10, 13 and 17 are also reported (Heywood & Humphries, 1977). Due to its prevalence, x = 9 is considered to be the ancestral basic number for the tribe (Solbrig, 1963; Powell *et al.*, 1974; Mehra, 1977). In the tribe Cynareae the gametic chromosomal numbers,

Table 3. Cytotypes recorded in Pakistani taxa of Asteraceae.

Tribe & Taxa	Base No.	Chromosome No. n	2n	Reference	Cytotypes
Anthemideae					
Achillea millefolium L.	9	9	—	Present count	2x
		—	36	Ferris in Fedorov, 1974	4x
		—	36, 54	Clausen in Fedorov, 1974	4x, 6x
Artemisia capillaris Thunb	9	8	—	Present count	aneuploid
		—	18	Arano in Fedorov, 1974	2x
		—	36	Peng & Hsu in Goldblatt, 1984	4x
Astereae					
Conyza bonariensis (L.) Cronq.	9	27	—	Present cout	6x
		18	—	Turner *et al.*, in Goldblatt, 1984	4x
Eupatorieae					
Ageratum conyzoides L.	10	10	—	Present count	2x
		10, 20	—	Mehra & Remanandan in Goldblatt, 1984	2x, 4x
A. houstonianum Mill.	10	20	—	Present count	4x
		10, 20	—	King *et al.*, in Goldblatt, 1981	2x, 4x
Heliantheae					
Blainvillea acmella (L.) Philip	17	17	—	Present count	2x
		—	72	Mehra *et al.*, in Fedorov, 1974	aneuploid
Coreopsis lanceolata L.	10	10	—	Present count	2x
		—	24, 48	Bilquez in Fedorov, 1974	aneuploid

Table 3. (Contd.)

Tribe & Taxa	Base No.	Chromosome No. n	2n	Reference	Cytotypes
		—	26	Turner in Fedorov, 1974	aneuploid
Dahlia variabilis (Willd.) Desf.	16	32	—	Present count	4x
		—	32	Gagnieu *et al.*, in Fedorov, 1974	2x
		—	64	Ishikawa in Fedorov, 1974	4x
Eclipta prostrata (L.) L.	11	11	—	Present count	2x
		—	18, 22	Mohan *et al.*, in Fedorov, 1974	aneuploid 2x
Galinsoga parviflora Cav.	8	8	—	Present count	2x
		—	16, 32	Magulaev in Goldblatt, 1985	2x, 4x
Parthenium hysterophorus L.	18	18	—	Present count	2x
		17	—	Gupta & Gill in Goldblatt, 1984	aneuploid
Inuleae					
Blumea lacera DC.	10	10	—	Present count	2x
		—	18	Subramanyam & Kamble in Fedorov, 1974	aneuploid
		—	36	Peng & Hsu in Goldblat, 1984	aneuploid
Pluchea indica (L.) Less	10	30	—	Present count	6x
		15	—	Sarkar *et al.*, in Goldblatt, 1985	3x
		—	20	Peng & Hsu in Goldblatt, 1981	2x

Table 3. (Contd.)

Tribe & Taxa	Base No.	Chromosome No. n	2n	Reference	Cytotypes
Lactuceae					
Launaea residifolia (L.) O. Ktze	8	8	—	Present count	2x
		—	18	Valdes-Bermejo & Gomez Gracia in Goldblatt, 1981	aneuploid
Sonchus asper (L.) Hill.	9	9	—	Present count	2x
		—	36	Kuzmanova & Georgieva in Goldblatt, 1984	4x
Tageteae					
Dyssodia tennuiloba (DC.) B.L. Robinson	12	12	24	Present count	2x
		—	16, 36	Johnston & Turner in Fedorov, 1974	aneuploid
Vernonieae					
Vernonia cinerascence Sch. Bip.	10	20	—	Present count	4x
		—	20	Turner *et al.*, in Fedorov, 1974	2x
		20, 10	—	King *et al.*, in Goldblatt, 1981	4x, 2x

ranged from 8-13, 15, 17 and 19 (or multiple) with a regular dysploid series (Dittirich, 1977). In Mutiseae, quite variable basic numbers (x = 6-11, 13, 15, 17, 23, 25) have been reported (Cabrera, 1977). However, Turner *et al.*, (1962) and later Powell *et al.*, (1974) considered x = 9 to be the basic number for this tribe.

Lactuceae is cytologically most thoroughly known tribe of Asteraceae. The representatives of this tribe exhibit basic numbers ranging from x = 3-9. Chromosome numbers for 21 taxa of this tribe are being reported where x = 9 is found to be the most frequent basic number. The ancestral base chromosome number for the whole family Asteraceae appears to be x = 9 (Raven, 1975). Solbrig (1977) has suggested 9 to be the modal chromosome number. The perusal of chromosome data on the 119 taxa from Pakistan is indicative of the prevalence of x = 9 as well. However, this is based on only about 1/5 of the taxa of the family studied so far.

REFERENCES

Ali, S.I. (1978). The Flora of Pakistan: Some general and analytical remarks. *Notes from the Royal Botanic Garden Edinburgh.* 36: 427-439.

Baquar, S.R. & Askari, S.H.A. (1970). Chromosome numbers in some flowering plants of West Pakistan-II. *Genet. Iberica.* 22: 41-51.

Cabrera, A.L. (1977). Mutisieae — systematic review. In: *The Biology and Chemistry of the Compositae.* (Eds.) Heywood, V.H., J.B. Harborne & B.L. Turner. Vol. II. pp. 1039-1066. Academic Press, London.

Darlington, C.D. & Wylie, A.P. (1955). *Chromosome Atlas of Flowering Plants,* George Allen & Unwin Ltd. London.

Dittrich, M. (1977). Cynareae — systematic review. In: *The Biology and Chemistry of Compositae,* (Eds.) Heywood, V.H., J.B. Harborne & B.L. Turner. Vol. II pp. 999-1016. Academic Press, London.

Fedorov, A.A. (1974). *Chromosome Numbers of Flowering Plants.* Otto Koeltz Science Publishers, West Germany.

Goldblatt, P. (1981). *Index to Plant Chromosome Numbers* 1975-1978. Monogr. Syst. Bot. Missouri Bot. Gard. 5: 1-553.

Goldblatt, P. (1984). *Index to Plant Chromosome Numbers* 1979-1981. Monogr. Syst. Bot. Missouri Bot. Gard. 8:1-427

Goldblatt, P. (1985). *Index to Plant Chromosome Numbers* 1982-1983. Monogr. Syst. Bot. Missouri Bot. Gard. 13: 1-224.

Goldblatt, P. (1988). *Index to Plant Chromosome Numbers* 1984-1985. Monogr. Syst. Bot. Missori Bot. Gard. 23: 1-264.

Heywood, V.H. & Humphries, C.J. (1977). Anthemideae — systematic review. In: *The Biology and Chemistry of Compositae.* (Eds.) Heywood, V.H., Harborne, J.B. & Turner, B.L. Vol. II. pp. 851-898. Academic Press, London.

Heywood, V.H., J.B. Harborne & B.L. Turner, (1977). *The Biology and Chemistry of Compositae.* Vol. I and II. pp. 1-1179. Academic Press, London.

Khatoon, S. & Ali, S.I. (1988). Chromosome numbers in Compositae from Pakistan. *Candollea* 43: 455-462.

Khatoon, S. & Ali, S.I. (1991). Cytological studies in the Angiosperms of Pakistan. Proc. Int. Symp. Plant Life of South Asia.

Mathew, P.M. & Mathew, A. (1983). Studies on South Indian Compositae V. Cytotaxonomic consideration of the tribe Vernonieae and Eupatorieae. *Cytologia* 48: 679-690.

Mehra, P.N. (1977). Cytological investigation on the Compositae VI Chromosome and evolutionary phylogeny. *Cytologia* 42: 347-356.

Merxmuller, H., Liens, P. & Roessler, H. (1977). Inuleae — systematic review. In: *The Biology and Chemistry of Compositae* (Eds.) Heywood, V.H., Harborne, J.B. & Turner, B.L. Vol. I. pp. 577-602. Academic Press, London.

Moore, R.J. (1973). *Index to Plant Chromosome Numbers for* 1967-1971. Regnum Vegetabile 90: 1-539.

Moore, R.J. (1974). *Index to Plant Chromosome Numbers for* 1972. Regnum Vegetabile 91: 1-108.

Nordenstam, B. (1977). Senecioneae and Liabeae — systematic review. In: *The Biology and Chemistry of Compositae* (Eds.) Heywood, V.H., Harborne, J.B. & Turner, B.L. Vol. II. pp. 799-830. Academic Press, London.

Powell, A.M., Kyhos, D.W. & Raven, P.H. (1974). Chromosome numbers in Compositae. X. *Amer. Jour. Bot.* 61: 909-913.

Raven, P.H. (1975). The bases of Angiosperm phylogeny; Cytology *Annals Missouri Bot. Gard.* 62: 724-764.

Raven, P.H., Solbrig, O.T., Kyhos, D.W. & Snow, R. (1960). Chromosome numbers in Compositae. I. Astereae. *Amer. Jour. Bot.* 47: 124-132.

Razaq, Z.A., Khatoon, S. & Ali, S.I. (1988). A contribution to the chromosome numbers of Compositae from Pakistan. *Pak. Jour. Bot.* 20: 177-189.

Razaq, Z.A., Vahidy, A.A. & Ali, S.I. (1992). Chromosome numbers in Compositae from Pakistan. *Annals Missouri Bot. Gard.* (In Press).

Smith, E.B. (1975). The Chromosome numbers of North American *Coreopsis* with phyletic interpretations. *Bot. Gazette* 136: 78-86.

Solbrig, O.T. (1963). The tribes of Compositae in Southeastern United States. *Jour. Arnold Arboretum* 44: 436-461.

Solbrig, O.T. (1977). Chromosomal cytology and evolution in the family Compositae. In: *The Biology and Chemistry of Compositae* (Eds.) Heywood, V.H., Harborne, J.B. & Turner, B.L. Vol. I. pp. 267-281. Academic Press, London.

Solbrig, O.T., Kyhos, D.W., Powell, A.M. & Raven, P.H. (1972). Chromosome numbers in Compositae VIII. Heliantheae *Amer. Jour. Bot.* 59: 869-878.

Stewart, R.R. (1972). Annotated Catalogue of Vascular Plants of West Pakistan and Kashmir. In: *Flora of West Pakistan.* (Eds.) Nasir, E. & Ali, S.I. 72: 711-801.

Strother, J.L. (1977). Tageteae — systematic review. In: *The Biology and Chemistry of Compositae.* (Eds.) Heywood, V.H., Harborne, J.B. & Turner, B.L. Vol. II. pp. 766-784. Academic Press. London.

Stuessy, T.F. (1977). Heliantheae — systematic review. In: *The Biology and Chemistry of Compositae.* (Eds.) Heywood, V.H., J.B. Harborne & B.L. Turner. Vol. II. pp. 621-672. Academic Press, London.

Turner, B.L., Powell, M. & King, R.M. (1962). Chromosome numbers in the Compositae. VI. Additional Mexican and Guatemalan species. *Rhodora*. 64: 251-271.

Proceedings of the International Symposium on Plant Life of South Asia held at the Department of Botany, University of Karachi, Karachi-75270, Pakistan. 24-27 February, 1991

Plant Life of South Asia, 169–182, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

A CONTRIBUTION TO THE STUDY OF EPIDERMIS IN SOME MEMBERS OF THE FAMILY EUPHORBIACEAE

M. REHAN SIDDIQI, SHABBIR AHMAD AND ZIA-UL-REHMAN

Department of Botany,
F.C. College, Lahore, Pakistan.

ABSTRACT

A study of epidermis in 47 species belonging to 20 genera of the family Euphorbiaceae has been made to assess their diagnostic value in the internal classification of this family. Stomata are either hypostomatic or amphistomatic. Anomocytic, anisocytic, paracytic, tetracytic, brachyparacytic, hemiparacytic and cyclocytic types of stomata have been observed in various species. Stomatal frequencies and stomatal indices have been calculated. The trichomes'are unicellular or multicellular. They may be filiform, conical, stellate or peltate. Rarely more than one type of trichome may be present on the same leaf surface. On the basis of this study of epidermis it is not possible to separate the various genera, tribes and sub-families of the family Euphorbiaceae.

INTRODUCTION

During the past four decades a large number of plant anatomists have emphasized the importance of epidermal studies in solving taxonomic and phylogenetic problems. Stebbins & Khush (1961), Siddiqi & Wilson (1975) and Kaster & Bass (1981) attached considerable importance to stomatal type in taxonomic groupings. Other workers such as Pant & Kidwai (1964), Inamdar & Chohan (1969) do not contribute to this view. On account of the inconsistencies of the stomatal type in the higher or the lower categories, they deny any taxonomic significance to this character. Metcalfe (1954), Syeduddin (1956) and Webster (1967) have repeatedly emphasized the need of anatomical data for the classification of Euphorbiaceae in general and *Euphorbia* in particular. In the present report an attempt has been made to study the epidermis in 47 specimens belonging to 20 genera of the family Euphorbiaceae to see whether the epidermal characteristics can be used in the internal classification of the family.

MATERIALS AND METHODS

Table 1 gives a list of the specimens studied. Some of the specimens were collected by the authors from Lahore and Rawalpindi, others were taken from the herbarium sheets provided by the National Herbarium, Islamabad and the herbarium of the Botany Department, Karachi University, Karachi.

Epidermal peels of lower and upper surfaces of young and fresh leaves were obtained with the help of a razor blade. In some cases where peels could not be easily removed, the leaves were first boiled in water or were given chilling treatment which easily removed the peels.

The specimens taken from herbarium sheets were first restored. The leaves placed in a detergent solution overnight were washed in water and boiled in 10% acetic acid for 3-5 minutes. The restored leaves were then scrapped and the peels obtained from the lower and upper surface. All peels were stained with Delafield's hematoxylin and mounted in glycerine jelly.

Observations were made on the type of the wall of the epidermal cells and the type of stomata. The number of stomata per mm^2, length and breadth of guard cells and pore of the stomata were measured. Stomatal frequency and stomatal indices were calculated from the count of the stomata and epidermal cells in unit area. Five counts were made at random from the peels on both surfaces of different leaves or only abaxial surface of a hypostomatic leaf. At least five leaves of a species were examined. Trichome types of each species were also studied from the epidermal peels.

OBSERVATIONS

Various features of the epidermis in the species of Euphorbiaceae are shown in Table 1. Out of 47 species studied 24 species have stomata restricted to lower surface only (Fig. 3 A, B). In 23 species they are present on both the surfaces (Fig. 3 C, D). Among these in 6 species more stomata are peresent on the upper surface compared to the lower surface i.e., they are epiamphistomatic. In 17 species there are more stomata on the lower surface compared to the upper surface i.e., they are hypoamphistomatic.The cells of the upper and lower epidermis are similar in shape and type of cell wall. The shape of the epidermal cells may be polygonal, isodiametric or elongated. The walls of the epidermal cells may be straight, slightly undulated or undulated. In most of the species the walls are undulated. In some cases e.g., *Dalechampia scandens*, the upper surface has straight walls while the lower surface has undulated walls. In other cases e.g., *Chrozophora oblongifolia*, the upper surface has undulated walls while the lower surface has straight walls.

Table 1 shows the types of stomata in the species studied. Anomocytic (Fig. 1, A), anisocytic (Fig. 1 D), paracytic (Fig. 1 B), tetracytic (Fig. 2 B, D), cyclocytic (Fig. 1 C, 2 A), brachyparacytic (Fig. 2 C) and hemiparacytic (Fig. 2 E) types of stomata were observed in the various species. Inspite of stomatal diversity in these species the most common type of stomata is paracytic. However in various species of *Euphorbia* the most prevalent type of stomata is anomocytic. In many cases more than one type of stomata were found in the same genus or in the same species or even on the same surface as in *Andrachne telephioides*. The size of the guard cells and the length and breadth of the pore are some features which vary in the different species. The length of guard cells vary from 13.00

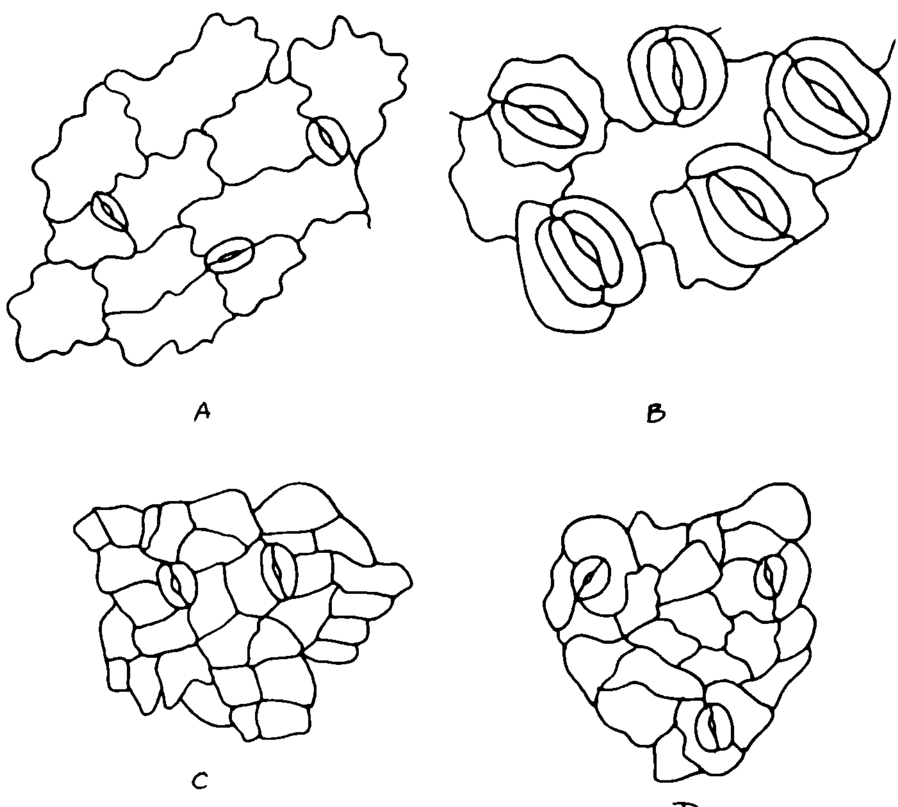


Fig. 1. Epidermal peels showing different types of stomata. A. *Euphorbia microphylla*: lower epidermis with undulated cell walls and anomocytic stomata. B. *Acalypha wilkesiana*: lower epidermis with paracytic stomata. C. *Euphorbia cognata*: lower epidermis with straight walls and cyclocytic stomata. D. *Andrachne telephioides*: lower epidermis with anisocytic stomata.

Table 1. The epidermal features of the various species of Euphorbiaceae.

Species	Leaf Surface	Cell Walls	Type of Stomata	Stomata/ Sq. mm	Size of Stomatal Pore L µm	Size of Stomatal Pore B µm	Size of Guard Cells L µm	Size of Guard Cells B µm	Stomatal Index	Trichome Type
Bridelia retusa	u	undulated	—	—	—	—	—	—	—	multicellular, uniseriate
	l	undulated	anisocytic	130	10.0	4.2	23.4	5.0	16.4	unicellular, uniseriate
B. verrucose	u	straight	paracytic	130	14.8	2.0	28.0	6.6	7.5	absent
	l	straight	paracytic	150	9.9	3.3	19.8	4.9	14.0	absent
Andrachne aspera	u	undulated	—	—	—	—	—	—	—	glandular, abundant
	l	undulated	paracytic	152	6.0	3.4	19.0	6.2	15.0	glandular, abundant
A. cordifolia	u	straight	—	—	—	—	—	—	—	absent
	l	slightly undulated	anisocytic	140	13.2	4.9	26.4	6.2	16.0	absent
A. telephioides	u	undulated	paracytic	135	8.2	4.9	23.1	8.2	14.0	absent
	l	undulated	anisocytic anomocytic	140	13.2	4.7	26.4	8.2	16.0	absent
Antidesma acidum	u	straight	—	—	—	—	—	—	—	absent
	l	straight	paracytic	259	14.8	3.3	29.7	4.9	25.0	unicellular with narrow canals
Flueggea verusa	u	undulated	—	—	—	—	—	—	—	absent
	l	undulated	paracytic	145	8.2	3.0	18.9	6.6	14.0	unicellular
F. microcarpa	u	undulated	—	—	—	—	—	—	—	unicellular
	l	undulated	paracytic	145	8.8	3.4	18.3	4.9	16.0	unicellular
Breynia niwosa	u	undulated	—	—	—	—	—	—	—	absent
	l	straight	paracytic anomocytic	79	18.5	5.2	26.2	8.7	7.7	absent

Glochidion velutinum	u	straight	—	—	—	—	—	—	—	absent
	l	slightly undulated	anomocytic paracytic	146	6.6	2.9	14.8	3.5	18.2	absent
Bischofia javanica	u	undulated	—	—	—	—	—	—	—	absent
	l	undulated	paracytic	340	17.5	5.5	24.5	7.0	25.0	absent
Chrozophora oblongifolia	u	undulated	paracytic	211	10.5	3.5	17.5	7.1	7.8	absent
	l	straight	paracytic tetracytic	684	7.0	3.5	15.7	5.2	23.0	peltate scales
Acalypha ciliata	u	undulated	—	—	—	—	—	—	—	absent
	l	undulated	paracytic anomocytic	237	19.2	5.2	35.0	10.5	29.0	multiseriate, uniseriate conical
A. hispida	u	undulated	—	—	—	—	—	—	—	multiseriate, uniserate conical
	l	undulated	paracytic anomocytic	263	17.0	5.5	30.5	8.0	30.3	multiseriate, uneseriate
A. wilkesiana	u	undulated	paracytic	53	22.7	5.2	38.5	8.7	6.9	multicellular, uniseriate, conical
	l	undulated	paracytic anomocytic	184	17.5	5.3	38.5	10.5	23.0	multiseriate, uniseriate conical
Dalechampia scandens	u	straight	—	—	—	—	—	—	—	unicellular
	l	undulated	paracytic	134	6.6	3.4	24.7	4.9	14.3	absent
Manihot esculenta	u	straight	—	—	—	—	—	—	—	absent
	l	straight	paracytic	316	11.5	2.6	24.5	6.1	11.0	unicellular
Jatropha integerrime	u	straight	—	—	—	—	—	—	—	absent
	l	straight	paracytic	237	19.2	7.0	35.0	14.0	22.5	absent

(Table 1. Cont'd.)

Species	Leaf Surface	Cell Walls	Type of Stomata	Stomata/ Sq. mm	Size of Stomatal Pore		Size of Guard Cells		Stomatal Index	Trichome Type
					L µm	B µm	L µm	B µm		
J. pandurifolia	u	straight	—	—	—	—	—	—	—	absent
	l	straight	paracytic	211	17.7	6.4	29.7	7.0	15.4	absent
Codiaeum variegatum	u	undulated	—	—	—	—	—	—	—	absent
	l	undulated	paracytic anomocytic	211	14.0	5.2	28.0	8.7	21.6	unicellular
Balispermum avillura	u	undulated	—	—	—	—	—	—	—	unicellular
	l	undulated	paracytic	145	9.9	3.4	19.8	8.2	15.2	unicellular
B. montanum	u	undulated	paracytic	173	16.5	3.5	26.4	6.6	25.0	unicellular
	l	undulated	paracytic	144	16.5	3.3	28.0	4.9	20.8	unicellular
Vernicia fordii	u	undulated	paracytic	170	16.5	3.6	26.4	6.6	19.0	unicellular
	l	undulated	paracytic	160	16.5	6.2	28.3	9.4	18.3	absent
Croton bonplandians	u	straight	paracytic	132	10.5	3.5	21.0	5.3	8.6	absent
	l	arched	paracytic brachyparacytic	421	8.7	3.5	22.7	5.2	21.9	peltate scales, stellate
Excoecaria cochinenchinis	u	undulated	—	—	—	—	—	—	—	absent
	l	undulated	paracytic himiparacytic	316	8.2	2.5	21.0	5.2	14.1	absent
Sapium sebiferum	u	straight	paracytic	53	17.5	5.5	28.9	7.0	5.3	absent
	l	straight	paracytic	237	13.1	4.6	26.2	6.1	19.5	absent
Euphorbia caeladenia	u	straight	paracytic anisocytic	145	16.5	4.9	26.4	4.9	18.5	absent
	l	straight	paracytic	145	9.9	3.3	26.4	8.2	17.2	absent
E. cornigera	u	undulated	—	—	—	—	—	—	—	absent
	l	undulated	anomocytic	145	16.5	3.5	33.0	9.9	14.7	absent

E. cotinifolia	u	undulated	—	—	—	—	—	—	—	absent
	l	undulated	anomocytic	289	8.7	2.6	19.2	5.2	16.1	absent
E. cyathophora	u	straight	paracytic	28	16.5	4.9	33.0	8.2	4.3	absent
	u	unduleted	anomocytic	145	13.2	6.6	19.8	8.2	19.2	unicellubar.
E. densa	u	straight	anomocytic	145	18.9	9.9	29.7	9.8	16.1	absent
	l	straight	anomocytic	116	17.1	6.6	26.4	7.2	14.3	absent
E. deracunculoides	u	straight	anomocytic	115	19.8	8.2	33.0	8.2	12.9	absent
	l	straight	anomocytic	145	16.5	6.6	26.4	9.9	19.2	absent
E. granulata	u	undulated	anomocytic paracytic	202	8.2	1.6	16.5	6.6	14.8	multicellular, uniseriate
	l	undulated	anomocytic	231	8.2	3.3	17.8	5.6	19.5	multicellular, uniseriate
E. helioscopia	u	undulated	anomocytic	105	8.7	3.5	21.0	7.0	15.3	unicellular
	l	undulated	anomocytic	107	10.5	5.5	28.0	8.7	11.0	absent
E. hirta	u	straight	anomocytic	84	11.5	4.2	18.1	7.2	9.3	multicellular, uniseriate
	l	undulated	anomocytic	86	7.3	2.9	18.9	5.6	9.4	multicellular, uniseriate
E. kanaorica	u	straight	tetracytic anisocytic	173	13.8	4.9	23.1	8.2	11.5	absent
	l	straight	paracytic tetracytic	107	13.2	6.6	21.4	8.2	10.5	absent
E. maddenii	u	straight	anomocytic	58	12.3	3.4	23.7	9.9	6.9	absent
	l	undulated	anomocytic anisocytic	145	13.2	3.6	23.1	8.9	15.1	absent
E. micractina	u	straight	anomocytic tetracytic	116	9.9	3.3	26.4	9.9	10.0	absent
	l	undulated	anomocytic tetracytic	202	19.9	3.3	24.0	8.2	16.2	absent
E. microphylla	u	straight	anomocytic	237	8.6	3.5	17.5	4.5	18.1	absent
	l	undulated	anomocytic	184	8.7	2.4	18.5	5.2	24.1	absent
E. prostrata	u	straight	anomocytic	553	7.0	1.7	15.7	5.2	21.4	absent
	l	undulated	anomocytic	237	8.7	2.7	15.7	3.5	16.0	absent

(Table 1. Cont'd.)

Species	Leaf Surface	Cell Walls	Type of Stomata	Stomata/ Sq. mm	Size of Stomatal Pore L µm	Size of Stomatal Pore B µm	Size of Guard Cells L µm	Size of Guard Cells B µm	Stomatal Index	Trichome Type
E. thomsoniana	u	straight	—	—	—	—	—	—	—	unicellular
	l	straight	anomocytic tetracytic	145	13.2	3.6	26.4	9.9	9.4	unicellular
E. thyrsoidea	u	undulated	—	—	—	—	—	—	—	absent
	l	undulated	anomocytic anisocytic	149	13.2	3.4	26.3	9.8	9.6	absent
E. tirucalli	u	straight	paracytic anomocytic	184	7.7	3.5	19.2	7.0	11.2	absent
	l	straight	paracytic anomocytic cyclocytic	289	12.2	3.5	24.5	7.7	18.9	absent
E. wallichii	u	straight	—	—	—	—	—	—	—	absent
	l	straight	anomocytic	202	13.2	3.3	29.7	13.2	18.4	absent
E. marginata	u	straight	anomocytic	145	19.8	6.6	13.0	9.9	19.2	absent
	l	straight	anomocytic	146	13.2	6.7	23.1	9.8	20.0	absent
E. cognata	u	straight	—	—	—	—	—	—	—	absent
	l	straight	anisocytic cyclocytic	173	16.5	6.5	29.7	9.9	16.2	absent
Padilanthus tithymaloides	u	straight	paracytic	126	13.5	5.5	17.5	7.0	2.25	absent
	l	straight	paracytic	132	13.6	5.7	18.2	7.5	10.45	unicellular, filiform

u = upper epidermis, l = lower epidermis, L = length, B = breadth µm to 38.50 µm and breadth from 3.50 µm to 14.00 µm. The length of the pore varies from 6.00 µm to 22.70 µm and breadth from 1.60 µm to 9.90 µm. The size of the guard cells is very large in *Acalypha* and *Jatropha*. Size of the guard cells varies in the lower and upper surface of the same leaf. The number of stomata per square mm varies from 53 to 684. The stomatal indices range from 2.25 to 30.?0.

One very important structural feature of epidermis is the presence of large varieties of trichomes. They have been used extensively in taxonomic comparisons. In Euphorbiaceae the trichomes are variable in density and form. They may be glandular or non-glandular. Glandular trichomes are found only in *Andrachne* (Fig. 4 B). In all other specimens the trichomes are non glandular. They

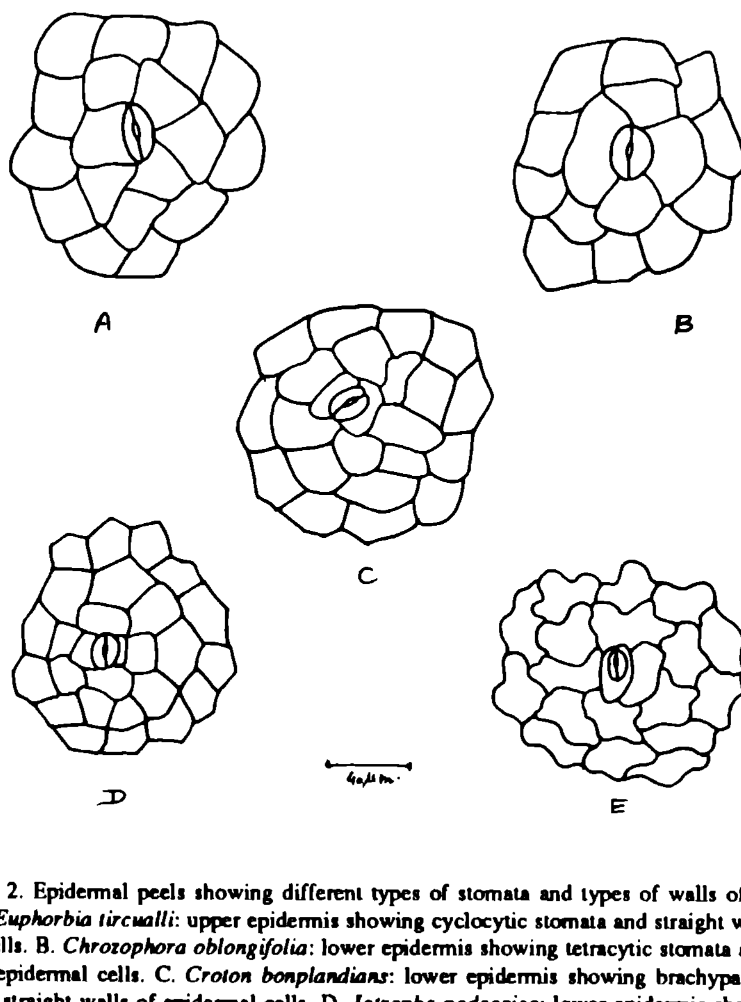


Fig. 2. Epidermal peels showing different types of stomata and types of walls of epidermal cells. A. *Euphorbia tircualli*: upper epidermis showing cyclocytic stomata and straight walls of epidermal cells. B. *Chrozophora oblongifolia*: lower epidermis showing tetracytic stomata and straight walls of epidermal cells. C. *Croton bonplandians*: lower epidermis showing brachyparacytic stomata and straight walls of epidermal cells. D. *Jatropha podagrica*: lower epidermis showing tetracytic stomata and undulated walls of epidermal cells. E. *Exoecaria cochinencpinis*: lower epidermis showing hemiparacytic stomata and undulated walls of epidermal cells.

may be unicellular, conical or filiform (Fig. 4 A), or they may be multicellular, uniseriate with pointed or curved apices (Fig. 4 C, D). Peltate scales were observed in *Chrozophora* (Fig. 4 F) and stellate trichomes were found in *Croton* (Fig. 4 E). In some cases trichomes are present on both the surfaces. Sometime they are present only on the lower epidermis or only on the upper epidermis. When they are present on both the surfaces the trichome type is the same as in *Bridelia retusa*. However the trichome on the two surfaces may be of different types. In many species trichomes are absent. Most of the species of *Euphorbia* are without trichomes.

DISCUSSION AND CONCLUSIONS

Metcalfe & Chalk (1950) have reported hypostomatic condition in most of the Euphorbiaceae. Amphistomatic condition has been reported only in few

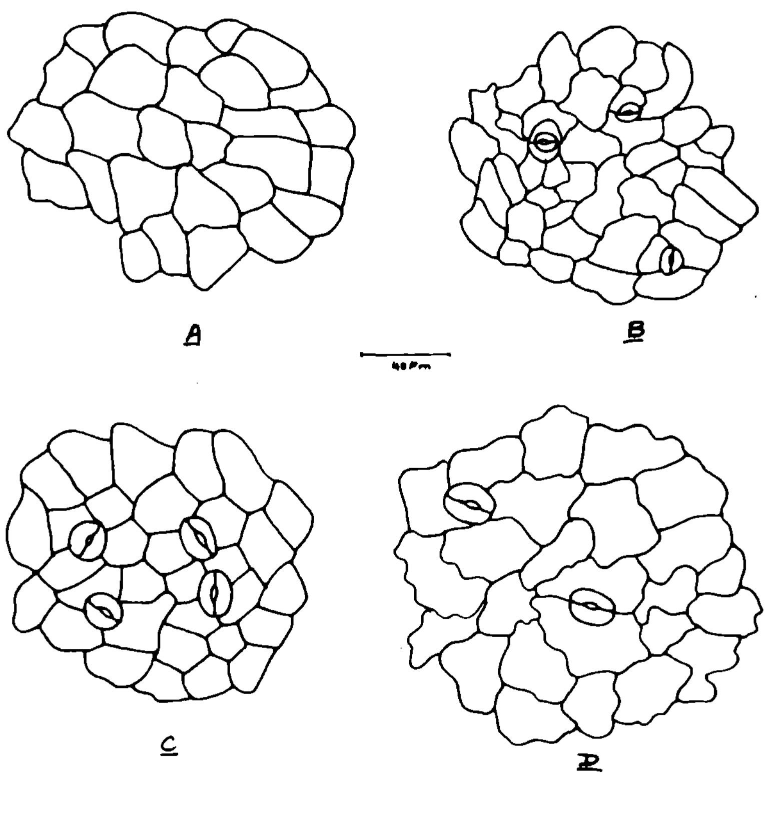


Fig. 3. Epidermal peels showing the distribution of stomataon the lower and upper surface. A. *Glochidion velutinum*: upper surface is astomatic. B. *Glochidion velutinum*: lower surface is stomatic and has anisocytic stomata. C. *Euphorbia kanarica*: upper epidermis with cyclocytic stomata. D. *Euphorbia kanarica*: lower epidermis with paracytic and tetracytic stomata.

cases. In the present study 23 out of 47 species have amphistomatic condition; 17 species being hypoamphistomatic while 6 are epiamphistomatic.

Most of the types of stomata found in dicots are also observed in the various species studied here (Table 1). Most common type of stomata is paracytic. Anomocytic type of stomata is found in most of the species of *Euphorbia*. In this regard the genus *Euphorbia* is different from other genera. Anisocytic, tetracytic, brchyparacytic, hemiparacytic and cyclocytic types of stomata are found only in few species. In *Euphorbia tirucalli* twin stomata and stomata with only one guard cell were also observed. Most anatomists have found stomatal index to be

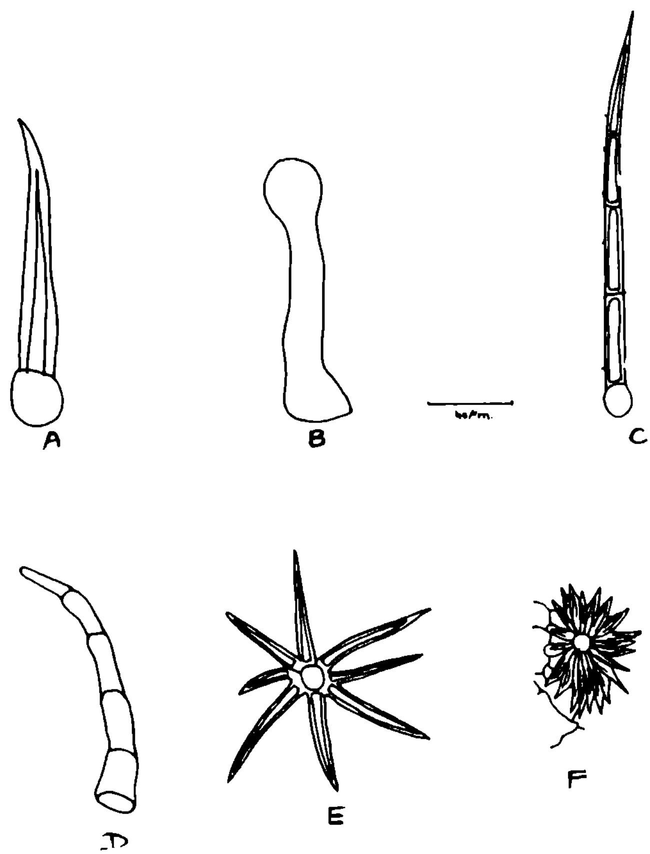


Fig. 4. Various types of trichomes in Euphorbiaceae. A. *Dalechampia scandens*: unicellular trichome with pointed apex found on upper surface. B. *Andrachne aspera*: lower epidermis with unicellular glandular trichome with broad foot and capitate tip. C. *Acalypha ciliata*: upper epidermis. Multicellular uniseriate trichome with pointed apex. D. *Bridelia retusa*: lower surface. Multicellular uniseriate trichome with slightly curved tip. E. *Croton bonplandians*: Lower surface. Stellate trichome. F. *Chrozophora oblongifolia*: Lower epidermis. Peltate scales.

Table 2. Types of stomata and types of trichomes in various sub-families and tribes of *Euphorbiaceae*.

Sub-family	Tribe	Stomatal Type	Trichome Type
Phyllanthoideae	Bridelieae	70% paracytic, 30% anisocytic	multicellular, uniseriate
	Poranthereae	60% anomocytic, 15% Paracytic	glandular, unicellular
		25% anisocytic	Unicellular with narrow canals
	Antidesmeae	paracytic	
	Phyllantheae	70% paracytic, 30% anisocytic	unicellular, uniseriate
	Bischofieae	paracytic	absent
Acalyphoideae	Chrozophoreae	80% paracytic, 20% tetracytic	peltate scales
	Acalypheae	64% paracytic, 34% anomocytic	multicellular, uniseriate
	Dalechampieae	paracytic	unicellular, uniseriate
Crotonoideae	Manihoteae	paracytic	unicellular, uniseriate
	Joannesieae	paracytic	absent
	Codiaeae	paracytic	absent
	Aleuritideae	paracytic	unicellular, uniseriate with acute tip
	Crotoneae	paracytic	stellate and peltate scales
Euphorbioideae	Hippomaneae	paracytic	absent
	Euphorbieae	80% anomocytic, 5% paracytic,	mostly absent, sometime unicelluar or
		5% tetracytic 5% anisocytic	multicellular uniseriate
		5% cyclocytic	

a reliable indicator of taxonomic affinity. In this study stomatal index does not show such significance. The value of stomatal index varies from genus to genus within the same tribe and from species to species within the same genus. Stomatal index therefore does not look like a reliable character.

Most of the species studied here have unicellular trichomes. Multicellular trichomes were found only in 6 species. Peltate scales were observed only in *Chrozophora oblongifolia* and in *Croton bonplandians* and stellate trichomes were found only in *Croton bonplandians*. Glandular trichomes were found only in *Andrachne aspera*. Inamdar & Gangadhara (1977) studied trichomes in some members of *Euphorbiaceae*. On the basis of their study they concluded that trichomes can be used in separating the various tribes of the family Euphorbiaceae. The present study does not agree with this conclusion. As is shown in Table 2 trichomes cannot be used to separate the various tribes.

Bentham & Hooker (1962) divided the family Euphorbiaceae into 6 tribes. Pax & Hoffmann (1931) divided the family into two groups, Platylobeae and Stenolobeae on the basis of the size of cotyledons. Platylobeae is divided into two subfamilies, Phyllanthoideae and Euphorboideae. Phyllanthoideae is further subdivided into two tribes and Euphorbiodeae is divided into 8 tribes. Webster (1975) on the basis of information available from palynology and other disciplines divided the family into five sub-families. These sub-families are further divided into 52 tribes. All these sub-families are represented in Pakistan except Oldfieldioideae. The genera studied here fall in 15 tribes in Webster's system (Table 2).

Table 2 shows the types of stomata and types of trichomes in Webster's sub-families and tribes. An effort was made to see if the various tribes and sub-families could be separated on the basis of stomata and trichome. As is clear from this Table it is not possible to use these characters in separation of these sub-families and tribes. Only tribe Euphorbieae differs from others in having mostly anomocytic stomata. From this study it can be concluded that Euphorbiaceae is a homogeneous family. The epidermal characters studied here are not useful in the internal calsssification of family Euphorbiaceae.

REFERENCES

Bentham, G. & Hooker, J.D. (1862). *Genera Plantarum*, 3: 588-600. London.

Inamdar, J.A. & Chohan, A.J. (1969). Epidermal structure and stomatal ontogeny in Malvaceae and Bombacaceae. *Ann. Bot.*, 33 : 55-66.

Inamdar, J.A. & Gangadhara, M. (1977). Studies on the trichomes of some

Euphorbiaceae. Feddes Report 88: 103-111.

Kaster, J. & Bass, P. (1981). Comparative leaf anatomy of the Asiatic Myristicaceae. *Blumea*, 27: 115-173.

Metcalfe, C.R. & Chalk, L. (1950). Anatomy of Dicotyledons. Oxford University Press, London.

Metcalfe, C.R. & Chalk, L. (1954). An anatomists view on angiosperm classification. *Kew Bull*, 9: 427-440.

Pant, D.D. & Kidwai, P. (1964). On the diversity in the development and organization of stomata. In *Phyla nodiflora* Mich. *Curr. Sci.*, 33: 653-654.

Pax, F. & Hoffmann, H. (1931). *Euphorbiceae*. In: Engler, A. & K. Prantl (Eds.) 1-251. Leipzig.

Syeduddin, M. (1956). Systematic Botany and its modern trends. Presidential address. 43rd. *Indian Science Cong*. Agra. Bot. Sec: 1-14.

Siddiqi, M.R. & Wilson, T.K. (1975). Leaf anatomy of the genus *Knemia*. *Biologia*, 21: 167-175.

Stebbins, G.W. & Khush, G.S. (1961). Variations in the organization of the stomatal complexes in the leaf epidermis of monocotyledons and its bearing on their phylogeny. *Amer. J. Bot.*, 48: 41-59.

Webster, G.L. (1967). The genera of Euphorbiaceae in the South Eastern United States. *J. Arnold Arb.*, 43: 303-430.

Webster, G.L. (1975). Conspectus of a new classification of Euphorbiaceae. *Taxon*, 24: 593-601.

VEGETATION

Plant Life of South Asia, 185–192, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

THE VEGETATION OF BANGLADESH

M. SALAR KHAN

Department of Botany,
University of Dhaka, Bangladesh.

ABSTRACT

Bangladesh represents two phytogeographic regions of the subcontinent, viz. the lower Gangetic plain, and the littoral forests of Sunderbans. The other special types of vegetation are the sal formation near Tangail, immense water bodies of Sylhet and north Mymensingh with abundant hydrophytes, and the sand-dunes of Cox's Bazar. Chittagong forests and the neighbourging hill-tracts, which are still under-explored, are represented by semi-evergreen type of vegetation dominanted by Dipterocarps and other lofty trees. This region is floristically related to Indo-China with a considerable admisture of Cachar and Khasia elements. There are eight angiospermic endemics so far known, and about twenty five species are placed tentatively on the threatened list.

INTRODUCTION

Bangladesh, lying roughly between 20°34' and 26°38' North, and 88° and 92°56' East with an area of about 142, 500 km² (55,020 sq. miles) has the highest density of any nation on earth other than small city states (Kurian, 1979). Excepting to the south where it faces the bay of Bengal, the country is bounded on all sides by the Indian territory but for the southern part of Chittagong Hill tracts (South of 22° North) and the Naf river (at the southern tip of Cox's Bazar district) where it borders on Burma (Fig. 1).

Physiography and geology:

The physiography, although generally described as a delta or a flat alluvial plain, presents, geologically speaking, a considerable regional variety, and can be divided into three broad categories namely the Tertiary Hill, the Pleistocene Uplands and the Recent Plains (Islam & Miah, 1981). The Tertiary Hills are situated in the Chittagong Hill-Tracts region with an average altitude of 304.8m (1000'), the highest peak being 1003.4m (3292') near the Bangladesh-Burma border. The Pleistocene Uplands comprise of Madhupur Tract which rises from

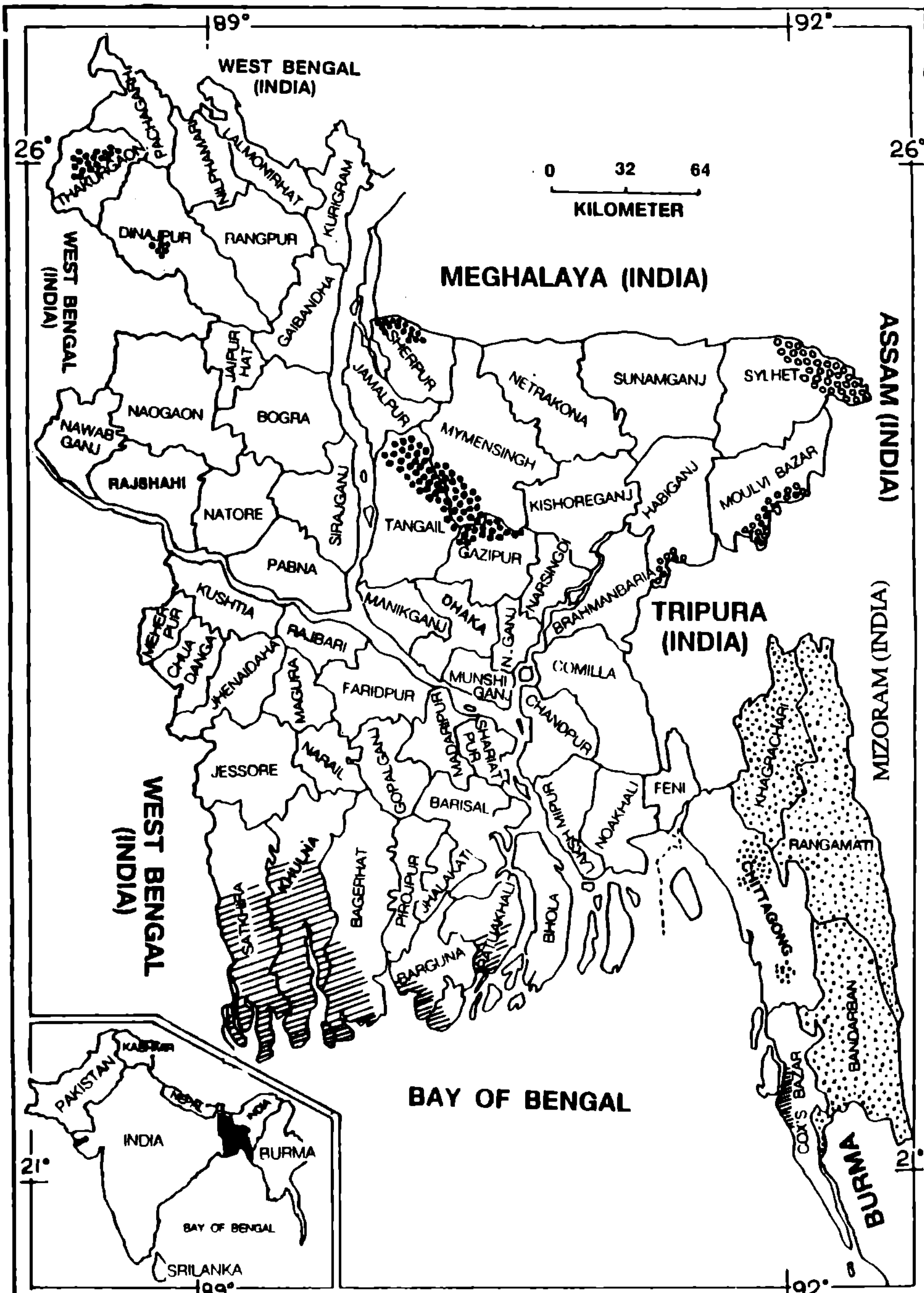


Fig. 1. District Map of Bangladesh

Littoral Forests.

Sylhet Forests.

Chittagong and Hill-Tracts Forests.

Sal Forests.

9m-18m above the flood plains lying all around. The rivers form a very significant feature of the landscape and belong to the three major river systems: the Padma (or Ganges), the Brahmaputra-Jamuna, and the Meghna.

Climate:

Bangladesh has a tropical monsoon climate with two distinct season, the cool and the warm. The average minimum temperatures at the coolest stations are about 10°C (50°F) and the summer maximum ranges from 32.2°C (90°F) to 35°C (95°F). The annual average rainfall varies from 1270-5080 mm (50-200"), winter being the drier season. The rainfall increases from west to east from about 1524 mm (60") in the west to nearly 4000 mm (157") in the east. Humidity during the monsoon remains more than 80%. The beginning of summer coincides with the period of thunderstorms which occur during late February and march, often with a wind velocity of 75 m.p.h or more causing extensive devastation. With the onset of monsoon, the south-western winds bring gales of great force accompanied by heavy downpour. The heavy monsoon rainfall coupled with location of the country at the lower most reaches of the three mighty rivers makes the floods during almost an annual phenomenon. The floods during 1988 had been the most devastating in the recent past.

The floristic areas:

The major part of Bangladesh falls under the flora province of the lower Gangetic plain as defined by Hooker (1906) and includes the greater Bengal, Orissa (north of Mahanadi), the Assam, Sylhet, Cachar, and Tippera plain. India Littorea, a phytogeographic subdivision suggested by Prain (1903) is most highly developed in the sunderbans area of the Gangetic delta. Sylhet hills and Chittagong are included, according to this classification, in the flora province of Burma. Among the vascular plants with an estimated total of 5000 species, there are about 27 species placed tentatively on the threatened list out of which 9 are endemic to Bangladesh.

THE SUNDARBANS OR THE LITTORAL FORESTS

Floristic studies of the Sunderbans started as early as 1796 when Roxburgh received collections from this region through his friends Carey and Buchanan-Hamilton (Prain 1903a). Subsequently Heinig provided more collections, and Clarke prepared an excellent account of the topography and vegetation in 1895. This compact forest tract forms a seward fringe of the Gangetic delta, the larger chunk of which falls under the southern portion of the Khulna district of Bangladesh, and the rest comprising a portion of the 24 Parganas district of the West Bengal (India). The Bangladesh Sunderbans comprises an area of about 3726 km^2 and is bounded on the east by the Balesar river and on the west by the river, Raimangal. Towards its north it merges gradually into the cultivated land which is fast encroaching into the forest. The forest is a vast deltaic swamp criss-crosssed by innumerable *khals* of varying width ranging from a few meters to 2 km or more, dividing the forest into numerous islands. Rivers in the central and eastern parts of the Sunderbans bring down enormous volumes of fresh water especially during the rains, and thus the *khals* in this area are less brackish than the western and southern ones. Together with the adjacent area in the state of West Bengal (India), Sunderbans are probably the largest single block of mangrove forests in the world.

The newly formed mud flats (*chars*) are first colonized by various grasses, especially *Oryza coarctata* and then by the stemless Nypa palms after which *Sonneratia apetala* makes its appearance followed by *Excoecaria agallocha* and finally *Heritiera fomes (sundri)* as the climax type. The species growing here have peculiar ecological features adapted to the clayey soil rhythmically flooded and drained daily due to tidal action. Some species like *Heritiera fomes* and those of *Avicennia* and *Sonneratia* amongst others produce a system of pneumatophores to facilitiate gaseous exchange, to trap silt during flood tide to reduce erosion, and to anchor the tree during storms. Other species like those of *Bruguiera* and *Rhizophora* have stilt roots.

The quality and density of forest is best in fresh water zones dominated by the *sundri* formation associated with *gewa* (*Excoecaria agallocha*) but thinner towards west and south due to greater salinity, and gradually replaced by *Ceriops decandra, Rhizophora* and *Avicennia*. Sundri stands have considerably degenerated due to top-dying, a malady which has not been successfully tackled so far, whereas the *gewa* trees are constantly felled to feed the only newsprint mills of Bangladesh at Khulna. These two predominant species are mixed with varying quantities of *Carapa, Bruguiera, Sonneratia, Avicennia, Ceriops, Cynometra ramiflora* and *Amoora cucullata*. The northern parts of the forest are greatly depleted due to human factor and replaced by *Pandanus* and tiger fern (*Acrostichum* spp.). In these areas, a woody creeper, *Hibiscus tiliaceous* forms thick entangled growth along the banks of the *Khals*. A prickly-leaved shrub, *Acanthus ilicifolius* and an interesting gregarious palm, *Phoenix paludosa* also grow along the banks.

The forest of sunderbans supplies timber, paper pulp, firewood, leaves of Nypa palm for thatching, and wild honey besides various minor products. The predominant wild life, being protected, includes the Royal Bengal tiger, spotted deer, crocodiles, and a variety of birds and snakes.

THE LOWER GANGETIC PLAIN

The plains are the predominant topography of the major part of the country and contrast with the upper Ganges valley in their greater humidity and more luxuriant vegetation. The vast stretch of flat land is built up by the enormous load of alluvial deposits laid down by the three mighty river systems with their numerous tributaries and distributaries. The plains, regarded as very fertile on account of rich alluvial soils, are given over to cultivation of rice and jute and remain mostly inundated during rains. There is abundance of the members of Araceae forming a conspicuous feature both in the wild and under cultivation. The fallow ground is studded with ponds, *beels, jheels* and *haors* of various sizes and description and often rich in aquatic vegetation, the common species being *Nymphaea nouchali, Nelumbo nucifera, Euryale ferox, Ottelia alimoides, Pistia stratiotes, Hydrilla verticillata,* species of *Ceratophyllum, Myriophyllum, Najas, Utricularia, Nymphoides, Trapa, Potamogeton, Aponogeton, Lemna, Sprirodela* and *Wolffia,* and the floating ferns, *Salvinia* and *Azolla.* These natural resources, especially in the larger water bodies of the northern and north eastern region of the country have hardly been given due attention for exploitation of their potentialities. These low lying areas were once dominated by *Barringtonia acutangula, Pongamia pinnata* and *Crataeva nurvala,* trees adapted to resist waterlogging, but these stands, at present, are in a very poor state resulting from fuel wood collection. The tropical American water weed, *Eichhornia crassipes* is very common in all water bodies and forms a distinctive feature of the landscape. The scenery is broken here and there by small villages (an estimated total number of 86,000 for the country) where the commonly planted trees are *Mangifera indica, Ficus bengalenis, Syzygium cumini, Zizyphus mauritiana,* and clumps of bamboos and bananas. The most characteristic feature of the landscape is undoubtedly the palm, the commonest species being the country date (*Phoenix sylvestris*), the betel-nut palm (*Areca catechu*), the coconut palm (*Cocos nucifera*) and the palmyra palm (*Borassus flabellifer*). On comparatively higher ground Jack fruit tree (*Artocarpus heterophyllus*) and the litchi (*Litchi chinensis*) are most frequent.

MADHUPUR TRACT OR SAL FORESTS

The once rich deciduous forest dominated by *Sal* (*Shorea roubsta*) is now represented by a secondary formation in the districts of Gazipur, Mymensingh, and Tangail. Another stand of *Sal* forest is found in Dinajpur district in the northern region and is evidently the remnant of the once dense forest continuous with submontane deciduous formation of the Himalayan region. The Madhupur Tract consists of several hundred separate blocks of trees interrupted by depressions cleared for cultivation of rice.

The main species of the forest is associated with the other deciduous trees like *Holarrhena antidysenterica*, *Cassia fistula*, *Careya arborea*, and species of *Terminalia*, *Albizia* and *Dillenia*. The undergrowth is rich in members of Zingiberaceae and Poaceae. The climbers are large and heavy, the common amongst which are *Spatholobus roxburghii*, *Bauhina vahlii*, species of *Dioscorea*, *Smilax* and various members of Vitaceae.

VEGETATION OF CHITTAGONG

The greater district of Chittagong is now divided into Chittagong and Cox's Bazar. The Chittagong forests are mostly hilly with a series of ridges and valleys in all directions. The rainfall is high with an annual average of 2710 mm. The outstanding feature of the forest are tall trees of *Dipterocarpus*, *Elaeocarpus*, *Albizia*, *Tertameles*, *Artocarpus*, etc. There is a narrow strip of cultivated land between the hills and the tidal forests that skirt the eastern bank of Naf river, and mostly dominated by *Avicennia*. The monsoon forests of this region belong strongly to the Malayan elements represented by Dipterocarps and bamboos that prevail along the coast range of Chittagong.

Chakaria Sunderbans:

The Chakaria Sunderbans, in the delta of Matamohuri river is situated in longitude 92° east and latitude 21°-41° north in the district of Cox's Bazar. This mangrove formation, lying about half way between the Sunderbans of the Gangetic delta and the littoral forests of Irrawady in Burma, is at present in a depleted state due to indiscriminate felling, and clearing for shrimp culture. This forest consists mainly of *Ceriops decandra* and *Avicennia officinalis* with an admixture of *Kandelia candel* and three species of *Bruguiera*. On muddy flats, which are mostly submerged, are found associations of *Aegialitis rotundifolia* and *Derris uliginosa* forming impenetrable thickets. On high land, the principal tree is *Heritiera* fomes along with *Excoecaria agallocha* and clumps of the gregarious *Phoenix paludosa*. The species most endangered in this area is the rare *Sonneratia griffithii* which is fast disappearing on account of fuelwood collection and agricultural expansion. *Dalbergia spinosa*, a thorny scrambler gives a characteristic feature throughout the area. Thick clumps of *Acanthus ilicifolius* are found commonly along the muddy intertidal zone. As the flow of sufficient freshwater is absent due to the smaller rivers, the water remains brackish all through the year resulting in the stunted trees. A notable feature of this formation is the paucity of species when compared to the Gangetic sunderbans.

Sand dune vegetation:

On the sandy beach stretching from Cox's Bazar to Teknaf, patches of *Casuarina* are met with, and the dune vegetation is dominated by *Ipomoea pes-caprae*. This typical vegetation along with dense growth of *Pandanus* is also found on the St. Martin's island which is the southern most part of the country in the Bay of Bengal.

CHITTAGONG HILL-TRACTS

These extensively hilly tracts are now distributed under the three districts of Banderban, Khagrachari, and Rangamati, and are bounded on the north by Tripura state of India, on the south by Akhyab region of Burma and on the east by the Lushi hills (India). The configuration of the ground is a system of low and elongated hill ranges running almost north-south with fairly broad valleys. The average rainfall is over 2286 mm (90") with the forest composition that can be classified broadly into (1) rainforests, (2) semideciduous forests, (3) bamboo brakes, and (4) grass lands. The more important component trees of the rain forest are *Swintonia floribunda*, *Artocarpus chaplasha*, *Bursera serrata*, *Toona ciliata*, and species of *Dipterocarpus*, *Syzygium* and *Quercus* the continuous canopy of these towering trees interlocking with each other casting deep shade on all other parts of the forest. The semideciduous forests are characterzed by *Duabanga grandiflora*, *Dillenia pentagyna*, *Gmelina arborea*, and species of *Terminalia*. The bamboo brakes occupy large areas, the common species being *Melocanna baccifera*, *Bambusa tulda*, and *Dendrocalamus longispathus* which are generally characterized by lack of undergrowth. The grass lands develop as a result of felling and clearing, and along the banks of the rivers and swamps, the more common species being *Imperata cylindrica* and *Saccharum spontaneum*. Many areas of the virgin forest are being systematically destroyed due to shifting cultivation or *Jhooming* by the tribals.

Floristically and geographically, the region of Chittagong and the Hill Tracts is more related to Indo-China and Arakan than to any part of the Indian subcontinent. The flora also shows a considerable admixture of Cachar and Khasia elements.

VEGETATION OF SYLHET AND ADJOINING REGIONS

The former Sylhet, now distributed under the four districts namely Habigunj, Moulvibazar, Sunamgunj and Sylhet, has a varied flora comprising of semideciduous forest, vast water bodies called *haors*, and extensive tea gardens. The rainfall is highest in the country with more than 5080 mm (200"). Rattans form impenetrable thorny thickets and there is a prevalence of eiphytes on the forest trees represented by orchids, ferns and mosses. The tea produced from 131 tea estates in Sylhet zone represents 93% of tea production of the country (Sana, 1989). The vast *haor* areas are partially dry during the winter when cultivation of rice is possible.

FLORA OF THE NORTHERN AND WESTERN DISTRICTS

The region is comparatively dry with an annual rainfall ranging from 1520 mm (60") to 182 mm (72") with *Acacia catechu* and *A. nilotica* thriving well. Deciduous forest predominates in the neighbourhood of Dinajpur district with *sal* forming the major crop. There are mango and litchi groves at Rajshahi, Dinajpur, and Kushtia yielding the best quality fruit in Bangladesh. Large areas are under sugar cane plantation, while tobacco and cotton are also grown as winter crops.

REFERENCES

Hooker, J.D. (1906). *A sketch of the Flora of British India*. Ed. 3. Imperial Gazetteer, Oxford, Indian reprint 1973. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Islam, M.A. & Miah, M.M. (eds.) (1981). Bangladesh in Maps, p. 9. University of Dhaka, Bangladesh.

Kurian, G.T. (1979). The *Book of World Rankings*. p. 2. MacMillan Press Ltd., London and Basingstoke.

Prain, D. (1903). *Bengal plants*, Vol. 1, p. 1. Reprint edition. 1963. Botanical Survey of India, Calcutta.

Prain, D. (1903a). *Flora of the Sundribuns*. Rec. Bot. Surv. Ind., 2: 231-370.

Sana, D.L. (1989). *Tea Science*. p. 8. Ashrafia Bio Ghar, Dhaka, Bangladesh.

MEDICINAL PLANTS

Plant Life of South Asia, 195–225, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

MEDICINAL PLANTS OF PAKISTAN

JAMES A. DUKE

Economic Botanist,
ARS, USDA, Beltsville, MD 20705, USA.

"The U.S. Department of Agriculture deserves credit for their wise choice of editors and for financing so much plant collecting and for the publishing of the flora. Too often, so called aid, given by my country to other nations, has been in the way of bombs and ammunition." (Stewart, 1982).

ABSTRACT

Cross referencing a catalogue of 250 promising phytomedicinal species of the world with an annotated catalogue of Pakistani plants shows that more than 40% of the species are common to both catalogues: Several other genera, e.g., *Adonis, Aesculus, Angelica, Astragalus, Borago, Colchicum, Commiphora, Corydalis, Crataegus, Cytisus, Daphne, Huperzia, Paeonia, Picrasma, Pimpinella, Pinus, Scutellaria, Senna, Sophora, Thymus, Trichosanthes, Urginea* and *Vinca*, are represented in Pakistan by other species. Possibly containing similar medicinal components, they could possibly be important in traditional medicine or for export. Data are presented to help interpret their potential for export.

INTRODUCTION

On a rainy day, one hundred years after the birth of R.R. Stewart, I first picked up my dusty copy of History and Exploration of Plants in Pakistan and Adjoning Areas (Stewart, 1982). I was hastily attempting to prepare for a trip to Karachi to commemorate the hundredth anniversary of Stewart's birth but also the 20th birthday of the Flora of Pakistan. Dr. S.I. Ali had invited me to speak at this occasion on Medicinal Plants of Pakistan. Thanks to the industry of the good Drs. Ali, Nasir, Stewart and their many coworkers, it is easy to write an armchair medicinal flora of Pakistan, just going through their scholarly floras and ticking off the species that have been reported to be major medicinal species. That's the beauty of the good flora such as the distinguished FLORA OF PAKISTAN (Nasir & Ali, 1970-1990); such floras constitute the foundation upon which specialist can construct the "applied floras", chemurgic plants, dye plants, economic plants, edible plants, endangered species, medicinal plants, poisonous plants, weeds. Sound "applied floristic" surveys must be preceeded by hardcore taxonomists, laboriously preparing the flora. Thanks again to all of you, those here today, as well as those gone yesterday, who have contributed to this magnificient building block, the Flora of Pakistan. You have made my job not only possible but easy. I will talk about medicinal plants that are or could be growing in Pakistan. But I will try to bring to this symposium my external thoughts about the more economically promising medicinal plants. I talk about Medicinal Plants of Pakistan from an American rather than a Pakistani perspective. For the Pakistani perspective, readers are referred to the execellent papers in the Special Number of *Pak. J. Sci & Ind. Res.*, 4(4): 1961 (Ahmad & Chughtai, 1961; Amin, 1961; Chaudhri, 1961; Siddiqui, 1961; Zaman, 1961). Chaudhri (1961) estimates more than 1,500 medicinal species in Pakistan, many of local importance in Ayurvedic and/or Unani traditions. I have a great respect for traditional medicine. Traditional medicine undergirds modern medicine just as basic "pure floras" undergird "medicinal floras". Soejarto & Farnsworth (1989) state that ca 75% of the "biologically active plant-derived compounds currently in use worldwide have been discovered through follow-up research to verify the authenticity of information concerning the folk or ethnomedical uses of the plants."

Today, jet-age medicinal plants, like many important food plants, are almost cosmopolitan. Most medicinal plants, grown in the Americas, including such imports as belladonna, digitalis, psyllium, senna, are or could be grown in Pakistan. In North America, with high hand-labor costs, we tend to import many economic plant products that we can grow and produce. I will first discuss native American medicinal plants like ipecac, jaborandi, and quinine, major medicinals native to South America, and cascara sagrada, coneflower and ginseng, native to North America. The ginseng, whose virtues may be a bit overrated, is the most lucrative among North America's export medicinals (nearly $50 million in one recent year). There is an increasing interest in America in all things natural, including natural medicines.

The most exciting phytomedicinal news to me is the Designer Food Program initiated by Drs. Ritva Butrum and Herb Pierson of the National Cancer Institute (NCI). Their program is devised to tailor food products to prevent cancer. Currently it looks as though the US Department of Agriculture (USDA) and I will become involved in this Designer Food Program. NCI and USDA are negotiating a five-year cooperative program, whereby the USDA will assist NCI in (1) picking the best varieties or chemovars of the best species to satisfy their needs, (2) cataloguing the phytochemicals in such varieties and species, even analysing for certain fatty acids, (3) insuring that their plants are taxonomically and nomenclaturally authenticated and (4) unveiling ethnic dietary eccentricities that might contribute to or deter dietary prevention of cancer. My part of the program will be the Designer Germplasm Program, locating the best germplasm of vouchered fruits, vegetables, cereals, herbs and spices for their Designer Food Program. Having spent about five years (1977-1982) with NCI's cancer screening program, I am pleased to rejoin NCI, this time searching for preventive rather than curative phytochemicals.

I would have termed such phytochemicals *natural products* until I read the following:

> "the most pragmatic definition of a natural product is a substance appearing to have no explicit role in the internal economy of the organism that produces it. Substances that apparently have no such role are known as secondary metabolites. Thus, we shall equate natural products with secondary metabolities." (Williams *et al.*, 1989)

This strange definition of natural products would exclude endogenous vitamins with known functions in the organisms producing them. Many of these are indeed important phytomedicinals. It will be difficult for me not to call them *natural products.*

THE QUEST FOR NUMBERS

Vital statistics on the economic value of phytochemicals are hard to find. Market data can also be misleading. Appended to this report is a tabulation of some natural-product imports to the US and their prices over a span of five years. The prices indicated in the appendix are f.o.b. New York. Such prices may run about 1/20th of catalogue prices for finished pharmaceuticals and botanicals. In this report, I use these inflated catalogue prices (Sigma, 1990), converted to $/kg, only to give an idea of the relative value of finished phytochemicals in small quantities at the retail level. One kilogram of some of these expensive phytochemicals might satiate the market. It is easy to find a price for a phytochemical but difficult or impossible to determine the size of US or world markets. Catalogue prices are clearly not great statistics, but they are a bit better than none.

Illustrating the difficulty of obtaining good numbers, I quote from a recent GATT study (Anon., 1982): "It is not possible to assess the volume or value of the trade in all botanicals that are used medicinally because trade statistics do not identify all the plants individually and of those listed, the statistics do not identify medicinal and other usage separately". I failed miserably in the good old USA when I tried to obtain import statistics on aloe, the alien, and native American jaborandi. After this experience, I view all statistics with some suspicion, and my audience should remember that. Some experts promulgate a fervent fallacy, echoing oft-quoted figures assigning billions of dollars to the value of rainforest medicinal plants. Finished medicines derived from crude medicinal plants may be worth billions of dollars, but the crude medicinal plants may be worth only millions, not billions. I accept the oft-quoted figure that 25% of medicines contain at least one ingredient derived from higher plants. I do not believe that 25% of modern medicines come from the rain forests, as many advocates claim. Soejarto & Farnsworth (1989) state that "23 of 121 drugs (20 per cent) that are currently used in the United States have been derived from plants originated from the tropics". As stated later, the US grows most of its tropical *Catharanthus* (drugs from which are worth an estimated $30 million per year) and is threatening to start growing its tropical *Ricinus* (worth an estimated $35-40 million per year). I do believe that most of the medicines of rain forest aborigines come from the rain forest. Perhaps more than 25% of modern medicines contain ingredients derived from higher plants, be it colchicine as a major ingredient or corn starch as an excipient. (Many Bristol-Myers Products in the 1989 Physicians Desk Reference {pp. 753-7, PDR, 1989}, contain carnauba wax, but as a minor rainforest ingredient, not as a major ingredient; many medicines contain or are contained in gelatin, at one time derived mostly from slaughter houses). Soejarto & Farnsworth (1989) state "Approximately one-fourth of all prescriptions dispensed from community pharmacies in the United States contain one or more ingredients derived from the higher plants {15}, which in 1980 was valued at $8.112 billion {16}".

If 25% of modern prescriptions contain one or more higher plant phytochemicals or derivatives thereof, we should not multiply the value of the world's finished pharmaceuticals, $100-150 billion, by 25% to estimate the value of crude botanicals. (In 1988, Sittig put the world pharmaceutical market at more than $100 billion! The Chemical Marketing Reporter, May 23, 1988, projected a 1992 value of $150 billion for the "world pharmaceutical market. . . for the top 17 countries"). Multiplying by 25% gives a value that may be two or more orders of magnitude high. The value of crude botanicals is probably closer to 0.0025 to 0.25% of the value of finished pharmaceuticals. My statistics are also suspect. Let that caveat presage my quotation of some GATT statistics (Anon., 1982).

"it would appear that the value of total imports of medicinal plants increased from $355 million in 1976 to $551 million in 1980" (speaking of the world) . . . "The value of the 28,326 tons of botanicals imported by the Federal Republic of Germany in 1979 was $56.8 million". . . . "The United States is a major importer of medicinal plants, although its imports declined from a value of $52 million in 1976 to $44.6 million in 1980; the overall United States internal trade in medicinals and botanicals reached $3,912 million in 1981". (As you will see below, GATT's Table 6 adds up to much more that $44.6 million, and I cannot rectify their figures without going to USDC statistics for which I have no greater respect). . . . "No botanical has shown dynamic growth in recent years, with the possible exception of ginseng, which is being promoted world wide by the health food industry". . . . "The United States is a major producer of medicinal plants and herbs; however, of those plants covered by this survey, only ginseng, and *Catharanthus roseus* are cultivated commercially".

GATT (Anon., 1982) summarizes US 1980 import data, which I round off below. Most, if not all of these American imports could conceivably be grown in Pakistan:

Licorice Root (ca $13 million, mostly from China). (But elsewhere we learn that 90% of licorice in the US goes to the tobacco industry, not the medicinal industry; while I personally think licorice should be investigated as an antitobacco {to help one quit smoking}, antiulcer, hepatoprotective drug, its opponents properly warn of its hypertensive and pseudoaldosteronic effects).

Licorice Extract (ca $5 million, mostly from Israel and Iran).

Aloes, Aconite, Mate (like coffee, more a beverage than a medicine), Ipecac, Digitalis, etc. (ca $2 million, mostly from the Netherlands).

Cinchona, its Alkaloids, Quinine, Quinidine and Salts (ca $34 million, mostly from Europe and Indonesia). (Note that none of this is imported from Andean America, center of origin of Cinchona).

Ginseng, Crude and Advanced (ca $6 million, mostly from Korea).

Psyllium seed and husks ($6 million, mostly from China, according to GATT; now, we get most from India, I am told; there is obviously something wrong with the psyllium column, total imports of $5,762,000 less than the China imports of $6,859,000).

Natural Crude Drugs (ca $10 million, from Canada, Chile, China, Germany, India, Jamaica, etc.).

In summary, according to GATT (Anon., 1982), US imports of "medicinal plants and derivatives" were $45 million *or* $76 million (if you accept my rounding of GATT's Table 6). If we subtract the 90% of the licorice value that goes to the tobacco industry (roughly $16 million), subtract the value of the derived quinidine and quinine and their salts, (ca $23 million), there's not much left for unadvanced natural products (like cinchona bark, ginseng and psyllium).

FUN WITH NUMBERS

Quinine and Quinidine:

As we approach the 500th anniversary of Columbus' arrival in America, it's interesting to see what has happened to Cinchona, source of quinine and quinidine. While the use of quinine as an antimalarial is on the wane (perhaps to be superceded by artemisinin or its derivatives), the use of quinidine as an anti-arrhythmic has been increasing. But the

> "markets for quinine and quinidine are softening due to competition from newer drugs. . . Quinidine demand has been eroding largely due to competition from newer anti-arrhythmnic drugs and beta-blockers. One market observer says there is a proliferation of new anti-arrhythmic drugs which are being recommended in place of quinidine, but adds that this does not always mean they are replacing quinidine as doctors will often return to prescribing it if the newer treatments are not successful. . . Quinine hydrochloride, for which the major end use is tonic waters, is reported to be a very stable market. . . Ciba-Geigy Pharmaceuticals, which. . . markets "Q-Vel". . . concludes that at doses of 250 mg its drug is effective in preventing night leg cramps (Chemical Marketing Reporter; p. 16. Feb. 5, 1990).

World production of Cinchona bark seems to fluctuate between 5,000 and 10,000 tons per year, based on estimated annual consumption of 300-500 tons of Cinchona alkaloids. Far from the Andes, Indonesia and Zaire were the principal producing countries in 1980 (Anon., 1982). The GATT study notes that crude bark was available in France at FF 10/kg in 1982. In the same period quinine salts in the US were $2.35-3.60/oz. The US imported 2.4 million ounces worth $5.7 million dollars, none of it apparently coming from its native Andean countries, most coming from Germany, Indonesia and the Netherlands. Today Sigma (1990) lists free base quinine at $122.70/100 g (translating to over a thousand dollars a kilogram).

Some cinchona bark may have been shipped from Andean countries for European extraction and re-export to the United States. Not all this quinine goes into medicine. Doraswamy & Venkatratnam (1982) note that substantial quantities of quinine salts are used in tonic drinks, gins, vermouths, "Coco-Cola" (sic), Russsia's "Pivo", and in hair oils, sunburn lotions, moth repellents, insecticides, vulcanization accelerators in the rubber industry, polarizing lenses, and even in pickling agents. India is producing Cinchona, which might be tried around Abbottabad and Lahore, Pakistan.

Cocaine:

Having mentioned coca cola, I should mention another Andean medicinal plant, the coca, *Erythroxylum* spp. Its major alkaloid, cocaine, is compounding our illicit drug problem in the US. The coca plant, I am told, contains fewer alkaloids than the quinine plant, also discovered by the Inca. But according to Andy Weil (personal comm., 1989), many of these coca alkaloids may share the anorectic properties of cocaine. I even hear rumors that one southern University may be seeking patent on one of them, as a weight-control anorectic agent. My dad used to talk about going to the drug store for "dope" (his word for a "coke"). Early vintage coca cola did contain cocaine, but now, the cocaine is removed, with decocainized leaves still imported to Rahway, New Jersey, to contribute thair flavour to the battles of the colas. *Erythroxylum* was also exported to Indonesia and has been grown there, but not with the success we have witnessed for quinine and rubber. Though cocaine still has legitimate pharmaceutical usages, it is a major component of the illicit drug industry, most of the profits going to organized crime. In 1988, I was told that the street value of illicit drugs in the US was $150 billion, more than Sittig's estimate of the world market for legitimate pharmaceuticals. Sigma (1990) lists free-base cocaine and crystalline cocaine-hydrochloride among their controlled substances at $76.50/10 g and $143.60/10 g which translate to ca $7,650 and $14,300/kg respectively.

Assuming yields of 5 tons coca leaf/ha and complete extraction of 0.5% cocaine, that's an incredible 25 kg cocaine/ha. At the legal Sigma price, that is more than $350,000 for the 25 kg of cocaine that a one-hectare coca plantation could conceivably produce. Let's go further with this fun with numbers game. The street value of cocaine figured at $10,00-35,000/kg in July, 1989, and is now figured at around $20,000/kg in Miami, I'm told by Drug Enforcement

Agency (DEA) officials. This suggests a street value of at least a half million for the cocaine production of one hectare of good coca.

Chlorophyll:

Many of us have experienced chicle and chlorophyll, as chlorophyll gum. Chlorophyll numbers are even more intriguing than the cocaine numbers. The Sigma 1990 catalog lists chlorophyll a (from Anacystis) at $208.30/10 mg, and chlorophyll b (from spinach) at $205.55 which translate to roughly $20,000 each per gram, or $20 million/kg. Assuming that tropical Extractive Reserves leaf yields are 5 MT DM/ha/yr (5 metric tons dry matter per hectare per year), and assuming only 0.1% chlorophyll in these leaves, we have 5 kg chlorophyll, worth a cool $100 million. If you want to put a high value on the tropical forest, you can multiply the number of hectares of tropical forest by that $100 million and you'll come up with a surprisingly high figure, the estimated value of the chlorophyll in the tropical forest, assuming it all could be sold at the Sigma price. But after all, chlorophyll is more than just a ferrugineous, antioxidant breath-freshener, it indirectly feeds us all and keeps us in oxygen, tying up a lot of greenhouse CO_2 in the process.

Ipecac:

Ipecac is another medicinal plant that comes to mind when you think of Latin America. When my secretary's grandson got into seeds of an African medicinal plant, ***Ricinus communis***, she got out the ipecac, still the emetic of choice in poison emergencies. Native to Central and South America, the ipecac is also grown commercially in India, as a source of emetine, for internal consumption and export. Crystalline emetine dihydrochloride lists at $26/g which translates to $26,000/kg. Recent imports of ipecac into the US have come from Brazil. Ipecac is not often cited as a component of the Extractive Reserve. Advocates of the Extractive Reserve claim that over a decade, a hectare of Brazilian rain forest yields better economic returns, sustainably, from brazilnut and rubber, renewably, than cleared rainforest temporarily yields in soybeans or cattle. Although emetine has been synthesized, it could be another renewable shadegrown product from the Extractive Reserve. At one time, Brazil was exporting more than 80 tons annually, and India was producing 20-30 tons. If you accept the GATT (Anon., 1982) figure of $40/1b and figure world production at 100 tons, that indicates a value of $8 million for crude ipecac, potentially available from Extractive Reserves.

Pilocarpine:

Jaborandi (*Pilocarpus* spp.) is still confined to Latin America, the derivative alkaloid, pilocarpine, being produced, almost monopolistically, by an international pharmaceutical concern in Brazil. When I visited jaborandi country in 1986, that concern was apparently buying leaves from middle men at $300-500 per ton. From a ton of leaf they could reasonably expect to get 4-10 kilos of pilocarpine, then worth $1,500-2,000/kg in the US. The Sigma catalogue lists crystalline pilocarpine-hydrochloride at $12.70/kg). The commercial price had gone up tenfold in a decade, even though pilocarpine was falling out of favorn as a drug of choice for glaucoma (with other natural products like physostigmine and now, perhaps, tetrahydrocannabinol being used for glaucoma). Pilocarpine's value was surging as North Americans were proving an Amerindian belief cradled in the Tupi word "*jaborandi* ", which means "that which makes you salivate". Fox *et al.*, (1986) showed that xerostomic patients salivated ten times more when given 5 mg pilocarpine a day for 4 days. In trying to learn how much pilocarpus or pilocarpine was imported to the US, I contacted all US importers of record. The few who responded indicated that such data were proprietary. One worded his answer such that I was left with the impression that the US imported 7-8 tons a year out of a world import of 11-13 tons, wih an intentional ambiguity; it was not clear whether he meant leaves or pilocarpine, giving me a possible latitude of 2 orders of magnitude. If forced to guess, I would guess that the US now imports 10 tons pilocarpine out of ca 15 tons exported from Brazil. Pilocarpine occurs in several Latin American species of *Pilocarpus*, some xerophytic, some mesophytic, including some that could occur or be interplanted in Extractive Reserves. Like most plants above, *Pilocarpus* could only be grown in frost-free regions of Pakistan, e.g., in Sindh, Southern Punjab and coastal Balochistan.

Curare:

Extractive Reserves are playing or could play host to some of the sources of the Amerindian curares, used by the Indians to poison their darts and paralyze or kill their prey. From such plants as *Chondrodendron tomentosum* we now get such drugs as tubocurarine, used as a myorelaxant in delicate operations. About 50 years after the discovery of the New World, Francisco de Orellana is said to have lost a companion to a curate-tipped arrow. About 100 years after discovery (1595) Sir Walter Raleigh took a sample back to England. Five hundred years after discovery it will probably still be used as an anticonvulsant (against strychnine or tetanus) and as a myorelaxant (e.g., in setting broken bones, for victims of cerebral palsy and polio, in abdominal surgery, for prevention of injury in epileptic seizures, and as a diagnostic agent in myasthenia gravis). Sigma (Anon., 1990) lists crystalline tubocurarine-chlorine at $63.80/g translating to ca $60,000/kg. Perhaps compounds similar to tubocurarine exist in Pakistani representatives of Menispermaceae.

Steroids:

The first American Revolution was partially triggered by the stimulant tea (*Camellia sinensis*), an important source of theophylline which, like caffeine and theobromine, still has many viable medicinal applications. I don't see tea in Stewart's Catalogue (1972) but feel sure that it could be grown locally. I attribute the second American Revolution, the Sexual Revolution, to the wild yam, *Dioscorea* spp. Wild yams finally yielded a practical source of steroids, leading ultimately to the development of inexpensive female contraceptives. There are many plants, including *Dioscorea*, in Pakistan which could also serve as starter materials for the modern steroid industry. As the Sexual Revolution progressed in the US, Mexico raised the price of its barbasco (*Dioscorea composita*) so often that drug manufacturers sought other starting materials, the Chinese soybean replacing the barbasco.

Now most of our steroids derive as byproducts of the soybean processing industry. The female contraceptive industry is still megabucks. Sigma (Anon., 1990) still lists diosgenin at $112.35/100 g, or $1,124/kg. Beta-sitosterol (ca 60% purity, with campesterol and dihydrobrassicasterol as impurities) commands only $56,55/500 g or ca $113/kg, but pure soybean sitosterol (minimum purity 97%) runs $109.45/10 mg which translates to roughly $10,000/g or $10 million/kg. Synthetic sitosterol (ca 95% pure) lists at $171.30/100 mg or ca $1,700/g or $1.7 million/kg. Unlike cocaine, sitosterol, like chlorophyll, seems to be ubiquitous in the higher plants.

Gossypol:

Buying North American, I'd perfer Apios "potato" chips cooked in Oenothera oil to *Solanum* cooked in *Gossypium* oil. The FDA only tolerates the aliens. (Seed oils of Actinidia, Borago, Oenothera and Ribes are battling for a GLA-market, not encouraged by the FDA). Cottonseed, if not cottonseed oil, could be contaminated with gossypol, an experimental contraceptive. Blacks quickly learned about *Gossypium* after their arrival in the southern US. They told us over a century ago that cottonseeds and roots could be both contraceptive and abortifacient. They were right on both counts. Pigs rooting through an old cotton field are subject to abort if they eat the cotton roots. Chinese have devoloped a reversible male contraceptive for humans from gossypol. I have not observed any

American males beating paths to Chinese doors, seeking this male contraceptive. In an intelligent Amazonian society, females might demand it. I predict no megabucks in the US for gossypol, unless scientists can induce feral male animals in excess to ingest enough to reduce feral populations. A byproduct of cottonseed processing, crystalline gossypol is listed by Sigma (Anon., 1990) at $131.60/500 mg which translates to ca $260/g or $260.000/kg. Cotton is of course a viable crop in Pakistan.

Licorice:

There are cosmopolitan genera like *Glycyrrhiza* with bioactive species used almost interchangeably. Chinese licorice root, followed by Turkish, then Pakistani licorice, is usually what we use instead of American licorice. Sometimes politics dictates where we get out licorice. Iran was once a major source. In 1980, we imported 21,665 tons from China, 871 tons from Turkey, 189 tons from Pakistan, 57 tons from elsewhere. Probably no more than 500 tons a year goes into American medicine (Anon., 1982). But in 1981, we imported none from Pakistan and 4,590 tons from Afghanistan. Prices for whole root ranged from $0.40-0.50/1b in 1981, probably making it cheaper to import than to grow and process. Its use in American medicinal and sweetening markets are probably on the wane. Growth of the largest consumer, the tobacco industry, may be slowing down. Ironically, some people chew on licorice sticks to help them curb smoking.

I know of no herb where the schism between herbalists and pharmacognoscists grows greater than in the controversy over licorice. Conservative Varro Tyler (1987) notes that herbal remedies may dose one with 500-1,500 mg/day glycyrrhizin, one active principle, enough to cause toxic effects in one week. "For persons suffering from high blood pressure or heart trouble, these could be serious" (Tyler, 1987). Dan Mowrey (1988) praises the herb for treating Addison's disease, arthritis, and hypoglycemia. He adds that "no other herb has been as thoroughly and unjustly maligned". He quips that the Chinese call it not a toxin but "the great detoxifier." Takagi (1989) notes that it is the most frequent herb found in the therapy called "Kanpo" (Japanese-Chinese herbal medicine). As I write this, I am sucking on a Chinese licorice stick, letting the juice trickle down my throat, checking out its expectorant activity. I've been coughing like a smoker's hack over a week now, somewhat alleviated by dittany, horsebalm and mullein, but that concoction has run out and my cough has not. Licorice' antitussive and expectorant activity has been proven. Leung (1980) suggests it is comparable to codeine as an antitussive, due to a derivative of 18-beta-glycyrrhetinic-acid. Even Tyler (1987) rates it as appararently efficacious in normal individuals as a demulcent and expectorant (p. 251). At 10 times the strength, glycyrrhizin has antiinflammatory activity comparable to cortizol. Just looking at the references I cite suggests that licorice or its important compounds can be of use in Addison's disease, allergy, arthritis, asthma, cancer, caries, convulsions, cough, diabetes, dermatitis, hepatitis, hypotension, inflammation, malaria, and ulcers. Like all good effective medicines, it is not for everyone, and can be toxic, if used inappropriately. I think the US should conduct an unbiassed heads-on comparison of the best non-herbal antiulcer drugs, something like Cytotec or Tagamet, with the best herbals, perhaps plantain and licorice, with controls (not only for safety and efficacy, but adding costs to the risk: benefit equation). I don't know whether Cytotec and/or Tagamet are safer and/or more effective than licorice and don't know anyone who does know. It would be nice to know. Sigma (Anon., 1990) lists 18-alpha-glycyrrhetinic acid at $50.65/10 g, 18-beta-glycyrrhetinic acid at $262.35/100 g and glycyrrhizin at $63.65/100 g which translate to ca $5,000, 2,500 and 600 a kilo respectively. Stewart (1972) reports three Glycyrrhiza species in Pakistan, including *Glycyrrhiza glabra.*

Ginger vs Scopolamine:

Another interesting battle is developing between advocates of two more plant-derived drugs, with jimson weed in one corner (Wood *et al.*, 1989), ginger in the other (Mowrey, 1986). Concluding that about one gram of ginger root was more effective against nausea than the usual dose of dramamine, Mowrey says:

> "The herb worked for over 90% of the people who tried it, if they used it correctly. . . After performing toxicity tests in scores of rats and mice, I did not observe even slight toxic symptoms at doses 10 times those that a human would normally ingest. . . To my knowledge, no other study exists that shows toxicity".

More recent studies suggest ginger may be useful for peptic ulcers and burns. Comparing scopolamine, derivative of jimsonweed, with dramamine and ginger, Wood *et al.*, (1989) conclude differently: "Ginger is ineffective when used as an antimotion sickness medication. . . The antimotion sickness drug of choice is scopolamine 0.6 mg with d-amphetamine 10 mg". Herbalists will tend to believe Mowrey while doctors and pharmacists will tend to believe Wood *et al.*, (1989) and you and I may never know. Clearly scopolamine (and probably amphetamine) can have serious side effects. A gram of ginger costs almost a penny in Washington, DC, a bit less as a rootcrop in Pakistan. A kilogram of jimsonweed leaves costs $0.40-0.45. The Sigma catalogue (Anon., 1990) lists scopolamine hydrochloride at $11.10/ g, about a penny a *milli*gram. In transdermal patches that deliver 500 micrograms over three days, you pay about a penny a *micro*gram for your scopolamine. Scopolamine can be derived from many solanaceous genera, including Pakistani species of *Datura*. A kilo of stramonium leaves selling for 45c (ca 20 cents/1b) can yield scopolamine worth $25,000 at the pharmaceutical level. Tropical leaf crops, even tea, can easily attain yields of 5 tons/ha annually. Five tons of datura leaf (stramonium) is worth $225 FOB New York. Five tons of stramonium leaves could yield scopolamine worth more than a billion dollars, if the market could handle it all. That's quite a markup. We would be more accurate in estimating $225 for the value of the raw product in the Extractive Reserve, not the hypothetical $1.25 billion value for pharmaceutical grade scopolamine in transdermal packages. Ginger is cultivated in the Sind and Punjab (Stewart, 1972).

Psyllium:

A quiet battle now, that may rage soon, might be termed the Battle of Battle Creek, involving one of our OTC (over-the counter) laxatives, psyllium, *Plantago ovata*. At least two major companies want the FDA to declare this pseudocereal a food, so they can add it to their cereals. Two other major companies, however, want the FDA to declare it a non-food so that they can continue their OTC sales. Due to its 10-30% mucilage, mostly in the husks, psyllium is both laxative, hypocholesterolemic and hypotensive. According to GATT (Anon., 1982), it is also used for its demulcent and emollient properties to help produce smooth, solid faecal mass after a colostomy and to treat irritation of the colon due to amoebic and bacillary dysentery and diarrhoea. It's even said, with good reason, that if the bowels are loose, psyllium will tighten, if they are tight, psyllium will loosen. Psyllium's historical use as a bonafide medicine is clear; historical use as a food is equivocal, especially here in the US. If it is approved for food use, American consumption could double. In 1982, World Consumption was put at 15,000 tons/a with an annual growth of 3%. India produced 13,000 tons seed a year and 3,200 tons husks, 90% exported. Pakistan has psyllium and could be a major producer, if she could intercept a market. Seeds were worth ca $3.30-5.50 and husks $2.20/kg FOB New York in early 1990 (CMR, Jan 29, 1990).

Guar:

Guar gum from *Cyamopsis tetragonoloba* is finding its way into the health food markets of the US as an important soluble fiber. It has long been used as a thickener in such diverse items as icecream and oil-drilling muds. Stewart reports guar from Attock Dt., Fatehjang, Jhelum, and Sind, noting that it is often cultivated in Pakistan. Guar prices in the US, heretofore, have been more closely attuned to the oil-drilling industry in the US. The Health Food industry may change that, especially if the fiber and Bowman-Birk inhibitor ratios prove to have cancer-preventive promise. Guar now runs ca $1.00-1.30/kg (fob, New York). Sigma lists it at $13.60/kg. But the Bowman-Birk Inhibitor (from soy, not guar) lists at $267.60/500 mg, which translates to $535,200/kg.

Other Gums:

My PL-480 colleague Dr. Mushtaq Ahmad at Lahore is studying other economically important gums in various of the more than 30 species of *Acacia* growing now in Pakistan. For *Acacia nilotica*, Ahmad reports 1.5-3.0 ppm cadmium, 2.8-17.4 ppm copper, 20.7-933.0 ppm manganese and 2.77-3.8 ppm zinc in the gum, which resembles gum arabic, now listed by Sigma at $23.70/kg. F.O.B. New York, gum arabic is closer to $3.30-5.70. Gum arabic, *Acacia senegal* is native to Balochistan and Sind in Pakistan (Ali, 1973). Among other gums that could be cultivated in Pakistan are carob (*Ceratonia*), listed by Sigma at $14.90/kg; guaiac (*Guaiacum*), listed at $168.00/kg; karaya (*Sterculia*), listed at $11.40/kg, and tragacanth (*Astragalus*), listed at $72.80/kg.

Immunoregulators:

Among the world's most touted immunoregulating plants, China's *Astragalus membranaceus* and America's *Echinacea* seem to be attracting most attention. Of *Astragalus*, Weiner (1989) says: "Prior to the discovery that this species enhances natural killer cell activity, it was employed to control diabetes, lower blood pressure, treat coronary heart disease, cirrhosis, anemia, uterine hemorrhage and glaucoma. Most recently *Astragalus* has been shown to induce interferon production, kill viruses, and destroy cancer cells". The immunostimulant activity is attributed to polysaccharides in both *Astragalus* and *Echinacea*. Recent studies suggest 10 mg/kg coneflower polysaccharide daily for 10 days is effectively immunostimulant, larger doses being counterproductive (Kindscher, 1989). With nearly 100 species of *Astragalus* in Pakistan (Ali, 1977), there could be some immunoregulatory activity.

GLA vs ALA:

The subtle battle continues between the purveyors of seed oils of America's evening primrose (*Oenothera biennis*), and currant (*Ribes* spp.), and the european borage (*Borago officinalis*), all competing for gamma-linolenic-acid (GLA) sales in the health food market. The FDA has challenged health food claims for GLA and confiscated several lots of evening-primrose seed or seed oil. Seeds of *Oenothera* were however eaten by Amerindians (Yanovsky, 1936), a claim that can't be made by advocates of psyllium as food. Further complicating the GLA war are claims being made by advocates of ALA, from flaxseed, perilla and other sources, and claims of EPA in the herb purslane, all competing with fishoil. USDA studies suggest that soybean oil, once ingested by humans, gets shuttled into the same cascade as the fishoils, and the soybean oil is cheaper and less smelly. All these genera are represented in Pakistan (Stewart, 1972). Sigma lists evening primrose oil at $108.10/25 g, translating to $4,324/kg.

Sanguinarine:

In 1989, some television ads featured *Sanguinaria* root on TV in the US. There may soon be a court battle over the use of the antiplaque alkaloid, sanguinarine, in toothpaste. So far, the bloodroot, *Sanguinaria*, and the plume poppy, *Macleaya*, are the only frequently mentioned sources of sanguinarine. There is a weedy shrub or small tree, *Bocconia*, in higher areas of some potential Extractive Reserves that might produce sanguinarine even more copiously. Sanguinarine also occurs in other members of the poppy family that grow in Pakistan. I would not bank on its continued use in toothpaste in the US however. The 1990 Sigma Catalogue lists sanguinarine chloride at $62.60/25 mg, translating to ca $2,500,00/kg.

Artemisinin:

Artemisia annua is a eurasian weed, locally quite abundant in North America. It has been a weed on my farm since I collected 100 pounds for Walter Reed Army Research where Dr. Dan Klayman is studying the antimalarial properties of the endoperoxide artemisinin and some of its derivatives. According to Liu (1989), the herb was first reported for malaria cerca 300 AD but the antimalarial compound was not isolated until 1972. Liu reports therapeutic indices suggesting the compounds are 5-50 times more effective than chloroquin, while less toxic, in the treatment of chloroquin-resistant malaria. I am trying to stimulate the study of endoperoxides such as occur in *Artemisia annua* and *Chenopodium ambrosioides* as food additives to reduce methane-laden eructations of ruminants, or as landfill weeds, to lessen methane generation, possibly alleviating the greenhouse effect. The active compounds from *Artemisia annua* are showing toxicity to several organisms, from weeds to microbes opportunistic in AIDS. *Artemisia annua* is reported to range from Peshawar to Waziristan in Pakistan (Stewart, 1972).

Capsaicin:

Like ginger, garlic, and onion, widely grown in Pakistan, *Capsicum* spp., have many medicinal applications. Crystalline capsaicin (8-methyl-N-vanillyl-6-noneamide), the hot bioactive principle, is listed at $151.75/g (Sigma, 1990). The pungent principles occur at levels of 1,000-15,000 ppm in the fruits. With yields of 10 tons/ha and capsaicin levels of 1,000 ppm, capsaicin yields could approach 10 kg, worth about $1.5 million at the Sigma Price above. Because it tends to block the pain factor, substance P, capsaicin is being investigated in arthritis, herpes zostger and the like.

Papain:

Papaya, *Carica papaya*, has long been an important source of proteolytic enzymes, like papain and chymopapain. Papaine, e.g., is used in the cosmetic, food and pharmaceutical industries. Over 80% is used in chill-proofing bear and in meat tenderizers. Purified papain is commonly sold at slightly over $6.00/1b (Anon., 1982). Sigma lists crude papain at ca $100-200/kg but purified pharmaceutical papain can run that much per gram. Papain competes with three other natural proteolytic compounds, bromelain from pineapple, ficin from fig, and zingibain from ginger. Chymopapain was recently approved by the FDA for injection into the spine for lower back problems. Stewart (1972) obtained fruit only once in Rawalpindi. Nazimuddin (1978) notes that the "papeeta" is widely cultivated in Sind and Punjab.

Castanospermine:

Originally discovered in the Moorestown Bay Chestnut (*Castanospermum australe* of Australia's "rain forest"), castanospermine has more recently been discovered in several species of *Alexa* of tropical America, adapted to the Extractive Reserves. The *Alexa* trees could be "tapped" renewably for the compound. Castanospermine is of great interest as a template for compounds with anti AIDS potential. "The drug appears to halt reproduction of the AIDS virus, alone or in combination with AZT, the only AIDS-fighting drug currently fully approved by the Food and Drug Administration" (Duke, 1989). It is also the basis of an antidiabetic patent. Sigma (Anon., 1990) lists it at $27.45/mg which translates to more than $27 million/kg. *Castanospermum* can survive in Pakistan where frosts are absent or mild and infrequent. Stewart (1972) already noted that it is cultivated in Pakistan gardens.

Colchicine:

The autumn crocus, *Colchicum autumnale*, is not native to America, but is widely cultivated here as an ornamental. The alkaloid colchicine is familiar to gout sufferers, trying to halve the pain in their joint, and cytologists, trying to double a set of chromosomes. Possessing both carcinogenic and antitumor activity, colchicine is now being investigated for potential relief of cirrhosis. Stewart (1972) lists *Colchicum luteum* as one of Pakistan's earliest spring flowers. Zaman (1961) notes that, as a good substitute for *C. autumnale*, *C. luteum* is scattered around Murree Hills and in Hazara district. Sigma (Anon., 1990) lists crystalline colchicine at $30.60/g, or $30,600/kg.

Harmaline:

Several tropical American species of *Passiflora* share harmaline and sedative activities with the temperate maypop, *Passiflora incarnata*. These species are being exported from America for the European sedative market. Surely *Passiflora incarnata* could be grown as well as the *P. edulis* and *P. lutea* reported by Stewart (1972). Sigma (Anon., 1990) lists crystalline free-base harmaline (1-methyl-7-methoxy-3,4-dihydro-beta-carboline) at $12.90/g translating to $12,900/kg.

Taxol:

There is intensive work in the US on taxol from *Taxus*, and in China on harringtonine from *Cephalotaxus* for their antitumor activity. Native and introduced ornamentals contain varying amounts of these or other antitumor compounds. These are not priced in Sigma. I have no data on the chemistry of Pakistan's *Taxus wallichiana*, reported by Stewart (1972) from mixed forests around Astor, Chitral, Hazara, Kurram, Murree Hills, Poonch, Swat, etc. NCI studies are limited by their inability to procure enough taxol from its main source *Taxus brevifolia*.

Huperzine:

Lycopodium lucidulum looks so similar to China's *Huperzia serrata*, that I have predicted anticholinesterase activity in *L. lucudulum*. *Huperzia serrata* contains two alkaloids, huperzine A and huperzine B with just such activity, triggering hopes that they might be useful in Alzheimer's Disease. Consequently I have submitted specimens of *L. lucidulum* to three concerns for analysis. Other species of *Lycopodium* have other anticholinesterase alkaloids, e.g., selagine and nicotine. The latter has been approved in transdermal nicotine patches for marketing in Ireland for the cessation of smoking. The patches deliver ca 1 mg/hr — equivalent to one cigarette per hour — for up to 24 hours. A New Drug Application (NDA) for the patches is pending in the US and is being filed in several major countries (Chemical Marketing Reporter {CMR}, Jan. 1, 1990). Sanberg *et al.*, (1988) reported that chewing nicotine gum, when added to continuing haloperidol treatment, produced rapid, striking and marked relief from tics and other symptoms of Tourette syndrome not controlled by haloperidol alone. Sigma (1990) lists free-base nicotine (98-100%) at over $400/kg ($432.85/1). Huperzine and selagine are not listed. Pakistan's *Lycopodium selago*, probably containing selagine, is reported from high elevations around Burzil Pass, Gilgit, Gulmarg, Nanga Parbat, etc. (Stewart, 1972).

Hypericin:

The St. Johnswort, *Hypericum perforatum*, is a photodermatitigenic weed, from coast to coast in the US. The USDA has successfully waged biological warfare on the weed, under the name of Klamath Weed, on the west coast. Studies this decade have shown antiretroviral activities for hypericin and pseudohypericin. Strangely, among my submissions to the NCI AIDS screen, *Hypericum hypericoides*, lowest in hypericin, showed more *in-vitro* activity than the species higher in hypericin (*Hypericum perforatum* and *H. punctatum*). Even more strangely, pure hypericin showed no activity in the NCI AIDS screen (Gordon Cragg, per comm., 1989). *Hypericum perforatum* is the commonest of the eight species reported for Pakistan (Stewart, 1972). Neither hypericin nor pseudohypericin are listed by Sigma (Anon., 1990).

Podophyllotoxin:

Etoposide (Vepeside) a semisynthetic derivative of podophyllotoxin, from North America's *Podophyllum peltatum* and Asian *P. emodi*, was approved in the past decade for cancer of the testicles and small cell lung cancer. The natural compound, podophyllin, long a drug of choice for venereal warts, contains various lignans which have antiviral properties. Podophyllotoxin is ichthyotoxic at 0.73-1.2 ppm and herbicidal at 500 ppm. Podophyllotoxin is antileukemic with ID-50 of 0.00554 µg/ml while deoxypodophyllotoxin is antileukemic with ID-50 of 0.0047 µg/ml (Inamori *et al.*, 1986). Zheng *et al.*, (1987) state that "purified podophyllotoxin is an inhibitor of microtubular aggregation, used in the treatment of cancer, psoriasis and rheumatoid arthritis". Stewart (1972) reports *Podophyllum emodi* from Astor, Chitral, Dras, Hazara, Poonch, Shendtoi Gorge, Swat, Zanskar, Ziarat, etc., at 6,000-12,0000 ft elevation. Sigma (Anon., 1990) lists podophyllotoxin, ca 75% purity at $45.85/500 mg, ca 98% purity at $76.70/500 mg which translaters to $91,700 to $153,400/kg.

Vinca Alkaloids:

Recent events with etoposide make *Podophyllum* the number two anticancer plant, still not challenging *Catharanthus roseus*, the long-outstanding number one anticancer plant. Dr. Anwar Khan, my PL-480 colleague, has obtained yields of 1,220-1,730 kg/ha fresh leaves and 510-820 kg/ha fresh roots from *Catharanthus* grown between rows of another medicinal plant, *Eucalyptus citriodorus*. *Catharanthus*, the so-called Madagascar Periwinkle, is widely grown as an ornamental, e.g., "in the plains" of Pakistan, and has naturalized as a weed in dry subtropical areas. It could be more widely grown in Pakistan. An American Pharmaceutical firm cultivates the species in Texas, having found external suppliers too unreliable. The alkaloids, used for decades in successfully treating certain types of leukemias and lymphomas, command incredibly high prices. Sigma lists vinblastine at $173.10/50 mg, vincristine at $445.30/25 mg, translating respectively to $3,462.000 and $17,812,000 per kilogram. Vincamine is more reasonable at $200/5 g, translating to only $40,000 per kilo. It can be obtained from temperate species, *Vinca minor*, "naturalized in Abbottabad and Murree and is planted in gardens and graveyards in the plains" (Stewart, 1972). Perhaps this may also occur in *Vinca major*, the only *Vinca* species listed for Pakistan by Nazimuddin & Qaiser (1983).

Castor Oil:

Unreliability of external suppliers is forcing the US back into growing its own castor bean, *Ricinus communis*. The US requires about 35,000-40,000 MT castor oil per annum.

> "Over the last 15 years, most of the US supply of oil has come from Brazil, but small crop harvests in recent years combined with growing European demand for Brazillian castor oil derivatives have left US users increasingly dependent on irregular shipments of lower quality Indian castor oil. . . Instability has driven prices higher over the past 18 months, to a peak of 54 1/2 cents per pound for Brazilian No. 1 grade oil. However, prices have begun to ease during the last two weeks as early shipments from this year's large Indian harvest reach the US. The US has produced castor oil in the past, averaging 20,000 tons annually, but production ended in 1975, dying rapidly after government price supports were discontinued in 1973" (Chemical Marketing Reporter [CMR] p. 10 Feb. 5, 1990).

In the same CMR issue, castor oil prices ranged from 53.5 to 79 cents per pound, roughly $1.20-1.75 a kilo, while listed by Sigma at $22.50 a liter. Not only castoroil, but ricin, the poisonous albumin, is finding new uses. Like pokeweed mitogen, ricin is being studied as an antiAIDS drug and for targeted delivery to tumor sites via monoclonal antibodies. Ricin-A lists for $36.90/mg and Ricin-B for $26.50/mg, translating to that many million dollars per kilogram at the Signa prices. In Pakistan, *Ricinus* is "widely planted to c. 4000' and may be self sown about villages" (Stewart, 1972).

Aconitine and Atropine:

Aconitine is another toxin of great interest. Two milligrams is enough to kill a human, and it can be absorbed through the skin (Duke, 1985). Aconitine occurs in many species of *Aconitum* including no doubt some of the dozen or so species in Pakistan. Atropine is the recommended antidote to aconitine. Atropine is derived from *Atropa belladonna*, closely related to Pakistan's *Atropa acuminata*, an alternative source of atropine. Amin (1961) noted that belladonna was going extinct in the wild, and that belladonna extracts were being imported, three decades ago. Perhaps as a consequence, Dr. A.A. Khan is studying the growth of widely distributed Pakistani *Atropa acuminata* in the Hill Forests. At Kuza Gali, he is attaining fresh-leaf yields of 2,770-3,470 kg/ha. Sigma lists aconitine at $118,90/250 mg which translates to $475,600/kg. The antidote, atropine, is cheaper at $849.50/kg.

Digitalis:

Digitalis and its glycosides remain some of the world's most important medicines. Dr. Khan is getting fresh-leaf yields of ca 650-3, 300 kg/ha at Kuza Gali. Stewart (1972) reports both major species, *Digitalis lanata* and *Digitalis purpurea*, as cultivated in Pakistan, for medicinal or ornamental purposes. Using the leaves can be dangerous because the lethal dose is not a great deal higher than the therapeutically effective dose. Sigma lists Digitoxin at $131.50/10 g, translating to $13,150/kg and digitoxigenin at $75.00/100 mg, translating to $750,000/kg.

Silymarin:

Having recently reviewed the literature on hepatoprotective herbs, I concluded that silymarin from the milk thistle, *Silybum marianum*, seemed to be the most promising natural compound both for preventing damage to the liver and for correcting damaged liver. According to Weil (1989), "Silymarin has been used in Europe to treat some victims of deadly *Amanita* poisoning with good results, U.S. doctors and poison control centers remain unaware of it. Milk thistle is a weed in Pakistan reported from Barikot, Hazara, Havelian, Kohat, Lahore, Peshawar, etc., (Stewart, 1972). Silymarin is a mixture of several of the following hepatoprotective compounds, mostly lignans, e.g., 3-deoxysilychristinsilybin, silandrin, silybin, silychristin, silydianin, and silymonin, none of which are listed by Sigma (Anon., 1990). Herbalist Chris Hobbs (1988) suggests that

> "The main indications for milk thistle are any liver-based disorder, such as cirrhosis, hepatitis, toxic stress from environmental factors, and alcohol or drug abuse. According to actual clinical experience, it can benefit people with psoriasis, providing up to a 60 per cent remission rate".

While the herb is not GRAS, it is what I call GRAF (Generally recognized as food), as we read in Medicinal Plants of the Bible (Duke, 1983):

> "The young leaves are often eaten as salad ingredients. The roots also are eaten like salsify. Birds like the seeds, which might also serve as famine food for humans. The heads were once eaten like artichoke. The seeds have served as coffee substitutes, and the seed cake is used for cattle fooder, the seed oil being used for food or lubrication."

THC:

Tetrahydrocannabinol (THC) from *Cannabis sativa* has received enough attention in the last two decades that the "chief administrative law judge of the Drug Enforcement Agency (DEA) recommended the DEA reclassify marijuana to a less restrictive status that would make it available by prescription to patients with multiple sclerosis or chemotherapy induced nausea. He called the drug 'one of the safest therapeutically active substances known to man'. Stewart (1972) notes that in Pakistan, *Cannabis*, "is a weed almost everywhere from the plains to 9000' and even higher. I think that I have only seen it cultivated in Hunza." According to Chaudhri (1961), "about 8,000 lbs. of 'Charas' is produced every year in Chitral and adjoining regions of Gilgit." Charas is Cannabis resin which adheres to cloth and is scraped off the cloth into a container.

Poppy Alkaloids:

From the poppy family, papaverine is being studied in AIDS protocols. It is also injected into the penis of impotent males. Protopine may have even more antiarrhythmic activity than quinidine. Thebaine from *Papaver bracteatum* (or from seedlings of *P. somniferum*) is a starting material for naloxone, a narcotic antagonist injected into new born children of heroin addicts, suffering withdrawal. Naloxone is also reported to induce copulatory behavior in sexually inactive rats (Gessa *et al.*, 1979). Thebaine can also be converted to an even more important poppy alkaloid, codeine, an irreplaceable analgesic and antitussive. *Papaver bracteatum* could be grown in Pakistan and *P. somniferum* "is widely planted in flower gardens for its beauty and in various places on the frontier for opium" (Stewart, 1972).

Compound "Q":

Since AIDS is such a new disease, any antiAIDS activity constitutes a new use for a product. For that reason, so-called Compound Q, in clinical trials for AIDS, is based on a patent for the use of trichosanthin, from *Trichosanthes kirilowi*. The patent also covers the use of momorcharin, from *Momordica charantia*, for AIDS (Duke & Foster, 1989), While trichosanthin had been used for years as a Chinese abortifacient and momorcharin as a Chinese antidiabetic, the patent embraces a new use, for AIDS. Sigma (Anon., 1990) lists neither of these but does list momordin, a highly purified lyophilized powder with ca 40% protein at $34.10/mg (translating to ca $34 million/kg) and lectin of *Momordica charantia* (ca 25% protein) at $28.95/mg (translating to ca $28 million/kg). Stewart. (1972) reports *Momordica balsamina, M. charantia, M. dioica, Trichosanthes anguina, T. cucumerina* and *T. dioica* from Pakistan.

Aloin:

Chaudhri (1961) notes that *Aloe vera* flourishes in the arid climate of Karachi, where it was introduced into graveyards, and then ran wild. Aloin now lists at $26.00/100g, translating to $260.00/kg. Under the trade name "Carrisyn", a purified and modified natural product from *Aloe* is being tested against AIDS.

Psoralen and Khellin:

For years used in the PUVA-treatment of psoriasis (Duke, 1988), psoralen (8-methoxy-psoralen) has been used independently for more than two millennia in Asia and Egypt for vitiligo. That's not new. It is now being used experimentally in photopheretic treatment of lymphomas in humans (Edelson *et al.*, 1987) and has shown anti-AIDS activity, *in vitro*. Two major sources of psoralen, *Ammi majus* and *Psoralea corylifolia*, both occur in Pakistan (Stewart, 1972). Sigma (Anon., 1990) lists 8-methoxy-psoralen at $12.60/g (translating to $12,600/kg). *Ammi visnaga*, source of khellin, was reported to have "almost been naturalized at Abbottabad, and is spreading in the neighbouring fields as an escape" (Zaman, 1961). Khellin, listed as a bronchodilator in Merck (8th ed) was more properly listed as vasodilator in Merck (9th ed). Khellin is carried by Sigma (Anon., 1990) at $108.00/100 g, translating to $1,080/kg.

Ephedrine:

Another antiasthmatic drug, ephedrine, was once a major export of Pakistan:

"*Ephedra gerardiana* Wall., is found throughout the region between the altitudes of 6,000-14,000 feet. At present the plant is collected only from the Balochistan region because of the nearness of the source to the Ephedrine factory at Quetta. The present annual consumption of the crude drug in the factory is around 1,000 tons. Pakistan has a world monopoly for meeting the entire world demand for natural ephedrine but is facing serious competition with the synthetic drug" (Chaudhri, 1961).

Today most of the world's natural ephedrine (about 1/3 of production) comes from China, with one-third being synthesized in Germany, another third in the US. Sigma (Anon., 1990) lists free base ephedrine (d-pseudoephedrine) at $60.25/100 g, translating to $602.50/kg.

Yohimbine:

Although banned by the FDA, the alkaloid yohimbine, alone or in combination with methyl-testosterone and nux-vomica extract (5 mg each in Aphrodex), still seems to be the most promising of the "aphrodisiac" alkaloids, with potentially dangerous anxiogenic side effects. Taberner (1985) surveyed double blind studies on Afrodex and concluded that after four weeks on Afrodex, patients had more than ten times as many erections and five times as many orgasms. Yohimbine is reported to be serotoninergic. Yohimbine is an alpha-adrenergic antagonist. Administered to rats, yohimbine induced increased mounting behaviour, improvement in initial heterosexual encounter and increased copulatory behaviour in sexually inactive rats (Wein, 1986). Yohimbine is reported from two extra Pakistani tropical trees, *Aspidosperma* and *Pausinystalia*, and the Asian snakeroot, *Rauwolfia serpentina*, reported only from Jammu by Stewart (1972). The 1989 Physician's Desk Reference still lists three brands of pills, each containing 5.4 mg yohimbine hydrochloride. Sigma (Anon., 1990) lists yohimbine hydrochloride at $6.50/g or $184.95/100 g (translating to ca $1,800/kg).

Ajmaline and Reserpine:

Siddiqui (1961) reminds us that another important alkaloid from *Rauwolfia*, ajmaline, was named, cerca 1930, for the great physician Hakim Ajmal Khan, while reserpine was not even named until 1952. Today ajmaline lists for $62.50/10 g translating to $6,250/kg in Sigma (Anon., 1990) while reserpine lists for $38.15/10 g, translating to $3,815/kg.

REFERENCES

Ahmed, M. & Chughtai, M.I.D. (1961). Studies on the medicinal plants of West Pakistan. Part I. Chemical investigation of *Inula grantioides*. *Pak. J. Sci. & Ind. Res.*, 4: 273-276.

Ali, S. I. (1973). Mimosaceae. No. 36 *in*: Nasir & Ali, eds., q.v.

Ali, S. I. (1977). Papilionaceae. No. 100 *in*: Nasir & Ali, eds., q.v.

Amin, M. (1961). Indigenous medicinal plants and the pharmaceutical industry in Pakistan. *Pak. J. Sci. & Ind. Res.*, 4: 217-218.

Anonymous. (1982). *Market for Selected Medicinal Plants and their Derivatives*. Int. Trade Centre UNCTAD/GATT, Geneva. 206 pp.

Atal, C.K. & Kapur, B.M., eds. (1982). *Cultivation and Utilization of Medicinal Plants*. Regional Research Laboratory, CSIR, Jammu-Tawi, India. 877 pp.

Chaudhri, I.I. (1961). Distribution of some important medicinal plants of West Pakistan. *Pak. J. Sci. & Ind. Res.*, 4: 207-211.

Doraswamy, K. & Venkatratnam, K.P. (1982). Chemistry, production and marketing of Cinchona alkaloids, pp. 230-243 *in:* Atal, C.K. & Kapur, B.M., eds. (1982). *Cultivation and Utilization of Medicinal Plants*. Regional Research Laboratory, CSIR, Jammu-Tawi, India. 877 pp.

Duke, J.A. (1983). *Medicinal Plants of the Bible*. Trado-Medic Books, Buffalo. 233 pp.

Duke J.A. (1985). *CRC Handbook of Medicinal Herbs*. CRC Press, Boca Raton, FL. 677 pp.

Duke, J.A. (1988). Bishop's Weed (*Ammi majus* L., Apiacae). *Econ. Bot.*, 42: 442-445.

Duke, J.A. (1989). Castanospermum and Anti-AIDS activity (Letter). *J. Ethnopharm.*, 25: 227-228.

Duke, J.A. (1990). Promising Phytomedicinals, pp. 491-498, *in*: J. Janick and J. Simon, (Eds.). *Advances in New Crops:* Proc. First National Symposium New Crops, Research, Development, Economics. Indianapolis, Indiana, October 23-26, 1988. Timber Press, Portland, OR. 560 pp.

Duke, J.A. & Foster, S. (1989). *Trichosanthes kirilowii:* A New Hope in AIDS-Relief Search? Herbalgram No. 20: 20-1, 25, 47.

Edelson, R., Berger, C., Gasparro, F., Jegasothy, B., Heald, P., Wintroub, B., Vonderheid, E., Knoabler, R., Wolff, K., Plewig, G., McKiernan, G., Christiansen, I., Oster, M., Honigsmann, H., Wilford, H., Kokoschka, E., Rehle, T., Perez, M., Stingi, G., & Laroche, L. (1987). Treatment of cutaneous T-cell Lymphoma by Extracorporeal Photochemotherapy. *New Eng. J. Med.*, 316: 297-303.

Fox, P.C., van der Ven, P.F., Baum, B.J., & Mandel, I.D. (1986). Pilocarpine for the treatment of xerostomia associated with salivary gland dysfunction. *Oral Surg., Oral Med., Oral Pathol.*, 61: 243-245.

Gessa, G.L., Paglietti, E., & Pellegrini Quarantotti, B. (1979). Induction of copulatory behavior in sexually inactive rats by Naloxone. *Science*, 204: 203.

Hanno, P.M. & Wein, A.J. (1986). *A Clinical Manual of Urology.* Appleton-Century-Crofts. Norwalk, CT. 704 pp.

Hobbs, C. (1988). Protect your liver with milk thistle. *Let's Live*, May, 42-43.

Inamori, Y., Kubo, M., Tsujibo, H., Ogawa, M., Baba, K., Kozawa & Fujita, E. (1986). The biological activities of Podophyllotoxin compounds. *Chem. Pharm. Bull.*, (Tokyo), 34: 3928-3932.

Kindscher, K. (1989). Ethnobotany of purple coneflower (*Echinacea angustifolia*, Asteraceae) and other *Echinacea* species. *Econ. Bot.*, 43: 498-507.

Leung, A.Y. (1980). *Encyclopedia of Common Natural Ingredients.* John Wiley & Sons, New York. 409 pp.

Liu, G.T. (1989). Advances in developing new drugs from Chinese traditional and folk medicine. *Int. J. Oriental Med.*, 14: 179-184.

Mowrey, D.B. (1986). *The Scientific Validation of Herbal Medicine.* Cormorant Books, 316 pp.

Mowrey, D.B. (1988). Licorice root: Poisonous or Priceless? *Let's Live*, Oct.: 64-65.

Nasir, E. & Ali, S.I., eds. (1970-1990). *Flora of Pakistan.* Issued family by family (from No. 1. Flacourtiaceae to 192 Labiatae). Dept. Botany, Univ. Karachi, Pakistan.

Nazimuddin, S. (1978). Caricaceae. No. 117 *in:* Nasir & Ali, eds., q.v.

Nazimuddin, S. & Qaiser, M. (1983). Apocynaceae. No. 148, in Nasir & Ali, eds., *Flora of Pakistan.* q.v.

Ng, T.B., Wong, C.M., Li, W.W., & Yeung, H.W.(1986). Isolation and characterization of a galactose binding lectin with insulinomimetic activities. *Int. J. Peptide Res.*, 28: 163-172.

Sanberg, P.R., Fogelson, H.M., Manderscheid, P.Z., Parker, K.W., Norman, A.B., & McConville, B.J. 1988. Nicotine Gum and Haloperidol in Tourette's Syndrome. Letter *in: The Lancet*, 1: 592.

Siddiqui, S. (1961). The Presidential Address. *Pak. J. Sci. & Ind. Res.*, 4: 144-147.

Sigma. (1990). *Biochemicals Organic Compounds for Research and Diagnostic Reagents (Catalog).* Sigma Chemical Co., St. Louis. 2078 pp.

Sitting, M. (1988). *Pharmaceutical Manufacturing Encyclopedia.* 2nd ed. 2 vols. Noyes Publications, Park Ridge, NJ. 1756 pp.

Soejarto, D.D. & Farnsworth, N.R. (1989). Tropical rainforests: potential sources of new Drugs? *Perspectives in Biology and Medicine*, 32:244-256.

Stewart, R.R. (1972). *An Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir.* Fakhri Printing Press, Karachi. 1028 pp.

Stewart, R.R. (1982). History and exploration of plants in Pakistan and adjoining Areas. *in:* Nasir & Ali, eds., q.v. 186 pp.

Taberner, P.V. (1985). *Aphrodisiacs-The Science and the Myth.* Croom Helm, London. 276 pp.

Takagi, K. (1989). The pharmacology of Licorice *(Glycyrrhizae radix). Int. J. Oriental Med.*, 14: 185-188.

Tyler, V. (1987). *The New Honest Herbal.* George F. Stickley, Philadelphia. 254 pp.

Weil, A. (1989). *A New Look at Botanical Medicine.* Whole Earth Review. Fall: 54-61.

Weiner, M.A. (1989). Herbs and the immune system. *The Herbal Hotline*, 1: 4-13.

Williams, D.H., Stone, M.J., Hauck, P.R. & Rahman, S.K. (1989). Why are secondary matabolites (Natural Products) biosynthesized? *J. Nat. Prod.*, 52:1189-1208. Nov.-Dec.

Wood, C.D., Manno, J.E., Wood, M.J., Manno, B.R., & Mims, M.E. (1989). Comparison of efficacy of Ginger with various antimotion sickness drugs. *Clin. Res. Practices & Drug Reg. Affairs*, 6: 129-136.

Zaman, M.B. (1961). The present resources of medicinal plants and their future development in Pakistan. *Pak. J. Sci. & Ind. Res.*, 4: 212-216.

Zheng, Q.Y., Wiranowska, J.R.S. & Hadden, J.W.(1987). Purified Podophyllotoxin (CPH-86) inhibits lymphocyte proliferation but augments macrophage proliferation. *Int. J. Immunopharm.*, 9: 539-549.

APPENDIX I: PRICES OF BOTANICALS (FOB New York)

PRODUCT	PRICE 1985[1]		PRICE 1987[2]		PRICE 1990[3] (Trend)	
Allspice	1.09 -	1.19/lb	1.00 -	1.13/lb	.83 -	1.28 (-)
Allyl isothiocyanate	5.40 -	6.90/lb	5.40 -	6.90/lb	5.40 -	6.90 (=)
Almond oil, bitter	3.50 -	3.60/lb	3.50 -	3.60/lb	118.00 -	125.00 (+)
sweet	1.24 -	1.50/lb	1.24 -	1.50/b		
Aloe	2.00 -	3.00/lb	2.00 -	3.00/lb	2.00 -	2.75 (-)
Aloin	6.00 -	6.70/lb	6.00 -	6.70/lb	6.00 -	6.70 (=)
Amyris oil	11.50 -	12.25/lb	10.00 -	/lb	10.50 -	10.75 (-)
Anethole	2.50 -	4.10/lb	4.50 -	4.60/lb	7.75 -	8.25 (+)
Angelica root oil	341.00 -	/lb	318.00 -	/lb	318.00 -	(-)
Anise oil	5.10 -	/lb	4.04 -	/lb	7.40 -	8.25 (+)
Anise seed	.50 -	.73/lb	1.05 -	1.40/lb	.72 -	1.40 (+)
Apricot kernel oil	2.05 -	/lb	2.05 -	/lb	1.75 -	2.05 (-)
Arabic gum	1.85 -	2.50/lb	1.85 -	2.15/lb	1.50 -	2.60 (-)
Avocado oil	4.00 -	4.50/lb	4.00 -	4.50/lb	4.20 -	4.50 (+)
Basil	.58 -	.88/lb	.66 -	.95/lb	.50 -	.90 (+)
Basil oil			55.00 -	62.00/lb	40.90 -	57.00 (-)
Bayberry wax	2.70 -	3.00/lb	2.70 -	3.00/lb	2.70 -	3.00 (=)
Bay oil	11.00 -	/lb	11.00 -	/lb	13.50 -	(+)
Benzaldehyde	1.10 -	1.24/lb	1.25 -	/lb	.73 -	1.00 (-)
Beragmot oil	16.00 -	/lb	21.36 -	/lb	50.00 -	60.00 (+)
Bois de Rose oil	10.75 -	12.00/lb	8.95 -	/lb	16.00 -	16.50 (+)
Caffeine	4.70 -	4.80/lb	5.80 -	/lb	6.90 -	7.25 (+)
Calamus oil	26.80 -	35.00/lb	26.80 -	35.00/lb	16.00 -	24.00 (-)
Camphor	3.63 -	3.70/lb	3.63 -	3.70/lb	1.80 -	3.70 (-)
Camphor oil	1.50 -	2.50/lb	1.80 -	2.85/lb	2.00 -	3.75 (+)
Canaga oil	9.00 -	/lb	9.55 -	/lb	13.18 -	13.60 (+)
Candelilla wax	1.90 -	2.10/lb	1.90 -	2.10/lb	2.00 -	2.30 (+)
Capsicum			.54 -	.79/lb		
Capsicum oleoresin	9.00 -	18.00/lb	9.00 -	18.00/lb		
Caraway oil	22.00 -	25.00/lb	18.00 -	/lb	15.00 -	16.00 (-)
Caraway seed	.78 -	.97/lb	.47 -	.54/lb	.34 -	.48 (-)
Cardamom oil	160.00 -	200.00lb	56.00 -	/lb	35.00 -	45.00 (-)
Carnauba wax	1.10 -	2.05/lb	1.10 -	2.05/lb	.90 -	2.75 (+)
d-Carvone	48.00 -	/lb	48.00 -	/lb		
l-Carvone	7.25 -	8.50/lb	7.00 -	7.25/lb	9.75 -	10.45 (+)
Cascara sagrada	1.00 -	/lb	1.00 -	/lb		
Cassia	.55 -	.83/lb	.85 -	1.20/lb	1.42 -	1.70 (+)
Cassia oil			16.50 -	/lb	15.00 -	16.00 (-)
Castoreum	18.00 -	35.00/lb	11.00 -	35.00/lb		
Castor oil	.62 -	1.00/lb	.35 -	.78/lb	.545 -	1.11 (+)
Castor pomace	.08 -	/lb	.08 -	/lb		
Catechol	1.69 -	3.60/lb	1.69 -	3.60/lb	1.90 -	2.60 (-)
Cedarleaf oil	17.50 -	/lb	17.50 -	/lb	30.00 -	32.00 (+)
Cedarwood oil	3.50 -	4.20/lb	1.55 -	4.75/lb	1.50 -	4.75 (-)

Cedrol	5.25 -	/lb	5.25 -	/lb	5.25 -	(=)
Celery seed	.84 -	.95/lb	.46 -	/lb	.46 -	(-)
Celery seed oil	60.00 -	/lb	37.00 -	/lb	34.00 -	37.00 (-)
Chamomile flowers	2.70 -	4.94/lb	2.70 -	4.94/lb	2.70 -	4.94 (=)
Chamomile oil, blue	340.00 -	370.90lb	370.90 -	545.00/lb	370.00 -	545.00 (+)
Chenopodium oil	15.00 -	/lb	15.00 -	/lb	15.00 -	(=)
Cinnamon	1.55 -	/lb	1.10 -	1.15/lb	1.90 -	(+)
Cinnamon bark oil	88.00 -	95.00/lb	105.00 -	110.00/b	240.00 -	(+)
Cinnamon leaf oil	4.50 -	5.00/lb	3.10 -	/lb	-	5.00 (+)
Citral	5.50 -	6.65/lb	3.18 -	6.65/lb	7.00 -	12.00 (+)
Citronellal	3.85 -	7.40/lb	5.00 -	11.00/lb	3.40 -	4.00 (-)
Citronella oil	2.25 -	2.50/lb	4.75 -	/lb	2.25 -	(=)
Citronellol	3.60 -	/lb	3.68 -	/lb	4.00 -	4.75 (+)
Clove bud oil	12.00 -	30.00/lb	11.36 -	4.73/lb	10.90 -	(-)
Clove leaf oil	3.00 -	4.20/lb	1.39 -	1.55/lb		
Cloves	2.00 -	4.20/lb	2.00 -	2.10/lb	1.15 -	(-)
Cocillana bark	.40 -	.45/lb	.40 -	.45/lb		
Cocoa butter	2.23 -	2.35/lb	2.19 -	/lb	1.35 -	(-)
Codeine	410.00 -	/lb	409.09 -	/lb	410.00 -	(=)
Copaiba balsam	2.25 -	/lb	1.50 -	/lb	2.30 -	(+)
Copaiba oil	1.35 -	2.00/lb	3.75 -	/lb		
Coriander oil	22.00 -	28.00/lb	32.00 -	34.00/lb	45.50 -	(+)
Coriander seed	.28 -	.31/lb	.34 -	.35/lb	.36 -	(+)
Corn oil	.13.5 -	.14/lb	.13.5 -	.14/lb	.135 -	.50 (+)
Cottonseed oil	.13 -	/lb	.18 -	/lb	.125 -	.127 (-)
Coumarin	6,05 -	6.20/lb	6.50 -	6.60/lb	7.25 -	7.55 (+)
Cube root	-	.60/lb	.60 -	/lb	.60 -	(=)
Cumene	.23 -	/lb	.23.5 -	/lb		
Cumin seed	.63 -	.66/lb	.90 -	/lb	.93 -	1.40 (+)
Cyclamen aldehyde	4.85 -	9.20/lb	4.85 -	9.20/lb	4.40 -	11.85 (+)
Digitoxin	1180.00 -	1360.00lb	1183.00 -	1365.00/lb	1190.00 -	1374.00 (+)
Dill oil	7.25 -	8.25/lb	7.00 -	7.50/lb	7.75 -	(=)
Ephedrine and salts	20.00 –	/lb	20.00 –	/lb	20.00 –	28.40 (+)
Epinephrine and salts	272.00 -	/lb	273.00 -	/lb	274.80 -	(+)
Eucalyptol	4.50 -	/lb	3.50 -	3.64/lb	6.68 -	6.82 (+)
Eucalyptus oil	2.50 -	2.85/lb	2.55 -	/lb	4.25 -	5.00 (+)
Eugenol	3.90 -	5.85/lb	3.43 -	/lb	1.25 -	1.48 (-)
Fennel oil	9.00 -	/lb	9.00 -	/lb	14.25 -	(+)
Fennel seed	.45 -	.58/lb	.59 -	.95/lb	.66 -	.98 (+)
Fenugreek seed or extract			.25 -	.32/lb	.35 -	.38 (+)
Fir oil	10.20 -	/lb	10.00 -	12.75/lb	9.75 -	14.50 (+)
Furfural	.66 -	/lb	.75 -	/lb	.75 -	(+)
Garlic oil	60.00 -	70.00/lb	52.27 -	50.09/lb	35.00 -	45.45 (-)
Geraniol	10.50 -	/lb	10.75 -	/lb	4.15 -	10.60 (-)
Geranium oil	15.50 -	40.00/lb	21.00 -	61.00/lb	16.00 -	46.00 (+)
Ginger	.66 -	1.70/lb	.55 -	.65/lb	.51 -	.92 (-)
Ginger oil	45.00 -	75.00/lb	18.64 -	29.55/lb	13.64 -	24.09 (-)
Ginger oleoresin	30.00 -	/lb	30.00 -	/lb	22.00 -	30.00 (-)
Grapefruit oil	1.40 -	3.45/lb	3.00 -	/lb	9.75 -	9.75 (+)

Guaiacol	2.70 -	/lb	2.70 -	/lb		
Guaiacwood oil	2.50 -	/lb	3.75 -	/lb	3.60 -	(+)
Gum guar	.50 -	.75/lb	.50 -	.85/lb	.35 -	.60 (-)
Heliotropine	9.00 -	11.00/lb	10.00 -	10.75/lb	10.00 -	(=)
Hemlock oil	8.00 -	/lb	8.00 -	/lb		
Henbane leaves	.55 -	/lb	.55 -	/lb	.55 -	(=)
Horehound	.25 -	.28/lb	.25 -	.28/lb	.25 -	.28 (=)
Inositol	10.00 -	10.90/lb	7.27 -	10.00/lb	13.64 -	20.45 (+)
Ipecac root	40.00 -	/lb	25.00 -	/lb	10.68 -	(-)
Isoborneol	7.25 -	/lb	7.25 -	/lb	7.25 -	(=)
Isoeugenol	5.20 -	5.60/lb	5.20 -	5.60/lb	4.25 -	4.50 (-)
Japan wax	5.50 -	5.60/lb	5.50 -	5.60/lb	7.00 -	(+)
Jojoba oil	55.00 -	60.00/gal	30.00 -	40.00/gal	6.93/lb -	(-)
Juniper berry oil	45.00 -	55.00/lb	52.27 -	/lb	43.18 -	54.55 (-)
Karaya gum	2.50 -	2.65/lb	1.95 -	2.25/lb	2.55 -	3.60 (+)
Kola nuts	.60 -	.65/lb	.60 -	.65/lb	.60 -	.65 (=)
Laurel leaves	.60 -	.68/lb	2.25 -	3.25/lb	.60 -	.90 (-)
Lavandin oil	4.25 -	/lb	6.50 -	/lb	7.30 -	(+)
Lavender flowers	.65 -	1.19/lb	.65 -	1.19/lb		
Lavender flower oil	9.25 -	15.45/lb	9.00 -	13.00/lb	11.00 -	16.00 (+)
Lecithin	.26 -	.36/lb	.26 -	.36/lb	.38 -	.40 (+)
Lemongrass oil	4.25 -	4.85/lb	4.75 -	5.11/lb	6.80 -	7.50 (+)
Lemon oil	6.50 -	11.50/lb	6.70 -	12.00/lb	6.50 -	10.50 (-)
Licorice root (whole)	.40 -	.95/lb	.40 -	.95/lb	.40 -	.60 (-)
Lime oil	10.50 -	18.50/lb	5.60 -	7.25/lb	8.75 -	11.00 (-)
d-Limonene	.85 -	.90/lb	.31 -	.39/lb	1.00 -	1.35 (+)
Linalool	2.90 -	6.35/lb	6.35 -	/lb	3.90 -	14.50 (+)
Linalyl acetate	18.00 -	21.00/lb	18.00 -	21.00/lb	4.70 -	5.10 (-)
Linden flowers	.78 -	1.15/lb	.78 -	1.15/lb	.78 -	1.15 (=)
Linseed oil	.53 -	.67/lb	.25 -	/lb	.65 -	.72 (+)
Locust bean gum	2.15 -	2.45/lb	4.75 -	5.00/lb	4.75 -	5.00 (+)
Lycopodium	6.50 -	8.25/lb	8.00 -	10.00/lb	8.45 -	13.00 (+)
Mace	3.30 -	3.80/lb	5.40 -	6.00/lb	5.90 -	6.40 (+)
Marjoram	.58 -	1.00/lb	.61 -	.89/lb	.66 -	1.00 (+)
Menthol	8.50 -	/lb	6.00 -	/lb	10.00 -	50.00 (+)
Methyl eugenol	3.55 -	3.80/lb	3.55 -	3.80/lb	3.55 -	3.80 (=)
Methyl salicylate	1.79 -	1.94/lb	1.60 -	1.75/lb	1.25 -	1.47 (-)
Morphine alkaloid	568.97 -	/lb	462.73 -	/lb	462.72 -	(-)
Morphine sulfate	386.36 -	/lb	386.36 -	/lb	386.36 -	(=)
Mustard seed	.27 -	.29/lb	.20 -	.21/lb	.32 -	.40 (+)
Myrrh gum	1.75 -	/lb	2.25 -	/lb	2.25 -	(+)
Nerol	4.60 -	5.75/lb	4.60 -	5.75/lb	3.20 -	5.75 (+)
Neroli oil	522.72 -	750.00/lb	733.91 -	/lb	670.00 -	(+)
Nutmeg oil	8.40 -	9.00/lb	14.09 -	15.00/lb	12.00 -	(+)
Nutmegs	.95 -	/lb	3.10 -	3.15/lb	2.60 -	2.75 (+)
Ocotea cymbarum oil	1.93 -	/lb	2.36 -	/lb	1.64 -	2.25 (-)
Oiticica oil	.55 -	.61/lb	.32 -	.42/lb	.45 -	.48 (-)
Olibanum oil	2.40 -	2.75/lb	2.10 -	/lb	1.60 -	2.10 (-)
Olive oil	5.10 -	8.00/gal	5.35 -	8.00/gal	7.00 -	10.00 (+)

Opium	56.81 -	/lb	56.81 -	/lb	56.81 -	(=)
Orange oil	.40 -	6.50/lb	.60 -	13.00/lb	1.04 -	16.00 (+)
Orange peel	.38 -	/lb	.38 -	/lb	.35 -	.38 (-)
Oregano	.53 -	1.08/lb	1.05 -	2.80/lb	.85 -	1.10 (+)
Origanum oil	12.27 -	/lb	15.91 -	/lb	25.90 -	(+)
Orris root	3.00 -	5.00/lb	3.00 -	5.00/lb	3.00 -	5.00 (=)
Ouricury wax	3.25 -	3.35/lb	3.25 -	3.35/lb	3.25 -	3.50 (+)
Palmarosa oil	19.00 -	21.00/lb	18.18 -	/lb	13.64 -	18.00 (-)
Palm oil	.30 -	.45/lb	.17 -	/lb	.21 -	.45 (-)
Papaverine hydrochloride	25.45 -	/lb	25.45 -	/lb	25.45 -	(=)
Paprika	.85 -	1.00/lb	.90 -	1.04/lb	1.02 -	1.30 (+)
Patchouli oil	18.10 -	20.00/lb	8.18 -	8.86/lb	7.05 -	9.10 (-)
Pelargonic acid	.70 -	/lb	.70 -	/lb	.97 -	(+)
Pennyroyal oil	5.90 -	/lb	10.25 -	/lb		
Pepper, black	1.15 -	1.21/lb	2.40 -	2.58/lb	1.03 -	1.65 (+)
Papper, red	.06 –	1.20/lb	.54 –	.79/lb	1.15 –	1.40 (+)
Pepper, white	1.60 -	/lb	2.97 -	/lb	1.28 -	(-)
Peppermint leaves	2.25 -	/lb	2.00 -	/lb	1.90 -	(-)
Peppermint oil	7.00 -	16.00/lb	2.95 -	15.00/lb	7.00 -	15.00 (-)
Peru balsam	9.50 -	/lb	3.25 -	/lb	6.00 -	(-)
Petitgrain oil	5.75 -	6.25/lb	5.00 -	/lb	3.00 -	(-)
Pilocarpine hydrochloride	200.00 -	208.00/lb	681.82 -	909.09/lb	681.82 -	909.09 (+)
Pimento leaf oil	19.50 -	/lb	13.90 -	/lb	20.00 -	(+)
Pine oil	.47 -	.54/lb	.47 -	.53/lb	.68 -	(+)
a-Pinene	.25 -	3.00/lb	.18 -	.74/lb	.43 -	1.05 (-)
b-Pinene	.45 -	3.00/lb	.35 -	1.05/lb	.55 -	1.30 (-)
Poppy seed	.37 -	.43/lb	.53 -	.59/lb	.46 -	.73 (+)
Psyllium seed	.90 -	2.85/lb	1.50 -	1.75/lb	1.50 -	2.50 (-)
Pyrethrum flowers	1.91 -	/lb	1.91 -	/lb		
Quassia chips	.57 -	/lb	.57 -	/lb	.57 -	(=)
Quince seed	2.00 -	2.75/lb	2.00 -	2.75/lb	2.00 -	2.75 (=)
Quinidine sulfate	55.20 -	56.00/lb	67.20 -	68.00/lb	64.00 -	(+)
Quinine hydrochloride	37.60 -	38.40/lb	39.20 -	40.00/lb	37.28 -	(-)
Quinine sulphate	36.80 -	38.40/lb	36.80 -	40.00/lb	37.28 -	(-)
Rapeseed oil	.54.5 -	.56/lb	.62.5 -	/lb	.527 -	.822 (+)
Rauwolfia serpentina root	3.75 -	4.00/lb	10.00 -	/lb	10.00 -	(+)
Reserpine	136.00 -	181.00/lb	182.00 -	193.38/lb	180.60 -	192.95 (+)
Rhubarb root	.45 -	.70/lb	.45 -	.70/lb	.45 -	.70 (=)
Rose oil	1022.54 -	1813.54/lb	2590.91 -	2818.18/lb	3318.00 -	3455.00 (+)
Rosemary oil	6.25 -	11.50/lb	4.09 -	7.95/lb	3.97 -	6.82 (-)
Rotenone resin	.21 -	.23/lb	.21 -	.23/lb	.38 -	.40 (+)
Safflower oil	.50 -	.90/lb	.55 -	.80/lb	.545 -	.80 (-)
Sage leaves	.80 -	1.68/lb	1.35 -	1.95/lb	1.10 -	2.15 (+)
Sage oil	9.50 -	58.00/lb	8.64 -	83.18/lb	11.82 -	27.10 (+)
Sandalwood	46.00 -	55.00/lb	81.82 -	86.36/lb	77.27 -	85.00 (+)
Scopolamine hydrobromide	576.00 -	744.00/lb	576.00 -	744.00/lb	576.00 -	744.00 (=)
Senna leaves	.70 -	1.10/lb	.70 -	1.10/lb	.70 -	1.10 (=)
Sesame oil	1.00 -	1.20/lb	1.00 -	1.20/lb	1.00 -	1.20 (=)
Sesame seed	.56 -	/lb	.52 -	/lb	.50 -	(-)

Soapbark			1.00 -	1.85/lb	1.35 -	1.85 (+)
Spearmint leaves	2.50 -	2.70/lb	2.50 -	2.70/lb	1.50 -	2.70 (=)
Spearmint oil	11.50 -	17.25/lb	5.50 -	18.50/lb	6.00 -	18.50 (-)
Spruce oil	8.00 -	/lb	8.00 -	/lb	11.00-	(+)
St. John's bread	.25 -	/lb	.29 -	.30/lb	.29 -	.52 (+)
Stramonium leaves	.15 -	.20/lb	.15 -	.20/lb		
Sunflower seed oil	.30 -	.31/lb	.15.75 -	/lb	.22 2 -	.232 (-)
Tangerine oil	10.50 -	28.00/lb	2.50 -	9.50/lb	4.50 -	11.00 (-)
Theobromine	4.00 -	4.50/lb	63.64 -	68.18/lb	63.64 -	68.18 (+)
Theophylline	5.90 -	6.02/lb	5.45 -	5.89/lb	8.00 -	9.57 (+)
Thyme leaves	.62 -	1.02/lb	.75 -	1.45/lb	.65 -	1.80 (+)
Thyme oil	23.00 -	33.00/lb	9.09 -	10.00/lb	27.27 -	(-)
Thymol	3.75 -	6.15/lb	3.75 -	6.15/lb	3.75 -	4.40 (-)
d-a-Tocopherol	22.76 -	/lb	22.76 -	/lb	24.76 -	(+)
Tolu balsam	7.60 -	8.68/lb	7.60 -	8.68/lb	7.00 -	(-)
Tonka beans	6.50 -	/lb	6.50 -	/lb	6.00 -	(-)
Tragacanth gum	35.00 -	40.00/lb	12.50 -	40.00/lb	12.50 -	40.00 (-)
Tung oil	.76 -	.85/lb	.56 -	.57/lb	.41 -	(-)
Turmeric	.98 -	1.10/lb	.62 -	.68/lb	.68 -	.72 (-)
Turpentine	.55 -	.65/gal	.80 -	.90/gal	2.00 -	(+)
Uva-Ursi leaves	.22 -	/lb	.22 -	/lb	.80 -	1.45 (+)
Valerian root	.45 -	.85/lb	.45 -	.85/lb		
Vanilla beans	27.00 -	37.00/lb	27.00 -	37.00/lb	27.00 -	37.00 (=)
Vetiver acetate	48.50 -	85.50/lb			92.95 -	(+)
Vetiver oil	15.00 -	50.00/lb	14.09 -	58.00/lb	23.50 -	62.00 (+)
Wheat germ oil	14.45 -	16.72/gal	14.00 -	17.50/gal		
Witch hazel bark	1.25 -	/lb	1.35 -	/lb	1.35 -	(+)
Witch hazel leaves	1.50 -	/lb	.8 -	1.75/lb	1.75 -	(+)
Wormwood oil	31.00 -	36.00/lb	31.00 -	/lb	30.00 -	(-)
Yerba santa leaves	82. -	31.75/lb	2.40 -	31.75/lb		
Ylang-ylang oil	13.04 -	23.93/lb	24.00 -	43.00/lb	24.00 -	52.00 (+)

[1]Source: Chemical Marketing Reporter, March 18, 1985.
[2]Source: Chemical Marketing Reporter, May 11, 1987.
[3]Source: Chemical Marketing Reporter, January 8, 1990.
(+) = Prices trending upward
(=) = Prices remaining the same
(–) = Prices trending downward

CONSERVATION BIOLOGY

Plant Life of South Asia, 229–234, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

THREATENED PLANTS OF PAKISTAN

YASIN J. NASIR*

National Herbarium,
N.A.R.C., Islamabad, Pakistan.

ABSTRACT

The present knowledge of the threatened plants of Pakistan is insufficient as no Red Data Book exists for our area. Preliminary lists (unpublished) include a conservative estimate of 580-650 plant species (i.e., c. 12% of the flora) that are threatened. The present paper is an attempt to highlight the status and predicament of some of our threatened plants. Brief notes along with ecology, flowering period, common name and local distribution for a select 14 taxa are given.

INTRODUCTION

Pakistan has a rich and varied flora. There are c. 4940 native flowering plant species (5738 if naturalised or cultivated are included) that are found in a variety of habitats from the seashore to the desert and to high mountainous areas in the North. About 372 species are endemic, found mainly in the Western and Northern mountain regions (Ali & Qaiser, 1986).

Unfortunately due to population pressure, urbanisation, overgrazing etc., the original flora is fast disappearing. It has been estimated by the IUCN/WWF Plant Advisory Group that as many as 60,000 plant species (out of 250,000 species worldwide) can become extinct by 2050 A.D., if the present trend continues. In Pakistan our broad leaf forests are disappearing at the rate of 10 sq. km/ year (Anon., report, 1980).

The majority of our native plants have never been examined for food, fibre or medicine; many are a potential source for pharmaceuticals or industrial raw materials. It is interesting to note that worldwide some 20 plants provide more than 85% of our food and only a few hundred species are cultivated widely. Unless drastic steps are taken, many of our valuable plant species will disappear.

*Present address: 284, Riseborough Circ., Markham, Ont., L3R 3J2, Canada.

The causal factors which threaten the existence of plants in Pakistan and other parts of the world in general are:

i) Habitat destruction of the plant species.
ii) Selective removal of plants by over-exploitation of plants of economic value.
iii) Introduction of alien plant species that can pose a threat through competition to our native plants.
iv) Air, water and land pollution through toxic wastes.

The identification of our threatened plants is part of WWF-Pakistan Plants Programme. A Red Data book on threatened plants for Pakistan has not been prepared so far. Our knowledge as yet is far from complete; for the majority of our taxa much more information is required concerning their distribution and abundance. According to preliminary estimates, based on checklists (K.H. Sheikh; Y. Nasir, ined.) at least 12% of our flora (i.e., 580-650 species of ferns and flowering plants) is threatened. The number will be appreciably more when the work on the flora of Pakistan complete (to date accounts of 192 plant families have been published).

In the present paper an attempt is made to highlight some of our plants in danger. The lists of plant species that follow are categorised according to the territory which comprise Pakistan. (Table 1).

Table: 1. Some families with the most threatened taxa in Pakistan.

Family	Native/wild spp. (approx.)	Threatened taxa
Compositae	604	119
Papilionaceae	492	100
Poaceae	490	83
Brassicaceae	236	52
Umbelliferae	162	42
Scrophulariaceae	57	33
Ranunculaceae	120	31
Cyperaceae	200	30
Boraginaceae	130	28
Rosaceae	164	26

1. *Extinct:*

Taxa which are no longer known to exist in the wild after repeated searches in their type locality and other known places.

Merremia palmata H. Hall vel aff. Fam.: **Convolvulaceae**

A trailing delicate herb with deep 5-palmately lobed leaves and pale yellow flowers.

Collected only on two occasions about 12 years ago, from the Margallas at 750 m, but not seen ever since. Possibly eradicated by construction and expansion of road. Flowers in September.

Holarrhena pubescens (Buch.-Ham.) Wall. ex G. Don Fam. : **Apocynaceae**

A small tree or shrub with elliptic or elliptic-oblong leaves. Flowers creamish, 2-4 cm broad, in terminal clusters.

Known only from a single gathering collected c. 40 years ago from the Nurpur area, Islamabad at the base of the Margallas. The leaves, bark and seeds are used medicinally for dysentry. The wood is used for light furniture. Possibly overexploited. Common name: 'Kurch, Kewar'. Flowers in March.

2. *Endangered:*

Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose habitats are reduced to an extent that they are in danger of extinction.

Cinnamomum tamala (Ham.) Th. G. Fr. Nees Fam.: **Lauraceae**

A medium sized tree with flowers in axillary panicles. The leaves are prominently nerved and sold as 'tez pat' as a spice.

Once found local in Nakial and Nawal Nadi (Azad Kashmir). Over exploited for economic use. Common name: 'Tez pat'. Flowers in May.

3. *Vulnerable:*

Taxa believed likely to move into the endangered category, if the causal factors continue operating.

Podophyllum hexandrum Royle — Fam.: **Podophyllaceae**

A forest herb from 30-50 cm tall. Leaves 2, prominent, palmately 3-lobed, 15-25 cm broad. Flowers white to pale pink, solitary. Fruit ovoid-oblong to ellipsoid, 3-5 cm long, red when ripe.

A medicinally important plant. The rhizome yields the drug podophyllin. The plant is also used in cancer research. Overexploited. Common name: 'Ban kakri'. Flowers April-May.

Colchicum luteum Baker — Fam.: **Colchicaceae**

An early flowering herb with solitary yellow flowers and 3-4 narrow cylindrical leaves up to 20 cm long.

The underground corm yields the alkaloid 'colchicine'. Overexploited. Flowers January-April.

Hygrophila auriculata (Schum.) Heine — Fam.: **Acanthaceae**

A spinose branched suffruticose herb up to 1.5 m tall with lanceolate leaves and pink flowers in axillary whorls.

Found in one spot in the Kittas area of Chakwal district. Also reported to be cultivated at the Pakistan Forest Institute (Medicinal Branch), Peshawar. The plant parts are used in jaundice, as a diuretic and in coughs. Might possibly be now endangered due to habitat destruction. Common name: 'Tal Makhana' Flowers September-October.

Rhododendron arboreum Smith — Fam.: **Ericaceae**

A small evergreen tree up to 6 m tall with large lanceolate or oblong leaves up to 18 cm long. Flowers large, showy, scarlet-red, in terminal clusters.

There are local pockets of this tree in the North West Frontier Province and Kashmir, in the Oak and Pine zone between 1500-1800 m. A few scattered trees remain in the Murree hills. The leaves are used as a cure for headaches and the flowers are not only picked for their beauty but used as a vermifuge. Common name: 'Kikari'. Flowers February-March.

4. *Rare:*

Taxa with small world populations that have a restricted geographical area or habitat or are sparsely scattered over a wider area.

Meconopsis aculeata Royle Fam.: **Papaveraceae**

A perennial prickly herb up to 70 cm tall with large blue to sky-blue flowers.

A plant of steep rocky places in the alpine zone from 3100-3700 m, found in the Kagan and parts of Azad Kashmir. Plant parts poisonous and narcotic. Flowers July-August.

Tetrastigma serrulatum (Roxb.) Planch Fam.: **Vitaceae**

A weak herbaceous straggler with digitately divided leaves and small greenish flowers in clusters.

Found locally in the Margallas, above Islamabad, at 1000 m. Flowers October-Novermber.

Nervilea gammieana (Hook. f.) Pfitzer Fam.: **Orchidaceae**

Plants precocious with globose corms. Leaves fan-like, orbicular to cordate, up to 12 cm broad. Petiole 10-15 cm long. Flowers recemose, drooping, 2-2.5 cm long, pink with a lemon yellow center.

Found in the *Pinus roxburghii* zone in the lower Murree hills, the Panjar valley and Margallas. The flowering is sporadic and may occur after several years interval. Threatened due to encroachment and modification of habitat. Flowers in July.

Balanophora involucrata Hook. f. Fam.: **Balanophoraceae**

A leafless erect glabrous fleshy herb up to 13 cm tall. Looks like a phalloid fungus.

Collected only once from Titri, Panjgul (Kagan valley in Hazara). Perhaps overlooked. Flowers July-September.

Cadaba heterotricha Stocks ex Hooker Fam.: **Capparidaceae**

A shrub or small tree up to 6 m tall with thickish round hairy leaves. Flowers yellow, 15-20 mm broad, in clusters.

Found on coastal hillocks of Hawkes Bay and Sona Pass in Karachi. Flowers in November.

5. *Indeterminate:*

Taxa for which there is not enough information, but are known to be extinct, endangered, vulnerable or rare.

Pseudomerternsia sericophylla (Riedl) Y. Nasir

A bushy perennial with softly hairy lanceolate leaves, 5-9 cm long. Flowers small, purplish blue, in clusters.

Endemic to Pakistan (Kurram and Hazara in N.W.F.P.) Very rare, may possibly be endangered or extinct. Flowers in August.

Eulophia graminea Lindley ex Wall. Fam.: **Orchidaceae**

A herb with flowers and leaves together. Leaves persistent, narrow. Flowering stalk up to 60 cm long. Flowers spreading, greenish with purplish netting.

The underground part of this orchid was collected only once from Bharatian (Panjar valley, E. of Rawalpindi). Apparently very rare. Flowers March-April.

REFERENCES

Anonymous. (1980). FAO/UNEP Report.

Ali, S.I. & Qaiser, M. (1986). A phytogeogrephical analysis of the phanerogams of Pakistan and Kashmir. Proceedings of the Royal Society of Edinburgh, 89B, 89-101.

Plant Life of South Asia, 235–239, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

CONSERVATION BIOLOGY: SCIENCE FOR SURVIVAL

I. M. SULAIMAN, M. K. PANDIT AND C.R. BABU

Department of Botany
University of Delhi, Delhi-110007, India

ABSTRACT

Protection of the biological diversity is the evolutionary responsibility of mankind. Conservation biology is a multidisciplinary approach used for evolving the appropriate conservation strategies for living resourcces and is hence treated as Science for Survival. This aspect is exemplified with the field and experimental data collected on two plant taxa *Coptis* and *Meconopsis*, both of which are listed in Red Data Books as endangered.

INTRODUCTION

The species extinction crisis is a threat to mankind next only to thermo-nuclear war. The endurance of *Homo sapiens* is dependant on the survival of rest of the species. The essential processes responsible for the functioning of ecosystem, in which man is just one among the myriad of species, are maintained by the biotic community. Within the biotic community, the plant species perform wide range of functions in the ecosystem — (i) constitute the prime life-supporting system; (ii) form earth's soft green 'security' blanket; (iii) regulate the atmosphere; maintain hydrological cycle; feed the mankind; provide raw materials for scientific, industrial and pharmaceutical innovations.

It is largely through anthropogenic activities that the present 9% rate of species extinction will jump to 50% within the next few decades resulting in mass extinction of the magnitude that took place about 65 million years ago. It is estimated, for example, that 60,000 plant speices are threatened to slide towards extinction during our lifetime (Lewin, 1986).

It has been estimated that with the disappearance of one plant species, some 30 odd species also vanish (Ehrlich & Ehrlich, 1981). Recent studies on the biological diversity in tropics demonstrate that a single tropical tree (in rainforest of Peru) harbour as many as 43 species of ants belonging to 12 genera (Lewin, 1986). The rainforests harbouring such rich biological diversity have been disappearing at the rate of 50 acres per minute. It has increasingly become evident that the species survival is a must not only for the survival of human species, but also for the very existence of biosphere. This awareness has led to the concept of ecological security and the protection of the biological diversity is central to this concept. The net result of this awareness has been the development of conservation strategies. However, the underlying scientific logistics of conservation programmes for the management of biological diversity are not adequately understood. The failure of reintroductions of endangered birds and marine animals into their natural habitats, after captive breeding exemplifies the problem beset with the conservation of biological diversity. The attempts to re-introduce the cheer pheasant *(Catreas wallichii)* into Pakistan, for example, initially met with failure because of non-availability of the data on the habitat requirements of the bird (Lyles & Mary, 1987).

CONSERVATION BIOLOGY: STRATEGIES AND PROTECTION

To secure the endangered taxa, understanding their basic biology, ecology, evolutionary genetics and biogeography are a prerequisite. In other words, sound conservation strategies are the outcome of conservation biological studies — an interface between systematics and ecology on one hand, evolution and genetics on the other. It is in this context that the conservation biology is aptly described as 'Science for survival'. To make this point explicit, mention should be made of the danger of captive breeding strategy (a method of *ex situ* conservation) for the conservation of living resources as evident by the genetic homogeneity among the Asiatic lions preserved in zoos across the world and the populations maintained in wildlife sanctuaries (Cohen, 1990). The same holds true for plant species maintained in botanic gardens and germplasm institutions. The plant tissue culture technology considered to be an effective conservation practice as an *ex situ* measure has the same inherent problem.

Recent successful stories of reintroductions of nearly extinct species, based on captive breeding, include lynx in Western Europe, cheer pheasant in Pakistan, Arabian Oryx, blackpooled ferret in U.S.A., and the tree snail of the genus *Partula* in tahitian Island of Moorea (Lyles & Mary, 1987). These reintroductions failed initially, but subsequent conservation biological studies, particularly of the ecological niche characterisation made these successful. However, the evolutionary potential of these reintroductions is still a moot question to be answered.

The role of conservation biology in fighting for survival of some 5,000 vanishing species every year is amply demonstrated by Seal (Chairman of the Species Survival Commission (IUCN) Captive Breeding Specialist Group), who remarked, "If we can identify a species, however small the population, and if we have adequate commitments from Governments, then the science we have at our disposal today can ensure the survival of the species".

Conservation biological studies of animals have received much more attention than those of plants. In fact, there is neither an example of the successful reintroduction of nearly extinct plant species into its native habitat, nor a detailed account of the conservation biological studies of such a species. It is rather difficult to explain such a contrasting situations between animals and plant conservation biological studies. This is perhaps due to the fact that animals exhibit a behaviour which plants do not, therefore, attract attention of man and his benevolence.

Third World countries are rich in resource base but lack technologies to exploit the resources on a sustainable basis. The overexploitation of living resources to earn foreign exchange for repaying debts has led not only to the ecological insecurity but also to economic instability. The United States of America, for example, imports around 70% of medicinal herbs for manufacturing some drugs from India. This is notwithstanding the fact that of medical prescriptions more than 25% drugs come from plant sources already under exploitation (Prescott-Allen & Prescott-Allen, 1986). Under these circumstances does the conservation biological studies of plants deserve any status in science and technology programmes of the Third World programmes? The answer is obviously YES, as evident by the following facts : (i) the tropical forests are disappearing at a rate of 3000 acres per hour; (ii) the loss of keystone species leading to disruption in ecological processes, which in turn lead to instability and prevention of ecosystem development; (iii) only a minute fraction of the species is known to science; (iv) scientific information on the biology and economic potential of even those that are catalogued is scarce; (v) genetic diversity found in natural populations permit the evolution of novel variants which can thrive under ever-changing environments as well as are superior in economic traits; the genetic resources serves as a reservoir for the constant infiltration of desirable genes into cultivated plants through conventional as well as nonconventional technologies; (vi) the conservation biological data are useful to monitor the impact of anthropogenic activities onthe ecosystem functioning; (vii) generating baseline data for evolving effective conservation strategies; (viii) species extinction is a threat to mankind; and (ix) aid in the preparation of Green Books.

If one has to achieve the goals set for in the conservation biology, the next question to answer is what are the scientific approaches available. The following are some of the ways and means by which the goals of conservation biology can be met with: (i) field exploration studies to assess the range of distribution of populations/species as well as to collect the field biological data; (ii) systematic investigations assessing the correct taxonomic status of the taxa; (iii) population biological and evolutionary genetic studies to understand the extent of population differentiation, genetic structure of populations, reproductive fitness and evolutionary strategies followed by the speices to acquire resources; (iv) ecological studies, particularly plant-herbivore and plant-pollinator interactions, coevolution, trophic relationships and community function; (v) cytogenetic investigations aimed at revealing the under lying mechanisms associated with reproductive fitness leading to speciation and extinction; (vii) phytochemical studies to explain the defence mechanism and to detect natural products of commercial value; (viii) development of appropriate *in situ* and *ex situ* conservation strategies for the sustainable utilization of the resource; and (ix) computer models for monitoring the taxon in time and space.

CONSERVATION BIOLOGY OF *COPTIS* AND *MECONOPSIS*

Our investigations on the two taxa, *Coptis* (Ranuculaceae) and *Meconopsis* (Papaveraceae), ranged from basic systematic studies to ecological and evolutionary genetics. Ecological studies (including mapping of the natural populations) indicate that both the taxa are restricted to small geographic areas in the Eastern Himalaya, and are characterized by small population sizes. The small population size appears to be an inherent property of the genetic system investigated. This is perhaps due to manifestation of the severe bottlenecks in the reproductive biology. Both the taxa are characterized by genetic homogeneity in their populations and have specific of *Coptis* and *Meconopsis*, for example, require soils with high acidic pH and high percentage organic matter. *Coptis teeta* prefers shaded habitats (Pandit, unpublished); whereas the different species of *Meconopsis* are distributed mostly in the alpine meadows and scree slopes (*M. horridula, M. paniculata, M. simplicifolia, M. sinuata),* rarely getting into the forest fringes (*M. villosa*).

The reproductive strategies of the two taxa are different, although both the taxa are characterized by small population size. The reproductive bottlenecks in *Coptis teeta* operate both at pre — and post-fertilization levels, whereas *Meconopsis spp.*, being a copious seed producer suffer mostly from post fertilization hazards. This is indicated by high pollen sterility in *Coptis* which is a consequence of high male meiotic abnormalities and ovary abortion (Pandit, unpublished). In *Meconopsis spp.*, though the seed production is high, the seedling lethality drastically brings down the number of individuals in different populations.

Based on the multidiscipilinary investigations on *Coptis* and *Meconopsis* the following conclusions on their conservation biology are drawn:

(i) small population sizes are inherent property of the genetic systems of the species investigated, and are the consequences of bottlenecks in reproductive biology. The abnormal meiosis in *Coptis teeta* prevents or restricts its sexual reproduction. In *Meconopsis* segregation of lethals in the form of seedling lethality introduces high genetic load,
(ii) genetic homogeneity, together with small population sizes, and high genetic load suggests that the species form evolutionary dead ends and may become locally extinct due to short-term perturbation,
(iii) the ecological niches of all the taxa defined so that successful reintroduction can be achieved,
(iv) *ex situ* conservation strategies for species which are characterized by genetic homogeneity and are subject to hard selection have little significance,
(v) protection of natural habitats is the major approach by which the taxa can be secured on long-term basis.

To sum up, conservation of biological diversity is the evolutionary responsibility of mankind and conservation biology is the tool to fulfil the responsibility.

ACKNOWLEDGEMENT

Financial assistance provided by Ministry of Environment and Forests, Government of India, New Delhi (grant no. L. 14020/1/84-Env. 5), is gratefully acknowledged.

REFERENCES

Cohen, J.P. (1990). Genetics for wildlife conservation. *Bio Science*, 40:167-171

Ehrlich, P.R. & Ehrlich, A. (1981). *Extinction. The Cause and Consequences of the Disappearance of Species*. Random House, New York.

Lewin, R.A. (1986). A mass extinction without asteroides. *Science (Washington)*, 234:14-15.

Lyles, A.M. & Mary, R.M. (1987). Problems in leaving the ark. *Nature* (London), 326:245-246.

Prescot-Allen, C. & Prescott-Allen, R. (1986). *The First Resource: Wild Species in The North American Economy*. Yale University Press, New Haven & London.

REPRODUCTIVE BIOLOGY

Plant Life of South Asia, 243–257, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

REPRODUCTIVE BIOLOGY OF SOME ASCLEPIADACEAE FROM PAKISTAN
I. Some reproductive parameters and tribal classification

TAHIR ALI and S. I. ALI

Department of Botany,
University of Karachi, Karachi-75270, Pakistan.

ABSTRACT

Information regarding the floral visitors, their pollen load, levels of pollinator activity in natural populations, pollinium morphology, locations of the germination locus with reference to the pollinium insertion in the stigmatic chamber, pollen — ovule ratio and the ratio of pollen grains per pollinium to the ovules per carpel of *Calotropis procera* subsp. *hamiltonii*, *Glossonema varians*, *Pentatropis nivalis* and *Pergularia daemia* of tribe Asclepiadeae and *Caralluma edulis*, *Ceropegia bulbosa* and *Leptadenia pyrotechnica* of tribe Ceropegieae is presented. The pollinium morphology viz., orientation and margin, type of germination locus, pollen-ovule ratio and the type of pollinating agents seems to be tribe specific. The insertions of the whole pollinarium into the stigmatic chamber of *Pentatropis nivalis* is also being reported.

INTRODUCTION

The floral complexity of Asclepiadaceae is rivalled only by that of Orchidaceae in the plant world. Though the floral structure and mode of pollination were studied in 18th century, quantitative studies of the reproductive biology were first attempted in 1940s, however most of the studies are confined to the genus *Asclepias* and *Calotropis* (Ali & Ali, 1989). In Pakistan, no comprehensive study of the reproductive biology of the family has so far been carried out. Attempt has been made to study the reproductive biology of (i) *Calotropis procera* subsp. *hamiltonii* (Wight) Ali (ii) *Caralluma edulis* (Edgew.) Benth. (iii) *Ceropegia bulbosa* Roxb. (iv) *Glossonema varians* (Stocks) Hook. f. (v) *Leptadenia pyrotechnica* (Forssk.) Decne. (vi) *Pentatropis nivalis* (Gmel.) Field & Wood and (vi) *Pergularia daemia* (Forssk.) Chiov. In each case the floral morphology, floral visitors, levels of pollinator activity in natural populations, pollinium morphology and pollen — ovule ratios have been studied. *In vitro* pollinium germination has also been studied to find out the position of the germination locus.

MATERIALS AND METHODS

Floral Morphology: Fresh flowers collected from the vicinity of Karachi University Campus (KUC), Malir (MAL), Darsano Chino (DAR) and Mangopir (MAN) [within the limits of Karachi] were used for the study of floral morphology.

In vitro pollinium germination: Pollinia collected from freshly opened flowers were germinated at room temperature (30-35°C) in a moist chamber on the medium recommened by Khatoon & Ali (1983).

Determination of the number of pollen grains per pollinium and ovules per ovary: The pollinia were soaked in water over night. Due to hydration, the pollen masses become loose and by teasing the pollinium wall with dissecting needles pollen grains may easily be separated from each other and counted. Likewise, the total number of ovules was determined by counting the ovules in the ovaries of the same flowers used for the pollen count.

Insects (pollinators and visitors): Most of the insects were collected between 8:00 a.m. — 11:00 p.m. The number and location of pollinaria and position of the corpuscula either directly (basal) or indirectly (distal) attached to different parts of the insect's body was also determined.

Level of pollinator activity in natural populations: Random samples of flowers of *Calotropis procera* subsp. *hamiltonii, Ceropegia bulbosa, Leptadenia pyrotechnica, Pentatropis nivalis* and *Pergularia daemia* were collected from the above mentioned localities and preserved in 50% ethyl alcohol. Later the preserved flowers were studied microscopically in order to determine the number of pollinaria removed and the number of pollinia inserted into the stigmatic chambers. Flowers were also counted for double insertions and for insertions into chambers flanked by intact versus removed pollinaria.

RESULTS

Floral morphology: In the studied taxa, generally the flower is composed of 5 sepals and 5 petals. Two free and superior ovaries are joined by their styles to form a gynostegium with lateral stigmatic surfaces. These surfaces are enclosed by the anther flaps of two adjacent anthers to produce five stigmatic chambers. Filaments of five stamens fused to form the staminal column. Corona is in one or two series, outer series attached to the carolla and the inner to the staminal column. Each anther is bilocular and each anther sac contain a pollinium. There are five pollinaria in each flower, each consisting of paired pollinia from adja-

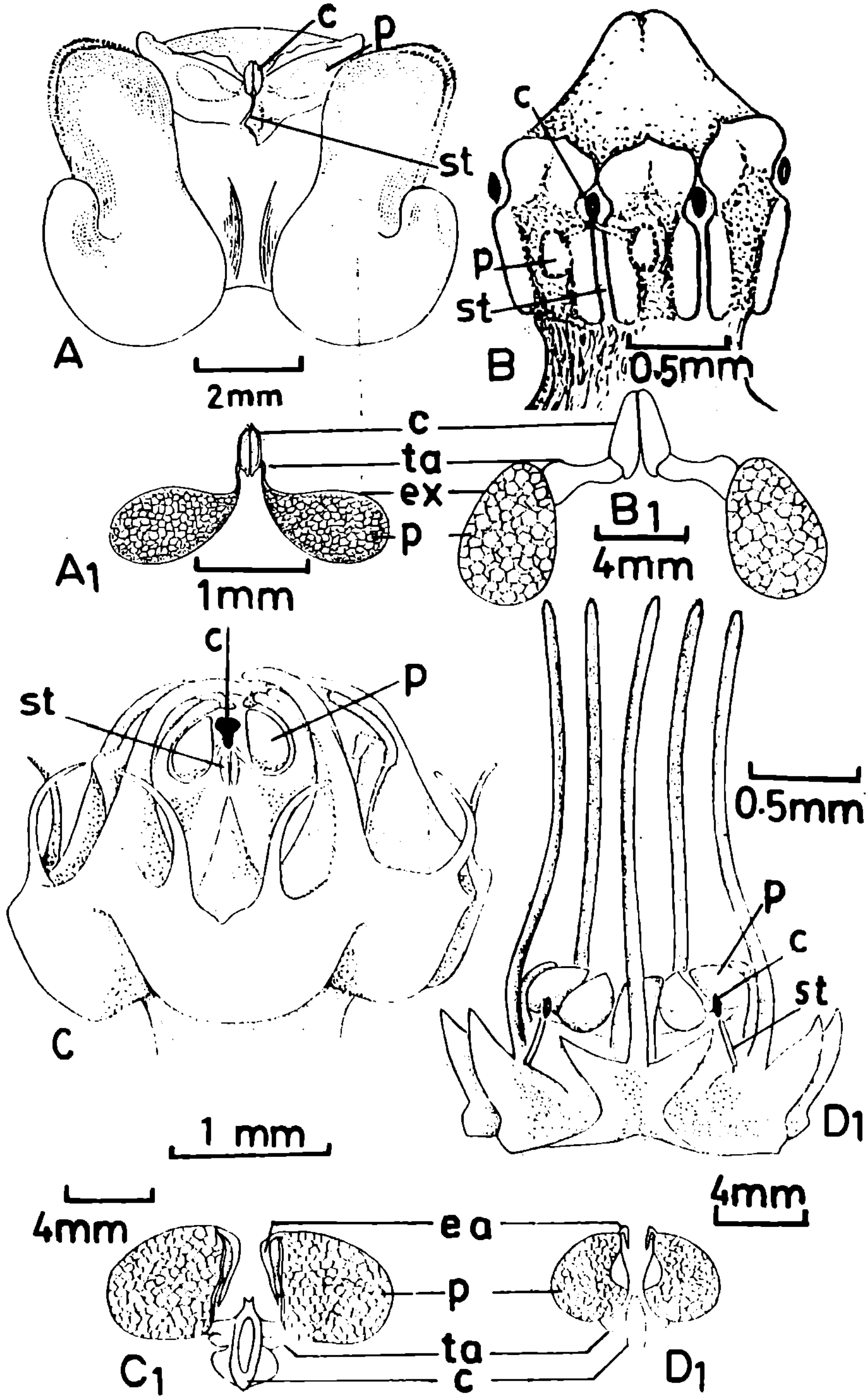


Fig. 1. Side view of Gynostegium (showing position of pollinia within anther sacs) and pollinarium. A-A1, *Calotropis procera* ssp. *hamiltonii;* B-B1, *Glossonema varians;* C-C1, *Caralluma edulis;* D-D1, *Ceropegia bulbosa.*

cent anthers joined by translator arms to a corpusculum located just above the opening of the stigmatic chamber. Pollinarium removal is effected when the corpusculum catches on a hair of an insect's body. Pollination is achieved when the pollinium lodges in the stigmatic chamber of another flower.

In *Calotrops procera* subsp. *hamiltonii*, *Glossonema varians*, *Pentatrops nivalis* and *Pergularia daemia*, the pollinia are located in the basal part of anther. Translator arms and pollinia are covered with anther sacs. Thus orientation of pollinium is pendulous and no external appendages are present on the pollinia (Fig. 1, A-B1). In *Caralluma edulis*, *Ceropegia bulbosa* and *Leptadenia pyrotechnica*, the pollinia are present in the apical part of the anther. Translator arms and pollinia are not covered with anther sacs. Thus orientation of pollinium is erect and pollinia are provided with external appendages at their distal end (Fig. 1, C-D1).

In vitro pollinium germination: In vitro pollinium germination studies are useful in determining the germination zone. This germination zone of the pollinium is designated as the germ furrow or germination locus to distinguish it from the germ pore of pollen grains. The germination locus is exocentrolateral in *C. procera* ssp. *hamiltonii*, exoproximolateral in *G. varians* and *P. nivalis*, exodistolateral in *P. daemia* and distal in *C. edulis*, *C. bulbosa* and *L. pyrotechnica* (Table 1; Fig. 2, A-D).

Table 1. Germination locus.

Taxa	Germination locus*
Tribe Asclepiadeae	
1. *Calotropis procera* subsp. *hamiltonii*	Exocentrolateral
2. *C. gigantea*	Exodistolateral**
3. *Glossonema varians*	Exoproximolateral
4. *Pentatropis nivalis*	Exoproximolateral
5. *Pergularia daemia*	Exosubdistolateral
Tribe Ceropegieae	
6. *Caralluma edulis*	Distal
7. *Ceropegia bulbosa*	Distal
8. *Leptadenia pyrotechnica*	Disital

* Terminology proposed by Rao & Kumari (1979) has been followed.

** Saoji & Chitaley 1975; Rao & Kumari 1979.

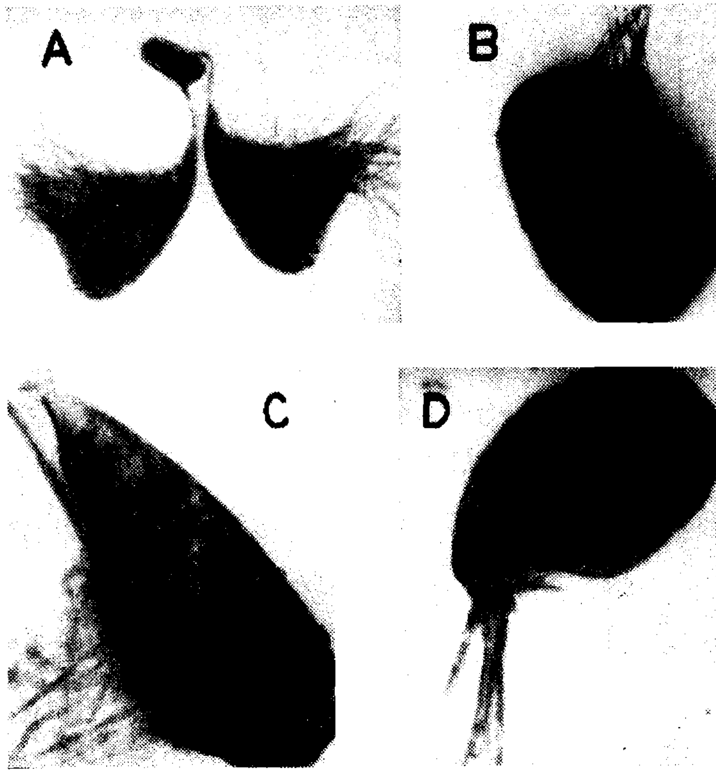


Fig. 2. Germination Loci: A. Exocentrolateral x 100 (*C. procera* ssp. *hamiltonii*); B. Exoproximolateral x 200 (*Glossonema varians*); C. Exodistolateral x 200 (*Pergularia daemia*); D. Distal x 200 (*Caralluma edulis*).

Insects (Pollinators): Floral visitors in the studied taxa belong to the orders Hymenoptera, Coleoptera and Diptera. The Hymenoptera are represented by 3 families, 6 species and 117 specimens, Coleoptera are represented by 2 families, 2 species and 7 specimens while Diptera are represented by 1 family, 1 species and 108 specimens. Details of pollen load i.e., number and location of pollinaria and position of corpuscula either directly (basal) or indirectly (distal) attached on different parts of the pollinators are given in Table 2. The insects bearing pollinaria are classified as pollinators. The main pollinators of the different taxa are listed in Table 3.

The level of pollinator activity: The level of pollinator activity is given in Table 4. The percentage of removed pollinaria ranges from 3.0 in *C. procera* subsp. *hamiltonii* (KUC) to 66.0 in *C. bulbosa*. However, the percentage of single insertion calculated on the basis of removed pollinaria varies from 3.0 in *P. nivalis* in (KUÇ) to 34.1 in (MAL) samples, whereas, the percentage of double insertions varies from 0-3.5. Thus it is obvious that the level of pollinator activity in the populations studied is low. Similar results have also been reported by Wyatt (1976) in *Asclepias*.

Table 2. Pollinaria load on insects (Pollinators).

Taxon	Insects	Sample size	Mouth part	Claws	Tibiae	Tarsi	
			B	B	B	B	D
Calotropis procera	Hymenoptera: Anthophoridae						
subsp. *hamiltonii*	*Xylocopa pubescens* Spin. ♂	5	—	—	—	30	—
	Xylocopa pubescens Spin. ♀	14	—	—	—	21	1
	Xylocopa fenestrata (F.) ♀	28	—	3	—	64	4
	Apidae						
	Apis florea (F.) ♀	10	3	—	5	32	2
Total		57	3	3	5	147	7
Pergularia daemia	Hymenoptera: Apidae						
	Apis florea (F.) ♀	6	—	8	—	—	—
	Braunsapis cf. *mixta* (Smith) ♀	24	—	5	—	—	—
	Vespidae						
	Ropalidia spatulata V.V. ♀	14	—	10	—	—	—
Total		44	—	23	—	—	—

Table 2. (Cont'd.)

Taxon	Insects	Sample size	Mouth part B	Claws B	Tibiae B	Tarsi B	D
Glossonema varians	Hymenoptera: Apidae						
	Apis florea (F.) ♀	6	20	—	—	—	—
	Scoliidae						
	Scolia quadripustulata Fabr. ♂ ♀	12	6	—	—	—	—
	Coleoptera: Dermestidae						
	Attagenus fasciatus (Thaumb.)	8	—	2	—	—	—
Total		26	26	2	—	—	—
Pentatropis nivalis	Hymenoptera: Apidae						
	Apis florea (F.) ♀	26	4	2	—	—	—
Ceropegia bulbosa	Diptera: Ceratopogonoidae						
	Forcepomyia sp.	108	28	—	—	—	—

Frequency and location of Basal (B) and Distal (D) corpuscula on insects.

Table 3. Pollinating insects.

Taxa	Tribe Asclepiadeae				Tribe Ceropegieae	
Insects	*Calotropis procera*	*Glossonema varians*	*Pentatropis nivalis*	*Pergularia daemia*	*Ceropegia bulbosa*	*Leptadenia pyrotechnica*
Xylocopa pubescens	+					
Xylocopa fenestrata	+					
Apis florea	+	+	+	+		
Braunsapis sp.				+		
Ropalidia spatulata						
Scolia quadripustulata		+				
Attagenus fasciatus		+				
Brumoides sturalis						+
Forcipomyia sp.					+	

Information about the pollinator of *Caralluma edulis* is not available.

Table 4. Level of pollintor activity.

Taxa	Localities	No.of flowers examined	Percentage of removed pollinaria	Percentage of single insertions of pollinia	Percentage of single insertions of pollinia in flowers with		Percentage of double insertions of pollinia
					Intact pollinaria	Removed pollinaria	
Tribe Asclepiadeae							
1. *Calotropis procera* ssp. *hamiltonii*	1, 2, 3	320	10.2	15.8	10.9	4.9	3.0
2. *Pentatropis nivalis*	1, 4	250	8.8	15.3	8.1	7.2	—
3. *Pergularia daemia*	4	167	3.6	15.0	11.7	3.3	—
Tribe Ceropegieae							
4. *Ceropegia bulbosa*	1	56	65.7	6.5	3.0	2.3	
5. *Leptadenia pyrotechnica*	1, 2, 3	227	39.7	5.9	4.1	1.8	0.3

1 = Karachi University Campus (KUC), 2 = Mangopir (MAN), 3 = Darsano Chino (DAR), 4 = Malir (MAL).

Pollen — Ovule Ratios: As pointed by Cruden (1977) Asclepiadaceae have low pollen — ovule ratio compared to other xenogamous species. In those members where pollinia are present, the important parameter is not p/o but the ratio of pollen grains in a pollinium to the number of ovules per carpel. The p/o in the studied taxa varies from 5.8-26.5 and the ratio of pollen grains per pollinium to the ovules per carpel varies from 1.2-5.3 (Table 5).

DISCUSSION

Sreedevi & Namboodiri (1982) have stated that the position of the germination locus is genus specific, however, the present study indicates that two or more genera may have similar germination locus. For instance *P. nivalis* and *G. varians* both have exoproximolateral germination locus and in *C. edulis*, *C. bulbosa* and *L. pyrotechnica* germination locus is distal. Furthermore, in some genera e.g., *Calotropis*, where the information about more than one species is available, intrageneric variation has also been observed. In *Calotropis gigantea* the germination locus is exodistolateral (Saoji & Chitaley, 1975; Rao & Kumari, 1979), whereas in *C. procera* it is exocentrolateral. Our observations also indicate that the position of the germination locus is strongly correlated with the tribal classification. In all members of the tribe Asclepiadeae, the germination locus is present in the broader part of the pollinium i.e., the germination locus is exolateral, whereas, in all memebers of the tribe Ceropegieae, the germination locus is located in the narrow portion at one end of the pollinium i.e., it is distal.

Tabel 5. Pollen — Ovule Ratios

Taxa	Pollen-Ovule Ratio	Pollen grains per pollinium/ovules per carpel
Tribe Asclepiadeae		
1. *Calotropis procera* ssp. *hamiltonii*	6.1	1.2
2. *Glossonema varians*	5.8	1.1
3. *Pentatropis nivalis*	8.9	1.7
4. *Pergularia daemia*	9.5	1.9
Tribe Ceropegieae		
5. *Caralluma edulis*	26.5	5.3
6. *Ceropegia bulbosa*	15.5	3.1
7. *Leptadenia pyrotechnica*	16.5	3.3

The pollinators (insects) seems to be species specific. The major pollinators of *C. procera* ssp. *hamiltonii* are *Xylocopa pubescens* and *X. fenestrata*. The pollinators of *G. varians*, *P. nivalis* and *C. bulbosa* are *Scolia quadripustulata*, *Apis florea* and *Forcipomyia* sp., respectively. *P. daemia* is pollinated by *Ropalidia spatulata* and *Braunsapis* cf. *mixta* (Fig. 3). Only *Apis florea* is the common pollinator of *C. procera* ssp. *hamiltonii*, *G. varians*, *P. nivalis* and *P. daemia*. It is interesting to note that *Apis florea* visits and pollinates only the members of the tribe Asclepiadeae. Most of the corpusculae are directly attached to the insects. In *C. procera* ssp. *hamiltonii*, *P. daemia* (Fig. 3, B & F) and *P. nivalis* the pollinaria are attached to the insect's leg while in *G. varians*, *C. bulbosa* (Fig. 3, E & G) and *L. pyrotechnica*, they are attached to the mouth parts.

The pollinator activity is assessed as the percentage of pollinaria removed from the flowers. In tribe Asclepiadeae, *P. daemia* has low pollinator activity (as indicated by low % of pollinaria removals) compared to the other two taxa while in tribe Ceropegieae, pollinator activity is high in *C. bulbosa* (high % of pollinaria removals) than *L. pyrotechnica*.

Tribe Asclepiadeae have more effective pollinator service than the tribe Ceropegieae. As in tribe Asclepiadeae, the rate of pollinaria removal is low and rate of pollinia insertions (of the removed pollinaria) in stigmatic chambers is high (thus loss of pollinaria is less) while tribe Ceropegieae has high rate of pollinaria removal and low rate of pollinia insertions (of the removed pollinaria) indicating that most of the removed pollinaria are lost, thus having less effective pollinator service.

Wyatt (1978) critically investigated the difference in the frequency of pollinium insertions in the flowers having intact pollinaria and those from which the pollinaria have been removed. He concluded that fewer pollinia are inserted into flowers with removed pollinaria than into flowers with intact pollinaria. Out of 10 populations studied by us (Table 4) in 8 populations, there were more insertions in flowers with intact pollinaria. Thus, our observations on 5 different genera also support Wyatt's conclusions. In his opinion, this process may affect some degree of temporal separation of the male and female function of the flower. As the probability of insertion is greater for flowers with intact pollinaria, out crossing is encouraged, since insertions are likely to be from flowers from which pollinaria have been removed to other flowers with intact pollinaria.

In most of the cases, the pollinium insertion mechanism described by Wyatt (1976) for the genus *Asclepias* holds good and only one pollinium is inserted into the stigmatic chamber and the translator arm breaks at the knee bend below

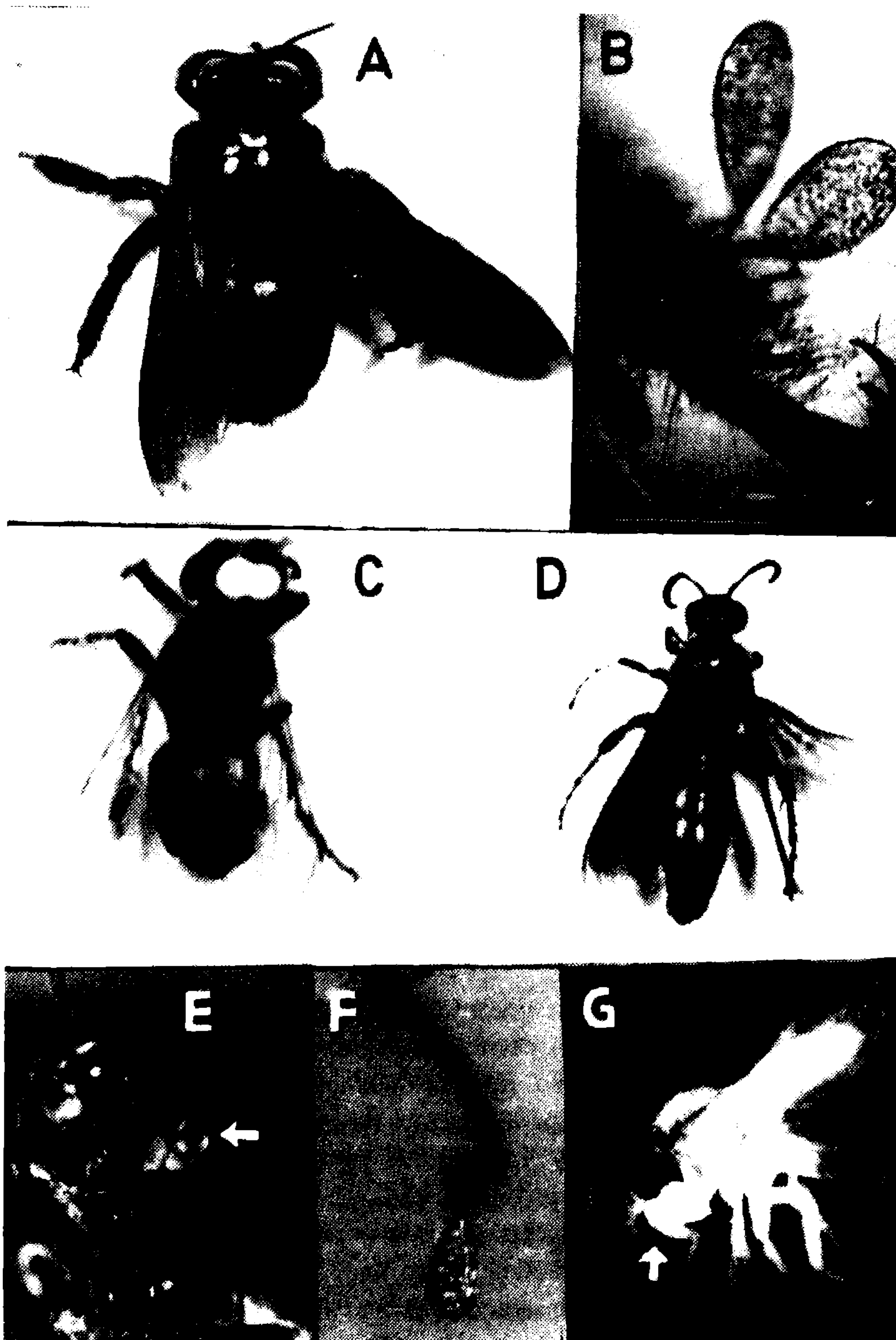


Fig. 3. Pollinators: A, *Xylocopa pubescens* x 2; B, pollinarium attached to its tarsal segment x 280 (*C. procera* ssp. *hamiltonii*); C, *Apis florea* x 5 (*P. nivalis*); D, *Scolia quadripustulata* x 5; E, pollinaria attached to its mouth part x 70 (*G. varians*); F, pollinarium attached to the claw of *Ropalidia spatulata* x 70 (*P. daemia*); G, *Forcipomyia* sp., pollinarium attached to its mouth part x 80 (*C. bulbosa*).

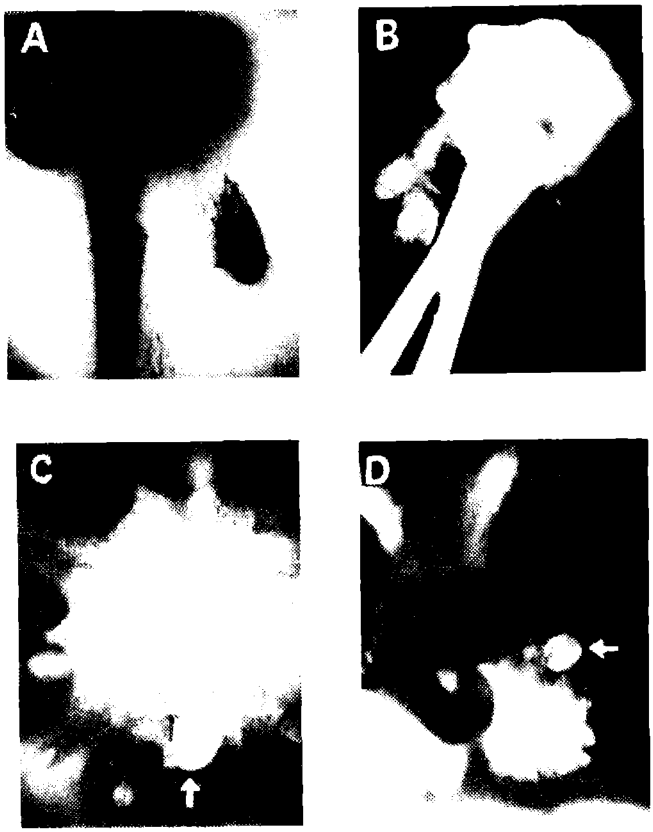


Fig. 4. A, Dissected stigmatic chamber showing insertion and germination of a pollinium x 70 (*P. daemia*); B, dissected stigmatic chamber showing entire pollinarium (Corpusculam with both pollinia) insertion and germination of both pollinia x 70 (*P. nivalis*); C & D, side view of gynostegium showing insertion of a pollinium only external appendages inserted and rest of the pollinium remain outside the stigmatic chamber (*C. edulis* x 70 & *C. bulbosa* x 280, respectively).

the corpusculum (Fig. 4, A). However, in *Pentatropis nivalis*, sometimes whole of the pollinarium is inserted into the stigmatic chamber and the groove of the corpusculum of an intact pollinarium does not serve as an attachment point for the translator arm (Fig. 4, B). In the members of the tribe Asclepiadeae, entire pollinium is inserted inside the stigmatic chamber and is rarely extended partly outside the anther flaps while in the members of the tribe Ceropegieae, only the external appendages i.e., germination locus is inserted inside the stigmatic chamber and rest of the pollinium remains outside the anther flaps (Fig. 4, C&D).

The p/o and ratio of pollen grains per pollinium to the number of ovules per carpel also seems to be tribe specific. In tribe Asclepiadeae p/o is upto 10.0 and in tribe Ceropegieae it is more than 15.0 while ratio of pollen grains per pollinium to the number of ovules per carpel in tribe Asclepiadeae is upto 2.0 and in tribe Ceropegieae it is more than 3.0.

Table 6. Some reproductive parameters and tribal classification.

Tribe	Orientation	Margin	Pollinium External appendages	Germination locus	Insertion in stigmatic chamber	Percentage of removed pollinaria	Percentage of single insertions of pollinia	Pollen-Ovule Ratio	Pollen grains per pollinium / Ovules per carpel
Asclepiadeae	Pendulous	Not pellucid	—	Exolateral	Entire pollinium	3.6-10.2	15-15.8	5.8-9.5	1.2-1.9
Ceropegieae	Erect	Pellucid	+	Distal	Only external appendages (Germination locus)	39.7-65.7	5.9-6.5	15.5-26.5	3.1-5.3

+ = Present; - = absent.

The reproductive parameters and tribal classification is summarized in Table 6. Thus tribe Asclepiadeae is characterised by pendulous pollinium, without pellucid margin and with exolateral germination locus which is not surrounded by external appendages. The entire pollinium is inserted inside the stigmatic chamber with the exception of *P. nivalis* where sometimes the entire pollinarium get inserted. The percentage of removed pollinaria is less than 15.0 and the percentage of single insertions of pollinia is more than 10.0; the raito of pollen per pollinium to the ovules per ovary ranges from 1.0-2.0 and the pollen — ovule ratio is up to 10.0. Floral morphology particularly, pollinium orientation seems to be adapted for pollination by strong and large insects, as the removal of pendulous pollinium is not easy and force is required for its removal whereas the tribe Ceropegieae is characterised by erect pollinium, with pellucid margin and distal germination locus which is surrounded by external appendages. Only the germination locus (external appendages) is inserted in the stigmatic chamber. The percentage of removed pollinaria is more than 15.0 and the percentage of single insertions of pollinia is less than 10.0, the ratio of the pollen per pollinium to ovules per ovary is more than 3.0 and the pollen — ovule ratio is more than 15.0. As the pollinia are located in the apical part of the anther, therefore they can be removed easily by small insects.

REFERENCES

Ali, T. & Ali, S.I. (1989). Pollination biology of *Calotropis procera* subsp. *hamiltonii* (Asclepiadaceae). *Phyton*, 20: 175-188.

Cruden, R.W. (1977). Pollen — ovule ratios: A conservative indicator of breeding systems in flowering plants. *Evolution*, 31: 32-46.

Khatoon, S. & Ali, S.I. (1983). In vitro pollinium germination of some Asclepiads. *Asklepios*, 29: 8-17.

Rao, M.R. & Kumari, O.L. (1979). Germination loci of pollinia and their taxonomic significance. *Geobios*, 6: 163-165.

Saoji, A.A. & Chitaley, S.D. (1975). Germination and storge of pollinia in *Calotropis gigantea* (Linn.) R.Br. ex Ait. *Botanique*, 7: 55-62.

Sreedevi, P. & Namboodiri, A.N. (1982). The germination of pollinium and the organization of germ furrow in some members of Asclepiadaceae. *Can. J. Bot.*, 60: 166-177.

Wyatt, R. (1976). Pollination and fruit set in *Asclepias*: a reappraisal. *Amer. J. Bot*, 63: 845-851.

Wyatt, R. (1978). Experimental evidence concerning the role of the corpusculum in *Asclepias* pollination. *Syst. Bot.*, 3: 313-321.

Proceedings of the International Symposium on Plant Life of South Asia held at the Department of Botany, University of Karachi, Karachi-75270, Pakistan. 24-27 February, 1991

Plant Life of South Asia, 259–265, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

ABSTRACTS OF POSTER EXHIBITS

TAXONOMIC STUDIES IN THE GENUS *ARTEMISIA* L. (COMPOSITAE) FROM PAKISTAN AND N.W. HIMALAYAS.

Abdul Ghafoor
Deparment of Botany, University of Karachi, Karachi-75270, Pakistan.

Based on the studies of extensive herbarium material, a revision of the genus *Artemisia* L., from Pakistan and N.W. Himalaya is presented. A new monotypic genus viz., *Artemisiella* is described. Generic limits and relationships with other genera of *Anthemideae* belonging to *Artemisia* group are discussed. In all 44 species have been recognized including *A. alii* and *A. khuzdarense* as new species. Two new varieties have been described. *A. swatensis* has been reduced to the synonymy of *A. cappillaris*.

BIOLOGY OF *GREWIA TENAX* COMPLEX FROM PAKISTAN

Rizwan Yousuf Hashmi and Mohammad Qaiser
Department of Botany, University of Karachi, Karachi-75270, Pakistan.

Grewia tenax (Forssk.) Fiori is generally considered as a highly polymorphic taxon. However, a biological study of this complex from Pakistan indicates the existence of two distinct taxa viz., *G. tenax* (Forssk.) Fiori and *G. erythreae* Schwienf. *G. tenax* is characterized by having taller growth habit, ovate-acute leaves and deeply 4-lobed glabrous ovary; while *G. erythraea* is delimited by smaller individuals with obovate-obtuse and entire, densely hairy ovary. The two taxa also differ on the basis of chemical and palynological characters. Both the species are facultative xenogamous, sympatric in distribution and the flowering period is also overlaping in southern Pakistan. An intermediate and a fairly heterogenous population was also found in southern Pakistan, indicating a possiblility of limited gene exchage between the 2 species in southern Pakistan.

A MICROMORPHOLOGICAL STUDY IN SOME REPRESENTATIVE GENERA OF THE TRIBES STACHYDEAE AND SATUREJEAE (LAMIACEAE)

Syed Zahoor Husain and M. Qaiser*
Department of Botany, Plant Science Laboratories, University of Reading, Whiteknights, Reading RG6 2AS, England.

Tho Old World genera in tribes Stachydeae and Saturejeae are usually distributed either in Europe and North Africa or in the temperate parts of Asia. The centres of distribution of investigated genera are mainly in the Mediterranean region and South West Asia. In taxonomic revisions very little reference is usually made to micromorphological characters, in particular, to nutlets and leaf indumentum, inspite of the stability of these characters. SEM of nutlet surface and patterns of leaf indumentum show a wide range of variation, not only among genera, but also at specific and infraspecific level. In view of this, nutlet surface and leaf indumentum, as seen in the SEM, of representative species of 18 genera in the tribes Stachydeae and Saturejeae provide useful additional character combinations in delimiting these closely related genera.

*Permanent Address: Department of Botany, University of Karachi, Karachi-75270, Pakistan.

THE EFFECT OF AMMONIUM SULPHATE, SUPERPHOSPHATE AND FARM YARD MANURE ON GROWTH, OIL AND MUCILAGE CONTENTS IN *OCIMUM BASILICUM* LINN.

Imtiaz-ul-Haq and Ihsan Ilahi
Department of Botany, University of Peshawar, Peshawar, Pakistan.

The effect of different fertilizers e.g., ammonium sulphate, superphosphate and farm yard manure in single and double doses, on the growth, oil and mucilage contents of *Ocimum basilicum* Linn., were studied.

It was observed that application of different fertilizers singly or in combination had different effects. Ammonium sulphate and superphosphate mixed double dose (60 gm/bed) increased the height of plants and length of leaves. Ammonium sulphate single dose (30 gm/bed) increased the oil contents, while by the application of farm yard manure the mucilage contents increased in the seeds of *Ocimum basilicum* as compared to control and other treatments of fertilizers.

MEIOTIC CHROMOSOME COUNTS IN MEMBERS OF FABACEAE FROM PAKISTAN.

Bushreen Jahan, Ahsan A. Vahidy* and S.I. Ali
Department of Botany, University of Karachi, Karachi-75270, Pakistan.

Chromosome counts were determined in 60 taxa belonging to 35 genera in 17 tribes of Fabaceae from Pakistan. New chromosome numbers are recorded for the following taxa: *Argyrolobium stenophyllum* Boiss. (n = 13); *Astragalus bicuspis* Fish. (n = 8); *A. ptilocephalus* Baker (n = 8); *Chesneya parviflora* Jaub. & Spach (n = 8); *Indigofera caerulea* Roxb. var. *caerulea* (n = 8); *Sophora mollis* (Royle) Baker ssp. *griffithii* (Stocks) Ali (n = 9) and *Taverniera glabra* Boiss. (n = 8). Counts for 36 other taxa are reporteed for the first time from Pakistan.

Department of Genetics, University of Karachi, Karachi-75270, Pakistan.

NEW CHROMOSOME COUNTS IN GRASSES OF PAKISTAN

M. Moinuddin, Nadeem Ahsan, A.A. Vahidy* and S.I.Ali
Department of Botany, University of Karachi, Karachi-75270, Pakistan.

Chromosome counts for 104 members of Poaceae are reported from Pakistan. Of these, the counts for 11 taxa viz., *Agrostis munroana* Aitch. & Hemsl. (n = 21), *Aristida funiculata* Trin. & Rupr. (n = 11), *Elionurus royleanus* Nees ex A. Rich (n = 10), *Leptothrium senegalense* (Kunth) W.D. Clayton (n = 10) *Panicum atrosanguineum* Hochst. ex A. Rich (n = 18), *Pennisetum lanatum* Klotzsch (n = 18), *Piptatherum gracile* Mez (n = 12), *Poa sinaica* Steud, (n = 7), *Sporobolus arabicus* Boiss. (n = 18), S. *nervosus* Hochst. (n = 18), *Stipagrostis plumosa* (L.) Munro ex T. Anderss. (n = 22), are new to science. Counts for 63 other taxa are new for the flora of Pakistan.

*Department of Genetics, University of Karachi, Karachi-75270, Pakistan.

A PALYNOLOGICAL STUDY OF THE FLORA OF KARACHI

Anjum Parveen and M. Qaiser
Department of Botany, University of Karachi, Karachi-75270, Pakistan.

Pollen morphology of 353 species, from Karachi belonging to 67 families, distributed in 58 Dicots and 10 Monocots, have been examined by Light and Scanning Electron Microscopy. Pollen morphology of these families is extremely varied in size, shape, polarity, structure, number and position of apertures and exine ornamentation. The size of pollen ranges from smallest (*Zygophyllum simplex* 9.7 x 9.8 μm) to largest (*Senera incana*, 100.2 x 111 μm). The grains are commonly prolate-spheroidal to oblate spheroidal, sometimes prolate to subprolate. The apertures are generally colporate, colpate or porate rarely nonaperturate. In some families more distinct heterocolporate grains are also observed.

Besides this, some miscellaneous type of apertures have also been found in *Neuradaceae*, *Sapindaceae* and *Menyanthaceae (Nymphioides cirstata)*. Tectum of the grains is extremely varied, i.e., echinate and tubliferous spinulose. In addition to this some families are remarkably distinct in their pollen types viz., *Acanthaceae*, *Boraginaceae*, *Convolvulaceae*, *Polygonaceae*, *Typhaceae and Zygophyllaceae*.

With few problematic exceptions, pollen data is well correlated with the accepted evolutionary trends.

FOLIAR MICRO-ARCHITECTURAL FEATURES OF SOME GRASSES OF PAKISTAN.

Abdur Rashid, Mohammad Ali and A.R. Beg*
Department of Botany, University of Peshawar, Peshawar, Pakistan.

Foliar epidermal microstructres of 22 species of grasses were examined. The study revealed that the plants could be divided into 2 groups, viz., Festucoid and Panicoid. While the Festucoid plants have generally horizontally elongated silica bodies with entire outlines and usually in short rows, generally parallel-sided stomata, macro hairs with a spherical base, short cells in short rows, the Panicoid group has mostly dumb-bell and cross, even nodular, crescent, saddle-shaped and oblong silica bodies, short cells generally in long rows, stomata triangular, long cells usually with sinuous-moderately sinuous walls, micro hairs and sometimes variable-shaped stomata, tall dome stomata, both oblique and small cuticular papillae.

The species investigated exhibit a big variation, cross, cross to dumb-bell, dumb-bell, saddle, crescent and horizontally elongated types of silica bodies, outlines of long cell walls entire to sinuous, thickness from thin to moderately thick, mainly triangular and parallel-sided, some low dome, rarely tall dome and variable-shaped stomata, micro hairs, macro hairs of 3 types (short rigid, long thick-walled with superficial base and long thick-walled with sunken base),

*Forest Botanist, Pakistan Forest Institute, Peshawar, Pakistan.

pointed, unpointed, hooks and angular prickles, oblique and small cuticular papillae and large thin papillae. The structures are quite reliable as taxonomic features. To further high-light the importance of the characters, a key to the species is given.

FOLIAR EPIDERMAL MICROSTRUCTURES AS AN AID IN THE TAXONOMY OF CHENOPODIACEAE AND AMARANTHACEAE

Abdur Rashid and Ihsan Ilahi
Department of Botany, University of Peshawar, Peshawar, Pakistan.

Foliar epidermal microstructures viz., trichomes, stomatal types and epidermal cells were studied in eight species of Chenopodiaceae and fourteen species of Amaranthaceae readily available. Species examined are generally hypoamphistomatic except *Haloxylon recurvum* and *Digera muricata* which are epiamphistomatic. Among the Chenopods examined, some possess no trichomes at all while others bear only glandular trichomes. As to the Amaranthaceae some have no trichomes, some only non-glandular and still others only glandular trichomes. Likewise, distinct variation occurs, too, in the stomatal complexes in both the families. The Chenopods possess four types of stomata viz., diacytic, anomocytic, anisocytic and hemiparacytic, the others possess only three of them with first named being absent. Over-all for the species checked, the stomata are found either pure or in fixed proportions of 2-3 types asociations; diacytic type is rare, only occurs pure and only in Chenopodiaceae, while the anomocytic-hemiparacytic association is rare in both the families; anomocytic type of stomata sometimes occur pure and only in Amaranthaceae while anomocytic-anisocytic-hemiparacytic and anomocytic-anisocytic associations being the most dominant and next below in occurrence respectively. The characters of trichomes and stomata in all their variations and associations were found reliable taxonomic features, that of epidermal cells proved to be of limited importance. Keys to the species are given.

PLASMID BORN COPPER RESISTANT *PSEUDOMONAS* FROM POLLUTED WATER.

AnjumNasim Sabri and Shahida Hasnain
Department of Botany, University of the Punjab, Quaid-e-Azm Campus, Lahore-20, Pakistan.

Industrial pollutants may be degraded and converted into valuable composit manure or they cannot be degraded by natural biological processes. These are poisonous, carcinogenic, tetragenic and mutagenic in action and copper is one of them, which due to being mobile in environment inhibits biotic growth by affecting cell division and cell density. Bacteria can play crucial role in clearing the heavy metals from the polluted waters, for that reason copper resistant bacteria from industrial wastes and wastes of MIRDC were isolated. Two isolates which could tolerate upto 400 µg/ml copper in the medium were obtained and were characterized morphologically, physiologically and biochemically. These studies revealed that both strains belong to genus *Pseudomonas*. Since extra chromosomal determinants may be present in extreme environment, these strains were screened for the presence of plasmids. Plasmids were present in both strains and conjugation experiments demonstrate that in one of them copper resistance is plasmid born.

POLYCYCLIC AROMATIC HYDROCARBONS DEGRADING *PSEUDOMONAS* SP. FROM OIL WASTES.

Samina Sardar and Shahida Hasnain.
Department of Botany, University of the Punjab, Quaid-e-Azam campus, Lahore-20, Pakistan.

Keeping the importance of biodegrading bacteria in pollution, bacteria was isolated from oil wastes of Filling Station. Purified colonies were morphologically and biochemically characterized. Bacteria were screened for degradation of aromatic hydrocarbons using a sprayed plate technique. One isolate was tentatively indentified as *Pseudomonas* sp., which had the ability to degrade diphenyl amine, biphenyl, naphthalene, xylene, benzene and taulene. Isolate was screened for antibiotic and heavy metal resistance. It could resist amplicillin and chloramphenicol and was sensitive to streptomycin, tetracycline and kanamycine. As regards the heavy metal resistance it could grow on media containng Mn^{+2}, Cd^{+2}, Ni^{+2}, Al^{+3}, Ba^{+2}, Hg^{+2}, Zn^{+2}, Sn^{+2}, Co^{+2} and Cu^{+2} while it was sensitive to Cr^{+3}. These isolate also harbour a plasmid which has not yet been characterized.

EFFECTS OF INDUSTRIAL EFFLUENTS ON GERMINATION, GROWTH, DNA, RNA AND PROTEIN CONTENTS OF 10 DAYS OLD SEEDLINGS OF *GOSSYPIUM HIRSUTUM* VAR. NIAB 78 AND *ALLIUM CEPA* VAR. PHULKARA.

Shahbaz Khan Sherwani and Shahida Hasnian
Department of Botany, University of the Punjab, Quaid-e-Azam Campus, Lahore-20, Pakistan.

Environment industrial pollution is deteriorating the soil conditions for plant growth. In the present study effects of polluted waters from different indstries on the growth of *Gossypium hirsutum* var. Niab 78 and *Allium cepa* var.

Phulkara were studied. Effluents thrown out in the environment were collected from different industries. Seeds were grown for 10 days in different polluted waters and effects on 10 days old seedlings were studied. Effects on germination growth and changes at molecular level (DNA, RNA and Protein) were evaluated. Each treatment was found to be affectiong differently on the two plant species. The changes observed in germination, growth, DNA, RNA and Protein content of seedlings will be presented.

Plant Life of South Asia, 267–274, (1991)
S.I. Ali and *A. Ghaffar* (Eds.)

LIST OF PARTICIPANTS

AUSTRIA

Prof. Dr. K.H. Rechinger,
Beckgasse 22,
A-1130 Wein,
Austria.

BANGLADESH

Prof. Dr. Salar Khan,
Department of Botany,
University of Dhaka,
Dhaka 1000,
Bangladesh.

Dr. Ansarul Karim,
Department of Botany,
University of Chittagong,
Chittagong,
Bangladesh.

CHINA

Prof. Dr. Y.C. Ma,
Biology Department,
Inner Mongolia University,
Hohhot,
Peoples' Republic of China.

INDIA

Prof. Dr. S.S. Bir,
Department of Botany,
Punjabi University,
Patiala 147002,
India.

Dr. I.M. Sulaiman,
Department of Botany,
University of Delhi,
Delhi-110007,
India.

PAKISTAN

Miss Farhat Agha,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Bashir Ahmad,
Lecturer in Botany,
Government College,
Jhelum.

Mr. Iftikhar Ahmad,
Department of Botany,
University of the Punjab,
New Campus,
Lahore.

Prof. Dr. Jamil Ahmad,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Laiq Ahmad,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Manzoor Ahmad,
Department of Botany,
Government Dayal Singh College,
Lahore.

Dr. Maqbool Ahmed,
Nematological Research Centre,
University of Karachi,
Karachi-75270.

Mr. Tufail Ahmad,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. S. M. Nadeem Ahsan,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Saeeda Ahsan,
Department of Botany,
University of Karachi,
Karachi-75270.

Mrs. Hajra Azhar Ali,
Department of Botany,
University of Karachi,
Karachi-75270.

Prof. Dr. S.I. Ali,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Tahir Ali,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Arif-uz-Zaman,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. Khadija Aziz,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Seemi Aziz,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Bushra Amin,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Naseem Anwar,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Mirza Mahmood Baig,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. A. R. Beg,
Forest Botanist,
Pakisten Forest Research Institute,
Peshawar.

Miss Tahira Bano,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Rubina Dawar,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Huma Fatima,
Department of Botany,
University of Karachi,
Karachi-75270.

Prof. Dr. Abdul Ghaffar,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Abdul Ghafoor,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Damian Gill,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Hamidullah,
Department of Pharmacy,
Gomal University,
Dera Ismail Khan,
N.W.F..P.

Mr. Imtiazul Haq,
Department of Botany,
University of Peshawar,
Peshawar.

Dr. M. H. Hashmi,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Rizwan Y. Hashmi,
Cereal Diseases Research Centre,
Pakistan Agricultural Research
Council,
University of Karachi,
Karachi-75270.

Mr. M. Habib,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. Shahida Hasnain,
Department of Botany,
Punjab University,
Quaid-e-azam Campus,
Lahore.

Mr. Khalid Hayat,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Syed Raza Hussain,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss. Farzana Intezar,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Mohammad Iqbal,
Department of Zoology,
University of Karachi,
Karachi-75270.

Mr. Shoaib Ismail,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Irfan Haider Jafri,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Bushreen Jahan,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Nusrat Jahan,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Shadan Jabeen,
Department of Botany,
University of Karachi,
Karachi-75270.

Mrs. Anjum Jalal,
Department of Botany,
University of Karachi,
Karachi-75270.

Prof. Dr. M. Jalaluddin,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. M. Ajmal Khan,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. Aminul Haq Khan,
C/o World Wide Fund for Nature,
P.O. Box 1312,
Ferozepore Road,
Lahore.

Prof. Dr. M. Ishaq Khan,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Zali Khan,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Amber Khatoon,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Surayya Khatoon,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Naushaba Khatoon,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. Khalida Khatoon,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Soofia Malik,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. M. Moinuddin,
Department of Botany,
University of Karachi.
Karachi-75270.

Mr. Tariq Mahmood,
Department of Botany,
University of Karachi,
Karachi-75270.

Mrs. Fatima Mehdi,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. Y.J. Nasir,
National Herbarium,
Pakistan Agricultural Research
Council,
Rawalpindi.

Ms. Summia Naqi,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Farah Naz,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Taifoor Naz,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Muhammed Niaz,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Saood Omer,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Anjum Parveen,
Departure of Botany,
University of Karachi,
Karachi-75270.

Prof. Dr. M. Qaiser,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Qurratulain,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. U.S. Qureshi,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Naila Rahar,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Abdur Rashid,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Atia Rasool,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Zeenat A. Razaq,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Ghulam Rasool Sarwar,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Rubina Nikhat Shaikh,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. Razi Abbas Shamsi,
Department of Botany,
Punjab University,
Quaid-i-Azam Campus,
Lahore.

Mr. Amjad B. Siddiqui,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. Khushnood A. Siddiqi,
Atomic Energy Agricultural Research Centre,
Tandojam.

Prof. Dr. M. Rehan Siddiqi,
Department of Botany,
F. C. College,
Lahore.

Miss Samina Siddiqi,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Atiya Durdana Siddiqui,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Rubina Siddiqui,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Tahmeena Siddiqui,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Rubina Shaukat,
Department of Botany,
University of Karachi,
Karachi-75270.

Mr. Akhlak K. Sherwani,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Seema Sultan,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Farrukh Sultana,
Department of Botany,
University of Karachi,
Karachi-75270.

Mrs. Fauzia Sultana,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss. Sobia Tayyab,
Department of Botany,
University of Karachi,
Karachi-75270.

Dr. Mubina Usman,
Department of Botany,
University of Karachi,
Karachi-75270.

Prof. Dr. A.A. Vahidy,
Department of Genetics,
University of Karachi,
Karachi-75270.

Miss. Qamar Zaman,
Department of Botany,
University of Karachi,
Karachi-75270.

Miss Zakia Zia,
Department of Botany,
University of Karachi,
Karachi-75270.

SRILANKA

Dr. (Mrs.) A. S. Seneviratne,
Department of Botany,
University Colombo,
Colombo 3,
Sril Lanka.

U.K.

Dr. J. Barnett,
Department of Botany,
University of Reading,
RG6 2AS
England.

Prof. I.C. Hedge,
The Herbarium,
Royal Botanic Garden,
Edinburgh EH3 5LR
U.K.

Dr. S. Zahoor Husain,
Department of Botany,
University of Reading,
Reading,
Whiteknights,
England.

Miss. J. M. Lamond,
The Herbarium,
Royal Botanic Garden,
Edinburgh EH3 5LR,
Scotland,
U.K.

Mr. A. Radcliffe-Smith,
The Herbarium,
Royal Botanic Gardens,
Kew, Richmond,
Surrey TW9 3AB,
U.K.

U. S. A.

Dr. James A. Duke,
Chief Medicinal Plant Resources Lab.,
Federal Research,
North Eastern Region,
Beltsville Agricultural Research
Centre,
USDA, Beltsville,
Maryland 20705, U.S.A.

Dr. Steven M. Goodman,
Field Museum of Natural History,
Roosevelt Road at Lake Shore Drive,
Chicago,
U.S.A.

Dr. Joseph H. Kirkbride, Jr.
Systematic Botany, Mycology &
Nematology Lab.,
Biosystematics & Beneficial Insects
Institute,
USDA, ARS
Beltsville, Maryland 20705,
U.S.A.

Prof. Dr. R.R. Stewart,
1420 Santo Domingo Ave.,
Duarte,
CA 91010, U.S.A.

Mrs. Ellen Stewart,
181 Glory View Drive,
Grand Junction,
Co 81503,
U.S.A.

FEDERAL REPUBLIC OF GERMANY

Prof. Dr. H. Freitag,
Morphologie und Systemmatrik der
Pflanzen
Gesamthochschule Kassel,
Henirich-Plett Str. 40,
D-3500 Kassel,
West Germany.

INDEX