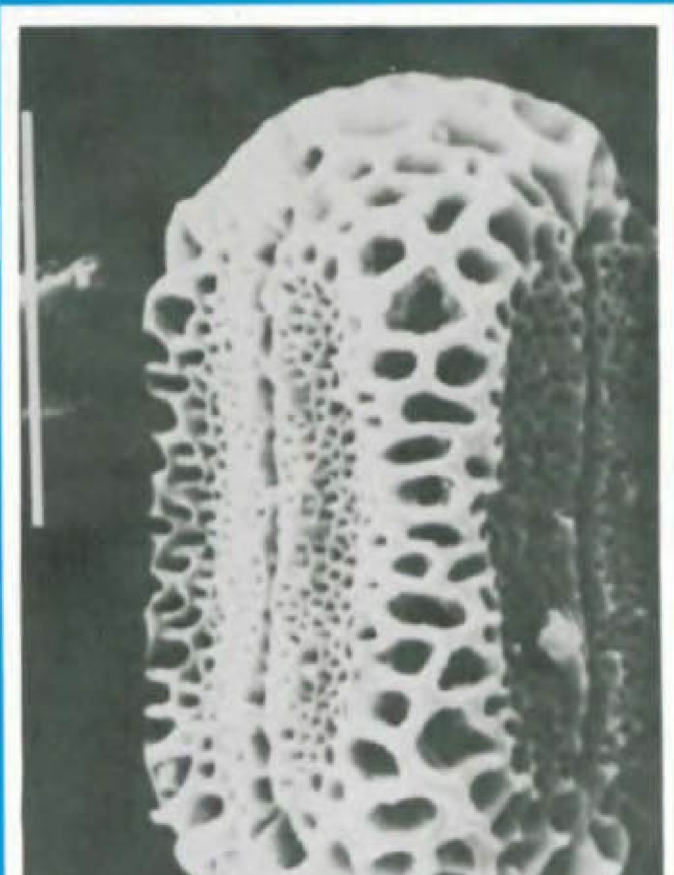
POLLEN MORPHOLOGY AND SYSTEMATIC RELATIONSHIP OF THE FAMILY POLYGONACEAE



M. S. MONDAL

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Cover Photo : *Polygonella articulata* (L.) Meissn. = *Polygonum articulatum* L.

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FOREWORD

Palynology-the science of pollen grains and spore is at present penetrating into many other domains of botany and allied sciences, from which it is not separated by distinct lines of demarcation.

Pollen diagnoses are increasingly added to the diagnoses of new species and it is gratifying to note that the results of suggestions obtained from pollen and spore morphology usually conform with those obtained from other branches of botany.

Polygonaceae is a family which is very much controversial from taxonomical and phylogenetical point of view. The Genera of the family have been treated differently by the taxonomists from time to time. In this work, the author has dealt the genera of the family, particularly the disputed & controversial ones with the morphology of the pollen grains, fine structure and ornamentation of the exine and aperture characters very cautiously and nicely and correlate those characters with other available biosystematical information from other branches of botany. In different chapters, author made a critical evaluation of palynological characters found to be taxonomically useful for general system of classification as well as infrafamilial recognition of taxa. Status of the genus *Polygonum* L. (*s.l.*) is very much discussed taxonomically in the past & present. Palynologically author supports the upliftment of certain section of *Polygonum* L. (*s.l.*) to the genera rank as suggested by different taxonomists. Author's observation reveals that the genera *Eriogonum*, *Fallopia*, *Koenigia*, *Persicaria*, *Aconogonum* and *Bistorta* are very much distinct palynologically. Correlating the palynological observations with taxonomical and other evidences the author supports the taxonomic circumscription of Nakai (1926) and Hedburg (1946) and also phylogenitic relationships as proposed by Nowicke & Skvarla (1977).

I am confident that this publication will be of great help to the students and research workers alike in their work.

P. K. Hajra
Director

Botanical Survey of India
P-8, Brabourne Road
Calcutta 700 001.

PREFACE

The application of palynology in taxonomic and phylognetic studies and also in analytical investigation is made from long back. Advancement in modern microscopy has added a new horizon in this field. With the progress in optical technology, Palynological Research becomes an important aid to taxonomy and phylogeny of the plant groups.

The present publication — "**Pollen morphology and systematic relationship of the family Polygonaceae**" is an addition to the evergrowing voluminous literature in the field. The present work is an attempt to use pollen morphological criteria and its correlation with other available biosystematical characters to find out the intra and inter-familial affinities, position and relationship of the long disputed family.

Botanical Survey of India
P-8, Brabourne Road
Calcutta 700 001.

M. S. Mondal
Deputy Director

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Sincere thanks are also extended to Dr. G.G. Maity, Reader, Kalyani University, Mr. G. S. Giri, Scientist, Botanical Survey of India and Mrs. S. Mahapatra, Scientist, Botanical Survey of India for their help in identification of materials, nomenclatural aspects and providing photographs and micorfiches of type/authentic materials.

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Lastly, a word of special thanks are due to my colleagues Shri Utpal Chatterjee, Scientist in charge, Publication Section, Shri R. G. Bhakta, Publication officer and staff of the Publication section who helped me in great measure in bringing out the Publication.

INTRODUCTION

Importance of palynological characters is at present penetrating into many other domains of botany and allied sciences in better understanding of the texonomical disputes and in the classification of plants. Since the time of Lindley (1830) after successful classification of Orchidaceae, Wodehouse (1935), Kuprianova (1948, 1965), Madam Van- Campo (1948, 1950), Erdtaman (1952, 1963, 1969), Guinet (1969) and others in the European countries and Raj (1961), Vishnu Mittre and Sharma (1962, 1963), Vishnu Mittre (1963), Nair (1965, 1967, 1969, 1972, 1979), Nair *et al.* (1965, 1979, 1985), Thanikaimoni (1965, 1970), Sharma (1968, 1969, 1970), recently Mondal (1990) and others enriched the palynological contribution towards taxonomy. With this, modern technology in the field of Microscopy revolutionised the application of pollen morphological and other biosystematical characters in modern taxonomy. Recent workers like Heslop-Harrison (1963, 1971), Nilsson (1967), Walker (1971, 1974a, b), Punt (1972, 1975, 1978), Walker and Doyle (1975), Dickison (1979), Huynh (1979) and many others are making profitable use of these modern microscopy in their palynological contributions.

The present contribution of the family Polygonaceae include pollen morphological studies on 156 species belonging to 22 genera from Indian and foreign taxa. Palynological findings have been correlated with other branches of botany viz., Anatomy, Cytology, Phytochemistry, Morphology etc., in resolving the taxonomic disputes and towards better understanding of the intra-familial as well as inter-familial controversies. Though some tribes/sects of the family have already been revised from the new point of view with modern technology, a considerable part of our new knowledge still has been consolidated with the preliminary findings towards better understanding of the phylogeny of the family and at the same time towards better understanding of the intra-familial relationship of the taxa.

METHODS ADOPTED IN THE PRESENT STUDY

Polliniferous materials were collected mostly from the duplicate herbarium specimens of the Central National Herbarium (CAL), different Circle Herbaria of Botanical Survey of India and herbaria of the University of Kalyani. For identification of some disputed specimens, photographs of type material/cibachrome print from Kew Herbarium and microfiches have been consulted in the Central National Herbarium. Foreign materials were available on personal communication as 'gift' from different eminent personalities of different foreign herbaria and institution, which have been acknowledged duly and details of specimens have been given in voucher specimen citations.

Pollen slides have been prepared by acetolysis method (Erdtman, 1960). The slides have been deposited in the sporotheck of Palynology Laboratory of the Central National Herbarium (CAL).

Observations were made by Olympus microscope— Model FFE Tr. With 1.3 apochromatic objectives (X100) and X15 eyepiece. Photomicrographs were taken by Olympus camera. The reading corresponds to the mean of 25 measurements of pollen grains for each material. They were taken from acetolysed non-chlorinated grains and are presented in μm. The exine thickness is given for ektexine and endexine together. Acetolysed / unacetolysed pollen grains were gold coated and observed with Philips PSEM-515 Scanning Electron Microscope at CNH (CAL).

The list of material studied with details of voucher specimens is given at the end of pollen description of respective genera. A glossary of pollen morphological terms used is appended at the end.

Abbreviations used

Ap., ap.	: Aperture	+	: Presence
B.	: Broad	Lolong, lolong	: Lolongate
Cir	: Circular	Mat., mat.	: Material
Col.	: Columella	Nex.	: Nexine
E.	: Equatorial axis	obs.	: obscure
Ectoap.	: Ectoaperture	P.	: Polar axis
Eq., eq.	: Equator	Ret., ret.	: Reticulate
Ex., ex.	: Exine	f. ret.	: Finally reticulate
Fig.	: Figure	m. ret.	: Microreticulate
Gr., gr.	: Granules	rug. ret.	: Ruguloreticulate
Indist.	: Indistinct	Sex.	: Sexine
Lalong, lalong	: Lalongate	Tap.	: Tapering
–	: Absence	Tec.	: Tectum

SCOPE OF THE PRESENT STUDY AND REVIEW OF LITERATURE

The family Polygonaceae comprising 40 genera and about 800 species (Airy Shaw, 1975) [30 genera and 1000 species; Cronquist, 1981] is mostly of herbs, but some members are shrubs and a few trees. The family is chiefly of North temperate distribution, a few tropical, arctic and southern. The plants are characterised by sheathing stipules called Ochrea, clasping the stems (excluding Eriogoneae) and a trimerous or pentamerous arrangement of floral parts. The family is included in the order Polygonales by Engler (1924), Hutchinson (1973), Dahlgren (1975), Takhtajan (1980) and Cronquist (1981). However, it is included in the order Chenopodiales by Thorne (1975, 1976), while Bentham and Hooker (1983) included it in the order Curvembryae.

Dating from Linnaeus' time, many attempts have hitherto been made to subdivide the family in various ways. From the beginning, the subgeneric taxa were usually founded upon the appearance of the inflorescence and perianth in the mature fruit stage. Later, other criteria like anatomical, palynological, cytological etc., have been used to subdivide the family. de Jussieu (1779) for the first time assembled all the genera of the family under the family (order) Polygonaceae. He recognised nine genera viz., *Atraphaxis, Calligonum, Coccoloba, Koenigia, Pallasia, Polygonum, Rheum, Rumex* and *Triplaris*. de Jussieu considered the characters shared by the constituent genera in a single family on the principle that the characters are to be weighed, rather than counted, and accepted a scale of relative values for plant organs. Before that Linnaeus (1753) included the genera of the family in three different category (classes) based on the number of stamens and carpel, as was in the Linnaeus system of classification under class hexandria (with six stamens) and class Octandria (with eight stamens). These classes were further divided in subclasses *digynia* and *trigynia* on the basis of number of carpels. In Linnaeus system *Polygonum, Rheum* and *Rumex* were placed in the class *Octandria* under the subclass *Trigynia* and *Atriplex* was included in *Hexandria* under the subclass *digynia*. Linnaeus also observed the heterogeneity within the genus *Polygonum* and divided the genus into four sections viz., *Persicaria, Bistorta, Polygonum* and *Helxine*.

Most significant contributions to the taxonomy of the family were made by Meissner (1826-1866) for the de Candolle's Prodromus. He divided the family into two tribes— Pterigocarpae and Apterigocarpae on the basis of achene and embryo characters. Each tribe was further divided into subtribes. The notable contribution in his recognition of the diversity in the genera *Polygonum* and *Rumex* which were divided into sections, most of which are still being recognised today with so many additional biosystematical considerations. He divided the genus *Polygonum* into 9 sections viz., *Auricularia, Persicaria, Amblygonon, Bistorta, Cephalophilon, Echinocaulon, Aconogonon, Tiniaria* and *Fagopyrum*. The genus *Rumex* was divided into 3 sections viz., *Acetosa, Acetocella* and *Lepathum*. These sections of the genus *Polygonum* are recognised by most of the modern taxonomists, Later, Bentham and Hooker (1980) in *Genera Plantarum* divided the family Polygonaceae into six tribes on the basis of involucre, bracts, stamens, perianth and fruit characters. Dammer

(1893) in Engler's Pflanzenfamilien divided the family into three subfamilies on the basis of floral and endosperm characters. These subfamilies were further subdivided into 8 tribes on the basis of habit and characters of the ochrea. Engler and Giles (1924) followed Dammer in their classification of the family except that they raised *Koenigia* to the status of a genus in the tribe Polygoneae along with *Polygonum* and *Fagopyrum*.

Anatomical characters were studied by Small (1895) and Perdrigeat (1900). Gross (1913a, b) in his primarily morphological investigation included both pollen morphology and anatomy. Later inconsistent and scattered works have appeared by Maheswari (1929), Joshi (1931-36), Lemesele (1934), Maheswari and Singh (1942), Kapoor *et al*. (1961) etc. A systematic studies in Polygonaceae of Kashmir Himalaya have been made by Munshi and Javeid (1986). Haraldson (1978) studied in details the anatomy of stem and petiole and made a critical evaluation of the anatomical characters in *Polygonum* L. s. lat. Studies on leaf venation have so far been neglected in this family except for Kapoor *et al*. (l.c.) who studied a few Indian species of *Polygonum* L. Marek (1954, 1958) studied the characteristics of fruit walls and the position of embryos in the seeds. Nakai (1926) on embryo characters and pollen morphology, gave a new classification of *Polygonum* L. (s.l.). Chromosome numbers of some members of the family were reported by Jaretzky (1928), Stebbins (1938), Smith *et al*. (1938), Love and Love (1942-48), Federov (1969) and Moore (1973-77). For Indian materials very good contributions on chromosome number reports have been complied by Kumar and Subramanian (1986). A few chemotaxonomic studies have also been made, mainly by Jaretzky (1925), Horhammer (1955, 1974), Boulter (1973) and Young (1981).

In short a review of literature shows that most workers have studied pollen morphology. Mohl (1834) and Fritzsche (1832, 1837) described the pollen morphology of this family in the 19th Century. Due to limitations in modern technique and microscopy their observations were limited to the descriptive part only. Since then significant contribution to the pollen morphology of Polygonaceae have been made by Meinke (1927), Wodehouse (1931), Hedberg (1946), Fritzsche (l.c.), Selling (1947), Erdtman (1952, 1969), Faegri *et al*. (1964), Nair (1965), Nair *et al*. (1976), Nowicke and Skvarla (1977), Munshi and Javeid (1986). Among them Wodehouse (l.c.) described the pollen morphology of 26 species representing 11 genera; Hedberg (l.c.) contributed much more of palynological information on the genus *Polygonum* L. and suggested a division of the genus into seven genera: *Koenigia, Persicaria, Polygonum* s. str., *Pleuropteropyrum, Bistorta, Tiniaria* and *Fagopyrum*. Nowicke and Skvarla, on a study of S.E.M. Of 85 species belonging to 36 genera, showed pollen morphological relationship of Polygonaceae to the order Centrospermae.

The genus *Polygonum* of Linnaeus has been variously divided by many worker; some treating different genera (as Nakai, Gross, Hedberg, haraldson etc. l.c.) or as sections (as Maissner, Bentham and Hooker, Dammer etc. l.c.). Consequently the number of genera within the family or under a tribe is at variance.

The objective of the present work was to make a critical evaluation of pollen morphological characters in different taxa of the family and to search for such characters that may be correlated with other biosystematical characters useful at the generic level and also to study pollen morphology of the family as a whole to classify the distinct pollen types and their distribution within the family. Out of the generally recognised 40 genera of the family, this study is based on 156 species belonging to 22 genera. Materials of some genera have not been available and in some genera, just one species has been studied. But in the vast majority of the species, gatherings from 3 to 10 localities from different parts of the world and received from different herbaria have been studied.

PHYTOGEOGRAPHICAL NOTES AND FOSSIL RECORDS

The polygonaceae is very large cosmopolitan family of herbs, some shrubs and a few trees, with a number of cultivated ornamentals and plants with edible seeds (buck wheat), stalks (rhubarb), leaves (sorrel) or berries (coccoloba). Most genera inhabit the temperate northern regions. A few are tropical or subtropical, notably *Antigonon* (Mexico and Central America), *Coccoloba* (tropical America and Jamaica) and *Muehlenbeckia* (Australasia and South America).

In India the Himalayas has its greater concentration of species. It is regarded that the family Polygonaceae had its origin in the East Mediterranean region and migrated to East and West wards. Towards the east the route followed was Mediterranian region, Iran, Afghanistan and Pakistan (Chatterjee, 1939). This hypothesis is based on the similarity of the general and species with West Asia. The Kashmir Himalaya is a region in which the sediments have been rigged up and folded, compressed and elevated into dry land only since the end of Mesozoic. Geological history reveal that the Kashmir valley has passed through three glacial and four inter-glacial periods after the formation of the Himalaya and this interplay has left a mark on the flora of the valley, the origin of which should be read through these periods. Kashmir Valley has fallen in the way of migrating plants in the Jurassic and early Tertiary but due to the late formation of the land the great majority of the plants could not establish. Therefore, there appears to have taken place a secondary migration of these plants from their secondary home from the adjacent countries, more so from West Asia and to some extent from the Western Himalaya. The Kashmir has land connection on the north and north-west with Afghanistan, USSR and China (east), but it has separated from Peninsular India by tall mountains. It is agreed that the land connection by one country with another supported by more or less uniform climatic condition tend to distribute plants from one to another and vice-versa by natural process of plant distribution (Chatterjee, 1947). Such a land connection existed between Western Asia and Southern Europe and Mediterranean Flora in the past, invaded Central Asia through Pakistan, Iran and Afghanistan.

The type genus *polygonum* L., occurs in all continents, but most genera are of restricted distribution, and several are localized endemics.

The family Polygonaceae in India is mainly distributed in Himalayas. Data about the number of species and their distribution in the Eastern and Western Himalaya are gradually increasing since the time of Hooker (1986). Hara (1966) enumerated the species of the family in Nepal and the adjacent areas. It is apparent that though the distribution of the genera are mainly throughout the Himalayas but concentration varies in East, West and Central Himalayas (Nepal) genus to genus. The family is represented by 31 species from Arunachal Pradesh (Choudhury *et al.*, In press, B.S.I.). The type genus *Polygonum* is cosmopolitan in distribution. In India, *Polygonum* has its greater concentration in Kashmir Himalaya and Arunachal Pradesh. Uptil-now, 9 species have been described from Kashmir Himalaya and 6 species from Arunachal Pradesh. The genus *Koenigia* represented by three species in W. Himalaya, two species in E. Himalaya and only one species in Central Himalaya (Nepal). The genus *Bistorta* was previously considered to be a typical arctic genus (Gage, 1903) but now four species have been recorded from Kashmir Himalaya and it is only from alpine zone. The genus has its representative in NWFP and Eastern Himalaya (Gage, l.c.) as well. The genus *Persicaria* is mainly a temperate element and less frequent in tropical and alpine zones. This genus is typically confined to NWFP, E. Himalaya and temperate alpine as well as subalpine zones of Kashmir Himalaya. Species of *Pleuropteropyrum* are restricted to the alpine zone of E. Himalaya and Kashmir Himalaya except one species in NWFP. The genus *Bilderdykia* is mostly a temperate one and represented from Tibet, Nepal and Kashmir Himalaya. It is interesting to note that **B. convolvulus* (L.) A. Love is in most of the cases reported to grow in close association with species of *Fagopyrum* in the alpine regions of Kashmir Himalaya (Munshi and Javeid, l.c.). The genus *Fagopyrum* is widely distributed in alpine regions of W. Himalaya, Kashmir Himalaya and Assam except a few temperate species. The monotypic alpine and subalpine genus *Oxyria* has comparatively wide distribution throughout Kashmir, Sikkim and Tibet. The genus *Rheum* is found throughout the alpine and subalpine regions of Himalayas. The plant is usually grows in rock crevices and a shade loving plant. Number of species are reported from NWFP, Tibet, Nepal and Sikkim. *R. emodi* has been exploited severely for its enormous medicinal values from Garhwal Himalayas as well as other locality and now at a serious threat for survival. *Rumex* is a temperate genus and distributed throughout the Himalayas.

Availability of fossil pollen of the Polygonaceous members dates back to the Palaeocene of Tertiary. Some stray leaf impressions are also reported from Assam tertiary and adjacent areas which are yet to be assigned perfectly. A leaf venation study of the family have been undertaken by the present author (jointly) which along with the pollen morphological informations will be very much helpful for proper identification of the fossil elements.

The pollen grains of the family Amaranthaceae and Chenopodiaceae are hardly could be differentiated and so far fossil pollen analysis they have been dealt together. The pollen grains of these two families have provisionallay kept in *Polyporina*. It is interesting to note that oldest Amaranthaceae-Chenopodiaceae pollen record is from the Maestrichian of Canada by Srivastava (1962). Kedves (1971) also recorded from the Maestrichian of Egypt. Nichols & Traverse (1971) recorded this type of

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* Pollen morphology of the taxa not studied for the present study due to lack of polliniferous material.

pollen from the Palaeocene of U.S.A, China & Ohyike. Sowunmi (1979) recorded the same type of pollen grains from the Eocene of Nigeria.

The occurrence of this type of pollen from Australia as well as from India is from Oligocene onwards. Martin (1978) noted several types of Amaranthaceae Chenopodiaceae pollen grains from Oligocene. This kind of behaviour in the opinion of Muller (1981), is probably due to the desication by this continent.

It is apparent that though the fossil pollen reports from the family Polygonaceae is very meagre so far, availability of Amaranthaceous and Chenopodiaceous fossil pollen from different parts of the world alongwith the so many uncertain/unidentified pollen grains of the group (Polyporina) may belong to the Polygonaceae-Amaranthaceae-Chenopodiaceae complex.

However, the present study on pollen morphology of the family will be of much help in identification of the fossil pollen grains in future.

MATERIALS

In the present study 350 materials from 156 species distributed over 22 genera have been worked out palynologically. About 200 materials from the species of the allied families have also been studied.

Nomenclature is based mainly on Gross (l.c.), Nakai (1952), Hedberg (l.c) and Haraldson (l.c.). In case of new combination (comb. nov.) and new status (stat. nov.) previous names are also maintained in the list of "Materials studied" In Table III for "summary of selected pollen morphological features" and in discussion, previous names have been used for better understanding, in favour of new proposals. For palynological observation polliniferous materials and/or pollen slides were obtained on loan or as gift from different Indian and Foreign herbaria and also from fresh collections. Details voucher reference have been given in the list of materials studied. For prepared pollen slides recovered from different Foreign Universities/Institutions etc., as gifts, the plant names inscribed on the slides have been maintained for constancy in future reference. In such cases in voucher reference the acronym of the herbarium have been given.

Pollen slides were prepared and studied as per general schedule as given at the beginning. For convenience, arrangement of the taxa have been made alphabetically for pollen description and presentation of data.

MORPHOLOGICAL CHARACTERS OF THE GENERA STUDIED

Polygonaceae is characterised by the usually bisexual flowers possessing a superior, unilocular, 2-4 carpellate ovary and the fruit a nutlet or achene. Members of the family are mostly herbs, shrubs and rarely trees, sometimes twinings, comprising 800-10000 species. (Airy Shaw, l.c., Cronquist, l.c.). Stems often with swollen nodes, occasionally geniculate; leaves alternate (rarely opposite) simple, usually with a sheathing stipular growth (ochrea) at petiole base (except in Eriogoneae); flowers usually bisexual (when unisexual, the plants monoecious or dioecious) actinomorphic, basically in cymes or cymules that often are disposed in racemes, panicles, spikes or heads; the perianth biseriate with usually 3,4,5 or 6 distinct undifferentiated tepals, the inner sometimes enlarged or modified with hooks, spines, wings or tubercles, the tepals often persistent, enlarged and membranous in fruit; the stamens mostly 6-9 in basically 2 series (the 6 outer often introrse, the 3 inner extrorse), the filaments free or basally adnate, the anthers 2-celled, dehiscing longitudinally; pistil 1, subtended by an annular (often lobed) nectar-secreting glandular disc; the ovary superior, sessile, compressed or 3 angled, 1-loculed (sometimes falsely 3-loculed), the carpels 2, 3 or 4; ovule 1 and seemingly basal, the style 1, the stigmas 2-4; fruit a flat angled or winged achene; seed with usually a curved embryo and copious mealy endosperm. *Eriogonum* (250), *Polygonum* (200), *Rumex* (200) and *Coccoloba* (125) are the largest genera.

Polygonum consists of several well marked sections and are often treated as distinct genera. *Fagopyrum esculentum* Moench is buck wheat. Many species of *Polygonum, Rumex* are common weeds, *Coccoloba* and some of its allies are unusual in the family in being tropical and woody. The family polygonaceae form a sharply limited and taxonomically rather isolated family. The unilocular ovary with a solitary basal ovule appears to be reduced from a basalty partitioned ovary with several ovules on a free-central placenta, quite in agreement with the structure of the Caryophyllaceae and some other families of Caryophyllales. The usually peripheral embryo which may be curved around the food-storage tissue of the seed is also reminiscent of the Caryophyllales (Cronquist l.c.). For convenience outline of system of classification by Meissner (1826-1866) for de Candolle's Prodromus, Bentham and Hooker (1883) in their *Genera Plantarum* and Dammer (1993) in Engler's *Pflanzenfamilien* are given below for ready reference.

SYNOPSIS OF PREVIOUS CLASSIFICATIONS OF THE FAMILY POLYGONACEAE

I. *Polygonaceae of Meissner (1826-1866) in de Candolle's Prodromous.*

Tribe I. PTERIGOCARPAE Meissn.

Sub Tribe I. COCCOLOBEAE

Tribe II. APTERIGOCARPAE Meissn.

Sub Tribe I. EUPOLYGONAE (*Polygonum, Koenigia*)

Sub Tribe II. RUMICEAE (*Rumex, Rheum, Oxyria*)

II. *Polygonaceae of Bentham & Hooker (1883)*

Tribe I ERIGONEAE (*Eriogonum, Oxytheca, Centrostegia, Chorizanthe)*

Tribe II. KOENIGIEAE (*Hollisteria, Nemacaulis, Lastarriaea, Pterostegia* and *Koenigia)*

Tribe III. EUPOLYGONEAE (*Calligonum, Pteropyrum, Atraphaxis, Oxygonum, Polygonella, Polygonum* and *Fagopyrum*)

Tribe IV. RUMICEAE (*Rheum, Oxyria, Rumex* and *Emex*)

Tribe V. COCCOLOBEAE (*Muehlenbeckia, Coccoloba, Campderia, Antigonon* and *Brunnichia*)

Tribe VI. TRIPLARIDEAE (*Leptogonum, Podopterus, Triplris, Ruprechtia* and *Symmeria*)

III. *Polygonaceae of Dammer (1893) in Engler's Pflanzenfamilien and of Engler and Giles (1924) in syllabus derpflanzenfamilien.*

Subfamily A. RUMICOIDEAE

Tribe I. ERIOGONEAE (No Ochrea)
(*Chorizanthe, Eriogonum*)

Tribe II. RUMICEAE (with Ochrea)
(*Rumex, Rheum, Oxyria)*

Subfamily B. POLYGONOIDEAE (Endosperm not ruminate)

Tribe III. ATRAPHAXIDEAE (Shrubs)
(*Calligonum*)

Tribe IV. POLYGONEAE (Herbs)
(*Polygonum, Fagopyrum*)
(Engler & Giles given the status of a genus to *Koenigia* and placed under this tribe).

Subfamily C. COCCOLOBOIDEAE (Endosperm ruminate)

Tribe V. COCCOLOBEAE (Usually bisexual flowers)
(*Muehlenbeckia, Coccoloba*).

Tribe VI. TRIPLARIDEAE (Usually dioecious plants)
(*Triplaris*).

IV. TREATMENT OF THE FAMILY BY J.D. HOOKER (1890)
FOR THE FLORA OF BRITISH INDIA

ORDER CXIX. ***Polygonaceae***

Tribe 1. EUPOLYGONEAE. *Perianth* 3-5 cleft. *Stamens* 1-8, rarely more. *Stigmas 2-3,* capitellate, rarely fimbriate.

* *Shrubs.*

Stamens 12-18. Styles 4 .... 1. *Calligonum*

Stamens 8. Styles 3 .... 2. *Pteropyrum*

** *Herbs or undershrubs.*

Stamens 8 or fewer. Cotyledons flat .... 3. *Polygonum*

Stamens 8. Cotyledons plaited .... 4. *Fagopyrum*

Tribe. 2. RUMICEAE. *Perianth* 4-6 cleft. *Stamens* 9, rarely 6, *Stigmas* fimbriate, peltate or horseshoe-shaped.

Sepals 6, unchanged in fruit, nut 3 winged .... 5. *Rheum*

Sepals 4, unchanged in fruit. Nut 2 winged .... 6. *Oxyria*

Sepals 6, 3 inner enlarged in fruit

(except. *R. acetosella*) .... 7. *Rumex*

See *Koenigia* under *Polygonum*

TREATMENT OF ***Polygonum*** L. (*s.l.*)

Key to the Sections.

A. *Stipules minute 2 partite.*

Sect. 1. *Koenigia.* : A minute annual. Flowers in terminal clusters. Stigmas subessile. Nut subterete. — Sp. 1.

Sect. 2. *Eleutherosperma.* Slender annuals. Flowers in terminal and axillary clusters. Styles minute free. Seed loose in the triquetrous nut.

B. *Stipules tubular elongate.* — Sp. 2-3.

Sect. 3. *Avicularia.* Herbs. Leaves small; stipules hyaline, cleft or torn. Flowers axillary. Styles minute free. Albumen horny.— Sp. 4-11.

Sect 4. *Amblygonon.* Perennial-rooted herbs. Flowers in spiciform racemes; bract tubular, truncate. Nut orbicular; cotyledons incumbent.— Sp. 12-14.

Sect. 5. *Tovara.* A perennial-rooted tall herb. Leaves broad. Flowers distant in very slender racemes; bracts tubular. Nut flattened with 2 rigid persistent hooked styles.— Sp. 15.

Sect. 6. *Bistorta.* Erect or prostrate annual or perennial-rooted herbs. Flowers in spiciform racemes; bracts hyaline, ovate or lanceolate not tubular.— Sp. 16-23.

Sect. 7. *Persicaria.* Erect or decumbent unarmed often glandular annuals or perennials. Leaves narrow. Flowers in slender or dencse spiciform racemes; bracts tubular— Sp. 24-38.

Sect. 8. *Cephalophilon.* Erect or prostrate unarmed annuals rarely perennials or shrubs. Leaves broad, sometimes lobed or auricled. Flowers capitate; bracts not tubular. — Sp. 39-48.

Sect. 9. *Echinocaulon.* Erect or ascending usually prickly annuals. Leaves usually broad, often hastate. Flowers capitate or racemose, bracts tubular. (Hardly distinct from *Cephalophilon.*) — Sp. 49 55.

Sect 10. *Aconogonon.* Erect shrubs, rarely herbs. Flowers in branched panicles; bracts open or very shortly tubular. — Sp. 56-67.

Sect. 11. *Tiniaria.* Twining herbs. Leaves broad, hastate or cordate. Flowers in axillary clusters or slender racemes; bracts not tubular.— Sp. 68 - 70.

DIVISIONS OF POLYGONACEAE ABOVE GENERIC RANK

Author	Subfamilies	Groups	Tribes / subtribes
MEISSNER 1856	Erigonoideae; Polygonoideae; Brunichioideae; Symmerioideae	(Polygonoideae:) Pterygocarpae; Apterocarpae	(Pterygocarpae:) Rabarbareae, Calligoneae, Rumiceae; (Apterocarpae:) Ceratogoneae, Polygoneae, Coccolobeae, Triplareae
BENTHAM & HOOKER 1883			Erigoneae, Koenigieae, Rumiceae, Polygoneae, Coccolobeae, Triplareae
DAMMER 1893	Rumicoideae; Polygonoideae; Coccoloboideae	(Rumicoideae:) Eriogoneae, Rumiceae; (Polygonoideae:) Atraphaxeae, Polygoneae; (Coccoloboideae:) Coccolobeae, Triplareae	(Eriogoneae:) Eriogoninae, Koeniginae
PERDRIGEAT 1900			Rumiceae (Koenigia), Calligoneae, Polygoneae, Coccolobeae (Symmeria), Muehlenbeckieae (Brunichia)
GROSS 1913b	Eriogonoideae; Polygonoideae; Coccoloboideae	(Eriogonoideae:) Hollisterieae, Erigoneae, Rumiceae; (Coccoloboideae:) Coccolobeae, Triplareae	(Polygonoideae:) Atraphaxinae, Oxygoninae, Polygoninae (Koenigiae), Coccolobinae; (Coccolobeae:) Antigoninae; (Triplareae:) Gymnopodinae, Triplarinae
JARETZKY 1925	Eriogonoideae; Polygonoideae	(Eriogonoideae:) Hollisterieae, Eriogoneae; (Polygonoideae:) Rumiceae, Polygoneae, Coccolobeae, Triplareae	(Rumiceae:) Atraphaxinae; (Polygoneae:) Polygoninae, Koenigiae
HARALDSON 1978	Polygonoideae		Rumiceae, Polygoneae, Persicarieae, Coccolobeae, Triplareae

OBSERVATION AND DISCUSSION

Aconogonum (Meissn.) Reich.

In 1826, Meissner founded the section - *Aconogonon* of the genus *Polygonum* Linn. Reichenbach (1837) treated it as a genus *Aconogonum* without adding any generic delimitations. Schur (1853) accepting the view of Reichenbach treated it as a distinct genus but named it as *Aconogonon* Meissn., considering *Aconogonon alpinum* (L.) Schur as the type species. He also did not provide the circumscription of the genus. Later, Rydberg (1917) characterised the genus *Aconogonum* of Reichenbach. However, Gross (1913b) described a new genus *Pleuropteropyrum* comprising of 3 species - *P.weyrichii* (F.Schm.) Gross, *P. pawlowskyanum* (Glchn.) Gross, and *P. tripterocarpum* (Gray) Gross which species were later placed under section *Aconogonon* of the genus *Persicaria* Mill., by Jaretzky (1925).

Hedberg (1946) was of the opinion that it is best to let the section *Aconogonon* Meissn., be treated as a genus and suggested the name *Pleuropteropyrum* Gross as it was the earliest valid generic name. Later workers such as Nakai (1952), Hara (1966) and Haraldson (1978) consider it as a distinct genus but Nakai named as *Aconopogon* and Hara named it as *Aconogonum* (Meissn.) Reichb., while Haraldson named it as *Aconogonon* (Meissn.) Reichb. It appears to be an orthographic error as the genus is spelt as *Aconogonum*.

Pollen grains prolate spheroidal to oblate spheroidal, 21-46µ x 21-46µ, 3 colpate or 3 colporate; colpi 13-30 µ x 1-2 µ, long narrow slit like; intercolpus distance 19-22 µ; apocolpium diameter 3-15 µ; ora indistinct, granulated (operculoid).

Exine 2.5-5 µ thick, uniform in thickness. Sexine 2-4 µ thick, surface rugulose, reguloreticulate or striate.

Species investigated :

Aconogonum campanulatum (Hook. f.) Hara
(= *Polygonum campanulatum* Hook. f.)

A. divaricatum (L.) Nakai
(= *Polygonum divaricatum* L.)

A. molle (D. Don) Hara
(= *Polygonum molle* D.Don)

A. molle var. *rude* (Meissn.) Hara
(= *Polygonum rude* Meissn.)

A. ochreatum (L.) Hara
(= *Polygonum ochreatum* L.)

A. songaricum (Schrenk.) Hara
(= *Polygonum songaricum* Schrenk.)

Interspecific differences

6 species studied under the genus *Aconogonum* present 3 distinct pollen size types. Pollen morphology of the genus *Aconogonum* can be characterised by tricolpate or tricolporate operculoid aperture character with more than 2.5 μ exine thickness and fine surface pattern. Most of the grains are medium sized, ranging from 32μ to 36μ polar axis (*A. songaricum, A. divaricatum* and *A. ochreatum*). *A. molle* var. *rude* and *A. campanulatum* present the smallest pollen type with 22 μ polar axis, whereas *A. molle* having spheroidal and distinctly largest pollen type within the genus. In *A. campanulatum* and *A. molle* the aperture is 3 colpate while in others 3 colporate aperture, ora indistinct, granulated (operculoid).

In exine pattern also *A. molle* is distinctly reticulate with large lumina size, *A. molle* var. *rude, A. campanulatum* and *A. ochreatum* with striate to striato- reticulate whereas the rest with rugulose excepting *A. bucharicum* with rugulo-reticulate.

Most authors accept a wider circumscription of the genus and this is supported by Haraldson (l.c.) while Gross (l.c.) characterised the genus as having trigonous and winged achenes with enlarged perianth in the fruit although he name the genus as *Pleuropteropyrum*. Hedberg (l.c.) gave the characters of this gènus under two heads e.g. general characters and pollen characters laying emphasis on the creeping rhizomatous habit, presence of a very short style and loose inflorescence.

Afrobrunnichia Hutch. & Dalziel

Hutchinson and Dalziel established the genus. A tropical genus mainly West African having two species.

Pollen grains prolate, size range 50-58μ x 36-43μ, 3 colporate; colpi 28-35μ x 1μ long, intercolpus distance 9-18 μ, apocolpate. Ora lalongate (10-14μ x indist.), sidewards not sharply limited.

Exine 2.5–3.5 μ thick, sexine 1.5–2.5 μ thick, thicker at pole, nexine 1 μ thick. Surface striato-reticulate with distinct columella.

Species investigated :

Afrobrunnichia errecta Hutchinson & Dalziel

Antigonon Endl.

This is a tropical American genus having *ca.* 8 species. *A leptopus* Hook. and Arn. is a (stem) tendril climbers.

Pollen grains subprolate, size range 58–70 μ × 41–60 μ; 3 colporate; colpi 50–60 × 1.5μ long, slit-like, extending from pole to pole, irregularly thickened at the colpi margin, parasyncolpate, intercolpus distance 22–25μ; ora indistinct, lolongate, 8–9μ in length.

Exine 4μ; sexine 3 μ, columella distinct; surface reticulate; lumina diameter 1.5–2μ, muri 0.5–1μ thick, simplibaculate.

Species investigated :

Antigonon leptopus Hook. & Arn.

Atraphaxis Linn.

It is a genus of variable habitat having *ca*. 25 species, mainly distributed in N. Africa, S.E. Europe to Himalayas and Siberia.

Pollen grains subprolate; size range 26–30μ × 19–23μ; 3-colporate, colpi 21–23μ × 1μ long, intercolpus distance 7–9μ, apocolpate, apocolpium diameter 4–5μ. Ora lalongate 3–4 μ indistinct.

Exine 2μ thick; sexine 1.5μ thick, surface striate, striae parallel to polar axis.

Species investigated :

Atraphaxis spinosa L.

Bistorta Mill.

This is mainly a temperate genus having *ca*. 50 species, distributed in temperate N. America and Eurasia.

Linnaeus in his earlier works (1737) regarded *Bistorta* as a genus, but later (1753) he ranked *Bistorta* as a section of his genus *Polygonum*. However, the genus *Bistorta* was first validly published by Miller in 1754.

Meissner (1826 and 1856) treated the species of *Bistorta* under a section of *Polygonum* L. Bentham and Hooker (1883) and Dammer (1893) did not recognised *Bistorta* as a distinct genus or even as a section but they treated it as a subsection of the section *Persicaria* under *Polygonum* L. However, in a later work Hooker (1890) treated *Bistorta* as a section of *Polygonum* L., and this has been followed by workers like Steward (1930), Komarov (1936), Grintzesco (1952) and Tutin *et al.* (1964).

Jaretzky (1925) preferred *Bistorta* as a section of *Persicaria* Mill. While Green (1904), Gross (1913), Hedberg (1946), Nakai (1952), Hara (1966) and Haraldson (1978) have treated *Bistorta* Mill., as a distinct genus.

Pollen grains prolate to subprolate, size range 29–70 μ × 29–52μ; 3-colporate; colpi 19–41μ × 1–1.5μ long, not extending from pole to pole, slit-like; intercolpus distance 6–27μ, usually apocolpate, apocolpium diameter 6–15μ, rarely parasyncolpate. Ora circular or lalongate, 4μ–12μ long, sidewards often not sharply limited.

Exine 2–6μ thick, thicker at the poles than at the equator. Sexine 1.5–5μ thick, nexine uniform in thickness. Surface rugulo-reticulate or micro-reticulate.

Species investigated :

Bistorta alopecuroides (Turez.) Komarov
(= *Polygonum alopecuroides* Turez.)

B. amplexicaulis (D. Don) Green
(= *Polygonum amplexicaule* D. Don)

Bistorta attenuata (V. Petr.) Komarov
(= *Polygonum attenuatum* V. Petrc.)
B. emodi (Meissn.) Hara
(= *Polygonum emodi* Meissn.)
B. bistortoides (Pursh.) Small
(= *Polygonum bistortoides* Pursh.)
B. major (L.) S.F. Gray
(= *Polygonum bistorta* L.)
B. vivipara (L.) S.F. Gray
(= *Polygonum viviparum* L.)

Interspecific differences :

7 species studied under the genus *Bistorta* are medium to large sized. The pollen size ranges above 36 μ polar axis length. Two species (*B. alopecuroides* and *B. major*) present pollen dimorphism in pollen size. In all the species the aperture is 3 colporate. The ora is lolongate to circular in *B. bistortoides;* circular in *B. vivipara,* circular to lolongate in *B. major* and *B. emodi* and lolongate in the rest (*B. alopecuroides, B. amplexicaulis* and *B. attenuata*). *B. amplexicaulis* is parasyncolpate, rests are apocolpate.

In Surface pattern they exhibit variability from rugulo-reticulate to micro-reticulate ornamentation. Exine rugulo-reticulate in *B. major, B. bistortoides, B. emodi* and *B. attenuata* and rest are with micro-reticulate ornamentation.

The genus *Bistorta* is distinguished not only by its characteristic pollen type which has minor interspecific variation but also by its vein architecture. All the species investigated have the characteristic swollen and expanded ends of the secondaries of their branches along the margin where they are recurved or falcate. However, some variations from the basic pattern exist amongst the different species studied. In *Bistorta amplexicaulis* the ends extend up to the margin thus forming the serrations or teeth. In *B. affinis, B. major, B. vivipara* and *B. emodi* the swollen and expanded ends extend beyond the marginal vein are recurved to meet it. The ends of the secondaries or their branches are falcate or faintly recurved in *B. nitens* and *B. vaccinifolia,* thereby the basic characteristic feature is well maintained.

This character in swollen, expanded and recurved veinlets at the margin, is distinctive and helpful in assigning the proper inclusion of species of *Polygonum* s.l.; under the genus *Bistorta.* The absence of this characteristic feature in *Polygonum pamiricum* Korsh., fully justifies its exclusion from *Bistorta* and placement under *Aconogonum* as done by Komarov.

Calligonum L.

This is a widely distributed genus having total species *ca.* 80, mainly distributed in Southern Europe, N. Africa and W. Asian countries.

Pollen grains subprolate in shape. Size range 31–50μ × 25–40μ, 3-colporate, colpi 26–36μ × 1μ long, intercolpus distance 9–15μ, apocolpate (apocolpium diameter 5μ) or parasyncolpate; ora circular to lolongate (2–7μ × 2–5μ).

Exine 2–2.5μ thick; sexine 1.5–2μ thick; surface finely striato reticulate.

Species investigated :

Calligonum comosum (L.) Heritier

C. polygonoides Linn.

Interspecific differences :

2 species studied under the genus *Calligonum* are subprolate in shape and medium sized. 3-colporate with large slit-like colpi, apocolpate in *C. comosum* and parasyncolpate in *C. polygonoides.* Ora lolongate (7μ × 5μ) in *C. comosum* and circular to lolongate (2–4μ × 2–3μ) in *C. polygonoides.* Surface striato-reticulate in both the species but in *C. polygonoides* muri granulated.

Chorizanthe R. Br. ex Benth.

The genus having *ca.* 50 species distributed in dry W. America and surrounding country. Some members have an ochrea, usually absent in this group. Flowers usually single inside the involucre.

Pollen grains prolate to subprolate; size range 34–50μ × 22–42μ; 3-colporate, colpi 16–33μ × 1μ long, not extending up to the pole, narrow slit-like. Intercolpus distance 2–15μ. Ora lolongate 4–8μ × 3–6μ.

Exine at pole 2.5μ – 5 μ thick and 3.5μ – 7.5μ thick at equator, nexine 0.5μ – 1μ thick; surface retipilate, rugulose striate and micro-reticulate.

Species investigated :

Chorizanthe diffusa Benth.

C. douglasii Benth.

C. frankenoides Remy.

C. membrancacea Benth.

C. parryi S. Wats.

C. statioides Gray.

Interspecific differences :

6 species studied under the genus *Chorizanthe* are subprolate to prolate in shape. Pollen grains medium sized, 31μ to 48.6μ polar axis. All species are 3-colporate with slit-like colpi not extending up to pole and having more or less circular to lolongate ora. Exine thickness varies from 2.5μ to 5μ at pole and 3.5μ – 7.5μ at equatorial region.

Surface pattern striate to reticulate and retipilate. In *C. diffusa* and *C. douglasii* the pattern is striate and retipilate respectively with distinct coarse columella of 1μ –1.5μ diameter. *C. membranacea* is characterised by exine pattern which is fine striate at equatorial zone (which is more or less equatorial belt extends up to the colpal end on either side), bacula diameter 0.5μ; whereas at pole the pattern is coarsely reticulate with lumina 1μ –1.5μ and muri about 1μ. This pattern is formed by distinct coarse bacula with large and thickened bacula head and narrow small neck.

C. frankenoides, *C. parryi* and *C. statioides* have fine surface pattern which is a striate in former and rugulose in the later two species. The diameter of bacula head is 0.5μ.

Emex Neck. ex Campdera

The genus have two species only distributed in Mediterranian, S. Africa and Australia. The fruit is surrounded by the perianth, three of which segments are spiny.

Pollen grains oblate spheroidal in shape, size ranges 20–25μ × 32–44μ; 3-colporate; colpi brevicolpate, colpus 6–10μ × 1.5μ. Intercolpus distance 25μ, apocolpium diameter 25μ; ora lalongate.

Exine 2μ thick, sexine 1.5μ thick (thicker at the apertural region) with micro-reticulate surface ornamentation. Nexine 0.5μ thick, tenuinexinous.

Species investigated :

Emex australis Steinh.

Eriogonum Michx.

It is a very big genus having *ca*. 200 species mainly distributed in N. America. Differs from most of the family in having no ochrea and cymose umbels or heads of flowers. The partial inflorescence are combined into heads.

Pollen grains prolate to subprolate; size range 27–65μ × 20–44μ; 3-coloporate, colpi 20–58μ long, extending from pole to pole, slit-like; intercolpus distance 5–18μ. Ora lolongate 3–7μ × 1.5–5μ. Exine 2–4μ thick; sexine 1.5μ thick, sexine thicker at equatorial region gradually narrowed towards pole and aperture.

Species investigated :

Eriogonum aberteanum Torr.

E. alatum Torr.

E. atrorubens Engelm.

E. baileyi S. Wats.

E. fasciculatum Benth.

E. hurmanni Deer & Hilg.

E. inflatum Torr.

E. Jamesii Benth.

E. latifolium sm.

E. nudum Dougl.

Emex polycladon Benth.

E. pyrolaefolium Book.

E. tenellum Torr.

E. wrightii Torr. ex Benth.

Interspecific differences :

14 species studied under the genus *Eriogonum* are all prolate to subprolate in shape, generally medium sized and few large sized pollen grains are noted specially in their polar axis length. 3-colporate with a long slit-like colpi and lolongate ora in all these species. Exine surface with small striate pattern which is characterized by perpendicular disposition of striae on either sides of aperture in all the cases. This tendency is however lost at intercolpal region as well as at poles.

Exine thickness shows a gradual decrease in bacula height from equatorial region towards polar region whereas tectum thickness is more at poles in compared to the equatorial region.

Fagopyrum Mill.

It is temperate Eurasian genus having *ca.* 15 species. Flowers like polygonum but heterostyled with long and short-styled forms.

Pollen grains prolate to subprolate in shape; size range 42–52μ × 27–40μ; 3-colporate, colpi 32–40μ × 2–4μ long, not extending up to poles, intercolpus distance 6–20μ, apocolpate, apocolpium diameter 5–11μ or syncolpate. Ora circular 3.5–4.5μ in diameter, lalongate 4–5μ × 7–10μ or lolongate 7–10μ × 4–8μ.

Exine 3–4.5μ thick; sexine 2.5–4μ thick, surface micro-reticulate of reticulate. Columella distinct with long bacula.

Species investigated :

Fagopyrum cymosum Meissn.

F. esculentum Moench.

F. sagittatum Gilib.

F. tataricum Gaertn.

Interspecific differences :

4 species studied under the genus *Fagopyrum* are prolate to subprolate in shape. *F. sagittatum* and *F. tataricum* are prolate and medium sized but *F. cymosum* and *F. esculentum* are subprolate and medium to large sized. All are 3-colporate, colpi apocolpate in *F. cymosum*, *F. sagittatum* and *F. esculentum* but syncolpate in *F. tataricum*. Ora lalongate in *F. cymosum*, circular in *F. sagittatum* and *F. tataricum* and lolongate in *F. esculentum*.

Exine thickness 4–4.5μ in *F. cymosum* and *F. sagittatum* and 3-43.5μ in *F. tataricum* and *F. esculentum*. Surface micro-reticulate in *F. sagittatum* and reticulate in the rest.

Fallopia Adans.

Adanson created this genus from *Polygonum* L. *ca*. 9 species distributed in north temperate regions.

Bentham and Hooker (1880) treated the species of *Polygonum* Linn., under 10 sections; two of which are *Tiniaria* Meissn., and *Pleuropterus* Turez. Later Hooker (1886) treated those species which were previously placed under section *Tiniaria* Meissn. and section *Pleuropterus* Turez., under a single section *Tiniaria* Meissn.

Dumortier (1827) established the genus *Bilderdykia* to accommodate *Polygonum convolvulus* L., as *B. convolvulus* (L.) Dum., and *Polygonum dumetorum* L., as *P. dumetorum* (L.) Dum. The generic name *Bilderdykia* was used by Green (1904), later by some American authors as well, besides Nakai (1926) and Kitagowa (1939).

Gross (1913) transferred the species which were under section *Tiniaria* Meissn., to genus *Fagopyrum* (Tourn.) Moench and treated *Pleuropterus* Turez., as a distinct genus, thereby differing from the previous treatment of the section as a genus. This was however criticised by many taxonomists. Jaretzky (1925) was of the opinion that sections *Tiniaria* Meissn., and *Pleuropterus* Turez., are closely related chemically as well as morphologically, and should thus be united and treated as a single genus.

Nakai (1926) treated those species of *Polygonum* L., that were previously placed in section *Tiniaria* of Hooker, under 3 separate genera *Reynoutria* Houtt., *Pleuropterus* Turez. and *Bilderdykia* Dum. Small (1895) however treated those species of *Polygonum* L., s. lat. under two genera only- *Pleuropterus* Turez., and *Tiniaria* (Meissn.) Reichb[1]. Komarov (1936) recognised the genus *Polygonum* L., but took cognisance of the 10 section as previously treated by Bentham and Hooker. (l.c.).

Hedberg (1946) was of the opinion that the limits between section *Tiniaria* and section *Pleuropterus* appear to be very vague and suggested that all species of *Reynoutria* Houtt. and *Bilderdykia* Dum., be considered under the genus *Tiniaria* (Meissn.) Reichb. ex Webb. et. Moq.[2] which in fact comprises the section *Tiniaria* Meissn., as given in Wallich (1832) and the section *Tiniaria* and *Pleuropterus* of Bentham and Hooker (l.c.). Tutin *et al.* (1964) recognise two genera *Reynoutria* Houtt. and *Bilderdykia* Dum. Adanson (1763) had described a genus *Fallopia* of the family *Polygonaceae*, which in later years (Haraldson, 1978) embraced all other genera that had been recognised from time to time out of the "*Tiniaria* Meissn." complex.

Thus, Haraldson (l.c.) has recognised *Reynoutria* Houtt. and *Fallopia* Adans., to be distinct on the basis of petiole and stem anatomy. However, haraldson has different section of the genus *Fallopia* e.g. section *Pleuropterus, Parogonum* and *Fallopia*.

Pollen grains prolate to speheroidal in shape, size range 21–33μ × 19–22μ; 3-colporate; colpi 13–24μ × 1–1.5μ long, not extending up to the pole, slit-like; intercolpus distance 6–16μ; Apocolpium diameter 3–8μ; Ora circular to lalongate (1.5–3μ × 3–9μ), sometimes extended sidewards to form a ring in the equator (zonorate). Exine 2–3μ thick, sexine 1–2μ thick, nexine slightly ticker around colpi, specially near ora region in some cases. Surface rugulose to micro-reticulate.

1 & 2 Reichenbach's generic name was 'nomen nudum'.

It was validated by Webb and Moquin — Tandon.

Species investigated :

Fallopia baldshuanica (Regel) Holub.
(= *Polygonum baldshuanicum* Regel)

F. cilinodis (Michx) Holub.
(= *Polygonum cilinode* Michx).

F. convolvulus (L.) A. Love
(= *Polygonum convolvulus* L.)

F. dumetorum (L.) Holub.
(= *Polygonum dumetorum* L.)

F. multiflora (Thunb.) Haraldson
(= *Polygonum multiflorum* Thunb.)

Interspecific differences :

6 species under the genus *Fallopia* investigated in the present study, have subprolate to spheroidal, medium sized, 3-colporate pollen grains. All the species are with lalongate endoaperture except *F. multiflora* with circular ora. In case of lalongate ora the size varies. Ora are elliptical in *F. baldshuanica, F. cilinodis* and *F. japonica* but ora ends are suddenly tapering in *F. baldshuanica* and in *F. convolvulus* & *F. dumetorum* the ora fuse equatorially to form a complete ring (zonorate).

Not only the endoaperture types but also the surface pattern, which varies from striate to reticulate, are helpful for specific identification.

The genus *Fallopia* Adans., can not be distinguished from the related taxa by 3-colporate pollen grain with polar axis not more than 35µ and fine surface pattern.

Jaretzky (1925) expressed that section *Tiniaria* and section *Pleuropterus* should be united into a single genus. Haraldson (1978) who recognises the genus *Fallopia* with three section, draws a line of difference between the genus *Fallopia* and *Reynoutria* on the characters of stem and petiole anatomy only. If all other characters such as chromosome number, trichome types, stigma, fruit, inflorescence and pollen morphology are considered then it will be seen that the two cannot be separated.

Plants named as *Polygonum songaricum* Schrenk, or *Polygonum alpinum* All., cannot be placed under the then section *Tiniaria,* the species of which were transferred to the genus *Fallopia* (Adanson l.c.) by later workers, primarily due to characters of marginal vein and pollen morphology (Hedberg l.c., Haraldson l.c.).

Koenigia L.

This is a genus having 7 Arctic, Himalayan and temperate E. Asian species, only one species distributed in temperate S. America.

The genus *Koenigia* L., has been retained by most authors except Hooker (l.c.) who treated it as one of the section under *Polygonum* L. Samuelsson (1929) supported Hooker but included *P. delicatulum* Meissn. and *P. filicaule* Wall., which were placed in section *Eleutherosperma* by Hooker under this section. Hedberg (l.c.) treated section *Koenigia* and *Eleutherosperma* as a distinct genus *Koenigia* L. and included *P. nunularifolium* Meissn., which had been placed under section *Cephalophilon* by Meissner (1826) and under section *Aconogonon* by Hooker (l.c.) and Steward (1930).

However, there have been different opinions as to the position of *Koenigia* L., within the family. Bentham and Hooker (l.c.) placed the genus under the tribe *Koenigieae*. Dammer (l.c.) treated it under the subfamily *Rumicoideae*, while Gross (l.c.) treated the genus under the tribe Polygoneae of subfamily *Polygonoideae*. Haraldson (l.c.) has treated this genus under the subfamily *Polygonoideae* and placed it in a different tribe *Persicarieae*.

Pollen grains spheroidal in shape, diameter range 22–24μ, polyporate (pore number c. 12); pores circular to elongated (2–3μ × 1.5–2μ), interporal distance 5–8μ.

Exine 2μ thick (excluding spinules), sexine and nexine are of equal thickness; surface spinulose, spinules 0.5μ or less in length.

Species investigated :

Koenigia islandica L.

Pollen grains of *Koenigia* L., is pantoporate with spinulose surface ornamentation while in *Persicaria* Mill., the pollen grains are pantoporate but distinctly reticulate with large lumina and thick muri. Thus then again points to the closeness of the two genera. Haraldson (l.c.) on the basis of stem anatomy places the genera *Koenigia* L., and *Persicaria* Mill., under one tribe. Similarly, Gross (l.c.) had shown earlier that these two genera are close to one another.

Present pollen morphology support the views of Haraldson and Gross.

Muehlenbeckia Meissn.

The genus has *ca*. 15 species mainly distributed in New Guinea, Australia, Newzealand and W.S. America. Flowers polygamous or dioecious.

Pollen grains prolate to prolate-spheroidal in shape; size 23–35μ × 19–25μ; 3-colporate, colpi 16–27μ × 1–2μ long, slit-like, extending from pole to pole, intercolpus distance 6–12μ, apocolpium diameter 3–6μ. Thickenings present at the colpi margin.

Ora lalongate (1.5–4μ × 4–12μ), sometimes extends sidewards to form a ring at the equator (zonorate, Erdtman l.c.).

Exine 1.5–3μ thick; sexine 1–2.5μ thick, thicker at the pole than at the equator, sometimes thicker around aperture. Surface micro-reticulate with distinct bacula (columella).

Species investigated :

Muehlenbeckia adpressa Lah. Meissn.

M. coccoloboides J.M. Black

M. saggitifolia Meissn.

M. volcania (Benth.) Endl.

Interspecific differences :

4 species studied under the genus *Muehlenbeckia* are prolate to prolate-spheroidal in shape. In *M. saggitifolia* the pollen grains are small, and in the other three species pollen grains are medium-sized. All species are 3-colporate. *M. adpressa* and *M. coccoloboides* are costicolpate. In all the species ora are lalongate but in *M. coccoloboides* ora fuse equatorially to form a ring (zonorate). In *M. adpressa* and *M. saggitifolia* ora are more or less elliptic and in *M. volcania* with tapering ends.

The exine surface is reticulate (*M. saggitifolia*) or striato-reticulate (*M. adpressa* and *M. volcania*). The surface pattern is obscure in *M. coccoloboides.*

The genus represent a homogeneous assemblage with more or less uniform pollen characters. The shape of ora could be a criterion for specific identification.

Oxyria Hill.

This is a monotypic genus. The only species *O. digyna* (L.) Hill., distributed in N. Arctic and subarctic mountains of temperate Eurasia and California.

Pollen grains spheroidal in shape, 25μ–30μ in diameter; 3-colpate (2% 3-colporate), colpi 10–14μ × 0.5μ long, not extending up to the pole, slit-like. Intercolpus distance 10–12μ, apocolpium diameter 4 μ, ora when present circular (4–5μ in diameter).

Exine 2.5μ thick; sexine 2μ thick with striate surface ornamentation; nexine 0.5μ thick, tenuinexinous.

Species investigated :

Oxyria digyna (L.) Hill.

Persicaria Mill.

The species of *Polygonum* L., now placed under the genus *Persicaria* Mill., were treated variously by different authors in the past. Linnaeus (1753, 1754) and Dumortier (1827) treated them under section *Persicaria* of *Polygonum* L. Meissner (1826, 1856) placed the species under 4 sections: *Persicaria, Aconogonon, Cephalophilon* and *Echinocaulon.* However, Rafinesque (1837) had raised the section *Echinocaulon* to a generic level and named as *Tracaulon.* Hooker (l.c.) rearranged the species and treated them under 5 sections adding *Tovara* to the already existing 4 sections. Green (l.c.) did not recognise any sections but maintained separate genera as *Persicaria* and *Tracaulon.* Gross (1913a, b) maintained the same opinion as of Hooker regarding the treatment of the species under 5 sections. However, he placed them not under genus *Polygonum* L., but under genus *Persicaria* Mill., and also included section *Aconogonon.* Jaretzky (1925) treated section *Aconogonon, Bistorta* and *Polygonum* L., under genus *Persicaria* Mill. Steward (l.c.) recognised *Tovara* Adans., as a distinct genus. *Tovara* is distinct from *Persicaria* had also been taken by Small (i.c.) and Nakai (l.c.). Similarly, Hedberg (l.c.) and Hara (l.c.) have treated *Persicaria* as a genus. Tutin *et al.* (1964) united all the 5 section (*Persicaria* Meissn., *Aconogonon* Meissn., *Echinocaulon* and *Tovara* Adans.) into one section—*Persicaria* under *Polygonum* L. Haraldson (1978) recognises *Persicaria* Mill., as a distinct genus but comprising of 4 section only : *Cephalophilon, Echinocaulon, Tovara* and *Pesicaria.*

Pollen grains spheroidal in shape, size range 33–75μ; 3-colpate, pantocolpate and pantoporate (number of pores 8 to 30 or more), size of pore range 2–4μ in diam., colpi 8–20μ long.

Exine 3–8μ thick; nexine 1μ thick. Surface reticulate with broad lumina (2–5μ × 1.5–3μ) and thick muri (2–3μ), simple or polybaculate.

Species investigated :

Persicaria alata (Buch. -Ham.) Nakai
(= *Polygonum alatum* Buch. -Ham)

P. amphibia (L.) S. F. Gray
(= *Polygonum amphibium* L.)

P. barbata (L.) Hara
(= *Polygonum barbatum* L.)

P. caespitosa (Blume) Nakai
(= *Polygonum caespitosum* Blume)

P. Capitata (Buch. -Ham ex D. Don) H. Gross
(= *Polygonum capitatum* Buch. -Ham. ex D. Don)

P. chinensis (L.) H. Gross
(= *Polygonum chinensis* L.)

P. coccinea (Muehl. ex spreng) Greene
(= *Polygonum coccineum* Muehl. ex Spreng)

P. flaccida (Meissn.) H. Gross
(= *Polygonum flaccidum* Meissn.)

P. glabra (Welld.) Gomez de la maza
(= *Polygonum glabrum* Willd.)

P. hydropiper (L.) Spach.
(= *Polygonum hydropiper* L.)

P. hydropiperoides (Michx.) Small
(= *Polygonum hydropiperoides* Michx.)

P. incarnata (Ell.) Small
(= *Polygonum incarnatum* Ell.)

P. lapathifolia (L.) S.F. Gray
(= *Polygonum lapathifolium* L.)

P. limbata (Meissn.) Hara
(= *Polygonum limbatum* Meissn.)

P. linicola (Sutulow) Nenjukow
(= *Polygonum linicola* Sutulow)

Persicaria maculata (Raf.) Love et Love
(= *Polygonum maculatus* Raf.)
P. microcephala
(= *Polygonum microcephalum* D. Don)
P. muricata (Meissn.) Nemoto
(= *Polygonum muricatum* Meissn.)
P. orientalis (L.) Spach.
(= *Polygonum orientale* L.)
P. peduncularis (Wall. ex Meissn.)
(= *Polygonum peduncularis* Wall. ex Meissn.)
P. pensylvanica (L.) Gomez de la Maze
(= *Polygonum pensylvanicum* L.)
P. posumbu (Buch. -Ham ex D. Don) H. Gross
(= *Polygonum posumbu* Buch.- Ham. ex D. Don)
P. perfoliata (L.) H. Gross
(= *Polygonum perfoliatum* L.)
P. prostrata (R. Br.) Nakai
(= *Polygonum prostratum* R. Br.)
P. runcinata (Buch. -Ham. ex D. Don) H. Gross
(= *Polygonum runcinatum* Buch.-Ham. Ex D. Don)
P. senegalensis (Meissn.) Sojak
(= *Polygonum senegalensis* Meissn.)
P. stagnia (Buch. -Ham. ex Meissn.)
(= *Polygonum stagnium* Buch. -Ham. ex Meissn.)
P. strigosa (R. Br.) Nakai
(= *Polygonum strigosum* R. Br.)

Interspecific differences :

28 species studied under the genus *Persicaria are* all with spheroidal, medium to large sized pollen grains. Apertures are 3-colpate, pantocolpate and pantoporate. Most of the species studied are under pantoporate group. The number of pores in pantoporate pollen grains ranges from 6—30 or more. This can be distinguished into three pollen types on the basis of the number of pore groups : 6 to 15 (*P. hydropiperoids, P. incarnata,* etc.) 18-15 (*P. barbata, P. caespitosa, P. coccinea, P. glabra, P. hydropiper, P. lapathifolia, P. limbata, P. linicola, P. maculata, P. peduncularis, P. pensylvanica, P, mitis, P. senegalensis* etc.) and 30 onwards (*P. amphibia, P. flaccida* etc). In case of pantocolpate pollen grains the number of colpi is *ca*. 20 and in 3 colpate grains colpi zonal, not extended up to pole (brevicolpate).

The exine is uniformly reticulate, muri at surface simple, appears dupli or tripli baculate at below. This is formed by fusion of 2-3 bacula. Lumina large, mostly studded with loose bacula which may be distinct and few in number or small and numerous. The height of these baculae are generally less than the bacula forming the muri. It is interesting to note that in case of 3-colpate grains loose baculae are totally absent.

The exine is very thick due to thick sexine. The muri forming baculae are distinct and these are helpful in categorisation of pollen grains.

Jaretzky (l.c.) proposed to unite the section *Aconogonum* and *Bistorta* with the genus *Persicaria* on the presence or absence of anthrachinones. Haraldson (l.c.) has treated the three genera *Aconogonum, Bistorta* and *Persicaria* as different but related to one another as is indicated by the stem and petiole anatomies. As is evident on the basis of vein architecture, the genera *Aconogonum* and *Persicaria* are close to one another.

On pollen morphology as well as on general habit, the two genera *Persicaria* and *Aconogonum* are clearly distinct as also suggested by Hedberg (l.c.). The pollens are more or less spheroidal in shape and with distinct reticulate surface pattern in *Parsicaria* while in *Aconogonum* the pollens are subprolate, tricolpate or tricolporate operculoidate with fine surface pattern.

It is beyond any doubt that the two genera *Persicaria* and *Aconogonum* are distinct from each other. The present study on pollen morphology lends support to previous workers who have treated two separate genera.

Polygonella Michx.

It is a N. American genus having *ca.* 10 species.

Pollen grains prolate in shape; size range 20–37µ × 14–27µ, 3-colporate, colpi 15–25µ × 1–1.5µ, apocolpium diameter 4–5µ. Ora lalongate, zonorate.

Exine 2.5–4µ thick, sexine 2–3µ thick with reticulate surface at pole and between the furrows.

Species investigated :

Polygonella articulata (L.) Meissn.

P. polygama Engelm. & Gray.

Interspecific differences :

2 species studied under the genus *Polygonella* are with prolate, 3-colporate pollen grains with long slit-like colpi and zonorate ora. In *P. articulata* pollen grains are medium sized while in *P. polygama* they are small sized. The exine is 4–5µ thick in *P. articulata* and 2.5–3µ thick in *P. polygama.*

Polygonum L., *s. str.*

Polygonum L., *s. str*. comprises the section *Avicularia* Meissn., *Duravia* S. Wats, *Pseudomollia* Boiss. and *Tephis* Meissn. of *Polygonum* L. *Sensu lato*. The species under these 4 section were previously treated by Bentham and Hooker (l.c.) under 3 sections (As *Tephis, Avicularia* and *Pseudomollia*). Later Hooker (l.c.) treated all the species under one section *Avicularia*. Dammer (l.c.) followed the same treatment as of Bentham and Hooker (l.c.). Green (1904) however rised the section *Duravia* S. Wats., including the species *P. californicum* Meissn. *P. bedwelliae, P. greenei* S. Wats. and *P. bolanderi* Brew ex Gray as a distinct genus *Duravia*. The genus *Duravia* (S. Wats.) Green was neither accepted by Gross (1913) nor by the majority of American authors notably Rydberg (1917) Small (l.c.) and also Nakai (1952). They have included the species under *Duravia* (S. Wats.) Green in *Polygonum* L., *s. str*. Haraldson (1978) treated 3 sections (*Polygonum, Tephis, Duravia*) under *Polygonum* L., *s. str*.

Pollen grains prolate to subprolate, more or less dumbell shaped. Size ranges $18-45\mu \times 12-24\mu$; 3-colporate, sometimes in *P. martimus* 4-colporate grains occurs frequently with 3-colporate grains. Colpi $13-24\mu$ long, slit-like, not extending from pole to pole; intercolpus distance $5-15\mu$; apocolpium diameter $4-8\mu$, sometimes parasyncolpate. Ora lalongate, $3-7\mu \times 7-15\mu$, sometimes equatorial margin not sharply delimited (zororate).

Exine 2.5μ thick, sexine not uniform in thickness, $1.5-2\mu$ thick. Surface rugulose to micro-reticulate.

Species investigated :

Polygonum arenarium Waldst. et Kit.

P. articulatum L.

P. aviculare L.

P. biaristatum Aitch. & Hemsl.

P. bucharicum Grig.

P. cognatum Meissn.

P. corrigioloides Jaub. & Spach.

P. floribundum Schlecht. ex Spreng.

P. humifusum Merk. ex Pall.

P. intermedium Nutt. ex S. Wats.

P. lanigerum R. Br.

P. laxmanni Lepech.

P. littorale Meissn.

P. macranthum Meissn.

P. maritimus L.

P. minimum S. Wats.

P. nodosum Pers.

P. paronychia Cham. & Schlecht.

P. paronychioides C.A. Mey

P. plebejum Br.

P. recumbens Royle

P. thymifolium Jaub. & Spach.

Interspecific differences :

Out of 21 species studied for the genus pollen grains of 15 species of *Polygonum* are prolate to subprolate in shape and characterised by more or less dumbell shaped outline in equatorial view. Three species (*P. corrigioloides, P. plebejum* and *P. recumbens*) have small pollen grains while the rest are medium sized, ranging from 25–42μ polar axis. Three species (*P. lanigera, P. macranthum* and *P. nodosum*) have spheroidal pollen grains. Colpi long, slit-like, parasyncolpate in *P. biaristatum* and *P. maritimus.* Ora lalongate in general, and lolongate in one species (*P. maritimus*) In case of lalongate ora, it is fused laterally to form a ring (zonorate) in *P. arenarium.* The breadth of ora are variable in size in rest of the species. *P. bucharicum* and *P. laxmanni* are characterised by operculoid aperture and seems to be exceptional within the species of *Polygonum.*

Exine pattern form micro-reticulate, reticulate, striate to pilate and retipilate ornamentation. In case of retipilate grains the pila (bacula) are free towards aperture in *P. intermedium* and towards pole in *P. paronichia.* The surface pattern is pilate in *P.minimum.* It is further noted in case of pilate and retipilate pollen grains that the sexine is significantly thick. Interestingly three species having spheroidal pollen grains (*P. lanigera, P. macranthum* and *P. nodosum*) are characterised by reticulate exine ornamentation and pantoporate aperture.

Linnaen genus *Polygonum* at present consists of several well marked section that are often, and not without reason, treated as distinct genera. *Polygonum* (s.l.); has been variously divided by taxonomists on the basis of gross morphology, anatomy or pollen morphology.

To treat *Polygonum* L., as a single genus is not favoured by most of the recent workers, thus they have divided it into a number of genera and many species are retained in *Polygonum* L., *sensu stricto.* From the present pollen morphological study it is apparent that *Polygonum lanigerum, Polygonum macranthum* and *Polygonum nodosum* are very much allied to the species of *Persicaria* as regard to pollen morphological shape, size and exine character. *Polygonum bucharicum* and *Polygonum laxmanni* on the other hand shows very much affinity with the species of *Aconogonum* pollen morphologically for shape, size, exine and especially for operculoid aperture character which is absolutely lacking in the species of *Polygonum.* Other biosystematical data from different branches of botany can affirm their position only. Present author have intension for working on the leaf architecture of the family. Some of the preliminary works shows significant result for better understanding of the intrafamilial relationships. Total works will be undertaken with the world materials from different phytogeographical regions and will be published elsewhere in near future.

Pteropyrum Jaub. & Spach.

It is a genus mainly distributed in South West Asian countries having *ca.* 5 species.

Pollen grains subprolate in shape; size range 30–36μ × 24–28μ; 3-colporate, colpi 24–29μ × 1μ long, intercolpus distance 6–9μ, apocolpate (apocolpium diameter 4–5μ); ora circular, 3–4μ in diameter.

Exine 2.5μ thick; sexine 1μ thick. Surface micro-reticulate with distinct columella.

Species investigated :

Pteropyrum olevirii Jaub. & Spach.

Reynourtria Houtt.

A temperate Asiatic genus having about 15 species. Only one species studied for the present study.

Pollen grains spheroidal in shape, diameter range 22–28μ, 3-colporate, colpi long, slit-like; intercolpus distance 6–12μ; apocolpium diameter 4–5μ; ora lalongate 2–3μ × 7–9μ. Exine 3μ thick, sexine and nexine of equal thickness. Surface micro-reticulate.

Species investigated :

Reynourtria japonica Houtt.

Pollen morphologically *R. japonica* Houtt., is very much allied to the species of *Fallopia.*

Rheum Linn.

This is a genus mainly distributed in temperate and subtropical Asia. Flowers like *Rumex,* but coloured and entomophilous, though they exhibit traces of anemophily in very large stigmas.

Pollen grains prolate to oblate spheroidal in shape; size range 21–46μ × 20–36μ; 3-colporate, colpi 13–30μ long, extending from pole to pole, intercolpus distance 3–14μ, apocolpate, apocolpium diameter 2–10μ or parasyncolpate; ora lalongate 1.5–6μ × 3–9μ, extending beyond limits of colpus margin.

Exine 1.5–3μ thick; sexine 1–2μ thick with rugulose, striate or micro-reticulate surface ornamentation.

Species investigated :

Rheum acuminatum Hook. f. & Thoms.

R. alexandrae Batlin.

R. delavarii Franchet

R. emodi Wall.

R. globulosum Gage

R. inopinnatum Prain

R. moorcroftianum Royle

R. nobile Hook. f. & Thoms.

R. palmatum L.

R. pumilum Maxim.

R. raponticum L.

Rheum ribes L.

R. spiciformae Royle

R. tartaricum L.

R. undulatum L.

R. webbianum Royle.

Interspecific differences :

16 species of *Rheum* are homogenous in their pollen morphology except *R. pumilum* which is oblate spheroidal in shape and the rest are prolate to spheroidal in shape. Pollen grains are medium sized except *R. pumilum*, small in size (22μ × 24.5μ). In others pollen size ranges from 26.5μ × 21.5μ (*R. nobile*) to 43.5μ × 33μ (*R. ribes*)

All the species are 3-colporate. In *R. pumilum* and *R. undulatum*, operculoid granules are observed. Parasyncolpate condition noted in *R. palmatum, R. raponticum, R. ribes* and *R. webbianum*. Ora lalongate.

Exine pattern finely reticulate, rugulo-reticulate and rugulose. Sporoderm is uniform with tectum, bacula and nexine. Sexine and nexine are of more or less same thickness.

Rumex Linn.

It is a cosmopolitan genus having *ca.* 170 species (*s. str.*).

Pollen grains prolate to oblate-spheroidal, size range 20–44μ × 16–40μ, 3-colporate or 4-colporate, colpi 12–21μ × 1–5μ long, intercolpus distance 7–21μ, apocolpate, apocolpium diameter 3–8μ or syncolpate. Ora circular to lolongate (2.5–7μ × 2–7μ).

Exine 1.5–2.5μ thick; sexine 1–2μ thick. Surface rugulose, rugulo-reticulate or micro-reticulate.

Species investigated :

Rumex acetosa L.

R. acetosella L.

R. acutus L.

R. alpinus L.

R. brownii Campd.

R. bucephalophorus L.

R. conglomeratus Murr.

R. crispus L.

R. dentatus L.

R. flexuosus Soland ex Forst.

R. gmelinii Turcz.

R. hydrolapathum Huds.

R. japonicus Meissn.

Rumex koloczii Reichb.

R. maritimus L.

R. marshellianus Reichb.

R. nepalensis Spring.

R. nigricans Hook. f.

R. orientales Buch. ex Schult.

R. palustris Sm.

R. pulcher L.

R. sanguinicus L.

R. scutatus L.

R. thiansohanicus A. Loss.

R. triangulivalvis (Dansen) Reichb. f.

R. trifolius (Wall.) Love

R. vesicarius L.

Interspecific differences :

25 species of *Rumex* are sub-oblate to prolate in shape. *R. acetosa* and *R. trifolius* are small sized and the rest are medium sized. Pollen size range from 21μ × 17.5μ (in *R. acetosa*) to 42.5μ × 38.5μ (in *R. nepalensis*). Pollen grains generally 3-colporate but 4-colporate grains are observed in *R. acetosella, R. acutus, R. hydrolapathum, R. nepalensis, R. orientales, R. palustris* and *R. trifolius*. In *R. gmelinii* 2-colporate grains are frequently noted along with the 3-colporate pollen grains.

Colpi syncolpate in *R. bucephalophorus* and *R. dentatus* and parasyncolpate in *R. hydrolapathum and R. triangulivalvis*. Ora lolongate to circular, sometimes indistinct, rarely distinct with crassinexinous margin (*R. alpinus* and *R. orientales*).

Triplaris Loefl. ex L.

This is a genus of tree habit having *ca*. 25 species, mainly S. American. All are said to harbour ants in their hollow stems. The three outer perianth grow into long wings which project beyond the fruits.

Pollen grains subprolate in shape, size range 30–48μ × 27–38μ; 3-colporate, colpi (26–40μ × 17μ) long, extending from pole to pole. Intercolpus distance 7–15μ, apocolpate, apocolpium diameter 3–7μ; ora circular (2–4μ in diameter) to lolongate (5–7μ × 8–10μ).

Exine 3μ thick; sexine 2μ thick; surface striate or microreticulate.

Species investigated :

Triplaris americana Linn.

T. gardneriana Wedd.

T. poepigiana Wedd.

T. surinamensis Chem.

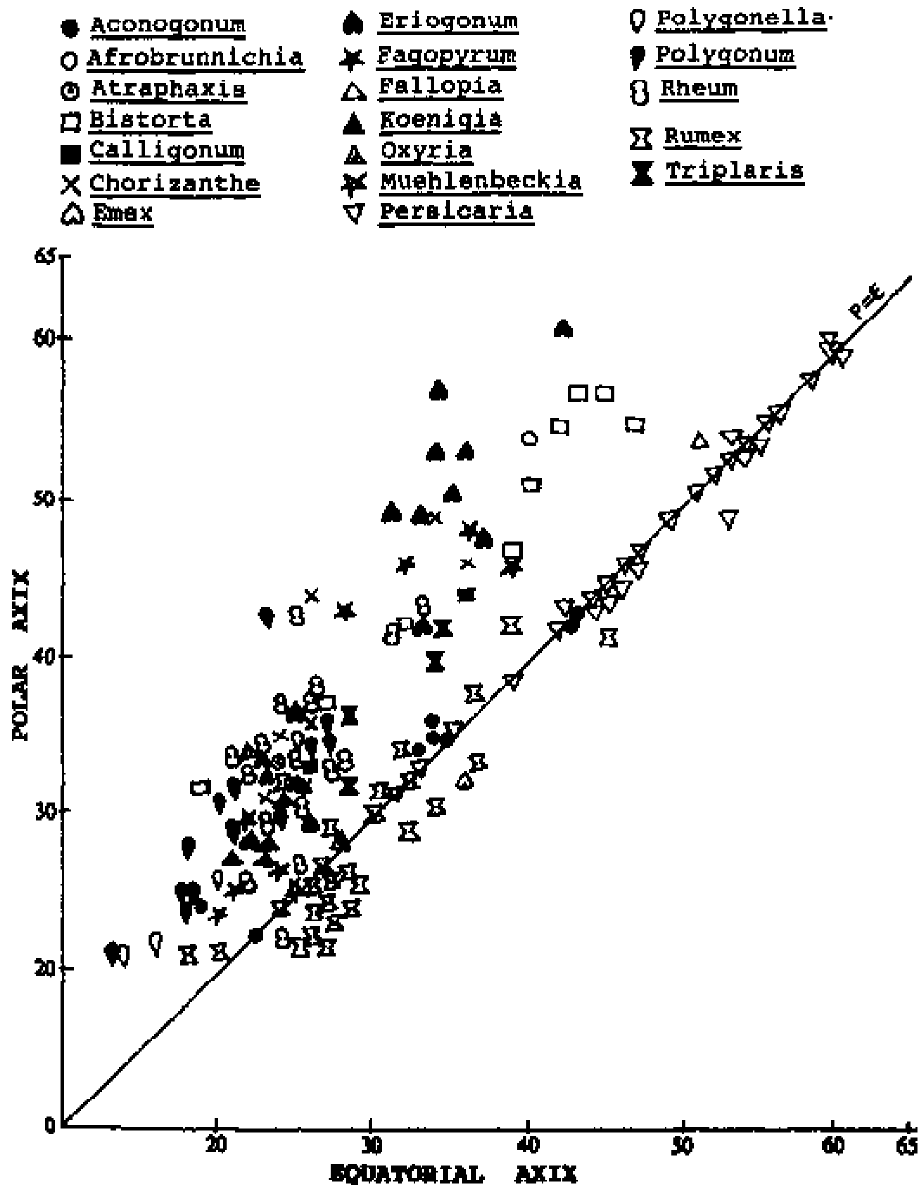

Fig. 1. POLLEN DIMENSIONAL DIAGRAM OF THE FAMILY POLYGONACEAE.

Interspecific differences :

4 species studied under the genus *Triplaris* are subprolate and medium sized; 3-colporate. *T. americana* and *T. surinamensis* have circular ora and in *T. gardneriana* and *T. Poepigiana* ora is lolongate. Exine surface striate/rugulose except in *T. poepigiana* where it is reticulate. In case of striate pattern striae perpendicular to polar axis in *T. americana*, with granules due to raised muri in *T. gardneriana*. In *T. surinamensis* the surface striae are distinct and infratectal finer striations are formed due to distinct bacula heads. In case of reticulate pattern in *T. poepigiana*, surface reticulation is formed by the bacula heads and below at lower tier, finer striations are formed by the long bacula neck and smaller bacula heads.

GENERAL POLLEN MORPHOLOGICAL CHARACTERS OF THE FAMILY POLYGONACEAE AND PALYNOLOGICAL FINDINGS.

The family polygonaceae is a distinctly eurypalynous family with a wide range of pollen morphological features. Out of the 156 species investigated, *Rumex acetosa, R. trifolius, Rheum pumilum, Polygonum corrigioloides, P. plebejum, Aconogonum molle* var. *rude, A. campanulatum, Muehlenbeckia saggitifolia* have the smallest grains while *Bistorta major, Persicaria amphibia, Antigonon leptopus* have the largest size range. Vast majority of the grains are medium sized. The length of polar axis ranges from 21 μ as in *Rumex trifolius, Polygonella polygama*, to 70μ as in *Persicaria amphibia.*

The shape of the grains varies from sub-oblate as in *Rumex flexuosus to prolate* as in *Eriogonum, Chorizanthe, Polygonella, Bistorta calostachyum, Fagopyrum saggitatum, F. tataricum* and some species of *Polygonum, Rumex* and *Rheum*. Again within the prolate type in *Polygonum* the grains are dumbell-shaped.

The intermediate shape classes such as oblate-spheroidal in *Emex australes, Rheum pumilum* and some species of *Rumex*, spheroidal in *Persicaria, Oxyria digyna, Rumex acutus, R. dentatus, R. nigricans, R. marshellianus, R. pulcher, R. trifolius* and *R. vesicarius* and prolate-spheroidal to subprolate in *Antigonon, Atraphaxis, Calligonum, Pteropyrum, Triplaris, Fallopia, Muehlenbeckia, Chorizanthe* (some species) and *Bistorta* etc., are available in the family (Fig. 1).

With regard to the apertures most of the pollen types are zonoaperturate : colpate as in *Rumex acetosa, Oxyria digyna, Persicaria capitata, P. chinensis, P. microcephala, P. alata, P runcinata;* colporate, as in *Rheum, Rumex, Emex, Antigonon, Muehlenbeckia, Atraphaxis, Triplaris, Polygonella, Polygonum, Bistorta, Fagopyrum, Fallopia, Eriogonum, Chorizanthe* etc. Some are panto-aperturate; panto-colpate as in *Persicaria amhibia, P. coccinea;* panto-porate as in *Koenigia, Persicaria* and in three species of Polygonum viz., *P. lanigerum, P. macranthum* and *P. nodosum.* These three species of *Polygonum* are more allied to the species of *Persicaria* on pollen morphological characters. It seems that the inclusion of these three species under *Persicaria* will be more natural assemblage.

The number of colpi are generally 3, but 2-colporate and 4-colporate pollen grains are frequently encountered along with 3-colporate pollen grains in *Rumex gmelinii* and *R. hydrolapathum* respectively. 4-colporate pollen grains are noted in

Rumex nepalensis, R. orientales, R. trifolius and 4-colpate pollen grains occur in *R. acetosella.* In panto-colpate types the number of colpi is *ca.* 20 and the number of pores varies from 6 to 30 or more in pantoporate type.

The colpi are mostly long, narrow slit-like, short in panto-colpate type, and brevicolpate in *Emex australis.*

The pollen grains of *Rheum palmatum, R. raponticum, R. ribes, Rumex hydrolapathum, R. triangulivalvis, Antigonon leptopus, Calligonum polygonoides, Bistorta amplexicaulis, Polygonum maritimus* and *P. biaristatum* are parasyncolpate and the pollen grains of *Rumex bucephalophorus, R. dentatus* are syncolpate.

The ora varies from lolongate to lalongate. The pollen grains of *Emex australis, Rheum, Atraphaxis spinosa,* most of the *Fallopia, Muehlenbeckia,* most of the *Bistorta,* and *Polygonum* are with lalongate ora. The ora are slit-like in *Rheum accuminatum* and zonorate conditions are encountered in *Polygonella, Fallopia convolvulus, F. dumetorum, Muehlenbeckia coccoloboides, Polygonum arenarium.* The ora are lolongate in the pollen grains of *Chorizanthe, Eriogonum, Calligonum, Triplaris, Rumex* and *Fagopyrum esculentum* while in the others ora are circular.

In the pollen grains of *Aconogonum alpinum, A. divaricatum, A. molle* var. *rude, A. ochreatum, Polygonum bucharicum, P. laxmanii, Rheum pumilum, R. undulatum* the ora are operculoid and in *Rumex orientales* the ora mrgin is crassinexinous.

The exine patterns in the Polygonaceae are likewise varied from the pilate pollen grains in *Polygonum minimum* to reticulate pollen grains in *Persicaria.* There exists many pollen grains with many different patterns such as spinulose, rugulose, rugulo-reticulate, micro-reticulate, striate-reticulate, striate, retipilate etc., in the family.

In *Polygonum articulatum, P. intermedium, P. paronichia* and *Chorizanthe douglasii* the exine surface is retipilate. Rugulose, rugulo-reticulate, striato-reticulate and micro-reticulate type of exine ornamentation are found in *Polygonum* (some species), *Chorizanthe, Oxyria, Rheum, Rumex, Emex, Fallopia* etc. The striate type exine ornamentation are observed in *Eriogonum, Chorizanthe, Triplaris* and *Fallopia cilinodis.* Reticulate exine ornamentation with small lumina (1-1.2μ) and thin muri are found in *Antigonon leptopus, Triplaris poepigiana* and *Muehlenbeckia saggitifolia.*

In *Persicaria* the exine surface is reticulate but with large lumina (diam., above 2.5μ) and broad muri. Muri may be simpli-, dupli or tripli-baculate. Lumina mostly studded with simple baculae which may be distinct and few in number or indistinct and numerous. The simplibaculae are totally absent in 3-colpate pollen grains of *Persicaria* species.

From the above pollen morphological discussion the family can be grouped into following categories, taking into consideration of the exine and aperture characters as primary and secondary importance respectively (Fig. 2).

Type I	:	Exine thickness over 2.5μ, pollen dumbell-shaped Polygonum *s. str.*
Type II	:	Exine thickness over 2.5μ, sexine thicker at pole- *Bistorta, Afrobrunnichia.*

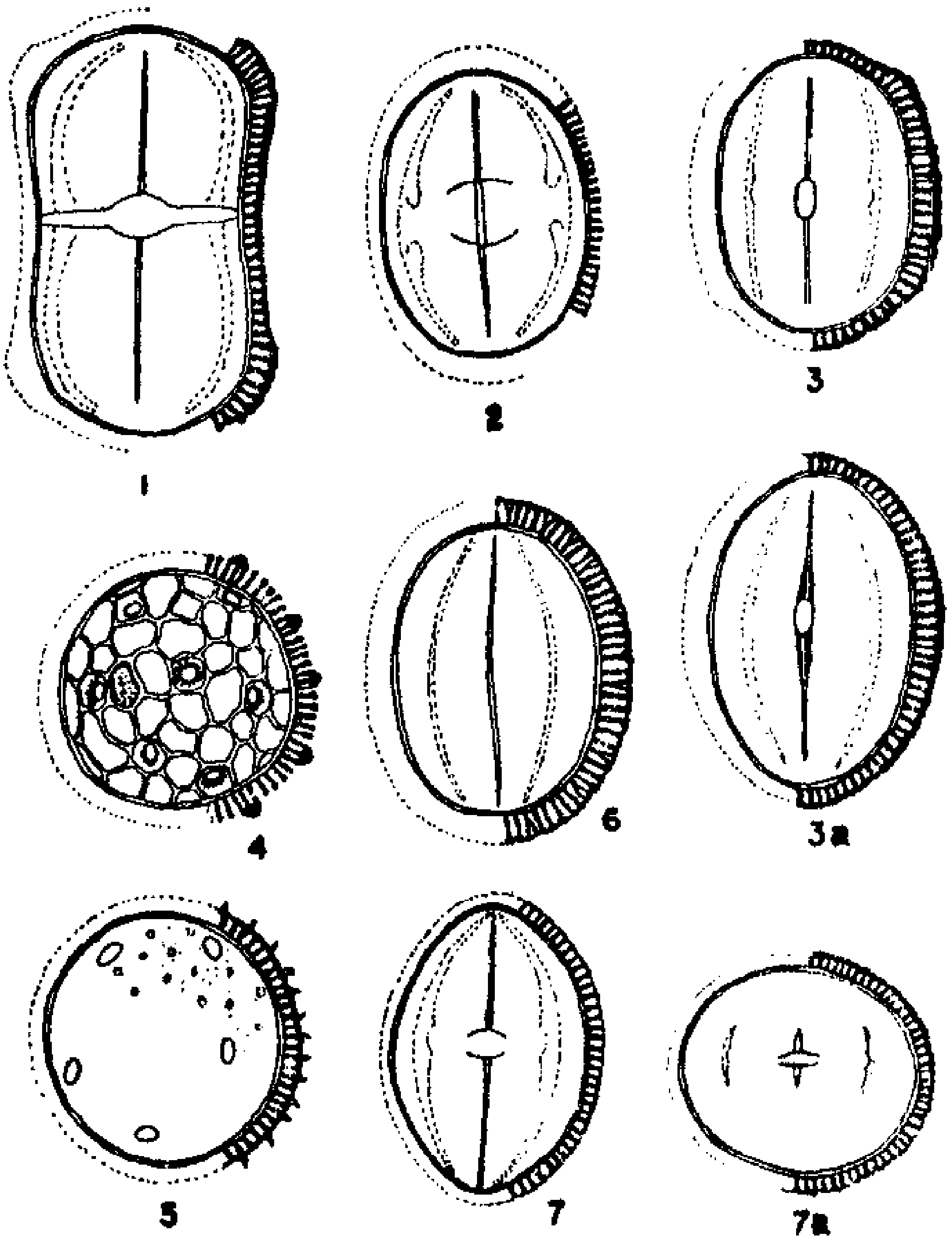

Fig. 2 : Pollen types - 1. Type I, 2. Type II, 3 & 3a. Type III, 4. Type IV, 5. Type V, 6. Type VI, 7. Type VII, 7a. Type VII.

Type III	:	Exine thickness over 2.5μ, sexine thicker at equatorial region *Chorizanthe, Eriogonum.*
Type IV	:	Exine thickness over 2.5μ, surface distinctly reticulate-*Persicaria.*
Type V	:	Exine thickness over 2.5μ, surface spinulose— *Koenigia.*
Type VI	:	Exine over 2.5μ, fine surface pattern, 3-colpate or 3-colporate (operculoid) — *Aconogonum, Antigonon, Triplaris.*
Type VII	:	Exine up to 2.5μ, 3-colporate with fine surface pattern— *Oxyria, Rheum, Rumex, Fallopia* etc.

Discussion on *Polygonum* L. *s. lat.*

Since the time of Linnaeus the genus *Polygonum* has been subdivided on various characters. Attention was focussed on the gross morphology of members and subgeneric taxa were recognised. Inflorescence and the perianth in the mature fruit were characters taken at the very beginning. Later, other criteria had been taken into consideration. As early as 1895, Small studied anatomical characters followed by Perdrigert (1900) and recently by Haraldson (1978). In his gross morphological studies, Gross (1913) added pollen morphology. Nakai (1926) focussed on the characters of fruit and embryo in his classification of the Linnaean *Polygonum.* Chemical substances in the family polygonaceae have been studied by Jaretzky (1925), Fairbairn *et al.* (1972), Boulter (1974) and some others. Similarly Federov (1969), Jaretzky (l.c.), Love and Love (l.c.), Stebbins (l.c.) and Moore (1973-77) and others have reported on the chromosomes of several members. Recently Kumar and Subramanian (1986) compiled reports on chromosome numbers of Indian Angiosperms. It is apparent that basic chromosome numbers ranging from 7 to 13.

A brief review, as outline, shows that different aspects of study have resulted in the accumulation of a wealth of information on the family, particularly on the genus *Polygonum* Linn. As anatomical and pollen morphological aspects have till recent years, received much attention besides gross morphological characters, it is felt that some details of those investigations is necessary particularly in view of the present study on pollen morphology.

Anatomical characters had been studied by Small (l.c.), Pordrigert (l.c.) and the recent one by Heraldson (l.c.) who paid attention to epedermis, trichomes, petiole anatomy and stem anatomy. As leaf venation pattern had been omitted by previous workers, the present author have intention to pay special attention to this and find some distinctive patterns, particularly the character of marginal vein as a toxonomic character in the different genera as reconnised by Hedberg and Haraldson in broad outlines. Some workers have contributed in the field which may lead to a conclusive remarks for some genera and species.

Thus, present palyanological observations with other biosystematical data inclined to regard six genera of *Polygnum* L. *sensu lato* and the distinctive characters from cytology, anatomy and morphology are fully substantiated by pollen morphology.

On the basis of the pollen characters, I am inclined to regard *Reynoutria* Houtt., as not different from *Fallopia* Adans. The materials received from different sources and named either as *Reynoutria or* Fallopia have similar pollen characters. Dammar (1893) and Green (1904) had combined the two on characters of gross morphology. Hedberg (1946) on pollen morphology treated all the species that were then placed under *Bilderdykia, Reynoutria, Tiniaria* together as belonging to a single genus *Tiniaria* which, however, later has been shown to be a nomen nudum and on rules of priority should be called *Fallopia* Adans. It is pertinent to mention about the treatment done by Haraldson (l.c.) who distinguishes between *Fallopia* Adans., and *Reynoutria* Houtt., on erect and twining habit besides petiole and stem anatomies but the stem anatomy overlap.

That there is a close relationship between *Persicaria* Mill., and *Aconogonum* (Meissn.) Reichb., as had been indicated by Gross (l.c.) and Jaretzky (l.c.) because they had a section under the genus *Persicaria,* is not acceptable from the present study.

Pollen morphologically the two genera are distinct, *Aconogonum* having operculoid and rugulose/striato-reticulate/stirate or micro-reticulate pollen grains and *Persicaria* on the other hand have spheroidal, non-operculoid and distinct reticulate pollen grains.

PALYNOLOGICAL FINDINGS

The present investigation in the family polygonaceae has been carried out to establish its relationship, affinities and position from its pollen charcters and to constitute palynological information along with the evidences available from other branches viz., leaf anatomy, wood anatomy, carpology, embryology and cytology etc., towards a more natural and modern taxonomy of the family. The present contribution covers the considerable aspects in pollen morphological diversity in polygonaceae. Special attention is paid to the aperture characters and exine ornamentation. Indistinct endoapertural area culmintes in its line of evolution into distinct endoaperture area and endoaperture with operculoid structure. In the line of exine ornamentation, pilate, rugulose exine ornamentation culminates into distinct reticulate and spinulose exine ornamentation through rugulo-reticulate and micro-reticulate exine ornamentation. Although the ontogenetical development and functioning of these operculoid structure and sexinous materials are still remain to be investigated, it appears probable that they are the result of evolution and cost of natural selection in the history of the family. In addition, this findings will help in fossil pollen analysis in particular for the study of palaeogeographical flora.

From the present palynological study on the family it may be concluded that:

1. The family Polygonaceae is a distinctly eurypalynous family with a wide range of pollen morphological features.
2. The *Polygonum s. lat.* is a very heterogeneous complex. Further research in sporoderm stratification and on different discipline of botany is to be undertaken for better understanding of the taxon.
3. In contra-distinction to *Polygonum s. lat.* and *Rheum* the genus *Eriogonum,*

Persicaria and *Aconogonum* are not eury but stenopalynous with regard to shape, aperture and exine ornamentation etc.

4. *Polygonum bucharicum* and *P. laxmanii* will be very much befitting and more natural if treated under the genus *Aconogonum* on the basis of pollen morphological characters, particularly the operculoid apertures.
5. *Polygonum lanigera, P. macrantha, P. nodosa* are more allied to the species of *Persicaria* pollen morphologically. Transfer of these three species under *Persicaria*, palynologically a more distinct genus, is suggested.
6. The genus *Koenigia* is also apparently seems to be very distinct being only pollen type having pantoporate aperture and spinulose exine ornamentation.
7. After a close comparison of the pollen types, it is possible to suggest a number of evolutionary trends in the family (Fig. 3). By the term "evolutionary trends" means here only the tendency from one form to the diverse form, as evidenced in the taxa studied. However, evolutionary trends for the family should be regarded as theory only and fossil evidences in favour of this postulations shall confirm the true evolution, which is yet to be investigated.

Fig. 3

EVOLUTIONARY TREND IN POLLEN MORPHOLOGY IN THE FAMILY POLYGONACEAE

1. **Shape :**

 (a) *Eq. view*

 Suboblate → Ob. Sph. → Sph. → Pro. Sph. →

 Sub. Pro → Prolate → (Prolate : Dumble shaped)

 (b) *Pol. view*

 Subangular → Circular

2. **Size :**

 Small → Medium → Large.

3. **Aperture :**

 Colpate → Colporate → Pantoporate

 Colpate → Colporate → Pantocolpate

 Parasyncolpate → Syncolpate

4. **Ectoaperture** (Colpus) :

 Long slit-like → Brevicolpate.

5. **Endoaperture :**

   (a) Circular → Lolongate → Lalongate

   (b) Simple → Operculoid

6. **Exine ornamentation :**

   (a) Pilate → Retipilate → Rugulo-reticulate → Micro-ret. → Reticulate.
   Striate → Striatoreticulate.
   — Spinulose

   (b) Homobrochate → Heterobrochate

   (i) Lumina size uniform throughout → Lumina size decreases towards aperture.

   (ii) Lumina size uniform in mesocolpium → Lumina size increases in apocolpium → Lumina fuse side by side to form liner lumina.

   (iii) Muri thin (up to 1 μ) → Muri thick (> 1μ).

7. **Sporoderm :**

   (a) Sexine : Sexine thicker than nexine → Sexine = Nexine → Nexine thicker than sexine.

   (b) Columella :

   (i) Indistinct → Distinct.

   (ii) Height uniform throughout → Height decreases towards aperture area.

   (iii) Shorter than tectum thickness → Equal to tectum → Higher than the tectum.

DIFFERENT DISCIPLINES OF BOTANY IN BETTER UNDERSTANDING OF THE CLASSIFICATION AND RELATIONSHIP OF THE FAMILY

Anatomical and Epidermal Evidences

The epidermal features in the family has received much attention from the past, as early as from the time of Constantin (1886), Schmidt (1897), Perdrigeat (1900), Massart (1902), Gluok (1924) and Mitchell (1968). Their studies were limited to some European taxa only and that was too restricted to only a few species. In India, Inamdar (1969, 1970) has worked out for few species of *Polygonum* L., *Rumex* L. and *Fagopyrum* Gaert. Kapoor *et al.* (1971) have described epidermal features of some species of *Polygonum s. lat.* and Mitchell (1971) worked on some species of American *Persicaria* Mill. Literatures reveal that epidermal cells in the family are in general polygonal, elongated and those which are not arranged in a definite pattern. (1) Polygonal type of cells have been found mostly in the genus *Polygonum s. str.* and also in the species of *Bistorta, Persicaria* (most of the species), *Pleuropteropyrum, Fagopyrum* and some species of *Rumex.* (2) Elongated type of cells have been observed on the abaxial surfaces of the species of *Koenigia* and *Pleuropteropyrum* and (3) Irregularly arranged polyhedral cells have been found in *Koenigia,* some species of *Persicaria, Bilderdykia, Oxyria, Rheum* and *Rumex.*

It is apparent that the shape of the epidermal cells are not effective as the diagnostic features of the genera except, however, the polygonal type of epidermal cells in *Polygonum s. str.* and sinuate cells in *Koenigia, Persicaria, Bilderdykia* and *Oxyria* are found to be distinct.

Solereder (1908) was of opinion that the stomatal characters may be significant for the delimitation of taxa. But Odell (1952) did not consider the stomatal character of any taxonomic value because of the considerable variation within the family, genus and species with ecological variations. Florin's work (1933, 1958) on developmental aspects of stomata, first evoked considerable interest of the texonomists for this aspects. Foster (1949), Metcalfe and Chalk (1950) and Stebbins and Kush (1961) recognise that mode of development of stomata, their spatial relationship to the guard cells, subsidiary cells etc., may be significant in the classification and phylogeny.

Metcalfe and Chalk (l.c.) observed that stomata in the family are always anomocytic type except in *Coccoloba, Oxytheca* and *Triplaris* which have paracytic stomata. Husson (1966) and Inamdar (l.c.) reported the occurrence of anisocytic, anomocytic and paracytic types. However, Kapoor *et al.* (l.c.) reported only two types anomocytic and anisocytic types and did not fined paracytic type in the species of *Polygonum.* Munshi and Javeid (1986) observed anomocytic type and anisocytic type of stomata in the species of *Koenigia;* anisocytic and paracytic type of stomata in the species of *Polygonum*; anisocytic and paracytic type in the species of *Bistorta;* anisocytic, paracytic or anomocytic type either single of mixed type in the species of *Persicaria;* anomocytic or anisocytic in the species of *Pleuropteropyrum;* anomocytic and anisocytic in the species of *Bilderdykia;* anisocytic in the species of *Fagopyrum. Oxyria, Rheum* and *Rumex* shows close relationship as regard the presence of amphistomatic conditions by anisocytic, paracytic and diacytic conditions.

TABLE I

Types of stomata in the genera of Polygonaceae

After Metcalfe and Chalk (l.c.), Inamdar (l.c.), Kapoor *et al.* (l.c.) and Munshi and Javeid (l.c.)

Stomatal Type : / Genera :	Paracytic	Anisocytic	Anomocytic	Diacytic
Koenigia L.			+	
Polygonum L.	+	+		
Bistorta Mill.	+ (rare)	+		
Persicaria Mill.	+	+	+ (rare)	
Pleuropteropyrum H. Gross		+	+	
Bilderdykia Dumort.	+	+	+	
Fagopyrum Gaertn.		+		
Oxyria Hill.	+	+		
Rheum L.	+	+		
Rumex L.	+	+		+

TABLE II

Selected characters from epidermal appendages

After Inamdar (l.c); Kapoor *et al.* (l.c.) and Mitchell, 1971

Characters : / Genera :	Glands	Valvet Chambers	Glandular Trichomes	Non-glandular Trichomes	Idio-blasts
Koenigia L.				+	+
Polygonum L.	+	+			
Bistorta Mill.			+	+	+
Persicaria Mill.	+	+	+	+	+
Pleuropteropyrum H. Gross				+	+
Bilderdykia Dumort.	–	–	–	–	–
Fagopyrum Gaertn.			+	+	+
Oxyria Hill.		+			
Rheum L.		+		+	
Rumex L.	+	+			

Abnormalities in the stomatal cells have also been reported by Munshi and Javeid (l.c.). He reported shunken stomata, a xerophytic character, in *Koenigia delicatula* (Meissn.) Hara, *Persicaria nepalensis* (Meissn.) Gross and *Rumex acetosa* L. Though rare, some conjugate type of stomata have been reported in *Persicaria punctata* (Elliott) Small, *P. salicifolia* (Brouss. ex Willd.) Munshi et Javeid and *Bistorta vivipara* Grey; single guard cell in the stomata is also reported in *Persicaria amphibia* (L.) Grey, *P. orientalis* (L.) Spach. and *Polygonum maritimum* L. Datta and Mukherjee (1952) are of opinion that somatal abnormalities are of diagnostic value particularly in case of crude drugs identification. From the above discussion it is apparent that the stomatal features are not adequate enough for the delimitation of genera of the family. However, in wide sense *Polygonum s. str.*, *Koenigia, Bistorta, Persicaria, Pleuropteropyrum* and *Fagopyrum* are to some extent distinct form the stomatal characters (Table I).

Trichomes of the family have been reported by Gross (1912), Mitchell (1968, 1971), Inamdar (l.c.), Kapoor *et al.* (l.c.) and some others. They reported unicellular, bicellular, biseriate and glandular trichomes and some valvet chambers as well as idioblast cells but it is apparent that the distribution of characters are overlapping for the genera and species of the family (Table II).

Cytological evidences :

Chromosome counts and karyotype reports are available enough from many workers in India and abroad. Cytological information on the family have been enriched by Mansurova 1969 (Fedorov), Kihara (1927), Jaretzkey (1928), Edman (1929), Pauwels (1959), Love and Love (1956, 1971), Sokolovskaya and Strelkova (1969) Fedorov, Hedberg and Hedberg (1964), Graham and Wood (1965), Timson (1965), Javurkovak (1980) and so many others. Indian reports are mainly contributed by Raghavan and Arora (1958), Sharma and Chatterjee (1960), Gajapathy (1961), Mehra and Dhawan (1966), Mitra and Datta (1967), Mallick (1968, 1969), Sarkar *et al.* (1975), Bhattacharya and Rahman (1978), Bir and Sidhu (1978, 1980), Subramanian (1980), Kumar (1986) and many others.

It is apparent from the available reports that 2n chromosome number ranging from 14-48 in the genus *Antigonon*, 16-32 in *Fagopyrum* 14-28 in *Koenigia*, 14-42 in Oxyria, 20-(24-44)-60-66-100-132 in *Polygonum*, 22-44 in *Rheum*, 14-42 in *Rumex* and 22 in *Triplaris*. Darlington and Wylie (1955) is of opinion that there are three series of basic sets of chromosome number in the genus *Polygonum* viz. 10, 11 and 17; and four series of basic sets of 7, 8, 9 and 10 in the genus *Rumex*. Mallick (l.c.) and Sharma and Chatterjee (l.c.) though did not get any members in the series 17 but they observed a new basic chromosome number set with n=12 in *Polygonum alatum*.

However, literature from chromosome number reports reveal that the genera of the family show a divergent lines of evolution from a common basic stock. Interestingly the family Caryophyllaceae have the chromosome number range overlapping the Polygonaceous numbers. Basic chromosome number sets are mostly ranging 8, 10 and 12 in the Caryophyllaceous taxa (Khoshoo, 1960; Khoshoo and Bhatia, 1965; Sharma and Sarkar, 1967-68; Kumar and Chauhan, 1975 and others). Aneuploidy and polyploid multiples of the basic sets are clear in the group. Chromosome number reports support the palynological findings for the family of being a polymorphs and divergent lines of evolutions from a common stock.

Embryological evidences :

Embryological evidences for the family is very meagre. The unilocular ovary with several ovules appears to be reduced from a basally partitioned ovary with several ovules on a free-central placenta, quite in agreement with the structure of the Caryophyllaceae and some other families of Caryophyllales. The usually peripheral embryo which may be curved around the food storage tissue of the seed is also reminiscent of the Caryophyllales (Cronquist, 1981).

Phytochemical evidences :

This branch of science is becoming an important aid in finding out the relationships of the plant families. However, important informations available from the work of Boulter (1974), Jaretzky (l.c.) and Fairbairn *et al.* (1972) is that structure of cytochrome C_3 suggest a relationship between the Polygonaceae and Caryophyllaceae/Centrospermae. Caryophyllaceae appears to be the most likely family since both have anthocyanin pigments. But plastid structure and characters are different in two families (Behenke, 1976).

Palynological evidences :

The present palynological investigations are not in full agreement with other evidences discussed earlier. To some extent it supports the anatomical and cytological evidences and some phylogenetic classification proposed time to time by different authors, for resolving better understanding of affinity and relationship of the family. Pollen morphologically the family Polygonaceae shares characters with the families of Caryophyllales. Erdtman (1963) from the point of view of NPC and for some other reasons is of opinion to relate Polygonaceae with Centrospermae, and their ancestry from a common stock. It has observed in the present study that the family Caryophyllaceae, Nyctaginaceae and Polygonaceae have 764 type of NPC mostly lent with other types available in all the families are 343, 344, 364, 663, 664, 443, 663 and 763. 3-colpate pollen grains in some species of *Aconogonum, Oxyria, Persicaria* and *Rumex* reminds the pollen types in Plumbaginaceae.

Within the family some genera are very distinct and some are eurypalynous. Pollen morphological characters of the genera do not support the further subdivision of the family into tribes at least in its present jurisdiction as in the tribe Rumiceae, *Oxyria* is very distinct with 3-colpate pollen grains but *Rheum, Emex* and *Rumex* are characterised by 3-4-colporate pollen grains.

The subdivision of the very heterogeneous genus *Polygonum s. lat.* is one of the best and most striking examples of parallelism between palynological characters on the one hand and non-polynological characters on the other. Present observation support previous contribution in the field by Hedberg (l.c.).

1. **Aconogonon hookeri** (Meissn.) Hara
(= *Polygonum acaule* Hook.)
from Sikkim

2. **Polygonum delicatulum** Meisn.
from Phalut, Darjeeling

5. **Koenigia islandica** (L.) Hook. f. (= *Polygonum islandicum* L.)
from Ladakh

6. **Persicaria Capitata** (Buch. -Ham. ex D. Don) H. Gross
(= *Polygonum Capitatum* Buch. -Ham. ex D. Don)
from Sikkim

TABLE III

SUMMARY OF SELECTED POLLEN MORPHOLOGICAL FEATURES

Taxa	Shape	Size in µm Mean/Range PXE	Aperture type	Aperture size im µm	Ora type size in µm	I.C.D. in µm	A.D. in µm	EXINE Thickness in µm E	S	Surface
1	2	3	4	5	6	7	8	9	10	11
ACONOGONUM										
A. campanulatum	Sph.	24×19 22-25×18-20	3-C.	15.5×1 14-17×1	×	6-8	6-7	2.5	2	Striato-reticulate
A. divaricatum	Pr., Sph.-Ob.-Sph.	36x34 33-38x33-36	3-Co.	27×1.5 24-30x1.5	Operculoid	11-19	9-12	3	2	Rugulose
A. molle	Sph.	43×43 37-46×37-46	3 Co.	18×1.5 16-20×1.5	×	18-22		5	4	Microreticulate
A. molle var. *rude*	Sph.-Ob.-Sph.	22×22.5 21-23×21-24	3-Co.	14×1 13-16×1	Operculoid	9-15	3-4	3	2	Striate
A. ochreatum	Spr.	32×25 30-34×24 26	3-Co.	22.5×1 21-24×1	Operculoid	6-7	5-7	3-3.5	2-2.5	Striato-reticulate
A. songaricum	Pr., Sph.-Ob.-Sph.	35×34 30-39×30-40	3-Co.	24×1.5 20-27×1-3	Operculoid	11-17	8-12	3.5-4	2.5-3	Rugulose
AFROBRUNNICHIA										
A. erecta	Pr.	54×40 50–58×36–43	3-Co.	32×2 28-35-1-2	Lolongate 10-14x..	9-18	—	3-4	2-3	Striato-reticulate

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
ANTIGONON										
A. leptopus	Spr.	64×51 58-70×41-60	3-Co.	55×1.5	Lolongate	22-25	Para- syn- colpate.	4	3	Reticulate
ATRAPHAXIS										
A. spinosa	Spr.	27×21 26-30×19-23	3-Co.	21-23×1	Lolongate undist. 3-4x	7-9	4-5	3-4	2-3	Striate
BISTORTA										
B. alopecuroides	Pr.-Sph.	42×32 32-52×25-97	3-Co.	27×1.5 19-35×1.5	Lolongate 4-9x ,,	11-17	7-9	3.5 2.5	3 2	Micro- reticulate
B. amplexicaulis	Sph.	56×46.5 48-61×38-52	3-Co.	31×105 26-36×1.5-2	Lolongate 7-8×8-9	15-34	Para- syn- colpate	2.5 3.5	2 3	—do—
B. attenuata	Pr.-Spr.	57×44 54-60×40-47	3-Co.	42×1 40-43×1	Lalongate	22-26	6-7	2.5 3	2 2.5	Rugulo- reticulate
B. bistortoides	Spr.	51×40 47-53×35-44	3-Co.	35.5×1 33-41×1	Lolongate to circular 9-12×9-10	18-25	12-15	4 3.5	3 2	—do—
B. emodi	Spr.	47×39 45-52×31-46	3-Co.	26.5×1 21-31×1	Circular 5-8	18-25	–	5 3	4 2	—do—
B. major	Pr.-Spr.	55×42 41-70×34-52	3-Co.	37×1 20-51×1	Circular 10-12 to Lolongate 7-9×8-12	15-27	–	3 2.5	2.5 2	—do

(Contd ....)

TABLE III *(contd.)*

1	2	3	4	5	6	7	8	9	10	11
Bistorta vivipara	Spr.	57×44 54-60×40-47	3-Co.	31×1.5 21-36×1.5	Circular 4-6	22-26	6-7	3 2.5	3.5 2	Rugulo- reticulate
CALLIGONUM										
C. comosum	Spr.	44×36	3-Co.	30-36×1.5	Lolongate 7×5	10-15	5	2.5	2	Striato- reticulate
C. polygonoides	Spr.	33×26	3-Co.	26-33×1	Circular to Lolongate 2-4×2-3	9-12	Para- syn- colpate	2	1.5	—do—
CHORIZANTHE										
C. diffusa	Spr.	35×24 34-37×22-26	3-Co.	24-26×1	Lolongate 4-5×3-3.5	11-13		3	4	Striate
C. douglasii	Spr.	46×37 40-50×31-52	3-Co.	26-33× 1-1.5	Lolongate 6-8×4-6	11-13		5 7.5	1	Retipilate
C. frankenoides	Pr.	49×34 47-50×32-35	3-Co.	30-32×1	Lolongate 6-7×4-5	13-15		2.5 3.5	0.5	Striate
C. membranacea	Spr.	31×23 29-35×22-25	3-Co.	16-17×1	Lolongate 4×3	10-12		2.5 3.5	0.5	Microreti- culate
C. parryi	Spr.	37×26 33-42×23-31	3-Co.	18-24×1	Lolongate 4-5×3-4.5	10-12		4 3	1	Striato- reticulate
C. statioides	Pr.	44×26 42-45×25-29	3-Co.	30-33×1	Lolongate 5-6×3-5	2-7		2.5 3.5	0.5	Rugulose

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
EMEX										
E. australis	Ob.-Sph.	32×36 30-35×32-44	3-Co.	8×1.5 6-10×1.5	Lolongate	24-25	25	2	0.5	Microreticulate
ERIOGONUM										
E. aberteanum	Pr.	36×25	3-Co.	30×1	Lolongate	5-7		1.5 2	0.5	Striate
E. alatum	Pr.	29×26.5 35-45×25-27	3-Co.	32×1 30-34×1	Lolongate 4×2.5	6-8		1.5 2	0.5	—do—
E. atrorubens	Spr.	47×37 40-50×31-40	3-Co.	40×1 36-42×1	Lolongate 2-5×2-3	9-16		2 3	1	—do—
E. baileyi	Pr.	32×23 27-35×20-25	3-Co.	24×1 20-26×1	Lolongate 3×1.5-2	7-11		2 3	0.5	—do—
E. fasciculatum	Pr.	53×36 48-60×34-40	3-Co.	45×1 42-50×1	Lolongate 3-4×2-3	10-12		2 3	1	—do—
E. hurmanii	Pr.	50×35 47-55×33-37	3-Co.	41×1 37-44×1	Lolongate 4-5×2-3	10-12		2 3	1	—do—
E. inflatum	Pr.	49×33 46-52×32-36	3-Co.	42×1 40-43×1	Lolongate 4×2	11-13		2 3	0.5	—do—
E. jamesii	Pr.	61×42 55-65×40-44	3-Co.	54×1 50-58×1	Lolongate 6-7×4-5	13-18		2 3	0.5	—do—
E. latifolium	Pr.	49×31 42-52×29-33	3-Co.	41×1 44-43×1	Lolongate 4-5×3-3.5	6-8		2 3	1	do

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
Eriogonum nudum	Spr.	42×33 36–45×28–36	3-Co.	36×1 33-40×1	Lolongate indist	6-10		2 3	1	Striate
E. polycladon	Pr.	33×23 30-35×21-22	3-Co.	26×1 25-28×1	Lolongate 3×1.5	8-12		1.5 2	1	—do—
E. pyrolaefolium	Pr.	57×34 55-58×32-35	3-Co.	46×1 45-50×1	Lolongate 5-7×3	8-10		1.5 3	0.5	do
E. tenellum	Spr.	28×22 26-32×20-23	3-Co.	22×1 20-25×1	Lolongate 3×1.5	8-10		2 3	1	- do--
E. wrightii	Pr.	53×34 50-55×32-37	3-Co.	43×1 40-50×1	Lolongate	5-9		2 3	1	—do—
FAGOPYRUM										
F. cymosum	Spr.	48×37.5 45-52×24-40	3-Co.	35×2 32-40×2	Lalongate 4-5×7-10	16 20	7-10	4-4.5	3.5-4	Reticulate
F. esculentum	Spr.- Pr.	46×39 40-56×30-56	3-Co.	41×1.5 40-42×1-2	Lalongate 7-10×4-8	12-13	5-6	3	2	Reticulate
F. sagittatum	Pr.	46×32 44-48×30-33	3-Co.	37×4 36-38×4	Circular 3.5-4	10-11	6-10	4-4.5	3.5-4	Microreti- culate
F. tataricum	Pr.	43×28 42-45×27-29	3-Co.	35.5×3 33-36×3	Circular 4-4.5	7-9	Syncol- pate	3-3.5	2.5-3	Reticulate
FALLOPIA										
F. baldshuanicum	Pr. Sph.	26×24 25-29×22-26	3-Co.	21×1 20-22×1	Lolongate 3×6	10-12	5-7	2	1.5	Striate

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
Fallopia cilinoids	Pr. Sph.-Spr.	23.5-20 22-25×19-22	3-Co.	18×1.5 16-20×1.5	Lolongate 1.5-2×3-5	6-12	3-5	2	1.5	Striate
F. convolvulus	Spr.-Pr.	29×22 26-32×19-24	3-Co.	18×1 15-21×1-1.5	Lalongate 2-3×...	10-16	7-8	2.5	1.5	Microreti-culate
F. dumetorum	Spr.	25×21 23-26×18-21	3-Co.	15×1 13-17×1	Lalongate	9-16	7-10	2	1	—do—
F. multiflora	Spr.	32×25 30-33×25-26	3-Co.	23×1 22-24×1	Circular 1.5 2	10-13	6-8	3	2	Reticulate
KOENIGIA										
K. islandica	Sph.	23 22-24	PP C.12	2-3×1.5-2	×	5-8	×	2	1.5	Spinulose
MUEHLENBECKIA										
M. adpressa	Spr.- Pr. Sph.	27×23.5 26-28×23-24	3-Co.	2.5×2 20-21×1.5-2	Lalongate 1.5-2×4-5	8-12	1-5	3	2.5	Striato-reticulate
M. coccoloboides	Pr.-Spr.	33×23 29-35×22-25	3-Co	25×1 23-27×1	Lalongate 4×...	8-10	4-7	1.5-2	1-1.5	Obscure
M. saggitifolia	Spr.- Pr. Sph.	24×21 23-25×19-22	3-Co.	18×1.5 16-19×1.5	Lalongate 2.3×5	6-9	3-4	2.5	1.5	Microreti-culate
M. volcania	Spr.- Pr. Sph.	26×22.5 25-27×22-24	3-Co.	19.5×1.5 18-21×1.5	Lalongate 2-3×9-12	8-11	3-5	2.5	2	Striato-reticulate
OXYRIA										
O. digyna	Sph.	27 25-30	3-Co.	12.5×5 10-14×0.5	Circular 4-5	10-12	4	2.5	2	Striate

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
PERSICARIA										
P. alata	Sph.- Ob. Sph.	49×53 45-56×49-57	3-Co.	12-20×3	10-16	2-5×3-5	2-3	6	5	Reticulate
P. amphibia	Sph.	67×67 58-75	PC C3	9-11×1	21	2-3×2-3	2-3	4.5-5	3.5 4	do
P. barbata	Sph.	54 43-62	PP C.21-24	2-3×2-3	4-5	3-6	2.5-3	4	3	—do—
P. caespitosa	Sph.	60 58-62	PP C.20-25	5-7	8-10	.5-7	2-4	6	5	—do—
P. capitata	Sph.	45 43-50	3-C.	10-28×1	20-22 AD-16-20	1-3	2-3	4-5	3-4	—do—
P. chinensis	Sph.	49 40-56	3-C.	20×1	AD-28-30	1-4×1-3	1.5-3	4-5	3-4	—do—
P. coccinea	Sph.	56.5 52-64	PC C.20	8-11×2	1.5-3×2-5	2-3	5	4		—do—
P. flaccida	Sph.	65 58-72	PP C.30	1.5-2	5	2-4×2 -8		2-3	7	—do—
P. glabra	Sph.	54 47-60	PP C.25	3 4×4-6		4 9×2 7	3-4	4	3	—do—
P. hydropiper	Sph.	60 56-67	PP C.20-25	3×3	5-6	2-5	2-3	6	5	—do—
P. hydropiperoides	Sph.	52 48-58	PP C.10-12	3-5	13-15	3-5×3-7	1.5-2	4-5	3-4	—do—
P. incarnata	Sph.	35 30-41	PP C.12-15	2-3	4-5	3-4×3-5	1.5-2	3	2	—do—

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
P. lapathifolia	Sph.	45 34-58	PP C.20-25	3-4	3-4	3-5	1.5-2.5	5	4	Reticulate
P. limbata	Sph.	46 43-49	PP C.20-22	2.5-3	2.5-4	3-5	2-3	6	5	—do—
P. limicola	Sph.	34 33-37	PP C.18-20	2 3	4-8	3-4×2-3	2	4	3	—do—
P. maculata	Sph.	38.6 34-42	PP C.18-20	2-3	3-4	3-5×2-5	1.5-2	3.5	2.5	—do—
P. microcephala	Sph.	31.8 27-34	3-C	18×1	8-12	2-3×2-3	2-3	4-5	3-4.5	—do—
P. mitis	Sph.	44 40-47	PP C.18-20	2×3	10	2-5×2-3	1.5-2.5	5	4	—do—
P. muricata	Sph.	63 45-63	PP C.40	2-2.5	9-11	2-3×2-5	3-4	7	6	—do—
P. orientalis	Sph.	53 43-65	PP C.40	3.5-5	9-11	2-3	2-3	7	6	—do—
P. peduncularis	Sph.	54 45-60	PP C.20-30	2-3	4-5	2-5×2-3	2-3	8	7	—do—
P. pensylvanica	Sph.	56 52-60	PP C.18-20	2-3	4-6	3-5×2-3	2	4.5	3.5	—do—
P. posumbu	Sph.	54	PP C.40	2-3	4-5	3-4	2-3	5.5	4.5	—do—

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
P. perfoliata	Sph.	46.8 42-50	PP C.8-12	2-3	8-12	4-5x3-5	2-3	5.5	5	Reticulate
P. prostrata	Sph.	45 45-40	PP C.9-12	2-3x2-4	6-9	3-4x2-4	1,5-2	4	3	—do—
P. runcinata	Sph.	51 43-56	3-C	19-24x2-3	2-3	2-2.5	6.5-7	5.5-6		—do—
P. senegalensis	Sph.	47 40-50	PP C.18-21	2-3	8-15	4-6x2-5	2-2.5	6	5	—do—
P. stagnia	Sph.	60 52-70	PP 8-12	2-3	4-6	4-5x2-5	2-3	8	7	—do—
P. strigosa	Sph.	44.4 45-55	PP C.15-20	3-4	7-9	3-6x3-4	2-4	6	4	—do—
POLYGONELIA										
P. articulata	Pr.	35x25 30-37x19-27	3-Co.	22x1.5 2--25x1.5	Lalongate 2x..	5-7	4-6	3 4	2 3	—do—
P. polygama	Pr.	21x14 20-22x14-15	3-Co.	15x1.5 15-16x1.5	Lalongate 2x..	6	×	2 3.5	1.5 2	Microreti- culate
POLYGONUM										
P. arenarium	Spr.-Pr.	25x18.5 23-28x16-20	3-Co.	16.5x1 15-19x1	Lalongate 4-5x10-15	5-8	4-6	2.5-3	1.5	—do—
P. articulatum	Pr.	31.5x18.5 30-34x18-20	3-Co.	20.5x1 20-22x1	Lalongate	4-7	–	2.5 3	2 2.5	Reticulate

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
P. cognatum	Spr. -Pr.	30×24 27-32×19-26	3-Co.	22×1 10-26×1	Lalongate	6-10	7-9	2.5-3	1.5-2	Striate
P. corrigioloides	Pr.	22×16 21-25×14-17	3-Co.	15×1 14-16×1	Lalongate 3-4×8-11	6-10	6-8	2.5-3	1.5-2	Striate
P. floribundum	Spr. -Pr.	26×20 24-28×15-22	3-Co.	18×1 16-19×1	Lalongate	8-9	4	2.5-3	1.5-2	—do—
P. humifusum	Spr.	29×21 25-33×19-23	3-Co.	19×1 15-22×1	Lalongate 3-4×..	4-9	4-7	3	2	—do—
P. intermedium	Pr.	28×17.5 27-29×17-18	3-Co.	14.7×1 14-15×1	Lalongate 2-3×9-11	4-7	6-8	4	2-3	Retipilate
P. lanigerum	Sph.	43 35-48	PP C.18	2-4	3-5	3-5	2-3	4	3	Reticulate
P. laxmanii	Sph	33×33 32-34×32-34	3-Co.	23.5×1 21-25×1	Operculoid	18-22	4-5	3	2	Rugulose
P. littorale	Spr.	34×25 33-35×24-26	3-Co.	25×1.5 24-27×1.5	Lalongate 4-5×7-8	5-8	4-5	2.5-3	1.5-2	Striate
P. macranthum	Sph.	58 55-62	PP C.20-25	3-4×3	4-6	3-4×5-8	2-3	6	5	Reticulate
P. maritimus	Spr. -Pr.	35×27 35-36×26-27	3.4-Co.	27×4 26-27×4	Lalongate	9-10	Para- syncol- pate	3	1.5-2	Microreti- culate

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
P. minimum	Pr.	31×20 30-32×19-22	3-Co.	18.5×1 18-19×1	Lalongate 4-5×11-12	6-10	×	3.5	2.5	Pilate
P. nodosum	Sph.	42 38-47	PP C.12-15	1.5-2	5-7	3-4	1.5-2	4	3	Reticulate
P. paronychia	Pr.	43×23 40-45×22-24	3-Co.	23×1 22-24×1	Lalongate 3×12-14	9-11	×	3-6	2-5	Retipilate
P. plebejum	Pr.	21×13.5 18-23×12-15	3-Co.	14×1 13-15×1	Lalongate 3-4×7-8	5-7	×	2.5-3	1.5-2	Striate
R. recumbens	Spr. -Pr.	24×18 23-25×18-19	3-Co.	17×1 16-19×1	Lalongate 3.5-4×9-10	7-8	3-4	2.5-3	2.5	—do—
P. thymifolium	Pr.	32×22 30-35×21-24	3-Co.	23×1.5 22-25×1.5	Lalongate 3-4×8-10	7-10		2.5-3	2	do
PTEROPYRUM										
P. olevirii	Spr.	33×26 30-36×24-28	3-Co.	24-29×1	Circular 3-4	6-9	4-5	2.5	1.5	Striato-reticulate
REYNOURTRIA										
R. japonica	Sph.	25 22-28	3-Co.	20×1 18-22×1	Lalongate 2-3×7-9	6-12	4-5	3	1.5	Microreti-culate
RHEUM										
R. acuminatum	Spr.	28×22 26-29×20-23	3-Co.	22×2 21-22×2	Lalongate 1.5-2×4	8-12	3-4	2	5	Rugulose

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
R. alexandrea	Spr. -Pr.	31×23 27-31×21-24	3-Co. 22-27×2-3	25×3	Lalongate 2.5-5×4-5	3-8	2-4	1.5-2	1-1.5	Rugulose
R. delavayi	Spr	33×26 30-35×24-27	3-Co.	28×3 25-31×3	Lalongate 3-4×5-7	5-10	2-3	2	1.5	Microreti-culate
R. emodi	Pr.	37×24 35-39×22-26	3-Co.	29×4 26-31×4	Lalongate 2-4	5-9	4-9	2	1.5	—do—
R. globulosum	Pr.	34×23 28-39×21-26	3-Co.	27×3 22-29×2-4	Lalongate 3-4×5-6	6-10	2-3	3	1.5	Striate
R. inopinatum	Pr.	43×25 35-47×24-27	3-Co.	34×5.5 30-38×5-6	Lalongate 4-5×7-9	5-11	4-5	2	1.5	Rugulose
R. moorcroftianum	Pr.	33×21.5 31-35×20-23	3-Co.	27×4 25-28×4	Lalongate 2-3	7-10	3-5	2	1.5	Obs-/Rug-
R. nobile	Spr.	26.5×21.5 25-27×21-22	3 Co.	16.5-3 16-17×3	Lalongate 3-4	7-9	3-4	2	1.5	Striate
R. palmatum	Spr. -Pr.	34.5×25.5 31-40×23-28	3-Co.	28×6 25-29×5-7	Lalongate 3-4×5-7	6-10	Para-syncolpate	2.5	2	Microreti-culate
R. pumilum	Ob. -Sph.	22×24.5 21-23×24-25	3-Co.	15×2 13-16×2-2.5	x	13-14	8-10	3	2	Striate
R. raponticum	Pr.	37×25 33-40×21-28	3-Co.	31×6 26-33×4-6	Lalongate 4-5×6-8	5-7	Para-syn-colpate	2	1.5	Rugulose

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
R. ribes	Pr. -Spr.	43.5×33 38-46×30-36	3-Co.	35.5×6.5 30-40×6-7	Lalongate 5-6×6-8	7-10	-do-	2	1.5	Rugulose
R. spiciformae	Pr. -Sph.	26.5×24.5 26-27×23-35	3-Co.	20.5×1 19-22×1-1.5	Lalongate 2-3×6	9-12		1.5	1	Microreti- culate
R. tartaricum	Pr.	42×32 40-44×30-33	3-Co.	34.5×4.5 30-38×4-5	Lalongate 4-6×7-12	7-14	2-4	2.5	2	—do—
R. undulatum	Pr.	38×25 35-41×23-30	3-Co.	31×3 30-33×3	Lalongate 4-4.5×6-6.5	8-11	3-5	2	1.5	Obscure
R. webbianum	Spr. -Pr.	32.5×23.5 28-35×22-25	3-Co.	26×1 22-30×1	Lalongate 2-3×3-5	5-11	Para- syn- colpate	2	1.5	Microreti- culate
RUMEX										
R. acetosa	Spr.	21.0×17.5 20-23×16-19	3-Co.	15×1 15-16×1	Circular	8-9	5-7	2	1.5	Reticulate
R. acetosella	Ca. Sph.	25.5×27 24-26×25-28	4-Co.	15×1 12-17×1	Circular 5×5	8-13	5-6	1.5	1	Microreti- culate
R. acutus	Sph.	30.3 30-31	2-Co. 3-Co.	23×1 22-24×1	Lalongate 4-5×2-3	13-14	2-3	2.5	1	—do—
R. alpinus	S. Ob.	23.8×28.6 22-26×26-31	3-Co.	19.3×1 18-21×1	Lalongate 4-5×3	15-20	4-7	2	1.5	—do—
R. brownii	S. Ob- Ob. Sph.	22.6×25 21-25×24-27	3-Co.	15.3×1.7 15-17×1.5-2	Lolongate 3-3.5×1.5-2	11-13	5-7	2.5	2	Striato- reticulate

(Contd.......)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
R. bucephalophorus	Spr.	29×32 27-30×21-23	3-Co.	25.4×1 24-26×1	Lolongate 3-4×2-3	5 10	Syn- colpate	2	1.5	Microreti- culate
R. conglomeratus	Ob. Sph	25.8×28.5 23-29×27-31	3-Co.	19×1 16-22×1	Lolongate 4-5×2-3	12-16	5-7	2	1.5	—do—
R. crispus	Ob. Sph.	30.4×33.6 29-32×32-36	3-Co.	25×1 24-26×1	Lolongate 4-5×3-5	18-20	8-11	2	1.5	—do--
R. dentatus	Sph.	34.5×31.5 34-35×31-33	3-Co.	34×4.5 30-39×4-5	Lolongate 5-6×4-5	12-15	Syn- colpate	2	1.5	- do -
R. flexuosus	S. Ob.	22x26 21-23x25-27	3-Co.	17×1.5 16-18× 1.5-2	Lolongate 4-9×2-3	11-12	6-7	2.5	2	- - do- -
R. gmelinii	Sob. -Ob. Sph.	24.5×27.3 22-26×25-30	3-Co.	21×17 19-83× 1.5-2	Lolongate 4-6×2.5-4	13-16	4-6	2	1.5	—do—
R. hydrolapathum	Ob. Sph.	41.7×45.7 40-43×45-47	4-Co. 3-Co.	27×1 26-28×1	Lolongate Circular 4×2.5-3	16-18	Para- syn- colpate	2	1.5	Microreti culate
R. japonicus	Pr.	32x23 28-35×20-25	3-Co.	25×1.5 23-27×1.5	Lolongate 4-4×2-3	5-7	4-5	2	1.5	Punctate
R. koloczii	Sph.	31 28×34	3-Co.	24×1 23-25×1	Lolongate 3-3.5×2	12-14	5-7	2	1.5	Microreti- culate

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
R. maritimus	Pr. Sph.	29×27 26-36×25-30	3-Co.	23×0.5 22-25×0.5	Lolongate 3-4.5× 2.5-4	13-15	3-4	1.5	1	Rugulose
R. marshellianus	Sph.	24 23-25	3-Co.	18.5×1 17-20×1	Lolongate 4-5×3	11-14	2-4	2	1.5	Rugulore- ticulate
R. nepalensis	Pr. Sph.	42.5×38.5 42-44×35-40	3-Co.	29×1.5 28-30×1.5	Lolongate 5-7×4-5	12-16	6-8	2-2.5	2	—do—
R. nigricans	Sph.	32.5 30-34	3-Co.	25×1 23-28×1	Circular 4-5.5	15-17	6-7	2.5	2	Microreti- culate
R. orientales	Ob. Sph.	33.8×36.3 30-36×32-38	4-Co.	23.3×5 23-24×0.5	Circular 5-6	19-21	6-10	2	1.5	Rugulore- ticulate
R. palustris	Pr. -Sph	37.8×36.5 37-39×35-38	3-Co. 4-Co.	25×1 24-26×1	Lolongate 5-6×3-3.5	15-18	5-8	2	1.5	Reticulate
R. pulcher	Sph.	26 25-28	3-Co.	19×1 18-20×1	Lolongate 3-4×2	10-15	6-7	2	1.5	Rugulore- ticulate
R. sanguinicus	Ob.-Sph.	23.8×27.3 23-25×26-28	3-Co.	18×1.5 17-19×1.5	Lolongate 3.5-4×2-3	13-15	7-9	2.5	2	Rugulore- ticulate
R. scutatus	Sob. -Ob. Sph	24×27 22-25×25-29	3-Co.	18.6×2 14-21×2	Circular 2.5×2	11-17	2	2	1.5	—do—
R. thiansohanicus	Ob. Sph.	25.7×27.4 22-29×24-30	3-Co.	21×1.8 18-23× 1.5-2	Lolongate 4-5×2.5-3.5	13-16	4-5	2.5	1.5-2	—do—

(Contd ....)

TABLE III (contd.)

1	2	3	4	5	6	7	8	9	10	11
R. triangulivalvis	Sob.	21.5×25.5 21-22×24-26	3-Co.	14.5×1 14.5×1	Circular-Lolongate 5×4.5	13-15	Para-syncol-porate	1.5	1	Rugulose
R. trifolious	Sph.	21	4-Co.	14.5×1 14.5×1	Circular 1.5×2	7-9	4-6	2	1.5	Reticulate
R. vesicarius	Sph.	26.5 26-27	3-Co.	20.5×0.5 20-21×0.5	Circular 4-5	12-15	5-7	2	1.5	Microreti-culate
TRIPLARIS										
T. americana	Spr.	42.6×34 40-48×31-36	3-Co.	34×1 31-36×1	Circular 2-3	10-16	5-7	3	2	Striate
T. gardneriana	Spr.	40-34 37-48×29-38	3-Co.	36×1 30-40×1	Lolongate 5-6×...	8-15	7	3	2	—do—
T. poepgiana	Spr.	36.5×28.3 35-38×26-31	3-Co.	32×1 30-33×1	Lolongate 6-7×0.5	9-13	3-7	3	2	Reticulate
T. surinamensis	Spr.	32.6×7 30-35×27-29	3-Co.	27×1 26-28×1	Circular 4	7-12	3-4	3	2	Striate

Abbreviations : Spr. — Subprolate; Sph. — Spheroidal; Ob.-Sph.— Oblate spheroidal; Pro-Sph.— Prolate spheroidal; Pr.— Prolate; S. Ob. — Suboblate; I.C.D.— Intercolpus distance; E. — Exine; S.— Sexine; A.D.— Apocolpium diameter; ..... - not accountable i.e. zonorate condition.

MATERIALS STUDIED

Aconogonum (Meissn.) Reich.

Aconogonum campanulatum (Hook.f.) Hara

= *Polygonum campanulatum* Hook. f.

Darjeeling: Mukherjee, J. *s.n.*, 27.9.1963 (Kln.). Biswas 69316 (CAL).

A. divaricatum (L.) Nakai

= *Polygonum divaricatum* L. URSS : Schischken, T.K. 323, 5.8.1925 (SOTON).

A. molle (D. Don) Hara

= *Polygonum molle* D. Don

Darjeeling : Mukherjee, J. *s.n.*, 20.9.1963 (Kln.,); Banerjee 1963, 10.9.1966 (CAL).

A. molle var. *rude* (Meissn.) Hara

= *Polygonum rude* Meissn.

Assam : Das, G. *s.n.* 15.10.1964 (ASSAM).

A. Ochreatum (L.) Hara

= *Polygonum ochreatum* L.

URSS : Tolstaya, P. *s.n.* 8.8.1978 (SOTON).

A. songaricum (Schrenk) Hara

= *Polygonum songaricum* Schrenk.

URSS : Smirnov, V. 2145, 21.7.1912 (SOTON).

Afrobrunnichia Hutch. & Dalziel

Afrobrunnichia erecta Hutch. & Dalziel.

Laire : Leonard, J. 948, 1.10.1946.

Antigonon Endl.

Antigonon leptopus Hook. & Arn.

Orissa : Panigrahi, G. *s.n.*, 2.11.59 (ASSAM) : Kalyani : Midya, A.K. 213, 4.9.78 (Kln,); Mondal, M.S. fresh, CAL 2462

Atraphaxis Linn.

Atraphaxis spinosa L. USSR : Szovits 103, Aderbeid - Schan (U).

Bistorta Mill.

Bistorta alopecuroides (Turez.) Komarov, USSR : Paplavskaya, G. 1515, 7.7. 1913 (SOTON).

B. amplexicaulis (D. Don) Greene, Nainital : Midya, A.K. *s.n.*, 14.4.75 (Kln.); Kosani : Mondal, M.S.- 613, 10.10.1986; Southampton: Kerr, A.- 242. 27.7.64 (SOTON)

Darjeeling : Bose, S. *s.n.* Oct. 1944 (Bose Institute); Poland : Inst. Bot. PAN, Krakow— 617, Bot. Gard. Krakow (KRA).

B. attenuata (V. Petr.) Komarov

= *Polygonum attenuatum* V. Petre, USSR : Mekhno, s.n. 27.6.1905 (SOTON).

B. emodi (Meissn.) Hara

= *Polygonum emodi* Meissn. Darjeeling : Brandis, *s.n.* 9.8.1950 (IBG); Brandis — 3558, N.W. Hismalaya, Sept. 1864 (CAL).

B. bistortoides (Pursh.) Small

= *Polygonum bistortoides* Pursh. USA : Ketner & Ketner 177, 31.8.1970 (U).

B. major (L.) S.F. Gray

= *Polygonum bistorta* L. Denmark : Jeppessen—677, 10.6.1971 (SOTON); Watson, L. *s.n.*, Murbrook near Leek, 10.6.1957 (SOTON), Meghalaya : Carter, H.G. s.n. April 1920 (CAL); Spica, W.W. *s.n.*, Itchen Abbas Hants, 6—1873 (SOTON); Poland : Inst. Bot. Pan, 68 (KRA).

B. vivipara (L.) S.F. Gray

= *Polygonum viviparum* L. Yorkshire : Wood *s.n.*, June, 1884 (SOTON); Norway : Wood, *s.n.* South Norway, Aug. 1995 (SOTON); Austria : Portman, M.E. - 17, 12.7.1973 (SOTON); Scotland : Hammett; R.R. W. — 11, 14.7.1963 (SOTON); Spit bergen, Inst. Bot. PAN— 501 (KRA); USSR : Payarkava, G. 56, 21.7.1940 (SOTON); Reznichenko, V. — 374, 24.7.1912; France : Vantier, S. 466, 16.6.1964 (SOTON).

Calligonum L.

Calligonum comosum L. Zeruzalem : Hib. UNI. Herb. *s.n.* 15.9.1969 (SOTON).

C. polyonoides L. Rajasthan : Shetty, B.V. —2334 (CAL).

Chorizanthe R. Br. Ex. Benth.

Chorizanthe diffusa Benth., California : Pringle, C.G. *s.n.*, Monterey, 16.7.1982 (SOTON); Pringle, C.G. *s.n.*, Santacruz mountains (SOTON).

C. douglassi Benth. California : Hoffman, F.W. 1552, South Coast Range, 9.5.1947 (U).

C. frankenoides Remy., Chili : Wadermann 373, Aug. 1924 (U).

C. membranacea Benth., California : Hutchinson, S. 5571, 26.4.1933 (U).

Chorizanthe parryi Watson, California : Pringle, C.G. *s.n.*, Cotton,
29.5.1982 (SOTON).

C. statioides Gray, California : Hoffman — 3376, 24.4.1950 (U).

Emex Neck. ex Campdera

Emex australis Steinh., Australia : Symon, D.E.— 4063,
South Australia, 28.9.1968 (SOTON);
Symon, D.E.— 3124, S. Australia, 20.11.1964 (SOTON).

Eriogonum Michx.

Eriogonum aberteanum Torr., Arizona : Pringle, C.G. *s.n.*, Tueson,
26.4.1884 (SOTON); Pringle. C.G. 681, Chihuahua, Aug. 1885
(SOTON); Pringle, *s.n.*, Santa Rita Mountains, 10.9.1884 (SOTON).

E. alatum Torr., Arizona : Pringle, C.G. *s.n.*, Mustang Mountains,
28.6.1884 (SOTON).

E. atrorubens Engelm., Arizona : Pringle, C.G.— 285, Chihuahua,
Aug. 1885 (SOTON).

E. baileyi Watson, California : Pringle, C.G. *s.n.*,
Mojave desert, 24.5.1882 (SOTON).

E. fasciculatum Benth. California : Pringle, C.G. *s.n.*,
San Bernardino country, 7.8.1882 (SOTON).

E. hurmanni Deer & Hilg., California : Duran— 2844, 4.8.1930 (U).

E. inflatum Torr., California : Webster et Hildreth— 7478 (U).

E. jamesii Torr. Arizona : Pringle, C.G. —680, Chihuahua,
4.8.1985 (SOTON).

E. latifolium Smith, California : Pringle, C.G. - *s.n.*
Mendocino, 4.8.1982 (SOTON).

E. nudum Dougl. California : Pringle, C.G. *s.n.*,
Cakeport, 16.8.1982 (SOTON).

E. polycladon Benth., Texas : Hinckley- 3542, 11.9.1945 (U).

E. pyrolaefolium Hook., California : Pringle, C.G. — *s.n.*,
Mount Shasta, 30.8.1882 (SOTON).

E. tenellum Torr., Arizona : Pringle, C.G. —169,
Chihuahua, 24.4.1885 (SOTON).

E. wrightii Torr. Arizona : Pringle, C.G. — *s.n.*, Maricopa,
28.10.1882 (SOTON); Princle, C.G.- 284, Chihuahua, Oct. 1885
(SOTON); California : Pringle, C.G. — *s.n.*, Sierra Nevada Mts.,
25.9.1982 (SOTON).

Fagopyrum Mill.

Fagopyrum cymosum Meissn. India : Mukherjee, H. — *s.n.*, Mussosuri, Oct. 1950 (Kln.); Kar, S.K. —*s.n.*, Shillong, 19.11.1962 (ASSAM).

F. esculentum Moench. Simla : Illegible — 142 (CAL); S.I.W. *s.n.*, Attan Hans, Sept. 1873 (SOTON); Japan : Ferasaki, Ferasaki, F. *s.n.*, Tokyo, Sept. 1905 (SOTON); Taylon, J. *s.n.*, Southampton Docks, 10.9.1953 (SOTON); G. & K. *s.n.*; Northward Church, 4.9.1837 (SOTON); Netherlands; Arnold— 16181, 1.7.1965 (U); NEFA : Ras. R.S. —*s.n.*, 17.11.1957 (ASSAM); Nepal : Proud, M.S.— 77, East Nepal (ASSAM).

F. sagittatum Gilib., Poland : Inst. Prot. PAN. Kradow, *s.n.*, Middle Poland (KRA).

F. tataricum Gaertn., Sweden : Inst. Prot. PAN Krakow, *s.n.* (KRA); Gilgit; Giles, G.M. *s.n.*, 1885 (CAL).

Fallopia Adams.

F. baldshuanica (Regel) Holub.

= *Polygonum baldshuanicum* Regel., USSR : Inst. Prot. PAN, Krakow- 2060 (KRA); Southampton : L.J.T.- *s.n.*, 5.8.1953 (SOTON).

F. cilinodes (Michx.) Holub.

= *Polygonum cilinode* Michx., Minnisota : Janssen- 43, 20.6.1962 (U).

F. convolvulus (L.) A. Love

= *Polygonum convolvulus* L. Denmark : Nielsen, L. & S. Jeppessn 599, 1553, 1969 (SOTON); USSR : Prokhorov, A-17, 21.8.1939 (SOTON); Eletrem, E-1207, 26.7.1931 (SOTON); Poland : Inst. Prot. PAN, Kramow- 1595 (KRA) : Proter, W. *s.n.*, Hamsurrey, 8.7.1929 (SOTON); USSR : Poplavskaya, G. *et al.* *s.n.*, 1.8.1913. (SOTON); G.S.K.— *s.n.*, Northwood Park, I of W., 27.8.1838 (SOTON); Southampton : L.J.T.— *s.n.*, 4.8.1953 (SOTON); England : Portunan, M.— 885, Hampshire, 20.8.1967 (SOTON).

F. dumetorum (L.) Holub.

= *Polygonum dumetorum* L. USSR : Rezuichenko, B.V.A.—42.5, 27.8.1909 (SOTON); Bramfield, *s.n.*, Petersfield Hants, 17.9.1849 (SOTON); Poland : Inst. Prot. PAN. Krakow, 1588, Harz Mts. (KRA).

Fallopia multiflora (Thunb.) Haraldson

= *Polygonum multiflorum* Thunb. Japan : Tarasaki, T., *s.n.*, Tokyo, Oct. 1906 (SOTON).

Koenigia L.

Koenigia islandica (L.) Hook. f.

= *Polygonum islandicum* L. Kashmir : Clarke, C.B.— 29813B, 31.7.1876 (CAL); Iceland : Costenland 1108, 26.7.1966 (U).

Muehlenbeckia Meissn.

Muehlenbeckia adpressa (Lahill) Meissn., Newzealand : Heywood, J. (Miss) *s.n.*, Tararaki, Nov. 1942 (SOTON); Gress, R.H. *s.n.*, 31.10.1888 (SOTON), Australia : Alcock, C.R. 1930, S. Australia, 31.1.1966 (SOTON).

M. coccoloboides J. M. Black, Australia : Symon, D.E.— 5855, S. Australia, 21.8.1968 (SOTON).

M. saggitifolia Meissn. Bolivia : Steinback— 3836, 22.3.1920 (U).

M. volcania (Benth.) Endl. Peru : Ellenberg— 451, Azangaro, 28.3.1957 (U).

Oxyria Hill.

Oxyria digyna Hill.

= Scotland : Hamonett, K.R.W. — 01, 17.7.1963 (SOTON); Benlawers. J.A.C. -*s.n.*, 18.7.1950 (SOTON); Ritackev 10169, Kickstona— Pass, 1.3.1975 (SOTON); Nepal : Banerjee, M.L. — 1941, Ptericche, 30.7.1966.

Persicaria Mill.

Persicaria alata (Buch.- Ham.) Nakai

= *Polygonum alatum* Buch. -Ham., Darjeeling : Midya, A.K. —*s.n.*, Oct. 1968 (Kln.); Mukherjee, S.K. — 7210 (CAL).

P. amphibia (L.) S.F. Gray

= *Polygonum amphibium* Linn. England : Porter, W.M.- *s.n.*, Kew— Richmond surrey, 11.10.1929 (SOTON); E.D.K. -*s.n.*, Hants, 29.7.1837 (SOTON); USSR : Kusnezow, J.W. — 4881, Zedet, 29.7.1914 (SOTON); Michigan : Inst. Bot. PAN, Kramow 1597 (KRA); Nielsen and Zeppensen— 383, Hald Lake Backkelund, 23.8.1967 (SOTON); Nielsen and Zeppensen 358, Lewss, Sa Hrup Bog, 25.7.1967 (SOTON).

P. barbata (L.) Hara

= *Polygonum barbatum* L. Darjeeling : Banerjee, R.N.— 2169, 16.101966; Mondal, M.S.— Neora Valley, 10.4.94 (FAA); Allahabad : Panigrahi, G-2169, 5.11.1962.

P. caespitosa (Blume) Nakai

= *Polygonum caespitosum* Blume, Worcester : Burton, N. Gates- *s.n.*, Dover Street, 25.9.1951 (SOTON); Nepal : Banerjee, M.L. —154, East Nepal, 14.4.1948 (Kln.).

P. capitata (Buch. -Ham. ex D. Don) H. Gross

= *Polygonum capitatum* Buch.-Ham. ex D. Don Darjeeling : Barrs, J.- *s.n.*, 3.9.1910 (L.B.G.); Southampton Univ. Campus : Barrs, J. - 534, 9.12.1965 (SOTON); Japan : Tarasaki, T. *s.n.*, Sept. 1905 (SOTON).

Persicaria chinensis (L.) H. Gross

= *Polygonum chinensis* L. Howrah : Mondal, M.S.— fresh, IBG, 16.3.1992; Maiti, G. 2613, Kalyani, Nadia; Kurseong : Chatterjee, U. 504, 1.9.1974.

P. coccinea (Muchl. ex Spreng) Greene

= *Polygonum coccineum* Nuchl. ex Spreng. Kansus : Gibson, G. 24, 20.8.1994 (U).

P. flaccida (Meissn.) H. Gross

= *Polygonum flaccidum* Meissn. Japan : Terasaki, T. *s.n.*, Tokyo, Aug. 1906 (SOTON); Assam : Huf. 21683, 25.8.1947 (SOTON).

P. glabra (Willd.) Gomez de la maza

= *Polygonum glabrum* Willd. Darjeeling : Mallick, R. *s.n.*, Feb. 1966 (L.B.G.); Chotonagpur : Clarke, C.B. —33871, 12.10.1883 (CAL).

P. hydropiper (L.) Spach.

= *Polygonum hydropiper* L., Mizo Hills : Dutta, R.M. *s.n.*, 10.7.1963 (ASSAM); Dankuny : Nandy, P.C.— *s.n.*, Jan. 1969; Denmark : Holm—Nielson, Jeppesen & Pederson- *s.n.* 13.8.1969 (SOTON); Hainard, P. - *s.n.*, Suisse, Tessim, 15.8.1967 (SOTON); Southampton : Kerr. A. - 163, 5.9.1964 (SOTON); U.D. Proter, W. *s.n.*, Kew, Richmond. Surrey, 30.6.1927 (SOTON); Denmark : Nielsen. Ivan—501, W.of Arhus, 28.8.1968 (SOTON); Poland : Inst. Bot. PAN 625 (KRA); USSR : Sipchinski, N.V.— 562, 20.8.1927 (SOTON); Borokov, U- 1305, 5.9.1980 (SOTON); Ohio : Lloyd, C.G. *s.n.*, 17.8.1882 (SOTON); Winchester : Lloyd, C.G. *s.n.*, 17.8.1891 (SOTON).

P. hydropiperoides (Michx.) Small

= *Polygonum hydropiperoides* Michx. Berlin : Gates, B. *s.n.*, *24.9.1949* (SOTON); USA : Reaze, F.N. *s.n.* Ellington, 17.8.1875 (SOTON).

P. incarnata (E11.) Small

= *Polygonum incarnatum* E11. Japan : Tarasaki, T. *s.n.*, Sept. 1905(SOTON).

P. lapathifolia (L.) S.F. Gray

= *Polygonum lapathifolium* L. USSR : Poyarkov, V. *s.n.*, July 1926 (SOTON); G.E.K. *s.n.*, Alverstoke Hants, 30.8.1882 (SOTON); Denmark; Ollgaard, Benjamin— 187, Norre Nebel, 20.8.1965 (SOTON).

P. limbata (Meissn.) Hara

= *Polygonum limbatum* Meissn. Bihar : Clarke, C.B. *s.n.*, (CAL).

P. linicola (Sutulow) Nenjukow.

= *Polygonum linicola* Sutulow, USSR : Poyarkov, V. - *s.n.*, July 1926 (SOTON); Australia : Alcock. C.R. *s.n.*, 31.1.1966.

P. maculata (Raf.) Love et Love

= *Polygonum maculatus* Raf. USSR : Postukov, M. 3596, 1.7.1920; Demisovai *s.n.*, 12.9.1963 (SOTON).

Persicaria microcephala (D. Don) H. Gross

= *Polygonum microcephalum* D. Don, Darjeeling : Midya, A.K. *s.n.*, Oct. 1968 (Kln.).

P. muricata (Meissn.) Nemoto

= *Polygonum muricata* Meissn. Poland : Inst. PAN. Krakow, Stuchlick— 9659, 1960 (KRA).

P. orientalis (L.) Spach.

= *Polygonum orientale* L. Kalyani : Midya, A.K. *s.n.*, 28.4.1976 (Kln.); Mondal, M.S.— 208 (fresh), 10.3.86 (IBG).

P. peduncularis (Wall. ex Meissn.) Nemoto

= *Polygonum pedunculeris* Wall. ex Meissn. Mepal : Banerjee M.L. — 96386; 10.9.1967 (Kln.).

P. pensylvanica (L.) Gomez de la Meze

= *Polygonum pensylvanica* L. U.S.A. : Richard, M. *s.n.*, 6.10.58 (U).

P. posumbu (Buch.- Ham. ex D. Don) H. Gross

= *Polygonum posumbu* Buch.-Ham. ex D. Don Darjeeling : Mukherjee, J. - *s.n.*, 29.9.1962 (Kln.).

P. perfoliata (L.) H. Gross

= *Polygonum perfoliatum* L., NEFA : Rao, P.S. -*s.n.*, 10.1.1957 (ASSAM); U.K. : Schuman, M-97, Ham Surrey, 24.8.1926 (SOTON).

P. prostrata (R. Br.) Nakai

= *Polygonum prostratum* R. Br.

P. runcinata (Buch. -Ham. ex D. Don) H. Gross

= *Polygonum runcinatum* Buch. -Ham. ex D. Don Darjeeling : Bose, S. -*s.n.*, Oct. 1944 (Bose Inst...)

P. senegalensis (Meissn.) Sojak

= *Polygonum senegalensis* Meissn. Rwanda : Troupin, G—5940, 4.2.1958 (U).

P. stagnia (Buch.-Ham. ex Meissn.) Nakai

= *Polygonum stagnium* Buch.-Ham. ex Meissn.
Nepal : Banerjee, M.L. — 36939, 6.6.1967 (Kln.).

P. strigosa (R. Br.) Nakai

= *Polygonum strigosum* R. Br. Nainital : Dr. King's Col. *s.n.*, 1986 (CAL).

Polygonella Michx.

P. articulata (L.) Meissn. Leominster : Burton, H—24604, 8.10.1949 (SOTON).

P. polygama Engelm. & Gray. USA : Richard- 117, 6.10.1958 (U).

Polygonum L. *s. str.*

P. arenarium Waldst. et Kit. USSR : Menvil - *s.n.*, *20.7.1932* (SOTON); Elin, M.M. & Grigoriev, U.C. — 1575, 3.7.1927 (SOTON).

P. articulatum L. Norway : Ellington- *s.n.*, 6.9.1975 (SOTON).

Polygonum aviculare L. U.K. : Wilson, D.A,.- 36, 10.8.1960 (U). Pedersen, P. 167, 31.8.1971 (SOTON); Poland : Inst. Bot. PAN. Kramow-621 (KRA); Young, D.J. —924, Milebush, Antrim, 20.8.1967 (SOTON); Japan : Terasaki, T. -*s.n.*, Tokyo, Aug. 1906 (SOTON); L.J.T. *s.n.*, Southampton, 20.8.1953 (SOTON); Denmark : Jensen, L.—451, 19.7.1968 (SOTON); Gates, H.- *s.n.*, Murray Ave., Worcestor, 28.6.1945 (SOTON); Symon, D.E.- *s.n.*, Adelaide, South Australia, 7.10.1965 (SOTON); USSR Lositsi, S. -*s.n.*, 3.8.1928 (SOTON); Vrinivel, O.—195, 7.8.1918 (SOTON).

P. biaristatum Aitch. & Hemsl., Afganistan : Mallick, R. —*s.n.*, 12.3.1970 (FRT).

P. bucharicum Grig. USSR ; Eletrem, E. —1237, 13.8.1931 (SOTON); Toncharov, E. —444, 1.7.1932 (SOTON).

P. calostachyum Diels, NEFA : Joseph— 40186, 20.9.1969 (ASSAM).

P. cognatum Meissn., Lahul : Bhattacharya, U.C. —48780, 21.7.1972; Bor, N.L.-*s.n.*, 24.8.1938 (Bose Inst.);

P. corigioloides Jaub. & Spach., USSR : Nadejhima, T.-*s.n.*, 25.8.1963 (SOTON); Poland : Int. Bot. PAN. Kramow — 2061 (KRA).

P. floribundum Schlecht. ex Spreng., USSR :Inst. Bot. PAN. Kramow-2062, Astrachan (KRA).

P. humifusum Merk. ex Pall., USSR : Kagankevitch, *s.n.*, 14.7.1952 (SOTON).

P. intermedium Nutt. ex. S. Wats. Columbia : Illegible, *s.n.*, (SOTON).

P. lanigera R. Br.

P. laxmanni Lepech., Poland : Inst. Bot. Pan, Kramow—2063.

P. littorale Meissn. Isle of Wight : Stralton, F. *s.n.*, Sept. 1868 (SOTON).

P. macranthum Meissn., Khasia hills : Clarke. C.B. -*s.n.*, 16.9.1886 (CAL).

P. maritimus L. Nepal : Banerjee, M.L. —96384, 10.9.1967 (Kln.).

P. minimum S. Wats., California : Pringle, C.G. *s.n.* Summit Valley, 21.9.1882 (SOTON).

P. nodosum Pers. Nepal : Banerjee, M.L.— 96391, 15.9.1967 (Kln.).

P. paronychia Cham. & Schlecht., Oregon : Pringle, C.G. -*s.n.*, Coss Bay, 2.11.1881 (SOTON).

P. paronychivides C.A.M. Lahul : Bhattacharya U.C. -*s.n.*, 18.7.1972 (CAL); USSR : Peletskova, V.V. -*s.n.*, 20.7.1945 (SOTON)

P. plebejum R. Br. Nepal : Banerjee, M.L. —96219 (Kln.).

P. recumbens Royle, Dharamsala : Clarke, C.B. *s.n.*, 17.10.1874 (CAL).

P. thymifolium Jaub. & Spach., USSR : Inst. Bot. PAN. Krakow—2064, Paunir Mts. (KRA).

Pteropyrum Jaub & Spach.

Pteropyrum olivieri Jaub. & Spach., Persia : Cizmur, R. — 372698, 11.10.1917 (U).

Rheum Linn.

Rheum acuminatum Hook. f. & Thoms. Nepal : Banerjee, *s.n.*, East Nepal 30.7.1966 (Kln.).

Rheum alexandrae Batalin., Tibet : Potanen -*s.n.*, 15.6.1893 (CAL).

R. delavarii Franchet, Tibet : Ludlow & Sheriff 0 9618, 14.6.1943 (CAL).

R. emodi Wall., Simla : Hole, R.S. -232, Dec. 1913 (CAL); Mondal, M.S. 604, Valley of Flowers, 8.8.1992 (CAL).

R. globulosum Gage, Tibet : Ludlow & Sheriff —9609, 10.6.1943 (CAL).

R. inopinnatum Prain, Gyangste : Walton, H.J. -*s.n.*, Sept. 1904 (CAL).

R. moorcroflianum Royle, Tibet : Walton H.J.- *s.n.*, 20.6.1886 (CAL).

R. mobile Hook. f. & Thoms., Sikkim : Gammie, G.A.-*s.n.*, 3.8.1892 (CAL).

R. palmatum L., Tibet : Gammie, G.A. -*s.n.*, (CAL).

R. pumilum Maoin, Chumb : Dungdoo 4624, 28.7.1977 (CAL).

R. raponticum L., U.K. : Victorin, M. -*s.n.*, Aug. 1908 (CAL).

R. ribes L., Chitral Relief Expedition, Harris, L.T.-16602, 1895 (CAL); Poland : Inst. Brot. PAN, Krakow- 1864, Podova Prot Garden (KRA).

R. spiciformae Royle, Netherland : Buyaman 689m 31.5.1782 (U); Midya, A.K. *s.n.*, Darjeeling 1963 (Kln.).

R. tartaricum L. Afganistan : Aitchinson- *s.n.*, 1885 (CAL).

R. undulatum L. Ex Horto Prot. Petropolitani, CAL- 12965.

R. Webbianum Royle, N.W. Himalaya : Lace, T.H. 1586, 19.6.1897 (CAL).

Rumex Linn.

Rumex acetosa L. Denmark : Jensen, Nielsen & Pedersen—440, 11.6.1968 (SOTON); Greuter and Hainard - 567, 11.5.1966 (SOTON); USSR : Denisovai- s.n., 11.6.1908 (SOTON); British Isles : Edmond Hopkin- 117, 27.6.1964 (SOTON); E. Hopkin- 76, Co Kerry, 26.6.1964 (SOTON); Richmond Surrey : R.Y. Kerr— 93, 14.6.1958 (SOTON); Poland : Inst. Prot. PAN, Kramow- 1591 (KRA).

R. acetosella L., Newmunster : L. H. Nielsen, Jeppesen & Pedersen- 10, 17.7.1969 (SOTON); Denmark : Jeppesen & Pedersen -325, 4.7.1964 (SOTON); Southampton : M. Portman-842, 29.5.1966 (SOTON); Ham Surrey : W. Porter- s.n., 25.5.1929 (SOTON); Japan : T. Tarasaki- *s.n.*, Tokyo, June 1905; Mexico : J.L. Sagarlyn- *s.n.*, 7.8.1937(SOTON); Southampton : J.T. -*s.n.*, 10.9.1953 (SOTON); J. Paton-11, 23.6.1953 (SOTON); British Isles : T.C.W.-960, 12.7.1961 (SOTON); Cokerry : E. Hopkin- 78, 26.6.1964 (SOTON); Kerr. R.Y.- 108, 21.6.1958 (SOTON).

Rumex acutus L. J. & K : Apridaun-*s.n.*, 25.6.1940 (SOTON).

R. alpinus L. Tatra Mountains : Inst. Prot. PAN. KRAKOW- *s.n.*, (KRA).

R. brownii (Campd.) S. Australia : Symon, *DE.*- 3874, 12.10.1965 (SOTON).

R. bucephalophorus L. Geneva : A. Charpin-*s.n.*, 22.5.1971 (SOTON).

R. conglomeratus Muri, USSR : A. Charpin-*s.n.* (SOTON).

R. crispus L. Winchester : Illegible -*s.n.*, Aug. 1878 (SOTON); Hampsire : Porter, W. *s.n.*, 2.7.1929 (SOTON); Southampton : L.J.T. *s.n.*, 13.8.1953 (SOTON); USSR : Postukov, M-1309, 1.7.1918 (SOTON); V.L. Reznichenkoo-69m 26.5. 1812 (SOTON).

Rumex dentatus L. W. Bengal : Banerjee, R.N. 1359, Purulia (CAL); Kalyani : Midya, A.K. -*s.n.* (*Kln.); Mondal, M.S. I.B.G. (fresh) -55, Paly, Lab. CAL; Howrah : Ramanurthy 2661, 19.10.1974.

R. flexuosus Soland ex Forst. New Zealand : Illegible-*s.n.* (SOTON).

R. gmelini Turex, USSR : M. Kopomkiu-330, 13.8.1912 (SOTON).

R. hydrolapathum Huds. Denmark : Jeppesen & Neilsen-556, 18.7.1964 (SOTON);Wichester : R.I.W.- *s.n.*, July 1976 (SOTON); Southampton : J. Paton-9, 19.6.1953 (SOTON); USSR : S.S. Genesin-*s.n.*, 6.8.1928 (SOTON).

R. japonicus Meissn. Japan : Terasaki *s.n.*, Tokyo,Aug. 1907 (SOTON).

R. kolocgii Rechb. USSR : L.V. Kusimika - *s.n.*, 29.5.1958(SOTON).

R. maritimus L. Denmark : Jeppesen, Neilsen & Pedersen 57, 6.8.1969 (SOTON); USSR : V. Sukachev & G. Paplavskaya -*s.n.*, 9.8.1911 (SOTON); V. Transel -*s.n.*, 11.9.1927 (SOTON).

R. marshellianus Reichb. USSR : S. Kucherovskaya- 1675, 29.7.1909 (SOTON).

R. nepalensis Spring. ASSAM : Khasi & Jayanti Hills, Kanjilal, U.N. *s.n.*, 29.5.1917 (ASSAM); Kameng : G. Panigrahi *s.n.*, 16.5.1958 (CAL).

R. nigricans Hook. f., Jaunpur : C.D. Allen- *s.n.*, May 1916 (CAL).

R. orientales Buch. ex Schutt. Spiti : U.C. Bhattacharya -*s.n.*, 27.7.1972.

R. palustris Sm., Britain : Illegible- *s.n.*, Aug. 1972 (SOTON).

R. pulcher L., USSR : T. Sakharov- *s.n.*, 6.5.1913 (SOTON).

R. sanguinicus L. Denmark : Neilsen, Pedersen & Jeppesen- 466, 30.7.1968 (SOTON); W.E. Bensen-147, 11.8.1981 (SOTON); USSR : K. Leonov- *s.n.*, 5.6.1951 (SOTON); Isles of Wight : J. & K. *s.n.*, 27.8.1839 (SOTON).

R. scutatus L. USSR : A. Lonasievsky -*s.n.*, 20.7.1912 (SOTON); France : S. Vantier *s.n.*, 12.5.1964 (SOTON); Southampton : A. Kerr. 246, 28.7. 1964 (SOTON).

R. thiansohanicus A. Loss, USSR : M. Kryakiev- *s.n.*, 6.7.1962 (SOTON).

R. triangulivalvis (Dansen) Reichb. F., Southampton : Wisawan, D. *s.n.*, 12.7.1954 (SOTON).

R. trifolius (Wall.) Love, Denmark : Kailarsen- 131, 23.6.1965 (SOTON).

R. versicarius L., South Australia : Symon, D.R. - 5536, 14.8.1968 (SOTON); Schtalhausen- *s.n.*, 1.4.1953 (SOTON).

Triplaris Loefl. ex L.

Triplaris americana L. Howrah : Midya, Aug. -*s.n.*, IBG., 26.3.77 (Kln.); Mondal, M.S.- I.B.G. (fresh)- 2810 (CAL).

T. gardneriana Wedd., Brazil : D. Santos & Souza 1829, 1968 (U).

T. poepigiana Wedd., Bolivia : Steinbach- 6424, 15.9.1924 (U).

T. surinamensis Chem., France : Bafog 7859, 19.9.1961 (U).

Magnification

PLATES : I-XI

All light microscopic photographs (Plate I-VII) × 1200.

All scanning Electron Microscopic (SEM) photomicrographs (Plate IX-XI) as mentioned after figures.

Plate I : Figs. 1-9

Aconogonum divaricatum (L.) Nakai (1-3) : 1. Optical section meridional. 2. Optical section equatorial. 3. Details of exine in apocolpium area.

A. leptopus Hook. & Arn. (4-6) : 4. Optical section meridional. 5. Median aperture and exine in apertural area. 6. Details of exine at mesocolpium.

Atraphaxis spinosa L. (7-9) : 7. Optical section meridional. 8. Details of exine and aperture. 9. Optical section equatorial.

Plate II : Figs. 1-7

Bistorta alopecuroides (Turez.) Komarov. (1-2) : 1. Aperture and details of exine. 2. Exine (L. O.)

Calligonum polygonoides Linn. (3-5) : 3. Optical section meridional and median (lower) aperture. 4. Optical section equatorial. 5. Details of exine.

Chorizanthe parryi : S. Watts. (6-7) : 6. Exine details at mesocolpium. 7. Optical section meridional.

Plate III : Figs. 1-6

Fagopyrum esculentum Moench. (1-4) : 1. Details of exine and median aperture. 2. Optical section meridional. 3. Optical section equatorial. 4. Optical section meridional showing aperture profile.

Emex australis Steinh. (5-6) : 5. Optical section meridional and exine. 6. Optical section equatorial.

Plate IV : Figs. 1-6

Eriogonum fasciculatum Benth. (1-3) : 1. Optical section meridional showing exine stratification. 2. Exine and aperture profile. 3. Optical section equatorial.

Muehlenbeckia adpressa Meissn. (4-6) : 4. Details of exine and aperture. 5. Optical section meridional. 6. Optical section meridional and aperture profile.

Plate V : Figs. 1-6

Fallopia cilinoides (Michx.) Holub. (1-2) : 1. Optical section meridional. 2. Details of exine and aperture.

Koenigia islandica L. (3-4) : 3. Optical section equatorial and distribution of apertures. 4. Details of exine.

Persicaria mitis (L.) Gilib. (5-6) : 5. Details of exine (L.O.). 6. Optical section equatorial.

Plate VI : Figs. 1-7

Polygonella articulata (L.) Meissn. *Polygonum articulatum* L. (1-3) : 1. Details of exine and faint aperture. 2. Optical section meridional and faint exine (O.L.). 3. Details of exine at mesocolpium.

Rheum spiciformae Royle, 4. Details of aperture and exine.

R. emodi Wall. (5-6) : 5. Details of exine and aperture. 6. Optical section equatorial.

R. ribes L. 7. Syncolpate apocolpium area showing exine stratification.

Plate VII : Figs. 1-6

Polygonum plebejum R. Br. (1-3) : 1. Details of apertures. 2. Exine ornamantation and aperture profile. 3. Optical section equatorial.

Pteropyrum oleverii Jaub. & Spach. (4-6) : 4. Optical section meridional and aperture (lower). 5. Optical section equatorial showing exine stratification. 6. Details of exine at mesocolpium area.

Plate VIII : Figs. 1-7

Triplaris americana L. (1-2) : 1. Optical section meridional. 2. Aperture and details of exine.

Rumex vesicarius L. (3-4) : 3. Details of aperture and optical section meridional.

4. Optical section equatorial.

R. nepalensis Spring. 5. Details of exine and aperture. *R. gmelini* Turez. 6. Biaperturate pollen.

R. hydrolapathum Meissn. 7. Optical section, tetra-aperturate pollen grain.

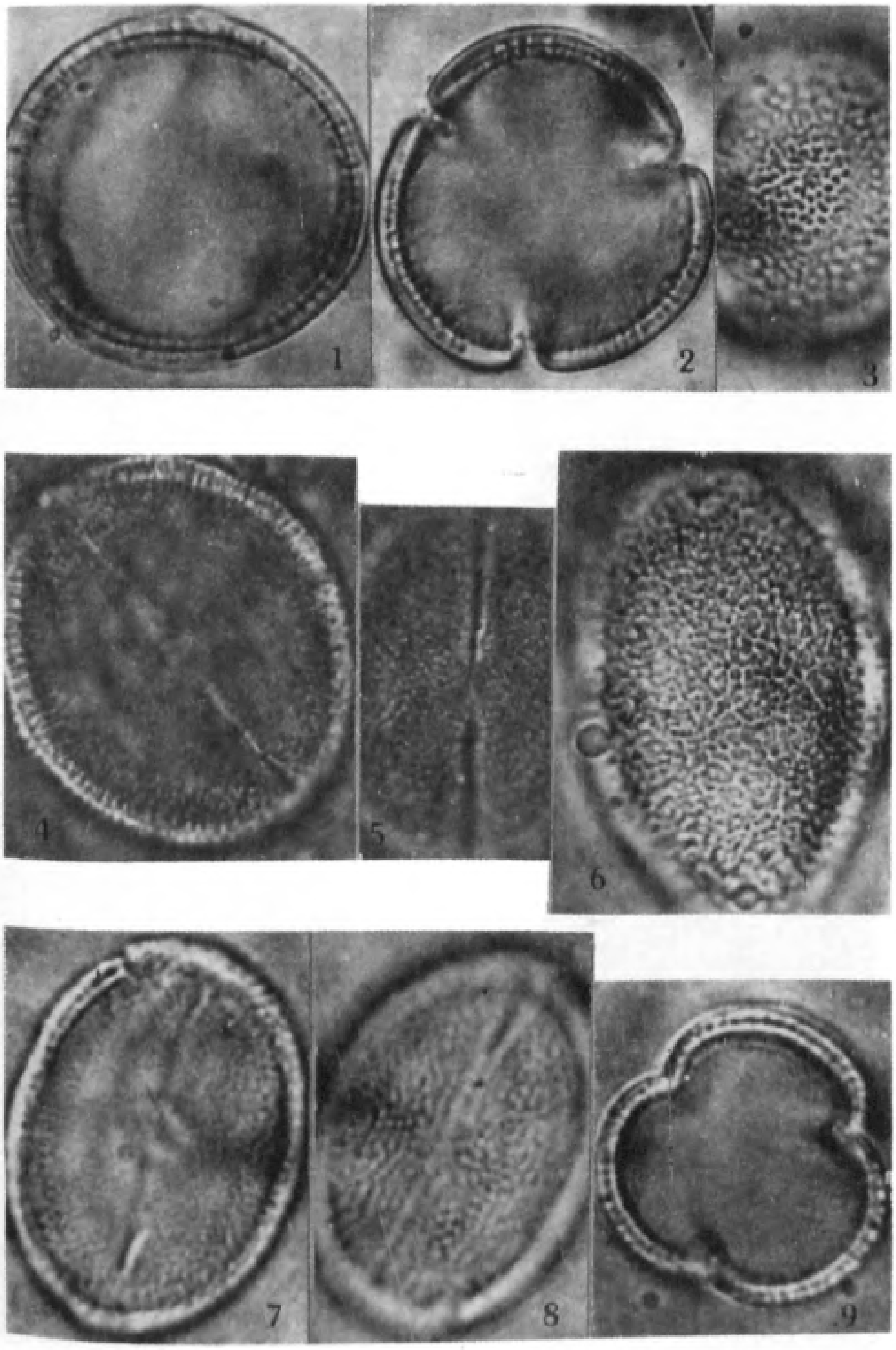

Plate 1 : Figs. 1-9

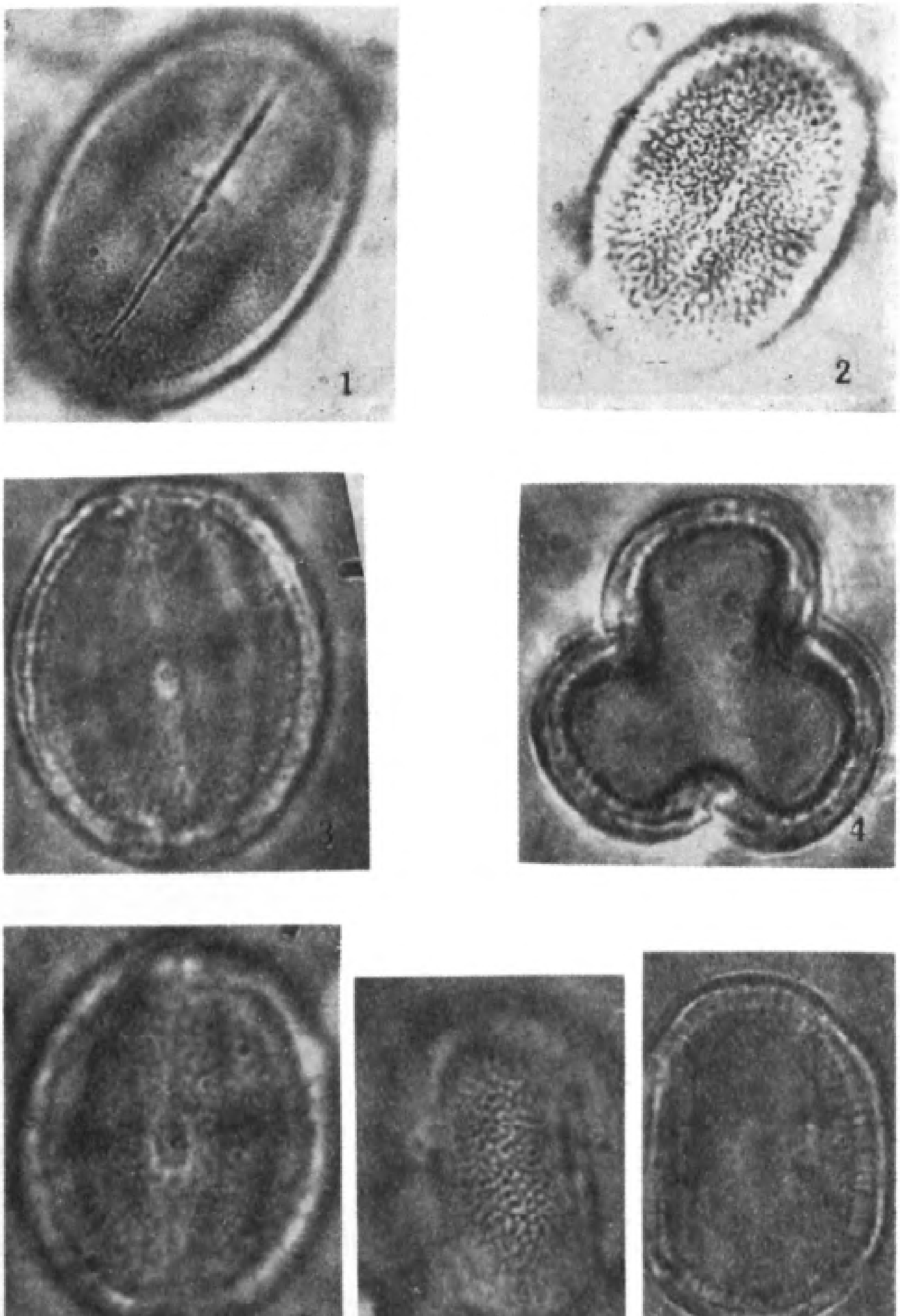

Plate II : Figs. 1-7

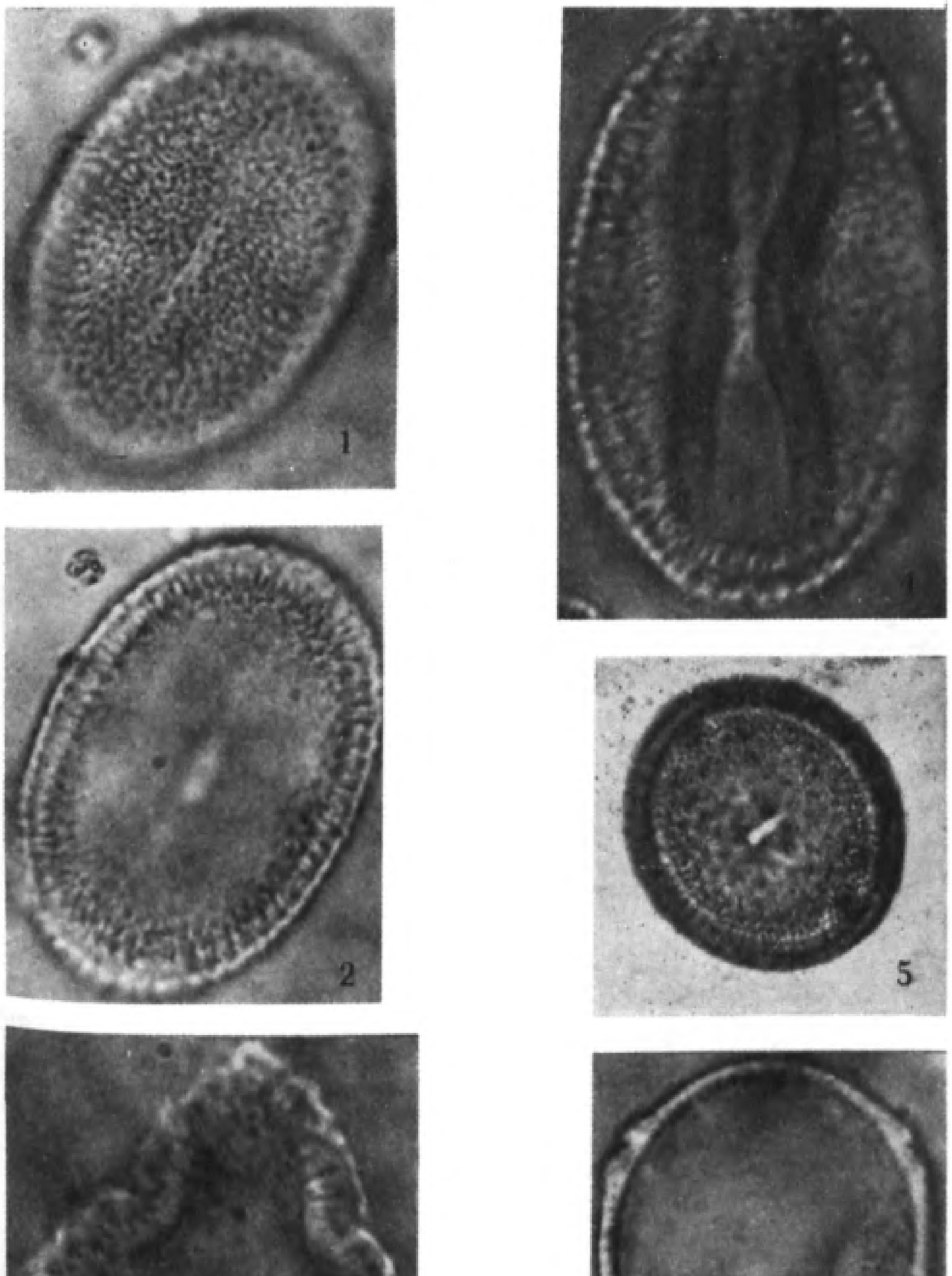

Plate III : Figs. 1-6

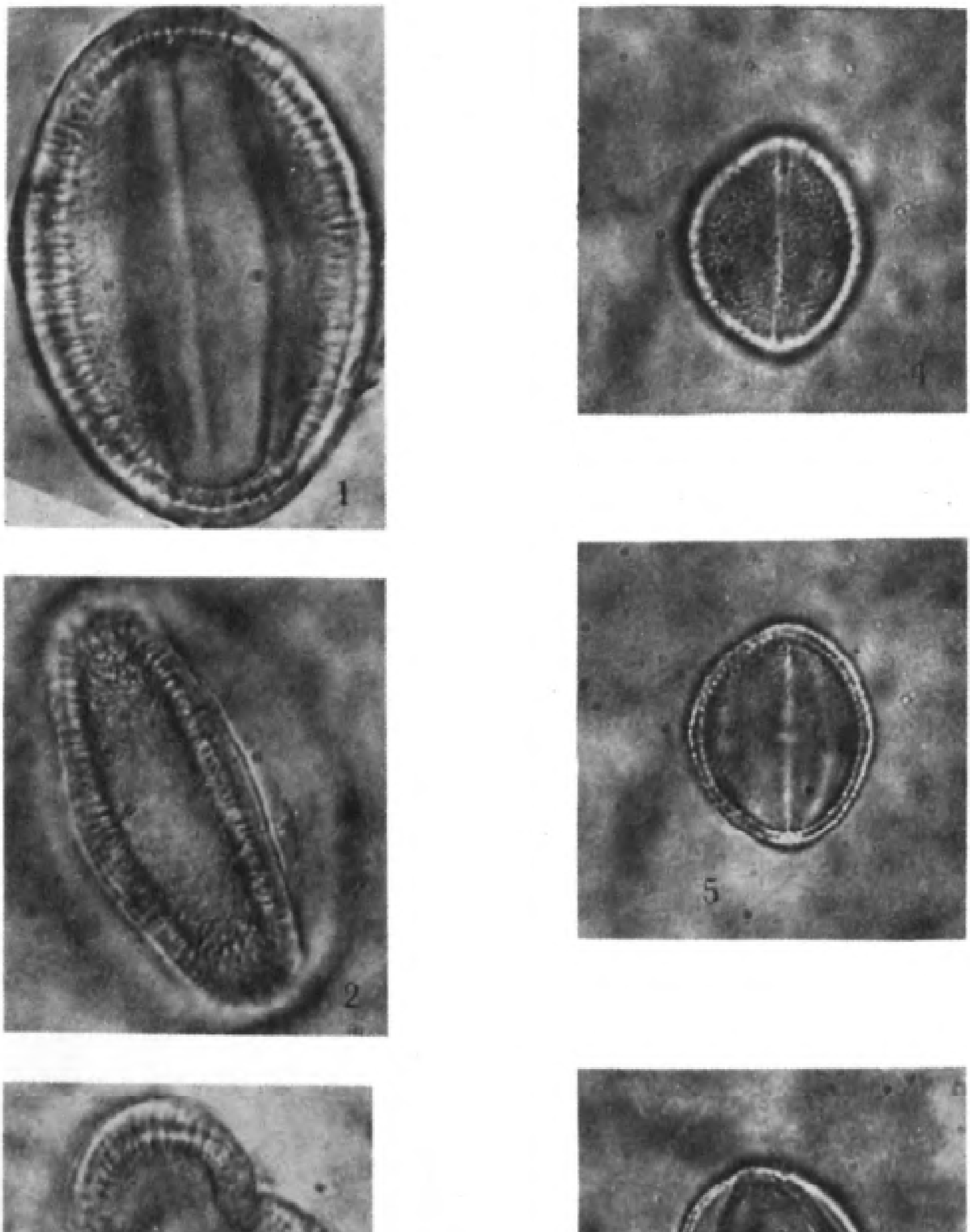

Plate IV : Figs. 1-6

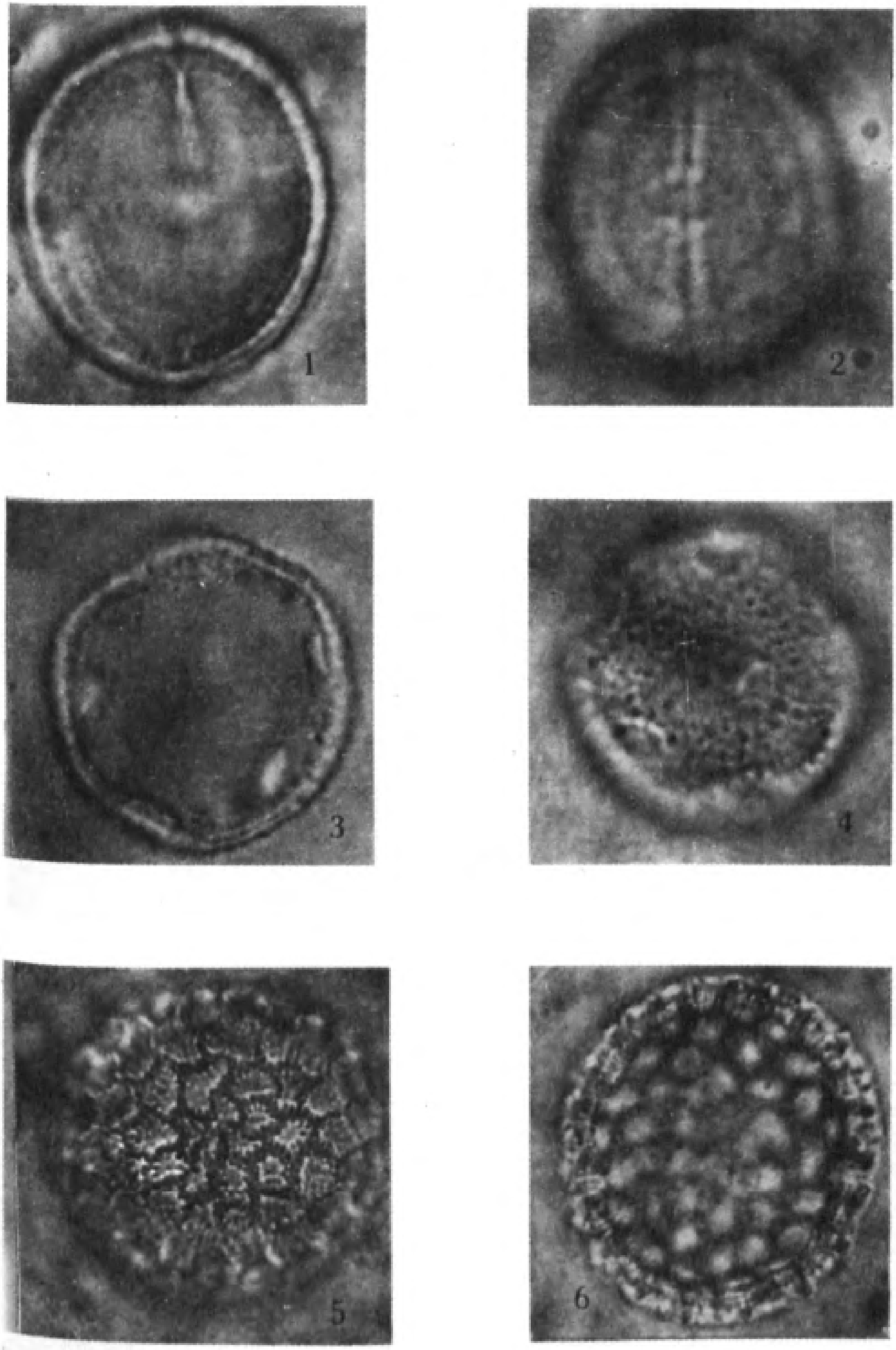

Plate V : Figs. 1-6

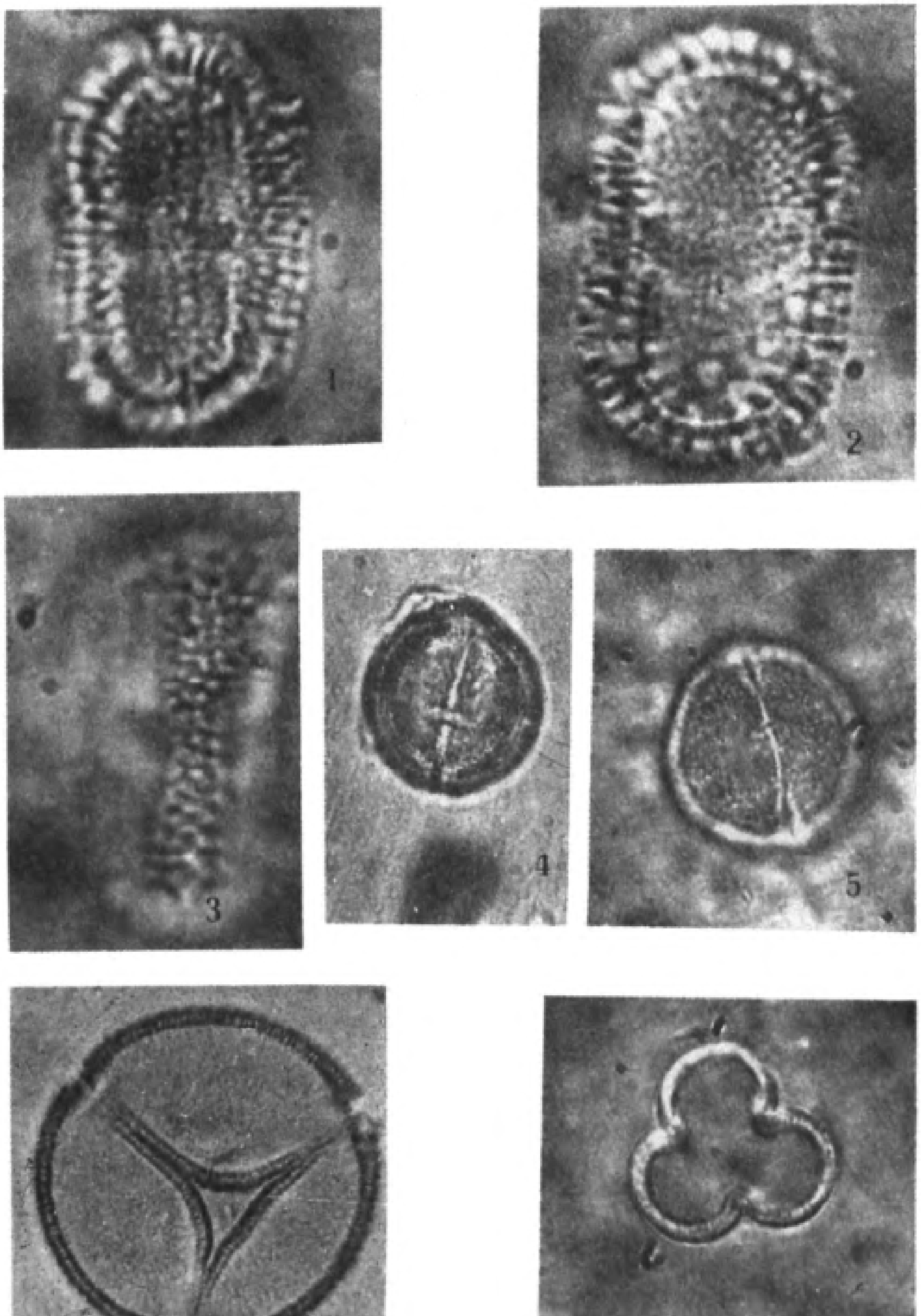

Plate VI : Figs. 1-7

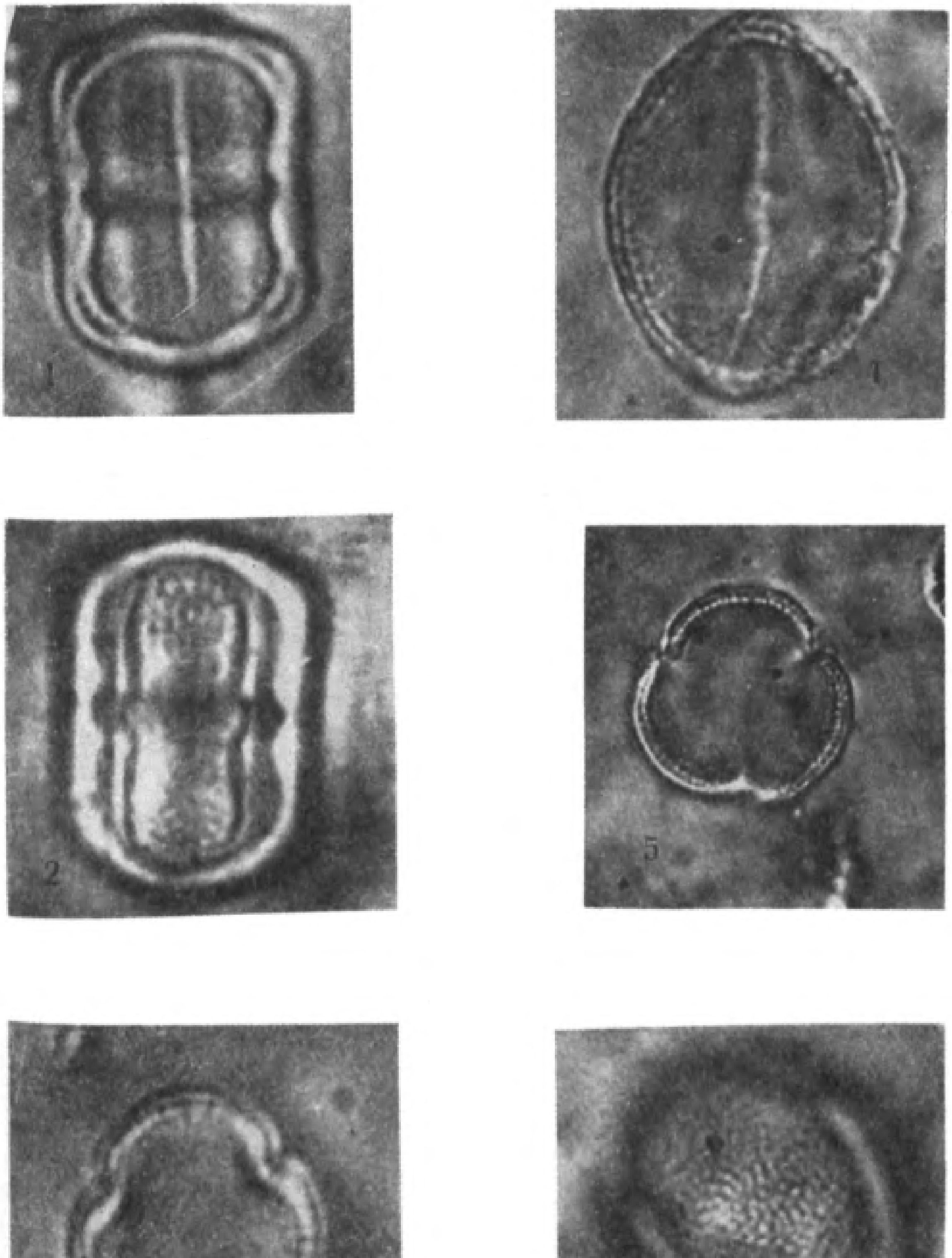

Plate VII : Figs. 1-6

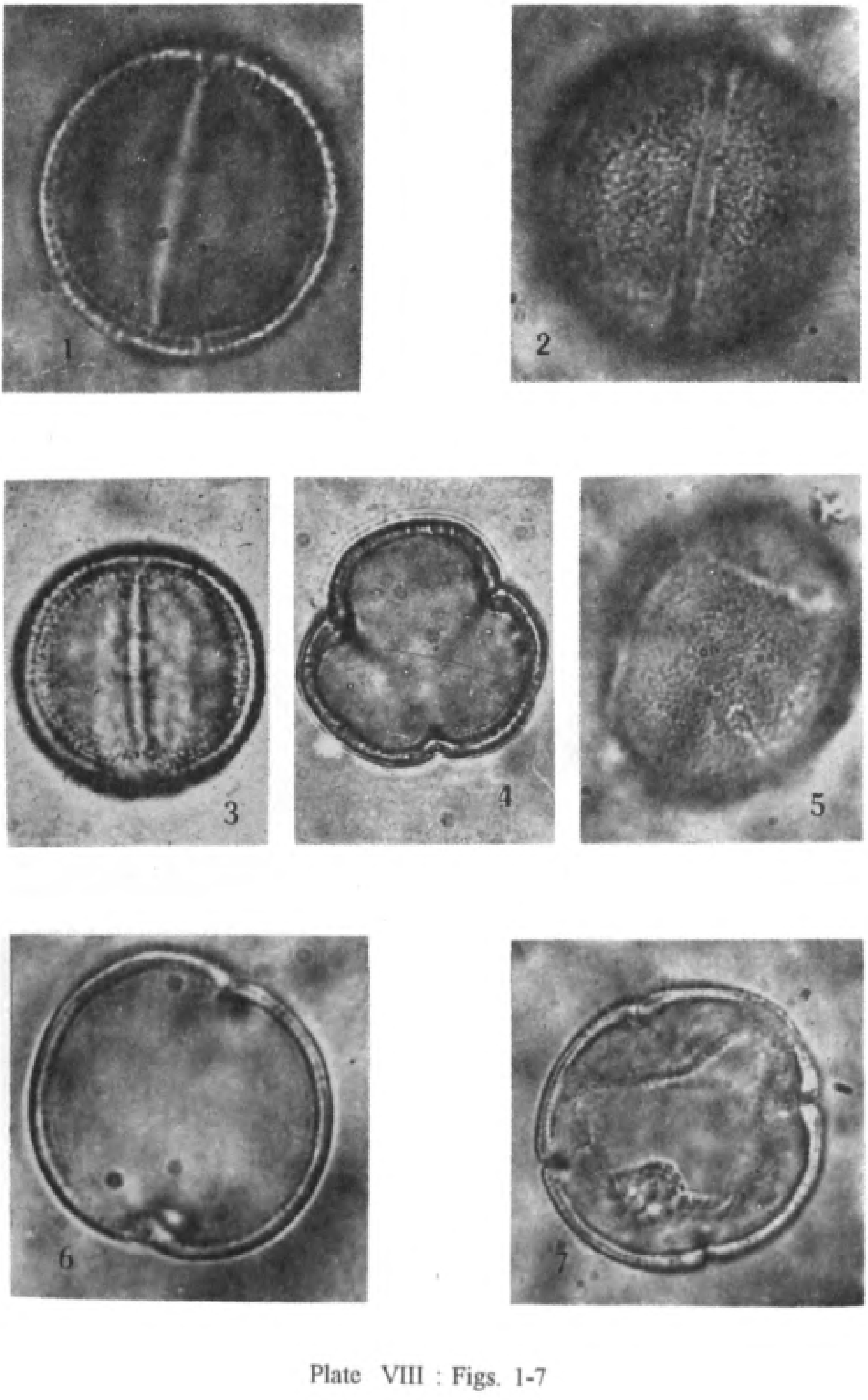

Plate VIII : Figs. 1-7

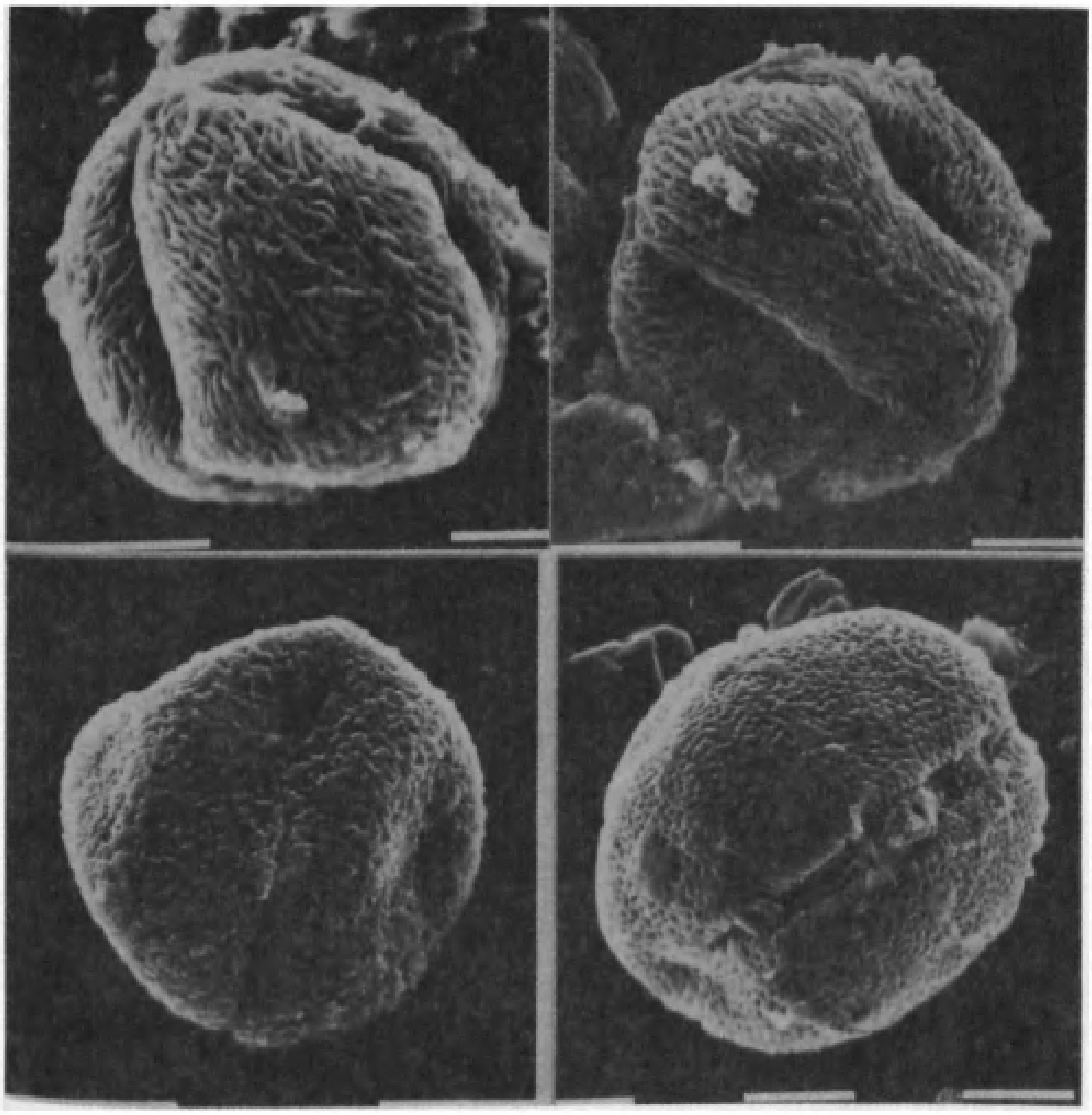

Plate IX Figs 1-4

Atraphaxis spinosa L. 1 × 2700 Showing striate / striato-reticulate exine ornamentation and apertures, 2. × 2700

Calligonum polygonoides L. 3 × 2300; 4 × 2500. Showing exine details and operculoid aperture.

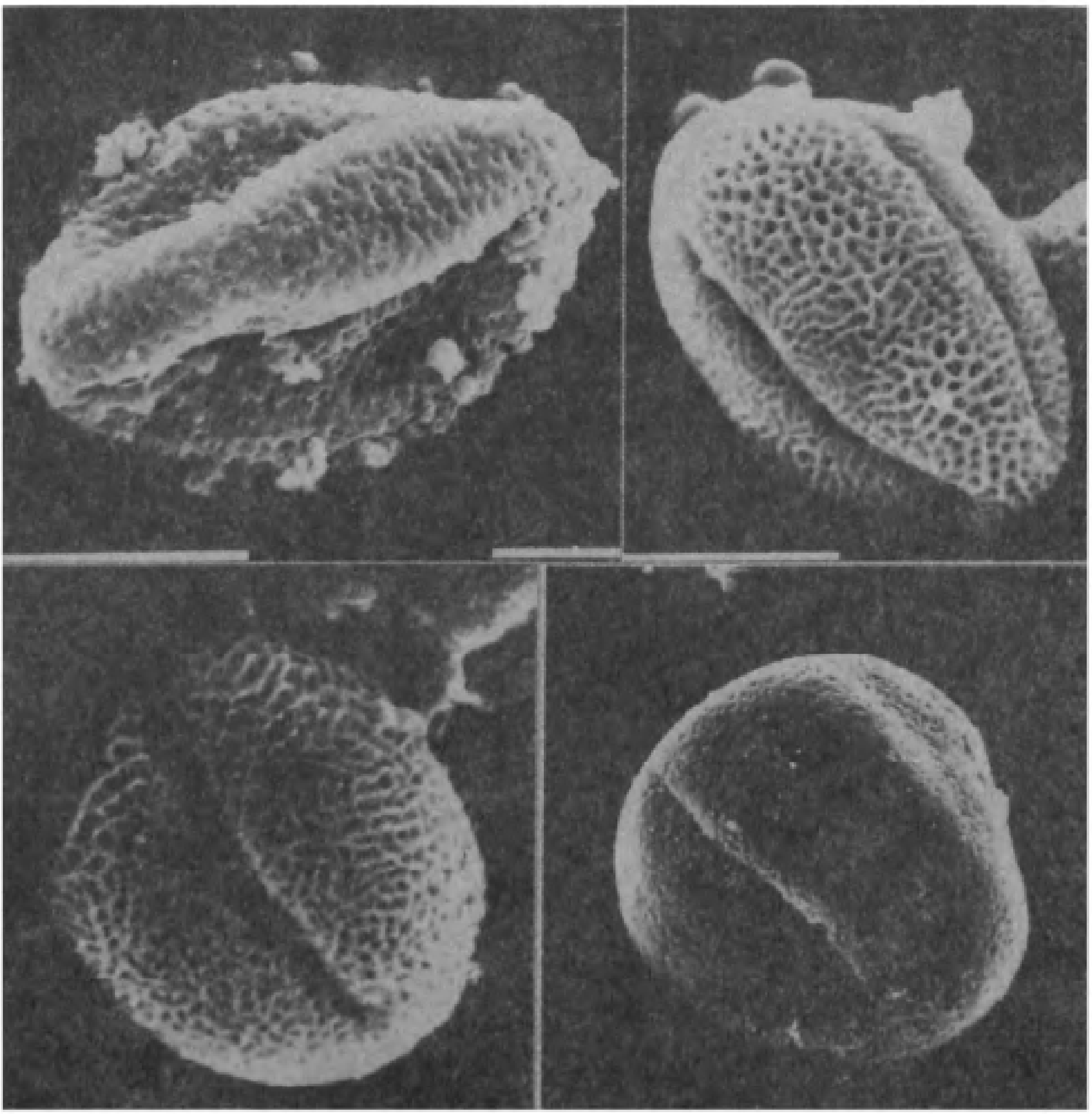

Plate X : Figs. 1-4

Eriogonum angulosum Benth. 1. × 2700. Equatorial view showing mesocolpium and aperture in profile.

Polygonella brachystachya Meissn. 2. × 3700. Equatorial view showing reticulate exine ornamentation and aperture in profile. Luminae linear towards aperture; 3. × 4000. Showing aperture and linear luminae towards aperture.

Rheum emodi Wall.. 4. × 1800. Aperture and pitted exine pattern.

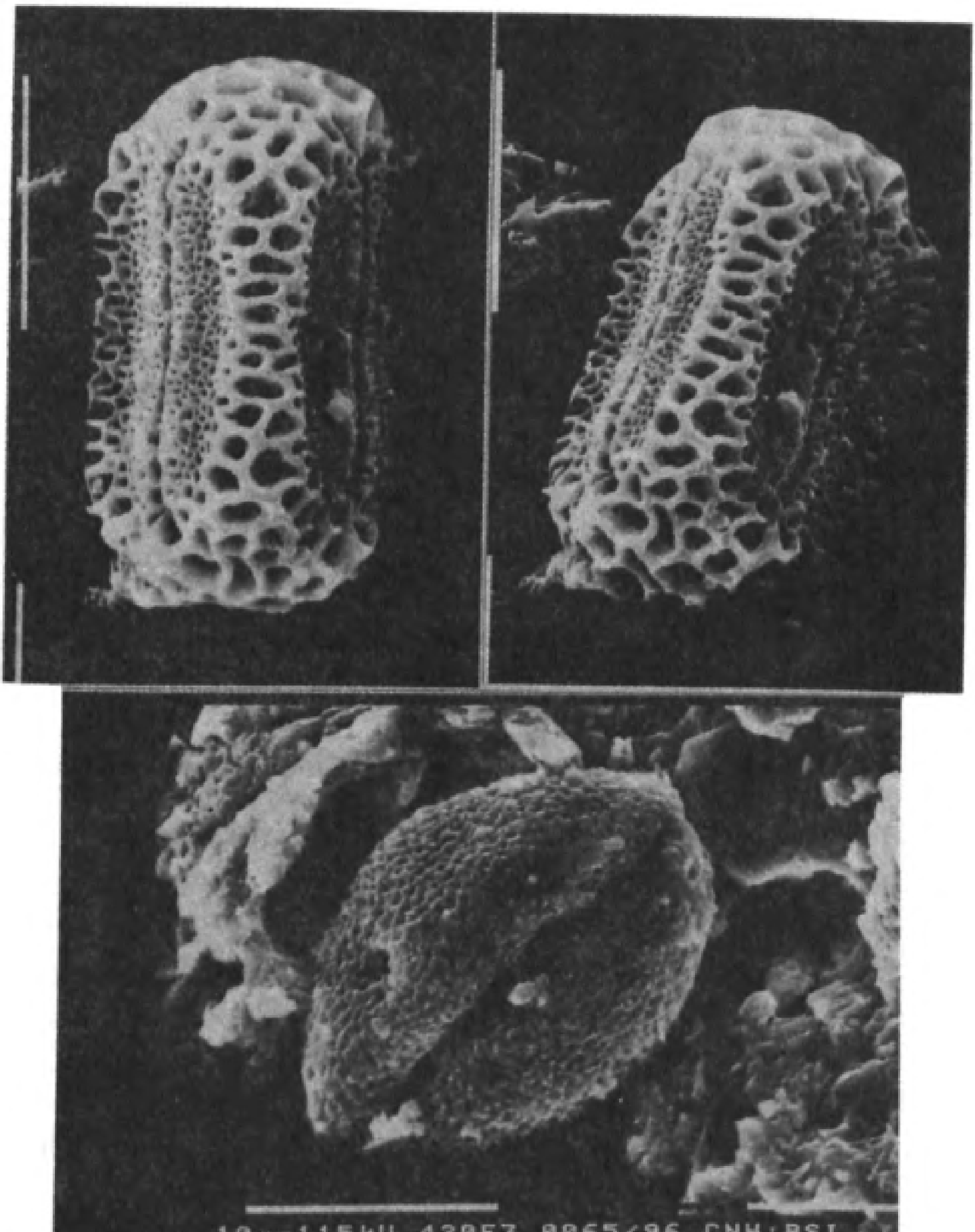

Plate XI : Figs. 1-3.

Polygonella articulata (L.) Meissn. = *Polygonum articulatum* L. 1 &2. × 3000. Showing exine ornamentation at mesocolpium area, details of aperture and finer ornamentation at apertural area.

Koenigia delicatula (Meissn.) Hara = *Polygonum delicatatum* Meissn. 3. × 3100. Details of exine and aperture extending up to poles.

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GLOSSARY OF POLLEN MORPHOLOGICAL TERMS USED

Apeture : In broad sense it includes both ecto and endoaperture. (Erdtman, 1947).

Apocolpium : (Erdtman, 1952; Faegri and Iversen, 1950 : Polar area) Area at a pole, delimited towards the equator by the polar limits of the mesocolpia.

Brochi : (Erdtman, 1952) The mesh of a reticulum. A brochus consists of a lumen and the adjoining half of the muri which separate that particular lumen from other lumina.

Coarse reticulate : Sculpture types consisting of reticula more than 1 μm with distinct muri.

Colporate : (Erdtman, 1945) Pollen types with ektexinous germinal furrow (Colpus), each provided with a central, endexinous pore (os) or pore like aperture.

Colpus : Simple aperture and also the ectoaperture of a composite aperture whose length/breadth ratio is equal to or greater than 2/1; in some cases the Colpi fuse : synocolpate. (Erdtman, 1947).

Colpus membrane : (Iversen and Troels-Smith, 1950; Pokrovskaya *et al.*, 1950) The thinned exine covering a colpus.

Columella : (Iversen and Troels-Smith, 1950) Rod shaped infratectal structure which has a diameter more of less same at the top and base. Used in the sense of bacula (Erdtman, 1952).

Costa : (Faegri and Iversen, 1950) Thickening of end exine, accompanying apertures. Types of costae are costae colpate, costae porate.

Dimorphic : (Erdtman, 1952) Plants with dimorphic pollen have two kinds of sporomorphs).

Ectoaperture : (= Colpus).

Ektexine : (= Ectexine, Erdtman. 1943) Outer layer of the exine composed of two major sublayers in tectate grains the columella and tectum.

Endexine : (Erdtman, 1943) Inner layer of the exine, homogeneous structure. The endexine will appear faintly pink after treatment with Fuchsin B where the ektexine is dark red. (Faegri and Iversen, 1950).

Endoaperture : (= os. Erdtman, 1952) The inner part of a composite aperture, the opening in the endexine.

Endo-cracks : (Oldfield, 1959) Certain small cracks observed in the endexine usually bordering the costae, parallel to the pore.

Equator : A broad line separating the distal and the proximal hemisphare and is perpendicular to the polar axis (Wodehouse, 1935).

Equatorial axis (E) : The greatest axis perpendicular to the polar axis.

Equidistant : (Erdtman, 1952) ± evently distributed.

Exine : The outer coat of the pollen grains. It consists of the ektexine and endexine (Potonie, 1934).

Finely reticulate : = Microreticulate (Praglowski and Punt, 1973).

Holo zone : (Bischoff, 1833, Iversen and Troels-Smith, 1950) ± Hyaline area surrounding an aperture. Corresponds to 'margo' of Faegri and Iversen (1950).

Heterobrochate : (Erdtman, 1952) with brochi of ± distinctly different sizes.

Homobrochate : (Erdtman, 1952) with brochi of ± same sizes.

Isopolar : (Erdtman, 1952) Pollen grains with ± symmetrical distal and proximal parts.

Lalongate : (Erdtdman, 1952) Transversely elongated endoaperture.

Lolongate : (Erdtman, 1952) Endoaperture with longer polar axis than equatorial diameter.

Longiaxial : Pollen type with polar axis (P.) greater than equatorial diameter (E.).

Lumina : (Potonie, 1934) The spaces between the muri of a reticulum.

Meridional : (Faegri and Iversen, 1950) Surface features perpendicular to the equatorial plane are called as meridional.

Mesocolpium : (Erdtman, 1952, Faegri and Iversen, 1950) (=Intercolpium) An area delimited by two adjacent colpi and by transverse lines drawn through the apices of the colpi. A mesocolpium thus borders on two colpi and two apocolpia.

Microreticulate : (Praglowski and Punt, 1973) Sculpture types consisting of minute reticulum with thin mure (< 1 μm in breadth) encompassing small lumina (< 1 μm in diameter.)

Muri : (Potonie, 1934) Ridges separating the lumina of an ordinary reticulum.

Negative reticulum : (Kuprianova, 1948) If the tubercles have the form of areas surrounded by narrow ditches a negative reticulate structure is formed.

Nexine : (Erdtman, 1952) = endexine (Erdtman, 1943).

Operculum : (Iversen and Troel-Smith, 1950) Thickened exine covering the aperture, often getting detached like a lid.

Granulated : (Operculoid) : No specific term as granules or operculum is used, as the structure referred differs from the cither of the two or involves the two. It is more or less a diffuse operculum constituted by granule like structures of exinous origin.

Whether it is an operculum under formation or degeneration, needs clarification. Moreover it's nature and ontogeny certainly reflect for species serminology for the structure.

Pole : The centre of a proximal and distal face of a pollen grains.

Psilate : (Wodehouse, 1935) Type of ektexine sculpture with either a smooth surface or pits less than 1 μm in diameter.

Reticulate : Netted type of ektexine sculpture.

Ruguloreticulate : A sculpture pattern ± intermediate between rugulate (Faegri and Iversen, 1950) and reticulate (Erdtman, 1947) or a combination of both i.e. rugae forming a network.

Sexine : (Erdtman, 1948) = ektexine (ectexine, Erdtman, 1943).

Sproderm : (Erdtman, 1952) The wall of a spore (and pollen).

Stenopalynous : (Erdtman, 1952) Plant families characterised by ± slight variation in spore types (their apertures, sporoderm stratifications etc.).

Tectum : (Iversen and Troels-Smith, 1950) The outer continuous layer of ektexine. It is used in the same sense as tegillum (Erdtman, 1952).

Shape class : (Erdtman, 1943) Shape classes and suggested relations between polar axis (P.) and equatorial diameter (E.).

Shape classes :	**P/E**	**100. P/E**
Peroblate	< 4/8	< 50
Oblate	4/8-6/8	50-75
Subspheroidal	6/8-8/6	75-133
Suboblate	6/8-7/8	75-88
Oblate spheroidal	7/8-8/8	88-100

	P/E	100. P/E
Prolate spheroidal	8/8-8/7	100-114
Subprolate	8/7-8/6	114-133
Prolate	8/6-8/4	133-200
Perprolate	> 8/4	> 200

Size Classes : (Erdtman, 1945) The following size classes, based on the length of the longest pollen or spore axis.

Very small (PI)	< 10 µm
Small (MI)	10 25 µm
Medium size (ME)	25 50 µm
Large (MA)	50 - 100 µm
Very large (PA)	100 - 200 µm
Gigantic (GI)	> 200 µm

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