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CONTENTS

Volume 35, 1956

No. 1

PAGE

The Botanical Exploration of India..........Santapau, H. 1

Production and Systematic Translocation of Fusaric Acid in *Fusarium* Infected Cotton Plants.........................
..........Kalyanasundaram, R. and Venkata Ram, C. S. 7

Studies on Colchicine induced Tetraploids of *Corchorus olitorius* Linn. (Jute)................Kundu, B. C. and Sarma, M. S. 11

Some Slime-Moulds from Southern India—IV. Agnihothrudu, V. 27

Fungi Isolated from Rhizosphere. II. *Starkeyomyces*, A New Genus of the Tuberculariaceæ..........Agnihothrudu, V. 38

Hitherto Unreported Hosts of *Dendrophthœ falcata* (L. F.) Ettings
.... Bahadur Singh 43

Soil Conditions and Root Diseases. XVI. Colonization and Survival of *Macrophomina phaseoli* (Maubl.) Ashby in Trace Element Amended Soils................Radha, K. 47

Hyphomycetes—I......................Subramanian, C. V. 53

The Clavariaceæ of the Mussoorie Hills—I..................
........................Thind, K. S. and Anand, G. P. S. 92

On Two New Species of *Terminalioxylon* Schoenfeld from the Tertiary of South Arcot District, Madras..................
..................................Ramanujam, C. G. K. 103

Sapucchaka, A New Genus of the Hemisphæriales............
.................................Ramakrishnan, K. 114

Natural Regeneration in *Pogonatum* Palis....................
......................Chopra, R. S. and Sharma, P. D. 117

Probable Factors Responsible for Formation of Sporogonia in *Mannia indica* St. and *Asterella pathankotensis* Kash.......
....Kachroo, P. 120

Some Abnormal Cones of *Equisetum debile* Roxb...Sinha, S. C. 123

Embryology of the Passifloraceæ. I. Gametogenesis and Seed Development of *Passiflora calcarata* Mast.....Raju, M. V. S. 126

PAGE

No. 2

On Factors Influencing Fruit-set and Sterility in Arecanut (*Areca catechu* Linn.). I. Studies on Pollen Grains.................................Raghavan, V. and Baruah, H. K. 139

Additions to Our Knowledge of Rusts of Hyderabad—II...........................Salam, M. A. and Ramachar, P. 152

Observations on Inter-Racial Rice Hybrids—The *japonica-indica* Rice Hybridisation....Subramanyam, K. N. and Roy, S. K. 158

Some Unreported Ferns of Bihar..............Mehta, A. S. 165

The Hydrophytes of Cuttack..Pattnaik, H. and Chyau Patnaik, N. K. 167

The Clavariaceæ of the Mussoorie Hills—III.......................................Thind, K. S. and Anand, G. P. S. 171

The Gametophytes of *Lycium europæum* Linn.....Jain, T. C. 181

Studies in the Family Euphorbiaceæ. I. The Gametophytes of *Chrozophora rottleri* A. Juss.........Gyanendra Sharma 189

A Contribution to the Knowledge of Fresh-Water Diatomaceæ of South-Western India. I. Fresh-Water Diatoms of Dharwar..............................Gandhi, H. P. 194

Some Slime-Moulds from Southern India—V..Agnihothrudu, V. 210

Studies in the Meliaceæ. I. Development of the Embryo in *Azadirachta indica* A. Juss........Garudamma, G. K. 222

On the Genus *Amphichæta* McAlpine.......................................Subramanian, C. V. and Ramakrishnan, K. 226

Studies on the Cytology and Phylogeny of the Pteridophytes. I. Observations on the Marattiaceæ...........Ninan, C. A. 233

No. 3

Ferns of Parasnath, Bihar......................Mehta, A. S. 241

Some New Record of Plants from the Parasnath Hill..Mukerjee, S. K. 245

Studies on the Cytology and Phylogeny of the Pteridophytes. III. Observations on *Osmunda regalis* L.........Ninan, C. A. 248

Studies on the Cytology and Phylogeny of the Pteridophytes. IV. Systematic Position of *Ceratopteris thalictroides* (L.) Brongn...............................Ninan, C. A. 252

PAGE

Fossil Silicoflagellates from Colebrook and Nancoori Islands.... ....Desikachary, T. V. and Maheshwari, C. L. 257

Annual Foray of the Indian Botanical Society to Bund Bareta, Agra, on January 7, 1956................Santapau, H. 265

Studies on Indian *Poria*............................Puri, Y. N. 277

Fossil Woods of Euphorbiaceæ from the Tertiary Rocks of South Arcot District, Madras......Ramanujam, C. G. K. 284

On the Recent Introductions in the Flora of Purnea (Bihar) ....Srivastava, J. G. 308

The Clavariaceæ of the Mussoorie Hills—IV................ ....Thind, K. S. and Anand, G. P. S. 323

Studies in Pteridaceæ. II. *Hemionites* Linn...Nayar, B. K. 333

Morphology of the Pachytene Chromosomes and Meiosis in *Sorghum subglabrescens*, a Eu-Sorghum................. ....Venkateswarlu, J. and Ramakrishna Reddi, V. 344

Contribution to the Ecology of Teak (*Tectona grandis* Linn. f.) in Madhya Pradesh......................Bhatia, K. K. 357

No. 4

Glœotilopsis planctonica Gen. et Sp. Nov., A New Member of the Ulotrichaceæ......Iyengar, M. O. P. and Philipose, M. T. 365

On Sexual Reproduction in a New Species of *Golenkinia*........ ....Iyengar, M. O. P. and Balakrishnan, M. S. 371

Observations on the Anatomy, Cytology, Development of the Reproductive Structures, Fertilization and Embryology of *Pelvetia canaliculata* Dcne. et Thur. Part I. Anatomy of the Thallus and Somatic Mitosis........Subrahmanyan, R. 374

The Vegetation of Patna District (Bihar)......Srivastava, J. G. 391

A Preliminary Account of the Soil Diatom Flora of Kolhapur.. ....Gandhi, H. P. 402

Growth of *Colletotrichum capsici* in Pure Culture..Durairaj, V. 409

Amino Acid Changes in the Healthy and 'Foot-Rot' Infected Rice (*Oryza sativa* L.)..Andal, (Miss) R. and Subba Rao, N. S. 414

The Embryo Sac and Endosperm of *Blyxa orizetorum* Hook. f. ....Govindappa, D. A. and Naidu, T. R. B. 417

PAGE

Sporeling Germination and Vegetative Reproduction in *Chiloscyphus himalayensis* Kash. and *Cololejeunea* sp.......... ....Kachroo, P. 423

Some Abnormal Pollen Grains of *Picea smithiana* Boiss....... ....Lakhanpal, R. N. and Nair, P. K. K. 426

Plant Types of the Ponds of the Lower Damodar Valley........ ....Kachroo, P. 430

Hyphomycetes—II.......................Subramanian, C. V. 446

Plant Ecology of Bikaner and Its Adjacent Areas in Comparison with the Rest of Western Rajasthan..........Joshi, M. C. 495

The Clavariaceæ of the Mussoorie Hills—V.................. ....Thind, K. S. and Sukh Dev 512

Felix Eugen Fritsch, 1879–1954........................... 522

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THE BOTANICAL EXPLORATION OF INDIA*

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Introduction

During the past year, whilst holding the post of Chief Botanist, Botanical Survey of India, it became my duty to find out the extent of botanical exploration in our country. For this purpose I made use of the extensive library facilities of the B.S.I. At the outset, however, I came across a serious difficulty in my quest; several of our Indian universities for some years have been doing excellent work in this line, the results of which have appeared in the various university journals of India. But to my great disappointment, I was unable to consult all such journals, for the simple reason that there is no university in India where the journals of *all* our Indian universities may be examined.

This limited circulation of our university journals raises a serious question on a matter of importance: it is about the validity of publication of some of the new genera or species of plants described therein; in view of the limited distribution of such journals, it is questionable if publication may be considered *effective* in the sense of the *International Code of Botanical Nomenclature.* In Recommendation No. 39 of the present Code it is stated: ''Botanists and others are urged scrupulously to avoid the publication of new species, names or combinations in ephemeral publications such as popular periodicals, *in any publication unlikely to reach the general botanical public*, or in those produced by such methods that their permanence is unlikely.'' (Italics mine own.)

To obviate such difficulties, I would strongly recommend that all universities in India would enter into an exchange of their Journals or Memoirs among themselves; further that copies of all journals be sent to the Botanical Survey of India, to the Directors of INSDOC, of UNESCO in India, and at least to the editor of *Biological Abstracts* and to some of the great herbaria of the world. Such abstracting or indexing organisations would see to it that the botanical public was kept informed of the progress of Botany in India.

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* Presidential Address delivered at the 35th Annual Meeting of the Indian Botanical Society held at Agra in January 1956.

In my quest for knowledge about the botanical exploration of India, I have examined some of the best herbaria in India and abroad, and have consulted most of our provincial or local floras. The impressions gathered from this examination are set forward in the following pages.

Some parts of India have been more or less intensively explored in the past by numerous botanists; this is the case with some of the more popular hill stations of India. During the summer vacation such hill stations have been explored, at times intensively; but little or no work has been done at other times of the year; the monsoon and the cold months of the year have often been left out completely.

WHAT HAS BEEN DONE IN THE BOTANICAL EXPLORATION OF INDIA

It had been my plan when preparing these notes to give a comprehensive list of the publications on the botanical exploration of the various botanical provinces of India; but finally I decided to leave this part out of my discussion, first because it would have made this paper much too long, and secondly because most of the relevant data have been given in a paper on *Progress of Botany in India*, which is in the hands of the editors ready for the press. In this paper I shall confine myself to some general remarks.

A careful examination of the literature on the subject shows that even though most parts of India have been explored at different times from the beginning of the last century, and that, as Hooker and Thomson remark in their *Flora Indica*, p. 128, "there are not many more phanerogamic plants to reward the labours of future investigators", yet it is plain that most parts of India are in need of a very thorough exploration.

It is clear that very few places have been explored methodically in the past; by this I mean that very few areas have been so explored that we may say that we know the complete flora of the area and the various changes that occur in the course of the year's seasons. Cooke in the Flora laments that a particular plant "unfortunately flowers in July, at which time the hill-sides are streaming with water, rendering plant-collecting a task of no ordinary difficulty". Over a century previously Sir William Jones had remarked: "Before I was acquainted with the method pursued by Van Rheede, necessity had obliged me to follow a similar plan on a smaller scale; and as this mode of studying botany, in a country and climate by no means favourable to botanical excursions, may be adopted.... (*Asiat. Res.*, **4**: 240, 1798, London edit.). The method of van Rheede was to send collectors into the field, and to prepare diagrams and descriptions of such plants as had been brought to him by his collectors. Such methods may have been useful when our knowledge of the botany of India was in its infancy, but they are totally inadequate at present. The "unfortunate" circumstance of the heavy rainfall during several months of the year should not deter botanists from going into the field; for it is at such times that some very interesting medicinal plants come into their own in many parts of the country. Any place, then, that is taken up for botanical exploration should be visited regularly in every type of weather, and the changes in the vegetation of the place noted down.

Further it is not sufficient to send collectors into the field; unless they are very well trained, they will not notice many details that may be of great interest for posterity. In my own experience, on a certain occasion I sent my collectors to a part of the Western Ghats that I thought was rather rich in its flora; they collected exactly four specimens, the only ones seen in flower by the collectors; the following day I went there personally and collected over sixty specimens, most of which had not been considered worth collecting by my assistants, or had not been seen by them.

Khandala on the Western Ghats of India is a place that for over a century has been visited by Bombay botanists beginning with John Graham. When, however, I started my work on the flora of the district, I was much impressed by the absence of references to the monsoon flora of the district; plenty of plants had been collected during October and May, the two months when the station becomes a summer resort, but the heavy rains seemed to have kept botanists away from the area. In other places, such as Mahabaleshwar, in addition to heavy rains there is great difficulty on account of leeches during the rains. The monsoon flora of such well-known spots is practically unknown.

When discussing this point with Dr. N. L. Bor, the Assistant Director, Royal Botanic Gardens, Kew, he wrote to me: "*Sapria himalayana* was collected by Griffith in the Mishmi Hills in 1833, and was never seen again until I collected it in the Aka Hills in 1933 in August. It is *extremely* common at that time in the leech infested jungles in the hills of both sides of the Brahmaputra. Again the grass genus *Cyathopus* collected by Hooker about 1848, remained a curiosity until my Sikkimese collector brought it in 1945. He collected it in June and July."

These remarks of Dr. Bor bring to my mind having noticed in Cooke's *Flora of the Presidency of Bombay* that a fair number of plants are therein classed as *rare* or *very rare*; in point of fact, however, many such plants are rather common and abundant during the months of July to September, the monsoon months for Western India. Due to the unpleasant weather of the time, such plants have seldom been collected and are scarcely represented in our herbaria. To mention but one example, the plant that goes under the name of *Dolichos bracteatus* Baker is said to be so rare that Kew Herbarium possesses but a few scraps of the same. On the other hand in my fieldwork I have found masses of the plant in most of the higher hills of Bombay State; the plant comes into flower in the middle of the monsoon, its fruits are gathered by local people as an article of food, so that when the fair weather of October comes, there is nothing left for the botanist who depends on fair weather for his collections.

Even today there are many spots in India, where practically no botanical exploration has been done. The reason may be the distance from any university centre, or political restrictions (as in the case of Bhutan), or the various inconveniences of the place such as heat or cold or mosquitoes, leeches, etc. It is rather surprising that such important areas as Rajputana, Saurashtra, Cutch, many spots in central India and large tracts of the Himalayas, have not attracted the attention of Indian botanists. Perhaps they have fallen into the common mistake of considering such places as not deserving of exploration because they do not possess evergreen or at any rate conspicuous forests.

This attitude is to be lamented; the flora of the arid or semi-arid regions of India is of great interest; many of the plants are of considerable medicinal importance, as shown by the use made of them by the local vaidyas; further the study of such areas becomes rather easier precisely because of the sparse vegetation of the same. This applies also to other and better or more favourable parts of the country during the dry months of the year; we need precise information on the arid or semi-arid regions of India and on the vegetation of the dry season of better areas.

Even the better explored parts of India can do with some more systematic study; it is desirable to have all the year observations, notes on the density of the vegetation or of a particular plant in a given district. In practice it is not a wise policy to separate systematic botany from ecological studies; if India is to make good use of the raw materials from the plant world, it is necessary to know the life-cycle of the plants in question, their relative abundance, and as far as possible the exact spots where plants are to be found, or at least the sort of association, the type of soil, etc., where a given plant may be found. It is clear, therefore, that for proper botanical collection it is the botanist himself that should go into the field, and not trust to collectors alone.

SUGGESTIONS FOR OUR UNIVERSITIES

I hope that it will not be considered presumptuous on my part that I dare offer suggestions to our universities on the subject of what may be their contribution to the complete botanical exploration of India. The ideas herein contained have been evolved in many years of work in the field, and after studying, as Chief Botanist, the needs of our country.

Most of our universities like many of the best universities of the world, are handicapped by the short funds at their disposal for research. For this reason it is important that whatever funds be made available for botanical exploration be employed wholly for this purpose. It is then suggested that as far as possible universities concentrate their botanical researches in their own districts and leave far away exploration to the Botanical Survey of India; in this way funds will be spent in real botanical work of great value to the country, and botanists will be free from the accusation that their aim is to have grand scale picnics at the Government's expense.

The area to be selected for botanical exploration should not be too big; it is surprising, once the work has started in earnest, how much work can be done in a relatively small area. I would recommend that an area about 10 miles in diameter round the university be taken as first object of exploration; this area may appear too small, but in fact it may even be too large for intensive exploration. Let our young botanists be trained in this restricted area until its flora is completely known; the area may then be expanded by a few miles more, and thus gradually the whole of India may be finally covered by the research workers of the various universities of the country.

Exploration must be intensive; there must not be any season left out on account of the inclemency of the weather. It is precisely in these adverse seasons when the more important and interesting plants come into flower or fruit. Once the area has been well and carefully selected and properly demarcated, the whole of it should be explored at least once every month, or even oftener if possible. No new plant may be recorded in this intensive exploration, but the phenology of each plant, its complete life-cycle, its relative abundance and distribution can be studied.

In my opinion it is a great mistake that is often made when field botanists do not collect or at least record in their field books a plant, because it may have been seen often in the field; as a result many of our Indian herbaria show very few specimens of the commoner plants, whilst they may contain large numbers of somewhat rarer specimens. Students of the herbarium alone can easily obtain a distorted idea of the vegetation of any area from the collections in such herbaria.

THE REVISION OF THE FLORA OF INDIA

Every botanist, who has had to handle Hooker's *Flora of British India*, needs no argument to convince him of the crying need for the revision of the book. Large numbers of new plants have been described since the book was published; many changes have been introduced into the nomenclature of plants; the identity of some important plants has been carefully studied and found to differ from what is written in Hooker's Flora. The need for a complete modern revision of the type of, say, *Flora Malesiana*, with plenty of illustrations and correct identifications and nomenclature of all our plants, is agreed upon by most botanists.

When speaking of Systematic Botany I do not mean to confine myself to the Angiosperms; we need national and provincial floras of the Algæ, Lichens, Bryophytes, etc. of the country; of late such plants have assumed great economic importance, and if our students wish to help in the development of the natural resources of India, they need proper floras to cover such aspects of our vegetation. It is to be regretted that sufficient work has not been done on many of these lower groups; but if at least we had proper floras to give in concise form whatever has been known about such plants more students might feel inclined to go for them in the field.

In the preparation of all these books, *i.e.*, the revision of the *Flora of India*, and the writing up of books on lower groups of plants, one serious question arises as to the suitability of the times for such books. The time seems propitious for the work to be started at once; the revival of the Botanical Survey of India, and the promise that the Records of the same will soon be revived, guarantees that the work will be carefully and properly done, and that facilities for publication will be given to every worker. Without wishing, however, to dampen the ardour of our botanists, it is necessary to point out the need for more intensive collection of plants from all over the present territories of India; many places are still completely left alone by botanists; many places have been explored in a far from methodical manner in the past, our monsoon plants are practically untouched. Nevertheless, it should be possible to start at once with the revision at least in a provisional manner; whatever we may include in the new revision will be of great help to field botanists all over the country; this is important at present when most of our provincial floras are out of date and out of print. The classical books of Wight, Beddome, etc. are completely unobtainable, and even when it is possible to consult them in some of the larger libraries, they are so brittle that their pages fall in pieces at the least touch; a modern illustrated flora on Angiosperms, Algæ, etc. would certainly answer the needs of the country.

There is, however, another and greater difficulty than merely finance or the time required for a work of this magnitude; in the recent past plant taxonomy has been very much neglected in most of our universities, and in consequence we have but a few systematists in our country. We have to train our personnel before the task is undertaken, and this may impose a delay of three to four years at the least.

In the study of plant systematics many of our students suffer from a great handicap; this is that such students have neglected the study of the more common European languages, in which the majority of the papers on systematic botany are written; French and German should be studied by at least every research worker in the subject; Latin, as the international language of Botany, should be so mastered that easy passages may be translated even without the aid of a dictionary; further, in view of the extensive literature in Russian, this language should also be studied. And above all, every systematist should make himself familiar with the provisions of the *International Code of Botanical Nomenclature*, without which it is next to impossible to do any serious work on the subject.

CONCLUSION

By way of conclusion I beg to be allowed to repeat some of the more important recommendations made in this paper:—

1. It is of little use reprinting Hooker's *Flora of British India* in the present form; the book has to be revised, the identity of many of the plants checked and their distribution and relative abundance properly determined.

2. In general it is desirable that greater attention be paid in our universities to Systematic Botany; and this includes not only the flowering plants but also lower groups such as Algæ, Lichens, Bryophytes, Mosses, etc.

It is only fitting that Independent India should be wholly responsible for the revision of its flora; we may obtain help from various specialists in other parts of the world, but the bulk of the work should be entrusted to Indians, who can best appreciate the needs of the country.

PRODUCTION AND SYSTEMIC TRANSLOCATION OF FUSARIC ACID IN *FUSARIUM* INFECTED COTTON PLANTS

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Introduction

Certain species of Fusaria are known to produce the phytotoxin fusaric acid (Yasue, 1949; Gäumann, Naef-Roth and Kobel, 1952). The *in vivo* detection of fusaric acid (Lakshminarayanan and Subramanian, 1955) and its translocation in *Fusarium vasinfectum* Atk. infected cotton plants is being reported in this paper.

Experimental

Detection of fusaric acid in vivo.—Bulk samples of 2–3 weeks old *F. vasinfectum* infected cotton plants as well as cut shoots of plants treated to solutions of pure fusaric acid were ground up with distilled water, centrifuged and the clear extract was concentrated *in vacuo* at room temperature. Chromatograms of the extracts were run (butanol, acetic acid, water solvent) in test-tubes (Rockland and Dunn, 1949), and the dried chromatograms were spread on bacterial seeded agar (Zähner, 1954) and R*f* value of fusaric acid determined in the usual manner (Table I).

Table I

Rf value of fusaric acid

	Pure sample	Detected in cut shoots of cotton treated to pure fusaric acid	Detected in cotton plants infected with *F. vasinfectum*
R*f* value ..	·89	·88	·87

The R*f* value of the antibiotic obtained from cut shoots of cotton treated to pure fusaric acid (Plate I, Fig. 1) and *F. vasinfectum* infected plants (Plate I, Fig. 3) corresponded to the R*f* value of pure fusaric acid (Plate I, Fig. 2), thereby indicating the presence of this toxin *in vivo* in infected cotton plants.

Quantitative estimation and systemic translocation.—The extract from 100 g. (fresh weight) of infected plants was concentrated to 5 ml. and employed neat and at 50, 10, 1, ·1 and ·01 per cent. levels for the quantitative determination of fusaric acid by the modified agar-cup technique (Kalyanasundaram, 1955 *a*). No antibiotic activity was detected in the extract at 1, ·1 and ·01 concentrations, but the two higher concentrations and the neat extract produced marked inhibition zones (Plate I, Fig. 4); neat extract of healthy plants showed no antibiotic activity. Fusaric acid yield from the infected cotton plants is given in Table II.

TABLE II

Fusaric acid in cotton plants

Total No. infected plants	Fresh weight of the plants	Fusaric acid yield per plant
100	100 g.	17·28 μg.

The translocation of fusaric acid within the cotton plants was studied employing Pramer's technique for detection of antibiotics in plants (Pramer, 1953). Root, stem and leaf sections of *F. vasinfectum* infected and healthy plants were cut, crushed between sterile glass plates and plated on bacterial seeded agar. Clear inhibition zones were formed only around infected plant sections (Plate I, Figs. 10, 11 and 12) and not around healthy tissues (Plate I, Figs. 7, 8 and 9). The plant exudate of infected cotton, absorbed on discs of filter-paper, similarly showed antibiotic activity (Plate I, Fig. 5), whereas the exudate from healthy plants did not contain any antibiotic (Plate I, Fig. 6).

DISCUSSION

In recent years much work has been done on the production of antibiotics in soil (Grossbard, 1952; Jefferys, 1952; Wright, 1952) and their uptake by higher plants (Brian, Wright, Stubbs and Way, 1951; Pramer, 1953), but very little is known about the production of 'wilt' toxins in soil by plant pathogenic fungi. However, earlier work (Kalyanasundaram, 1955 *b*) showed that *Fusarium vasinfectum*, the cotton wilt pathogen, produced appreciable quantities of fusaric acid in sterilized and amended soil. The present work has shown that fusaric acid is produced *in vivo* in cotton plants infected with *F. vasinfectum*, the identity of the toxin having been established by the chromatographic bioassy method (Plate I, Figs. 1, 2 and 3). The detection of free fusaric acid in cut shoots of cotton treated to various concentrations of the toxin (Table I) and the antibiotic activity observed in leaf, stem and root sections of infected plants (Plate I, Figs. 10, 11 and 12) demonstrated the systemic presence of the toxin and its translocation within the cotton plants. Fusaric acid, therefore, resembles many of the other antibiotics which are known to be taken up and translocated by plants (*loc. cit.*) but unlike other antibiotics fusaric acid is toxic to plants at comparatively low concentrations (Gäumann, 1951).

Quantitative estimation of fusaric acid showed the amount present in a single infected cotton plant was 17·28 μg. The fact that smaller quantities of the toxin, present *in vivo*, is sufficient to produce typical disease reaction in cotton, compared to larger quantities of fusaric acid required to produce symptoms in cut shoots (30 mg. toxin/1 kg. fresh weight, Gäumann, 1951) shows that other factors present within the plants may be interacting in increasing the sensitivity of the cotton plant to the toxin *in vivo*. This seems to be in line with the earlier observation of Gäumann *et al.* (1952) who stated that the toxic potency of fusaric acid is dependent on the fresh weight of the plant, pH of the substrate, synergistic action of the plant constituents and its dissociation factors.

Scheffer and Walker (1953) and Dimond and Waggoner (1953) stated that lycomarasmine, another wilt toxin, being a lytic product could not be produced in a short period of 14 days within the tomato plants, although such plants infected with *F. lycopersici* wilted during this period. In the case of fusaric acid, however, the toxin could be detected in culture filtrate within 4 days of fungal growth (Kalyanasundaram, 1955 *c*) and is produced in cotton plants soon after infection; symptoms of fusaric acid toxicity were noticeable in 13 days old seedlings (Kalyanasundaram, 1954), and actually 17·28 μg. of fusaric acid were obtained per plant from 2-3 weeks old plants (Table II).

The evidence presented here further substantiates the toxin theory of wilting in fusariose wilts inasmuch as fusaric acid, an established wilt toxin, has been detected *in vivo* in infected cotton plants using chromatographic bio-assay. Further, it is possible that fusaric acid plays an important part in other fusariose diseases, such as wilt of tomato and foot rot of paddy, since this toxin is known to be produced by *F. lycopersici* and *Gibberella fujikuroi* (Gäumann *et al.*, 1952) the respective pathogens.

SUMMARY

The present work reports the *in vivo* detection of fusaric acid in cotton plants infected with *Fusarium vasinfectum* Atk., using chromatographic bioassay technique. It was also possible to demonstrate the systemic translocation of free fusaric acid inside an infected plant. The quantity of fusaric acid inside an infected plant, 2-3 weeks old, was 17·28 μg. under the growing conditions now reported.

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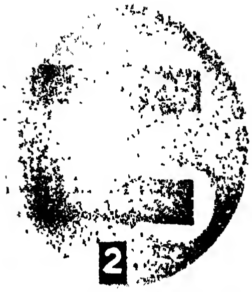
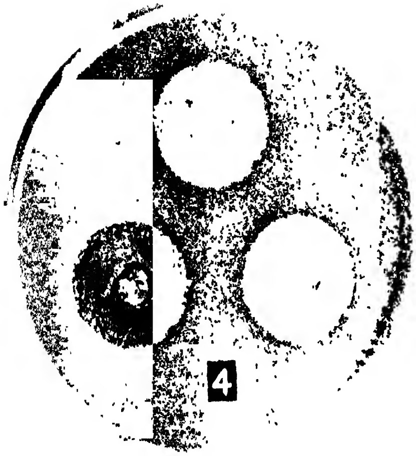
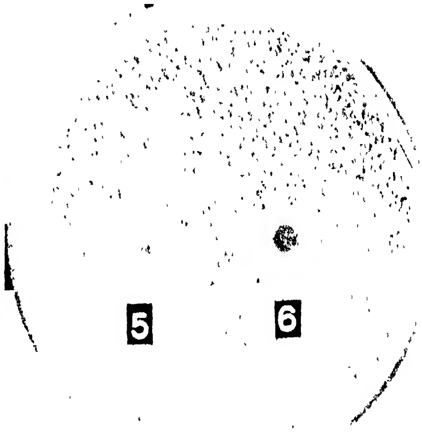
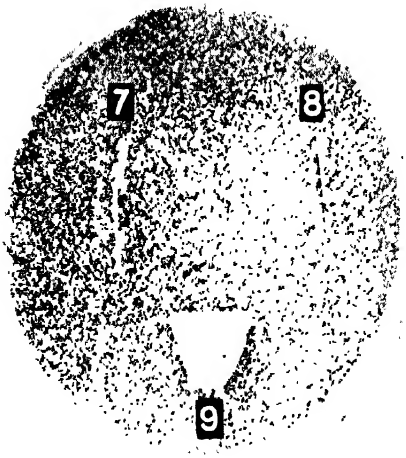
EXPLANATION OF PLATE

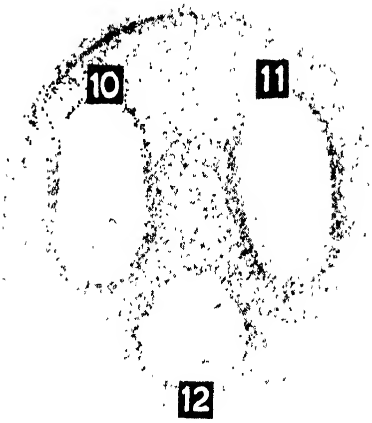
PLATE I. Quantitative and chromatographic bioassay of fusaric acid. Fig. 1, extract of cut shoots of cotton previously treated to pure fusaric acid; Fig. 2, pure fusaric acid; Fig. 3, extract of *F. vasinfectum* infected plants. Fig. 4, quantitative determination of the toxin in infected plants by the agar-cup technique. Discs of filter paper with exudates from infected (Fig. 5, note inhibition) and healthy (Fig. 6) plants. Root, stem and leaf of healthy (Figs. 7, 8 and 9) and infected plants (Figs. 10, 11, and 12) plated on bacterial seeded agar showing inhibition around the infected tissue.











R. Kalyanasundaram and C. S. Venkata Ram

STUDIES ON COLCHICINE INDUCED TETRAPLOIDS OF *CORCHORUS OLITORIUS* LINN. (JUTE)

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INTRODUCTION

THE two cultivated species of *Corchorus* (Tiliaceæ), *C. capsularis* and *C. olitorius*, from which jute fibre of commerce is derived have each certain desirable characters. *C. capsularis* is comparatively more resistant to flood and drought but slightly more susceptible to diseases and pests; it gives the 'white' fibre of commerce which is slightly weaker. *C. olitorius* is tolerably resistant to diseases and pests, grows generally on high and medium land and produces the strong 'tossa' fibre of commerce with a slight tinge of dark red. A combination of the desirable characters of the two species in a single hybrid with ability to grow almost on all types of land, comparative immunity to diseases and pests and with strong white fibre would make an ideal jute plant. Thousands of straight crosses made between the diploids of the two species failed (Ghose and Patel, 1945) and it was felt that incompatibility might be overcome by crossing the two species in the tetraploid state.

Rao, Sanyal and Datta (1944–45) treated seeds of both the species and tips of vigorously growing young plants of *C. capsularis* with different concentrations of colchicine solution for different periods and obtained tetraploids in *C. capsularis* in the 0·1 per cent. concentration and 24 hours duration treatment, but failed to induce polyploidy in *C. olitorius*. The affected *capsularis* plants showed increase in the size of stomata, floral parts and fruits. The ultimate fibres showed greater length and breadth and wider lumen but the thickness of the cell-wall did not show much change. The fibre bundles were also larger in size and this was due to the increase in the breadth of the ultimate fibres, rather than their number. Bhaduri and Chakrovarti (1948) successfully obtained tetraploids of both the species by treating seeds and seedlings. They crossed the tetraploids and even expected a few fertile F_1 plants. The tetraploids showed giganticism of several morphological characters but the number of ultimate fibres did not increase though the total volume of fibre as compared to the diameter of the stem increased. Nakajima (1949) also treated seeds of *C. capsularis* and studied the tetraploids. However, studies on economically important characters like fibre yield, maturity, etc., have not been reported by any of the authors.

Studies were undertaken by the authors to evaluate the desirable characters, if any, of the tetraploids, especially of *C. olitorius*, and the possibilities of utilising them in a programme of interspecific hybridization.

MATERIALS AND METHODS

Seeds of both *C. capsularis* and *C. olitorius* were treated during 1948 and again during 1950. In 1948 only two tetraploid plants were obtained in *C. capsularis*, one in 24 hours—0·15 per cent. and the other in 18 hours—0·20 per cent. treatments but polyploidy was not induced in *C. olitorius*. The treatment was repeated in 1950 when tetraploids of both the species were obtained. Seeds of *C. capsularis*, variety D 154 and *C. olitorius*, variety Chinsurah Green (C.G.) were treated for 3, 6, 12, 18 and 24 hours with 0·0125, 0·025, 0·05, 0·10 and 0·15 per cent. water solutions of colchicine. Fifty well developed seeds were soaked directly in the solution and at the end of each treatment, washed in running water and sown in specially prepared plots. The germination was recorded at the end of a fortnight and plants exhibiting morphological abnormalities were selected at the end of a month from the date of sowing. Observations on the selected plants and controls were recorded at periodical intervals and single pods (fruits) were collected separately from all the selected plants for further studies. From the C_2 generation onwards the elites were maintained by propagating the plants from seeds collected from separate pods of each of the selected plants.

For cytological studies flower-buds were fixed in 1 : 3 acetic alcohol mixture and anthers were squashed in acetocarmine. For anatomical studies plants were collected at small-pod stage and were sectioned with a base sledge microtome. Ultimate fibres were studied after maceration with 5 per cent. chromatic acid. Seeds of whole plants were used for yield and correlation studies where adequate population was required but the stock material was always propagated by using seeds of single pods of selected plants.

Though studies have been made in both *C. capsularis* and *C. olitorius*, observations only on *C. olitorius* have been reported in the present paper. Observations on *C. capsularis* will be dealt with in a separate paper.

OBSERVATIONS

As stated earlier, 50 treated seeds of *C. olitorius*, variety Chinsurah Green, were sown in each treatment and germination was recorded after a fortnight; plants showing morphological abnormalities were selected after another fortnight. The table below gives the details.

In general, the germination of treated seeds decreased with increasing concentrations except in the 3 hours group. With increasing duration, however, germination perceptibly decreased only in the higher concentrations. As compared to the control, the viability of seeds, even in mild concentrations of solutions and shorter durations of treatment was severely affected and the proportion of plants showing morphological abnormalities roughly increased with increase in the concentrations of the alkaloid employed and the duration of the treatment used.

TABLE I

Number of seeds germinated and number of plants with morphological abnormalities in the C_1 generation

Duration of treatment (Hours)	Number of seeds germinated					
	3	6	12	18	24	Total
Concentrations						
0·0125	14	17	18 (2)	9 (3)	20 (3)	78 (8)
0·025	7	20	3 (1)	2 (2)	5 (4)	37 (7)
0·050	19	13 (1)	4 (2)	0	3 (3)	39 (6)
0·100	18	8 (1)	1 (1)	0	0	27 (2)
0·150	14	7	0	0	0	21
Total ..	72	65 (2)	26 (6)	11 (5)	28 (10)	202 (23)
Untreated (control) ..	45					

(Figures in brackets indicate the number of plants selected for morphological abnormalities.)

Of the 23 plants selected, one plant from the 0·025 per cent. concentration and 24 hours duration was sterile and another was destroyed by external agencies. During the C_1 generation the plants were weak in growth, possibly due to late sowing, and only 160 pods were collected from 21 plants and the seeds of each pod were counted and classified into healthy and unhealthy. Pods from 18 of the plants contained varying proportions of good and bad seeds and seeds from the rest were all healthy showing that they were unaffected by the treatment. The number of good seeds in the pods was variable but the selected plants recorded an average of 49 seeds in the pod against 157·58 of the pods of controls.

In the succeeding year, the seeds from each pod were sown separately in lines. Only pods from four of the 21 plants gave progenies that showed variations characteristic of tetraploids and the rest produced normal plants. One of these, 5095, was a pure tetraploid and in the other three, all the plants from the seeds of any single pod were of one type, either normal or tetraploid, but seeds from different pods of the same plant or even of the same branch produced both normal and tetraploid plants, showing that in these three the plant as a whole or even the branch was a mixoploid. The table below gives the details.

The $4n$ plants in the C_2 and later generations show giganticism characteristic of the tetraploids even from the cotyledonary stage. The cotyledons are larger and more succulent. The leaves are broad

TABLE II

Showing the behaviour of pods from C_1 selections giving tetraploid progenies

Concentration	Duration (Hours)	Selection number	Number of pods sown	Number of pods producing tetraploids
0·0125	24	5053	7	3
0·0250	18	5051	10	9
0·0500	12	5095	3	3
0·1000	6	5092	32	24

and coriaceous. The stomata are larger in size but are fewer in number. Though increase in the length of the leaves was not observed, definite increase in breadth was noticed, thus marking off the tetraploid leaves as broad (Pl. III, Figs. 1 and 2). The comparative size of the leaves is given below: -

	Length (mm.)	Breadth (mm.)	Length-Breadth ratio
4 *n*	191·34	101·82	1·88
2 *n*	191·04	83·80	2·28

(Average of 5 leaves per plant, 5 plants per plot, 6 plots of each.)

The younger leaves of the tetraploids are susceptible to 'scalding'. Portions of the leaf near the tip begin to wither and dry up and the disease spreads towards the petiole. As no pathogen responsible for this could be isolated, the disease appears to be physiological; it is, however, peculiar that diploids are immune to the disease.

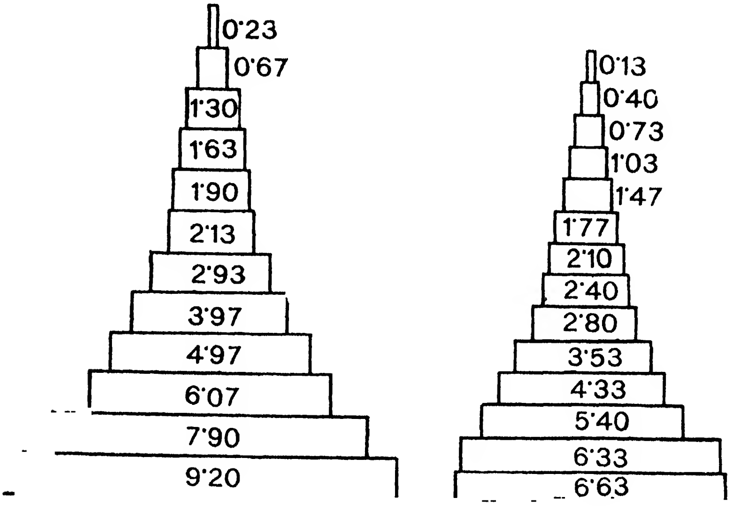
In general, the tetraploids are more branched, the average number of branches per plant in the tetraploids being 11·7 and 6·2 in the diploid.

The cytology of the normal diploids has been worked out by Banerjee (1932) and Datta (1952) and some details of the cytology of tetraploids of *C. olitorius* have been given by Bhaduri and Chakrovarti (1948). The P.M.C.s show occasional irregularities, both multivalents and univalents being formed in the first meiotic metaphase. One to two tetravalents, one of them a ring of 4, a trivalent and 1–5 univalents generally occur, the rest being present as bivalents (Pl. II, Figs. 1 and 3). The pairing is fairly regular and in anaphase I, 1–6 laggards often corresponding in number to the univalents, are noticed. However, all the laggards manage at the end to reach the poles. In certain of the cells, the spindle fails to be formed in the second division, the chromosomes are irregularly dispersed and restitution nuclei result (Pl. II, Fig. 2). Occasionally due to the complete failure of the second division diads are formed. In one instance a hexad was noticed (Pl. II, Fig. 4). This might possibly be the result of further division of two of the cells of the tetrad. In spite of these occasional irregularities, the pairing in the majority of the P.M.C.s is regular and the cells of the tetrad do not show much variation either in the number of chromosomes or in the size. The percentage of fertile pollen grains as shown by aceto-carmine test averages from 88-96 per cent. as against 92 per cent. of the diploids and confirms this.

Though the flowering in the 4 *n* population begins at about the same time as that of the normal plants, the duration of the flowering period is prolonged by nearly a month after it has ceased in the normals. The flowers are about 1·5 times larger than those of the diploids (Pl. II, Fig. 6) and all the floral parts show increase in size, this being most marked in the corolla (124 per cent.) and ovary (53 per cent.). The number of stamens does not increase but fasciation of filaments into bundles of 2–8 is noticed in all the flowers (Fig. 8) and at least 2 such bundles are a feature of every flower. The rest of the stamens are free. The pollen grains are, as compared to those of the diploids, large and slightly more roundish. The dimensions are given below:—

	Length (μ)	Breadth (μ)
4 *n*	48·59	43·03
2 *n*	36·85	32·21

In cross-sections from corresponding regions of plants with equal basal diameter and at similar stage of maturity, the differences in the total number of fibre bundles in the first layer adjacent to the cambium and the shape of the fibre bearing wedge indicate the differences in the yield of the plant with some degree of accuracy. The ratio between the number of bundles in the first layer and the average number of bundles in the wedge, called the wedge ratio, is also a measure of the fibre content (1955). Larger number of bundles in the first layer, broader wedges and higher wedge ratios are associated with greater fibre content. The number of bundles in the first layer of tetraploids ranges between 480 and 543, the average number of bundles at the base of the wedge is 6·63 and the wedge ratio is 5·46. The corresponding values for control are 846–897, 9·20 and 4·66. The average number of bundles in the wedge in 4 *n* is 39·67 and in normal 42·90. Though the length of the wedge decreases by about 12 per cent. (Pl. II Figs. 10 and 11) the number of fibre layers increases. In spite of the increase in the wedge ratio and the number of fibre layers, as the number of bundles in the lowermost layer is less and the wedges are narrower, the average number of bundles (in the entire cross-section) in tetraploids (2793) is lower than in controls (4062) of similar base diameter.



TEXT-FIG. 1. Diagrammatic representation of the average number of fibre bundles in the corresponding fibre layers of the wedge of diploid (right) and tetraploid (left). Note the large number of fibre layers in the tetraploid and larger number of fibre bundles in the diploid.

Significant differences were not noticed in the number of bundles in the wedge or in the number of ultimate fibres in the bundle which is 20·52 in 4 *n* and 20·44 in 2 *n* plants. However, the tetraploids showed increase in the length, breadth and size of the lumen of ultimate fibres but the thickness of the wall did not increase as shown below:—

	4 *n* (μ)	2 *n* (μ)
Length* ..	2121·81	1609·25
Breadth* ..	22·63	17·56
Lumen* .	10·86	6·38
Thickness of wall†	5·92	5·59

* P = 0·01; † P = large.

The figures given above are averages of 250 readings. On statistical analysis, except the thickness of wall all the others are significantly different at one per cent. level.

Rao *et al.* (1944–45) have already pointed out that increase in the size of the tetraploids of *C. capsularis* was due, in almost all cases, to the increase in size of the individual cells rather than their number. The data on the fibre bearing portions (Text-Fig. 1) show that the height of the fibre wedge decreased though the number of bundles in the wedge and the number of ultimate fibres in the bundle remained fairly constant. But as the average total number of wedges in the transverse section is

$$\frac{\text{Average number of bundles in the first layer}}{\text{Average number of bundles in the first layer of the wedge}}$$

it is seen that the gross fibre content has greatly decreased in the tetraploids.

Yield studies.—The yield of fibre from the tetraploids was not studied in the C_1 and C_2 generations as the population was inadequate in both the years. Sufficient seed was, however, obtained in some of the selections of the C_2 generation and in 1952, 5 progenies from two elites, 5051 and 5053 and 10 progenies from 5092 were tried out in a family block trial in 6 replications along with the diploid parent C.G. and an improved strain of *C. olitorius*, JRO-632. The 10 selections of the elite 5092 were treated as two families of 5 progenies each; thus 6 families including two controls, C.G. and JRO-632, were tried out. The results summarised below give the number of plants emerging, plants harvested, fibre yield and other details.

TABLE III

Results of the tetraploid yield trial 1952

Family	No. of seeds sown	No. emerged	% of germination	No. of plants harvested	% of plants harvested against seeds germinated	Fibre yield (gm.)	Fibre yield per plant (gm.)
JRO-632	3120	1907	61·12	1458	76·46	21049	14·43
C.G.	3120	1390	44·55	1116	80·29	13828	12·39
5051	3120	1144	36·67	810	70·80	10346	12·76
5092(2)	3120	1068	34·23	683	63·95	7383	10·81
5053	3120	990	31·73	662	66·87	7335	11·08
5092(1)	3120	1058	33·91	731	69·09	7176	9·81
C.D.		464·88		384·73		3104·53	
P		0·01		0·01		0·01	

(Seeds sown in two rows per plot at the rate of 2 seeds per point, points 6″ apart in rows 13′ long and 1′ apart. Number of replications—6.)

In 1953, when the tetraploids were in the C_4 generation, 15 progenies of the elite 5051 which performed best among the tetraploid lines during the previous year and 5 progenies of each of 5053, 5092 and 5095 were again tried out in a family block trial consisting of 6 tetraploid families and 2 controls. The results are summarised below.

TABLE IV

Family	No. of seeds	No. emerged	% of germination	No. of plants harvested	% of plants harvested against seeds germinated	Fibre yield (gm.)	Fibre yield per plant (gm.)
JRO-632	2880	1107	38·44	753	68·02	14444	19·18
C.G.	2880	959	33·30	658	68·61	10591	16·10
5095	2880	830	28·82	499	60·12	6339	12·70
5051(1)	2880	707	24·55	443	62·66	6239	14·08
5051(2)	2880	776	26·94	479	61·73	6206	12·96
5051(3)	2880	734	25·45	412	56·13	5941	14·42
5092	2880	761	26·42	450	59·13	4564	10·14
5053	2880	722	25·07	409	56·65	4471	10·93
C.D.		220·38		164·03		2189·88	
P		0·01		0·01		0·01	

(Seeds sown in one row per plot, at the rate of 2 seeds per point, points 4″ apart in rows 16′ long and 1′ apart. Number of replications—6.)

In laboratory tests, all the viable seeds of C.G., which recorded a germination percentage of 99·70, germinated at the end of the first day. In tetraploids, however, the germination was slower, 58·49 per cent. of the seeds germinated at the end of the first day, 31·29 per cent. at the end of the second day, 7·16 per cent. at the end of the third day and the balance of 3·06 per cent. failed to germinate. Though the difference in the percentage of germination of normal and tetraploid seeds is not considerable, the results of field tests show that the slow germination of tetraploid seeds affects normal emergence under field conditions. The yield per plant in the case of tetraploids is also lower. The yield in all the tetraploid families was significantly below that of the two diploid controls during both the years. In spite of the low population and the resulting increase in the available space, the 4*n* plants failed to attain significantly greater height or basal diameter. The average height and basal diameter of 4*n* are 107·56 inches and 1·48 cm. and those of the diploid parent C.G. are 124·28 inches and 1·52 cm.

The yield of fibre in jute bears a direct and positive correlation with the height and the basal diameter of the plant, the coefficient of correlation for yield with height being 0·761 and that with basal diameter being 0·914 (Ghose and Patel, 1945). In the C_4 generation single plants were collected for studies on the fibre content of the plants and the correlation of fibre yield with height and basal diameter (B.D.) was worked out. The results are given below:—

Elite	*r* (Yield and height)	*r* (Yield and B.D.)	Fibre percentage (Fibre weight/ green weight)
5051	0·6993	0·8095	6·428
5053	0·7354	0·8758	5·643
5092	0·5176	0·8353	5·377
5095	0·7330	0·8045	5·866
C.G.	0·6952	0·8884	5·415

The basal diameter which in normal diploids has higher correlation with yield, gave in most cases lower correlations in the tetraploid lines. Though higher values for correlation of height with the fibre yield have been obtained in three of the elites, the combined effect of slight increase of one and marked reduction of the other results in lower out-turn of fibre as the average height of the tetraploids is significantly lower. These factors when considered along with the reduced germination under field conditions tend to point to the fact that the cultivation of tetraploids for fibre is uneconomical. But the high fibre-content of elite 5051 shows, however, that tetraploidy may not be altogether detrimental in *C. olitorius.*

The pods of the 4*n* plants are short and thick and are 3·45 cm. in length and 0·58 cm. in thickness as compared to 5·09 and 0·51 cm. of the normal pods (Pl. II, Figs. 7 and 8). In spite of the high fertility of pollen grains, the number of healthy seeds in the capsules of raw tetraploids is very low. Bhaduri and Chakrovarti (1948) observed that in *C. capsularis* tetraploids the average number of seeds ranged from 0–4 in each capsule in the earlier generations and by judicious selection the number could be increased to 5–20. Improvement in fertility was effected in the present case by (*a*) selecting within the elite, plants with largest number of pods and (*b*) by using pods with the highest number of seeds (healthy and floaters included) for propagating the elite in successive years. By this method the number of healthy seeds per pod was increased by over 300 per cent. A slight fall in the number of seeds was, however, recorded in 1954.

TABLE V

Average number of good and bad seeds in the pods

Elite	1950		1952		1953		1954	
	Good	Bad	Good	Bad	Good	Bad	Good	Bad
5051	13·30	0·00	36·49	5·48	43·55	8·60	35·03	4·17
5053	14·71	16·14	36·33	7·92	36·65	10·40	42·64	7·00
5092	24·84	14·83	37·81	8·36	42·65	8·50	38·53	4·18
5095	14·70	7·00	40·64	6·48	51·60	9·11	43·25	4·10
C.G.	157·58	3·48	155·45	4·38	171·43	6·32	162·83	5·84

The good seeds are large (Pl. II, Fig. 9) and weigh about 330 seeds whereas normal seeds of C.G. weigh about 500 per gram. The colour and shape are not much different from those of the normal though the leek-green colour in the case of the tetraploids tends to be slightly more greenish. The bad seeds are shrunk, light in weight and have an unhealthy appearance. A number of them (floaters) were dissected and it was observed that they were invariably empty though the size attained by them was only slightly below that of the healthy seeds.

Beginning from the year 1951 when tetraploid plants of both *C. olitorius* and *C. capsularis* were available in sufficient numbers, about 30 crosses were made each year between them but viable seeds were not obtained. In a large proportion of crosses attempted, the pollinated flowers dropped off within 24 hours and many of the rest before 72 hours. The results, thus, were even more disappointing than the crosses between the diploids of the two species attempted each year, where development of pollinated flowers into fruits is obtained in about 5 per cent. of the cases, though the seeds resulting from such crosses are 'floaters' and invariably fail to germinate. The small proportion of pods that develop from crosses between the tetraploids of the two species have an unusually thick pericarp; about a dozen seeds obtained during these 3 years were shrunk and had an unhealthy appearance and failed to germinate on sowing. It appears that the two species have to be hybridised by methods other than the ones so far practised.

DISCUSSION

Though autopolyploids of a number of crop plants have been produced and studied, very few bast fibre plants except flax have received detailed attention in this respect. Tetraploids have been produced in flax (Levan, 1942, 1948; Masima, 1942, etc.), *Hibiscus cannabinus* (Badenhuizen, 1941; Toxopeus, 1948, etc.), *H. sabdariffa* (Toxopeus, 1948), *Cannabis sativa* (Nishiyama, 1941) and jute but in most cases except flax studies have been restricted to the morphological and not economically important variations. Badenhuizen (1941) treated *H. cannabinus* with colchicine and observed that the 4 *n* plants were less branched though they showed, besides other variations, giganticism of stomata, epicalyx, petals, and seeds. The differences in the rate of growth of 2 *n* and 4 *n* plants were not very marked but he expected that the tetraploids would combine higher yield with greater resistance to diseases. Reduction in the number of branches on the increase of the number of genomes has also been observed in flax by Levan (1942) who found that the branches were also shorter. Ramanujam and Parthasarathy (1953) quoted the unpublished records of the Indian Agricultural Research Institute and stated that instances of increased branching and branches of a higher order than the diploid are not infrequent in some flax types. In the present instance, the autotetraploids of *C. olitorius* are more branched than the diploids.

Levan (1942) also observed that slight increases in height were noticeable in the tetraploids of linseed types but in the case of flax types reduction in the height was more frequent. This was stated to be due to the selection in the fibre flax of genes for tallness which exhausted the possibilities of desirable variations in that direction whereas in linseed types which were bred for seed irrespective of height, the reserve stock of genes for tallness showed up on multiplication of genomes (Kuckuk and Levan, 1951). The straw weight of the tetraploids of flax was only 53·3 per cent. of the diploid. A similar state of affairs exists in the case of tetraploids of cultivated *olitorius* where intensive selection for height and fibre yield has been practised for a number of years and doubling of chromosomes results in lowering of both height and yield.

Toxopeus (1948) obtained tetraploids of *Hibiscus cannabinus* and noticed that they were more vigorously growing and had enlarged diameter of ultimate fibres and other elements of bark and wood. It is rather unfortunate that all his plants were sterile and their yield could not be studied in the C_2 and subsequent generations when larger population is usually available.

The vigour in the early stages of growth of 4 *n* *C. olitorius* is only slightly below that of normal plants though the broad leaves of tetraploids present a healthy appearance to the plants till they get attacked by 'scalding'—an unidentified disease.

The chimæral nature of a large proportion of the C_1 plants has been reported by several workers in a number of crops. Ramanujam and Joshi (1941) treated seeds of *Cicer arietinum* and obtained periclinal chimæras. Baker (1943) treated dry seeds of potato—a natural tetraploid—and obtained periclinal chimæras with 8 *n* epidermis and 4 *n* core but in the first tuber generation these revealed only normal potato plants with 4 *n* tissues. Bhaduri *et al.* (1948) stated that in *C. olitorius* periclinal chimæras as evidenced by plants with 2 *n* and 4 *n* branches were occasionally found among the treated plants. But, it is not clear how these chimæras were obtained as they treated both seeds and seedlings and obtained tetraploids. The present authors observed that seeds from separate pods collected from different branches of C_1 plants gave progenies which were either diploid or tetraploid. The progenies of the seeds of any single pod were only of one type. The mixture of pods obtained even in the same branch shows that the chimæras were mericlinal or periclinal resulting in tetraploid fruits from the affected regions. Adequate proof of sectorial chimæras could not be obtained during the present studies.

Pods in the C_1 generation were collected from plants showing a degree of morphological variation definitely distinct from the normal plants and though pods from 21 such plants were grown in the C_2, only four plants gave tetraploid progenies. Even of these four, only a single plant was a pure tetraploid. Thus most of the plants of the C_1 showing variations appear to be affected only superficially and heritable variations are few and rare.

The tetraploid seeds of *C. olitorius* germinate more slowly and this lack of quick response to moisture leads to reduced germination under field conditions. Similar observations have been made by Noguti, Oka and Otuka (1940) in *Nicotiana*, Newcomer (1941) in cabbage and Levan (1948) in red clover. The moisture content in jute fields at the time of sowing is often inadequate and capacity for quick germination is a highly desirable character in jute. Normal *C. olitorius* jute seeds retain viability for about 3 weeks under conditions of insufficient moisture and germinate in 2 or even 3 instalments. Tetraploids, on the other hand, germinate in a single instalment and in the event of drought the rest of the seeds perish. So far as survival during the period of growth is concerned, though a large proportion of plants reach the harvest stage in both the types, the percentage of survival in the tetraploid was less. It would, anyhow, be too early to draw definite conclusions about the ability of tetraploids to grow normally as they have not been found to be more susceptible to diseases.

Studies conducted at the Institute show that in normal plants, upto a certain limit, the yield of individual plants increases with increase in spacing between them (1945). The yield in the tetraploid families was significantly lower, though, during both the years, the average space available to the $4n$ plants was 59·25 per cent. more than that available to the diploid C.G. as the population in the $4n$ families was only 62·80 per cent. of the C.G. families. Even in the best tetraploid family 5051, the average single plant yield was less than that of C.G.

The observation that the ultimate fibres increased both in length and thickness, the latter mainly due to increased breadth of the lumen than the thickness of the wall, corroborates the studies of Rao *et al.* (1944–45) in *C. capsularis* and the general observation that the increase in the case of polyploids is in the size rather than the number of individual cells. Bhaduri and Chakrovarti (1948) stated that the total volume of fibre as compared to the diameter of the stem increases and felt that it would be better to find out if this leads to increase in the yield of fibre. From the anatomical evidence it is difficult to conclude that the volume of fibre increases as it is seen that the fibre bearing wedges are distinctly narrower and the gross fibre content of tetraploids decreased by about 40 per cent. as compared to diploids of equal base diameter. The fewer and narrower fibre bearing wedges, smaller number of fibre bundles in the lowermost bast layer and the increased volume of individual cells with wider lumens have cumulative effect in reducing fibre yield.

Though increase in size is noticed in the leaf, floral parts, seed, etc. the fruit in tetraploid *C. olitorius* is smaller. The diameter of the pod increases but the length decreases even more resulting in a reduction in the total volume of the fruit. This is in contrast to the observations made by Rao *et al.* (1944-45) in *C. capsularis*, Uchikawa (1947) in *Cucurbita*, Hartman (1950) in *Cucumis melo* var. *flexuosa*, Derman (1954) in grapes and others who noticed that increase in the number of chromosomes leads to fruits of larger size. Batra (1952), however, obtained fruits of smaller size in tetraploids of musk melon.

It has already been pointed out that meiotic irregularities are few and the fertility of pollen is sometimes even higher than that obtained in normal plants. The total number of ovules in the ovary is lower and so the total number of seeds including the 'floaters' was lower in the fruits of all the tetraploids. Similar observation was made by Schwanitz (1951) who found that in some of the crops he investigated, the number of ovules in the ovary is fewer in the polyploid state and this was correlated with low seed-set. The number of healthy seeds in tetraploid *C. olitorius* was increased by selecting in successive generations, plants with the largest number of pods and again by propagating each line by using seed from pods bearing the highest number of seeds including the 'floaters'. The success attained by this method is considered to be fair as the number of healthy seeds increased by a little over 300 per cent. and the number of 'floaters' showed a general downward trend thus showing that definite increase in the number of ovules in the ovary was obtained. Levan (1948) found that in raw tetraploids of seed flax the seed yield is only about 40 per cent. of that of the diploid but when selected for seed production the yield could be increased to about 60 per cent. and the best lines even equalled the diploid. Kuckuk and Levan (1951) stated that such improvement in seed yield was more marked in families exhibiting low fertility in the beginning. Müntzing (1951) isolated populations of tetraploid rye with nearly 85-90 per cent. of the yield of diploids by selecting within the tetraploid lines over about 9 years. Parthasarathy and Rajan (1953) worked with the tetraploids of *Brassica campestris* var. *toria* and by the 'mass pedigree method' of Harland (1949) increased the number of seeds per siliqua to almost the level of the diploid. In all these cases the greater weight of tetraploid seeds often tends to compensate the decrease in their number; thus the yield (weight) of seeds per plant is not markedly lower in grain crops. But in a bast fibre crop like jute what is more necessary is the increase in the number of viable seeds irrespective of the weight of individual seeds. In the case of

C. olitorius tetraploids the seed weight of healthy seeds did not increase in successive years. Though some increase in the number of healthy seeds was obtained, it must yet be admitted that the number of seeds in the fruits is very low and stands poor comparison with the normal diploid.

SUMMARY

Seeds of *C. olitorius*, variety C.G., were treated with 5 concentrations of colchicine ranging from 0·0125–0·150 for 5 different periods from 3 to 24 hours. The effective concentrations for induction of tetraploidy range from 0·0125–0·10 per cent. of colchicine and duration from 6 to 24 hours. Higher concentrations are more effective even when shorter periods of treatment are used.

Periclinal and mericlinal chimæras were obtained by the treatment but the progenies of each pod were found to be pure, either diploid or tetraploid.

The tetraploid seeds germinate more slowly and this character affected the germination under field conditions adversely. The leaves, stomata, floral parts, pollen grains and seeds are all larger in the tetraploid *olitorius*. The plants are shorter and more branched. The tetraploids flower along with the diploids but the period of flowering is prolonged by about a month. The filaments of some stamens are united into bundles of 2–8 though the anthers are free; each flower has at least two such staminal bundles.

In spite of occasional meiotic irregularities, the pairing of chromosomes is normal and the fertility of pollen is satisfactory.

The number of fibre bundles in the first layer adjacent to the cambium and the number of bundles in the fibre wedge decrease though the reduction in the latter is only slight. The length of the fibre bearing wedge also decreases but the number of fibre layers in the wedge increases. The ultimate fibres are longer and thicker though the increase in thickness is due to larger lumen than thicker wall. The volume of fibre shows a slight reduction.

The yield of fibre in all the tetraploid families is significantly lower than that of the diploids.

The pods of tetraploids are smaller in size and the number of ovules in the pods is low. By selecting plants with the largest number of pods and pods with the highest number of seeds, including bad seeds, about 300 per cent. increase in the number of seeds per pod was obtained in about 3–4 years.

ACKNOWLEDGEMENT

The authors express their thanks to Mr. B. Das Gupta, Botanist of this Institute, for help in planning the yield trials. Thanks are also due to Mr. S. K. Mahalanabis, for helping in field studies.

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EXPLANATION OF PLATES

PLATE II

FIG. 1. Metaphase I of tetraploid showing 2 IV, 1 III, 7 II and 1 I. Two other univalents are out of focus, × 900.

FIG. 2. Restitution nucleus, × 900.

FIG. 3. Metaphase I of tetraploid showing 2 IV, 1 III, 6 II and 3 I. Two other univalents are slightly out of focus and are just visible lower left of tetravalent ring, × 2,100.

FIG. 4. Hexad. Five spores are seen within and one outside which has come out through a puncture in the wall of the mother cell, × 640.

FIG. 5. Fasciation of filaments: the anthers are usually free. See text for explanation, × 10.

FIG. 6. Flowers of (*a*) tetraploid and (*b*) diploid, × 1/3.

FIG. 7. Capsules of diploid, × 2/5.

FIG. 8. Capsules of tetraploid, × 2/5.

FIG. 9. Seeds of diploid and tetraploid, × ½.

FIG. 10. T.S. of stem of diploid showing fibre wedges, × 10.

FIG. 11. T.S. of stem of tetraploid showing fibre wedges. × 10. Note that the wood is thicker in tetraploid.

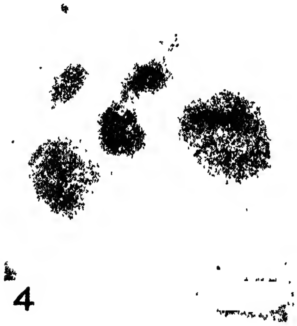
PLATE III

FIGS. 1 and 2. Top portions of tetraploid and diploid plants. Note the wider leaves in the tetraploid.


1


2


3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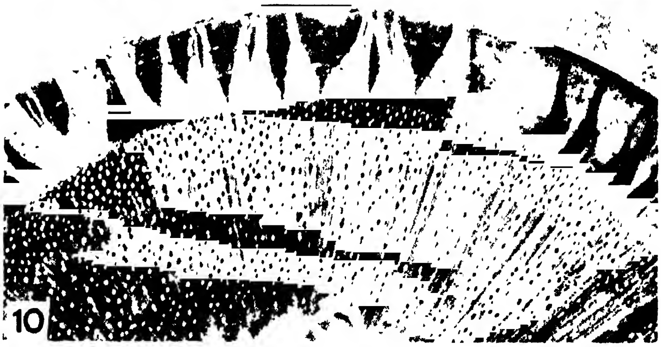
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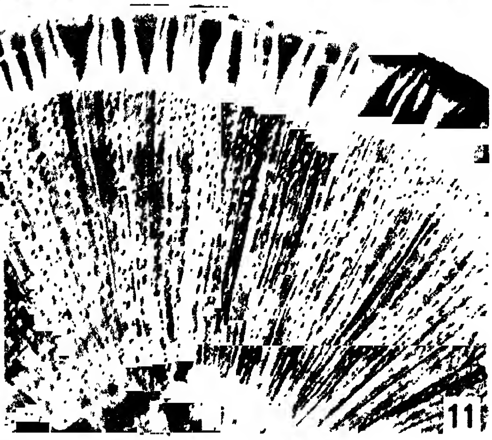
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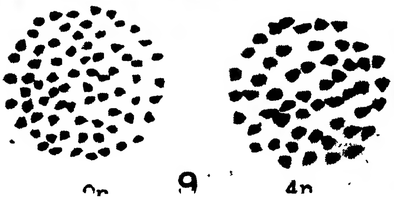
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C. Kundu and M. S. Sarma

SOME SLIME-MOULDS FROM SOUTHERN INDIA—IV

By V. Agnihothrudu

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13. *Didymium crustaceum* Fries in *Syst. Myc.*, 3: 1829, p. 124; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 118-119; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, p. 121.

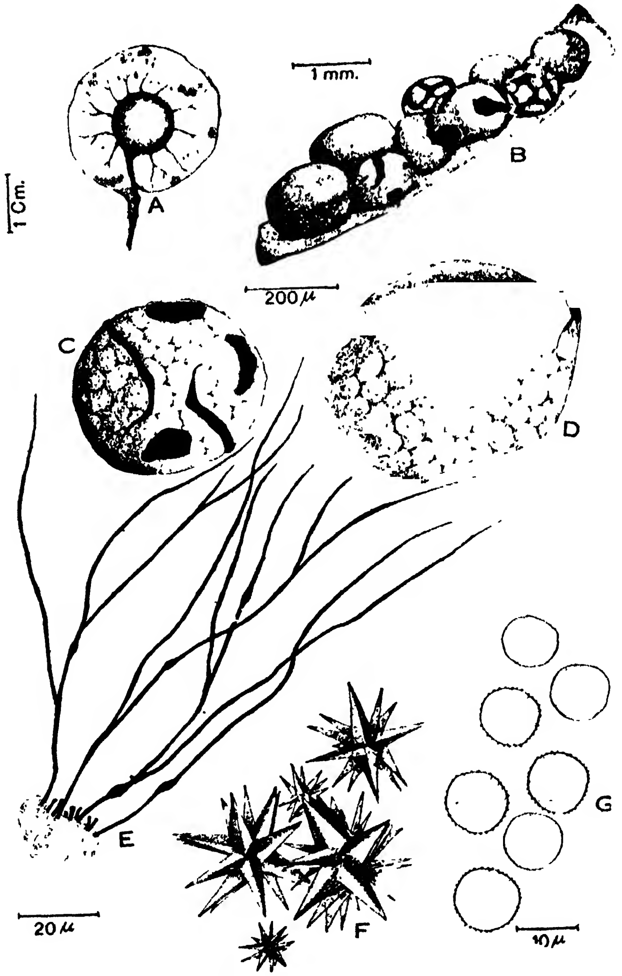

Fig. 1. *Didymium crustaceum* Fries.—A. Sporangia on a fruit of *Pterocarpus marsupium*. B. Gregarious sporangia on a decomposing twig. C and D. Indi-

vidual sporangia showing the scaly nature of peridium and the method of dehiscence. E. Capillitial threads showing fusiform enlargements. F. Calcareous crystals in the peridium. G. Spores.

Plasmodium not observed. Sporangia closely aggregate, often confluent, rarely separate, spherical or subglobose, not infrequently deformed by mutual compression. In all the collections examined the sporangia were sessile, measuring 0·5–2 mm. in diameter, smooth snow-white. Peridium well developed, crustaceous, composed of loosely compacted lime crystals, extremely frail and fugacious and falling off in flakes exposing the spore mass. When the crust has fallen off the sporangia appear hemispherical and ashen grey. Hypothallus scanty and evanescent, concealed under the sporangia, evident only after the spore dispersal. Capillitium consisting of stout pale violaceous threads, scantily branched, 0·5–1·0 μ in diameter, often with fusiform enlargements. Columella absent. Spores violaceous brown, globose to spherical measuring on average 11·8 μ, range 9·6–12·8, mostly 12·2 μ.

On dead twigs and fruits of *Pterocarpus marsupium* Roxb. Agri-Horticultural Gardens, Madras, 8–8-1954 (Herb. M.U.B.L. No. 1220). On dead twigs of *Nyctanthes arbor-tristis* L., Ayanavaram, Madras, 10–8-1954 (Herb. M.U.B.L. No. 1221); On dried leaves of *Antigonon leptopus* Hk. and A., Soundarya Nursery, Madras, 10–9–1954 (Herb. M.U.B.L. No. 1222); On decomposing leaves of *Porana volubilis* Burm., Perambur, Madras, 16-9–1954 (Herb. M.U.B.L. No. 1223). All the collections were made by V. Agnihothrudu.

14. *Didymium clavus* (Alb. and Schw.) Rabenhorst, in *Deutsch. Krypt. Fl.*, i, 1884, p. 280; as *Didymium commutabile* Berk. and Br. *J. Linn. Soc.*, **14**: 1873, p. 83; as *D. masseeanum* Sacc. and Syd., in *Syll. Fung.*, **14**: 1899, p. 836; as *D. clavus* (Berk. and Schw.) Rost. Schinz, in *Rabenhorst's Kryptogamen Flora*, Abt. X, p. 210; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 122; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, p. 114; Petch, *Ann. R. bot. Gdns., Peradeniya*, **4**: 1909, p. 348; Brühl and Sen Gupta, *J. Dep. Sci. Calcutta Univ.*, 1927, p. 116.

Plasmodium not observed. Sporangia gregarious, scattered, discoid, orbicular or pileate, stipitate, snow-white to ashen-grey in colour and at times mottled. Total height of the fructification 0·5–1 mm., sporangium proper measuring 0·5–1 mm. in diameter and about 0·2 mm. thick with thin peridium encrusted with calcareous crystals. In some cases the sporangium is naked below. Stalk cylindrical, solid, longitudinally furrowed, dark brown to almost black in colour with a well-developed hypothallus. Stipes are broad below, tapering towards the sporangial end. In some collections, the stipe was seen to narrow down so abruptly that the discoid sporangium is almost nodding. Columella absent. Capillitium well developed, consisting of pale purple threads spraringly branched. Spore mass fuliginous, spores individually violaceo-fuscous, almost smooth, measuring on average 7·6 μ, range 6·4–8·4 μ and mostly 8·0 μ.

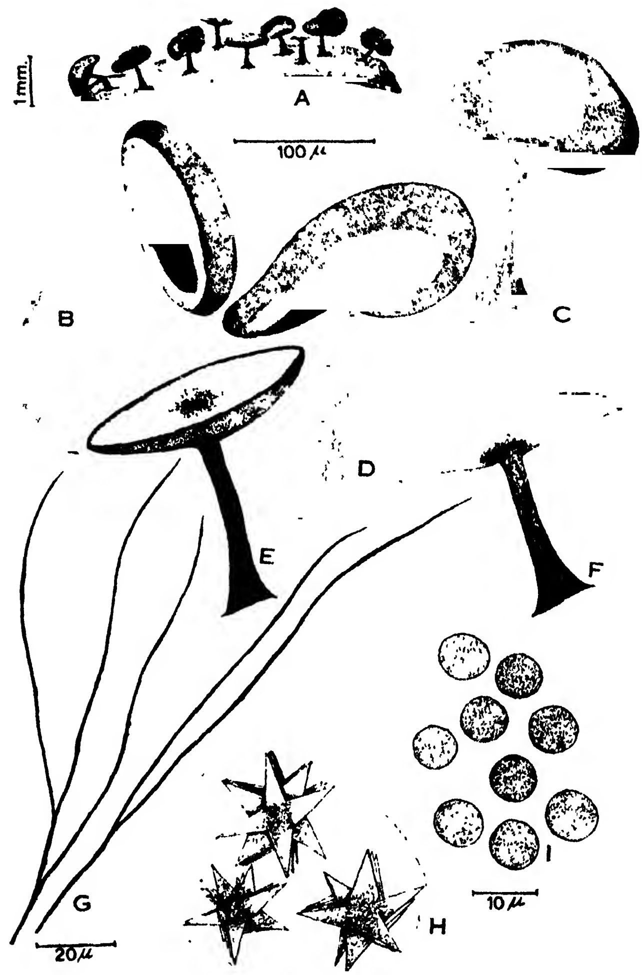

FIG. 2. *Didymium clavus* (Alb. and Schw.) Rab.—A. Sporangial aggregation on a twig. B, C, D and E. Showing sporangia of different shapes, the stipe and the hypothallus. F. A dehisced sporangium showing the unbroken sporangial base and the spore mass. G. Capillitial threads. H. Stellate crystals of the peridium. I. Spores.

On twigs of *Ocimum canum* Sims., University Botany Field Laboratory campus, 15–8–1954 (Herb. M.U.B.L. No. 1224); On dead leaves of *Terminalia paniculata* Roth., Agri-Horticultural Gardens, Madras, 15–8–1954 (Herb. M.U.B.L. No. 1225); on dried leaves of *Antigonon leptopus* Hk. & A., Marina, Madras, 18–10–1954 (Herb. M.U.B.L. No. 1226); on twigs of *Malvastrum* sp. Kilpauk, Madras, 15–10–1954 (Herb. M.U.B.L. No. 1227); on decomposing twigs of *Croton sparsiflorus* Morung., Villivakkam, Madras, 18–8–1954 (Herb. M.U.B.L. No. 1228). On dead twigs of *Peltophorum ferrugineum* Benth., Queen Mary's College campus, Madras, 12–9–1954 (Herb.

M.U.B.L. No. 1229); on leaves of *Porana volubilis* Burm., Kodambakkam, Madras, 20–9–1954 (Herb. M.U.B.L. No. 1230). All the collections were made by V. Agnihothrudu.

15. *Didymium squamulosum* Fries in *Symbolæ Gasteromycorum*, 1818, p. 19; as *Didymium effusum* Link, Lister, *Mycetozoa*, 1894, p. 99; as *Didymium squamulosum* (Alb. and Schw.) Fries, Macbride, *The North American Slime-Moulds*, New ed., 1922, pp. 119–121; Lister, *A. Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 117–18.

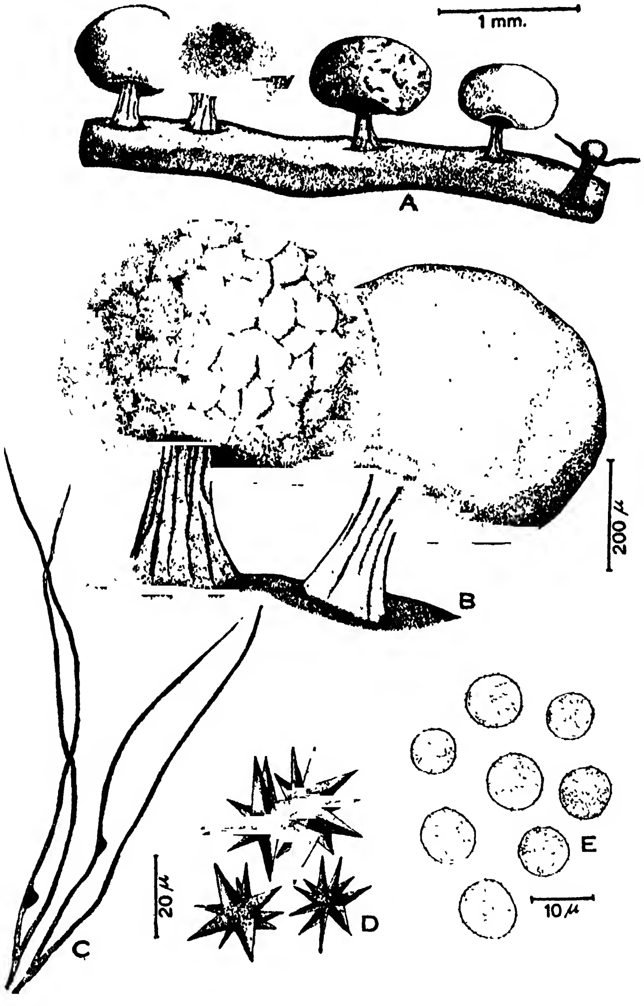

FIG. 3. *Didymium squamulosum* Fries.—A. Twig with sporangia. Well-developed columella is seen in the dehisced sporangium. B. Sporangia showing scaly and smooth peridial walls and a well-developed longitudinally striate stipe. C. Caplllitial threads with irregular thickenings. D. Stellate crystals in the peridium. E. Spores.

Plasmodium not observed. Sporangia gregarious, typically globose or depressed-globose to sub-hemispherical, umbilicate, 0·4–1·2 mm. in diameter, snow-white to pale grey in colour, stipitate. Sessile forms were not observed. Peridium smooth, white or mottled, thin membranous impregnated with abundant stellate calcareous crystals, breaking away in the form of scales. Stipe short, stout, varying in length from 200–500 μ and up to 250 μ broad with an incipiently developed hypothallus, white or pale yellow grey, deeply furrowed with deposits of small calcareous crystals. The peridium breaks up and after spore dispersal the prominent white hemispherical to subglobose columella is distinctly visible. Capillitium well developed, composed of coarse, sparingly branched threads, purplish brown, hyaline at the ends with irregular thickenings at the base. Spores appearing deep violaceous brown *en masse*, individually pale violaceous, spherical, distinctly verrucose, measuring on average, 10·1 μ, range, 7·8–10 μ, mostly 10 μ in diameter. Only one collection was made.

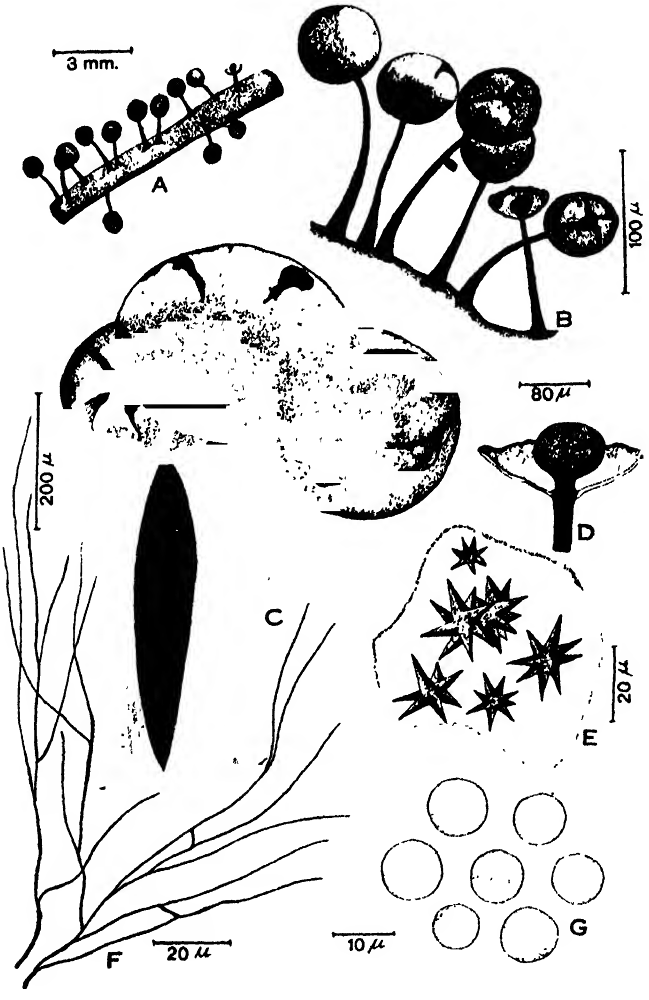

FIG. 4. *Didymium nigripes* (Link.) Fries.—A. Sporangial aggregate on a twig of *Pterocarpus marsupium*. B and C. Sporangia showing the long stipe and radiate dehiscence. D. Columella. E. Stellate calcareous crystals in the peridium. F. Capillitial threads. G. Spores.

On dead unidentified twigs, Mylapore, Madras, 29–9–1954, coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1231).

16. *Didymium nigripes* (Link) Fries in *Syst. Myc.*, III, 1829, p. 119; Saccardo, *Syll. Fung.*, **7:** 1888, p. 382; as *Didymium microcarpon* Fries, Petch, *Ann. R. bot. Gdns., Peradeniya*, **4:** 1909, p. 348; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 123; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, p. 116; Lodhi, *Publ. Univ. Punjab*, 1934, p. 13.

Plasmodium not observed. Sporangia gregarious, globose, subumbilicate, stipitate, measuring 0·75–1·5 mm. in total height. Sporangium proper measuring 0·5–0·75 mm. in diameter. Sporangial wall membranous, white to pale greyish brown in colour, profusely charged with stellate calcareous crystals, dehiscing laciniately or in some collections radiately, exposing the spore mass. Stalk long, measuring up to 1 mm., cylindrical, straight or slightly bent, longitudinally striate, broader at the base with a scutate hypothallus, slightly tapering towards the sporangial end, olive brown above, deep brown or ochraceous at the hypothallic end due to enclosed refuse matter. Sporangium lodges a distinct spherical to subspherical columella dark brown in colour and impregnated with irregular angular lime crystals. Capillitium well developed, consisting of purplish brown threads, sparingly branched. Spores fuscous brown *en masse*, individually pale violaceous brown, smooth, measuring on average 9·8 μ, range 8·0–10·8 μ, mostly 10 μ in diameter.

On dead twigs of *Pterocarpus marsupium* L., Agri-Horticultural Gardens, Madras, 22–8–1954 (Herb. M.U.B.L. No. 1232); on unidentified decomposing leaves, Ayanavaram, Madras, 26–8–1954 (Herb. M.U.B.L. No. 1233). All the collections were made by V. Agnihothrudu.

17. *Didymium melanospermum* (Persoon) Macbride in *The North American Slime-Moulds*, 1899, p. 88; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 121; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 114–116.

Plasmodium not observed. Sporangia gregarious, globose or hemispherical or depressed, deeply umbilicate below, typically stipitate, measuring 0·4–1·25 mm. in total height, sporangium proper measuring 0·5–1·0 mm. in diameter. Peridium frosted with minute stellate crystals of lime, white to ashen grey in colour, breaking irregularly. Stalk terete, straight, stout, deep brown to dull black in colour smooth or slightly striate, measuring 0·4–0·8 mm. long, up to 200 μ thick, enclosing refuse matter with a well-developed hypothallus. Columella well developed evident after spore dispersal, hemispherical, umbilicate, rough enclosing nodules of lime. Capillitium well developed, stout, scantily furcate, pale purple brown in colour showing no thickenings.

Spores appearing dark brown to almost black in mass, deep purplish grey in transmitted light, spinulose spherical to subspherical, measuring on average 11·0 μ, range 9·6–11·8 μ, mostly 11·2 μ in diameter.

On dead twigs of *Tamarindus indica* L., Kilpauk, Madras, 8–9–1954 (Herb. M.U.B.L. No. 1234); on dead unidentified twigs, Elliots beach, Madras, 15–9–1954 (Herb. M.U.B.L. No. 1235). All collections were made by V. Agnihothrudu.

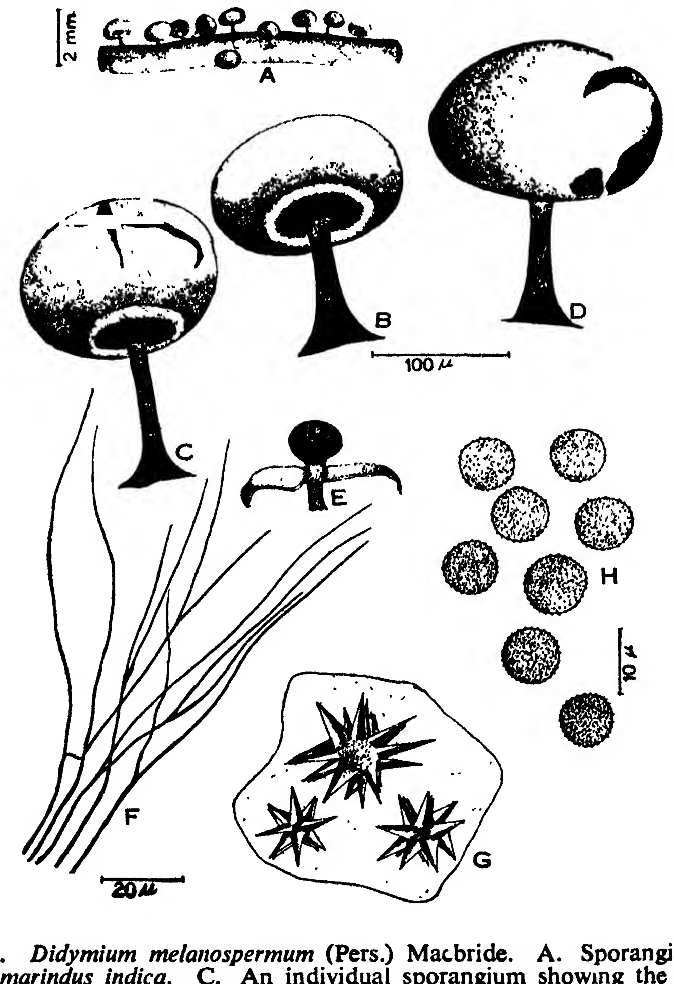

Fig. 5. *Didymium melanospermum* (Pers.) Macbride. A. Sporangia on dead twig of *Tamarindus indica*. C. An individual sporangium showing the umbilicate nature and the well-developed stipe with the hypothallus. D. Sporangium showing the flaky dehiscence. E. Comluella. F. Capillitial threads. G. Stellate crystals in the peridium. H. Spores.

18. *Perichæna vermicularis* Rostafinski in Appendix to *Sluzowce* (Mycetozoa) *Monografia*, 1876, p. 34; as *Ophiotheca vermicularis* Massee, Macbride in *The North American Slime-Moulds*, New ed., 1922, p. 240; as *P. variabilis* Rost., Lister, *Mycetozoa*,

1894, p. 199; Petch in *Ann. R. bot. Gdns., Peradeniya*, **4:** 1909, p. 370; as *P. vermicularis* Rost., Lister in *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 248–249.

Plasmodium not observed. Sporangia sessile, scattered, simple, globose to subglobose or subhemispherical somewhat narrow at the base, measuring up to 0·6 mm. in diameter. Plasmodiocarps simple, straight, or vermiform and rarely reticulate, ochre yellow or umber in colour. Peridium distinctly composed of two layers, an outer thicker layer granular in appearance enclosing small crystals of lime. This layer is closely attached to an inner thinner subcartilaginous transluscent papillose membrane. The outer thicker wall is not distinct in the upper aspect of the sporangium where usually the peridium dehisces exposing

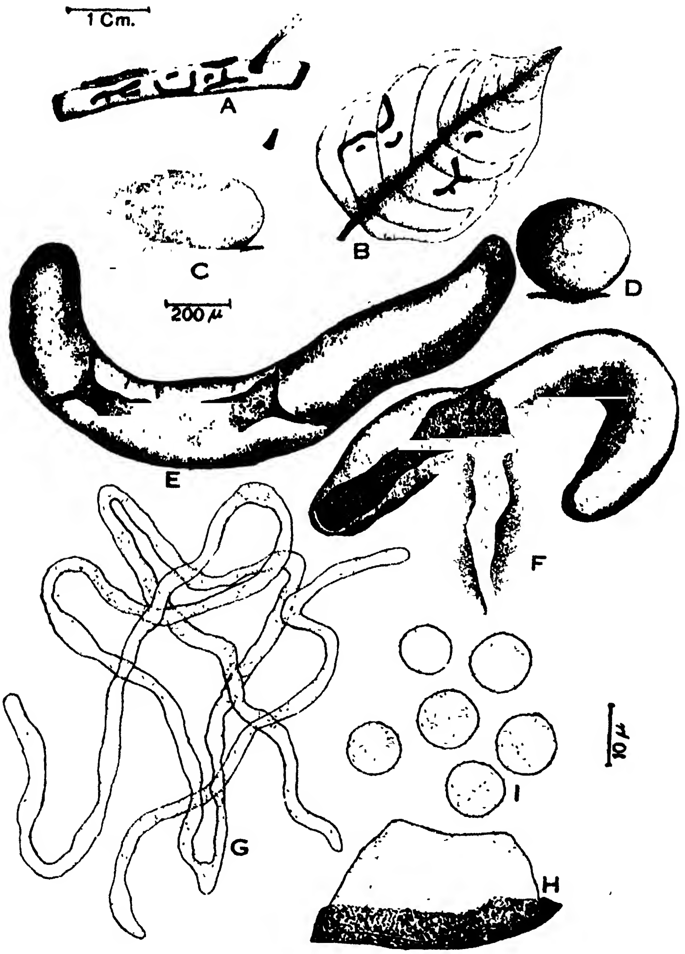

FIG. 6. *Perichæna vermicularis* Rost.—A. Plasmodiocarps on a twig. B. Plasmodiocarps on the leaf of *Bignonia unguis-cati*. C, D, E and F. Showing sporangia and plasmodiocarps of different shapes and the method of dehiscence. G. Capillitium. H. The double-layered peridium. I. Spores.

the capillitial threads with the enclosed spore mass. Capillitium is a profuse reticulum of scantily branched threads, yellow in colour, measuring up to 3·6 μ in diameter, constricted at irregular intervals with minute warts which give it a rough appearance. Spores typically citron yellow in mass, pale yellow to almost hyaline individually, minutely but distinctly warted, spherical to sub-spherical, measuring on average 12·2 μ, range 10·8–14·0 μ, mostly 12·8 μ in diameter.

On decomposing leaves of *Bignonia unguis-cati* L., Agri-horticultural Gardens, Madras, 15–10–1954 (Herb. M.U.B.L. No. 1247); on unidentified decomposing plant twigs, University Botany Laboratory campus, Madras, 18–10–1954 (Herb. M.U.B.L. No. 1248).

19. *Perichæna depressa* Libert *Pl. Crypt. Ard.*, Fasc., **4**: 1837, p. 338; Macbride, *The North American Slime-Moulds*, New ed., 1922, pp. 242–243; Petch in *Ann. R. bot. Gdns., Peradeniya*, **4**: 1909, p. 368; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 244–245; Saccardo, *Syll. Fung.*, **7**: 1888, p. 420.

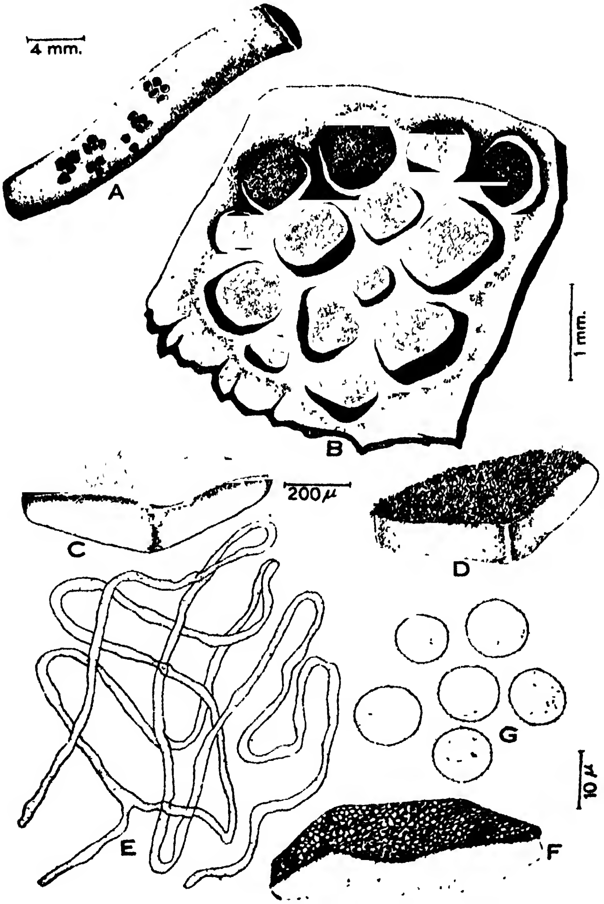

FIG. 7. *Perichæna depressa* Libert.—A. Sporangia on a twig. B. Sporangial aggregate on a leaf fragment. C. A single sporangium showing the deeply coloured operculum. D. Dehisced sporangium showing the capillitial threads. F. Double-layered peridium. G. Spores.

Plasmodium not observed. Sporangia typically sessile, flat, applanate, crowded, polygonal, up to 1 mm. in diameter. Sporangia were all simple and no plasmodiocarps were observed. Colour of the sporangium varying from deep fuscous brown or lilac to chestnut brown, upper part of the sporangium deeper in the hue than the bottom. Sporangium dehiscing by a well-defined operculum exposing the bright yellow spore mass with the capillitium lodged in the shallow spore-cases. Sporangial wall typically composed of two layers, an outer deeply coloured thick wall enclosing lime crystals closely adpressed to an inner smooth membranous transluscent layer. Capillitium a well-developed web of sparingly furcate and anastomosing yellow threads, measuring up to 3 μ in diameter with irregular thickenings. Spore pale yellow to almost hyaline in colour measuring on average, 10·8 μ, range 9·6–12·0 μ, mostly 11·2 μ in diameter.

Only one collection was made on decomposing vegetable débris. Avadi, 22–1–1955, Coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1249).

20. *Arcyria ferruginea* Sauter in *Flora*, **34**: 1841, p. 316; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 253; Petch, *Ann. R. bot. Gdns., Peradeniya*, **4**: 1909, p. 365; Schinz, *Rabenhorst's Kryptogamen flora*, Abt., X, p. 371, 1920. Saccardo, *Syll. Fung.*, **18**: 1906, p. 212; Brühl and Sen Gupta, *J. Dep. Sci. Calcutta Univ.*, **8**: 1927, p. 121. Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 229–230.

Plasmodium not observed. Sporangia gregarious, closely crowded, measuring 1–2·5 mm. in height. Sporangia typically stipitate, ovoid cylindrical up to 1·5 mm. long, orange red in colour fading into dull rose-red. Calyculus well developed, shallow infundibuliform, marked with reticulations on the inner aspect. Sporangial wall thin and evanescent, reticulate. Stalk cylindrical, up to 1 mm. long, 40–200 μ thick, pale red or almost white in colour with a basal membranous hypothallus. The stipe is filled with mass of spore-like cells. Capillitium a well-developed close reticulum of ornamented threads attached to the calyculus centrally. The capillitial threads are profusely branched, reddish yellow, measuring 4·8–6·4 μ in diameter at the base, diminishing to 1·6–3·2 μ diameter. The threads towards the base of the sporangium are triangular in cross-section with bars and close reticulations arranged in a loose and irregular spiral on one aspect with warts or broken reticulations on the other aspect. Some of the threads have free ends which are clavate and rounded. Spores pale rose coloured, spherical to globose, faintly warted, measuring on average, 9·6 μ, range 8·0–11·2 μ, mostly 10 μ in diameter.

Only one collection was made on decomposing twigs of *Bignonia unguis-cati* L. Agri-Horticultural Gardens, Madras, 24–10–1954. Coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1250).

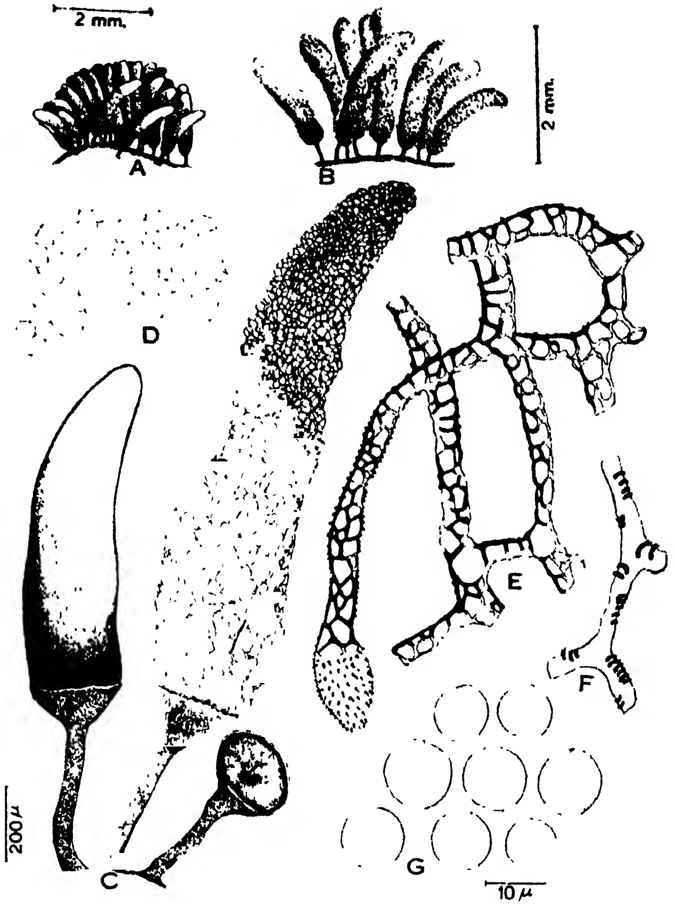

FIG. 8. *Arcyria ferruginea* Sauter.—A. Undehisced sporangial aggregate. B. Dehisced sporangia. C. Sporangia showing the well-developed stipe, calyculus and the capillitium. D. A fragment of the peridium. E. Capillitial threads at the base of the sporangium. F. Capillitial threads at the apex of the sporangium. G. Spores.

ACKNOWLEDGEMENTS

My thanks are due to Professor T. S. Sadasivan and Dr. C. V. Subramanian for their helpful suggestions in the preparation of this paper. My thanks are also due to Dr. K. Ramakrishnan for critically reading the manuscript and to the Government of India for the award of a senior scholarship.

FUNGI ISOLATED FROM RHIZOSPHERE

II. *Starkeyomyces*, A New Genus of the Tuberculariaceæ

By V. Agnihothrudu

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(Received for publication on October 29, 1955)

In the course of investigations on the rhizosphere microflora of pigeonpea [*Cajanus cajan* (Linn.) Millsp.] plants in relation to the wilt caused by *Fusarium udum* Butler, very frequently an interesting tuberculariaceous fungus was isolated from dilution plates and root platings of plants. The same fungus was isolated from the rhizosphere of many weeds growing in and around the city of Madras and soils collected from Mount Abu (Bombay), Ahmedabad (Gujerat-Bombay), Nilambur (Malabar-Madras), Guruvayyur (Malabar-Madras), Anamalais (Coimbatore-Madras), Vijayawada (Andhra) and Bangalore (Mysore). The following is the description of the fungus:—

The fungus in culture produces abundant aerial mycelium with sporodochia which are irregular or circular in outline, separate at first but coalescing later. The spore mass appears Brunswick green (24 A 12) or Tyrolian (32 A 12) or Balsam green (32 H 5). Colour characters are recorded with the help of Maerz and Paul's *A Dictionary of Color*, McGraw-Hill, N.Y. (1930). The numerical designations corresponding to different colours in the dictionary are included in parenthesis. The sporodochia are cupulate and superficial measuring 0·5–3·0 mm. in diameter and up to 100 μ tall. The sporodochia are not fringed by any setæ or sterile hairs. The conidiophores are irregularly ramose and the ultimate branches are closely aggregated to form a hymenial layer. The conidia are produced acrogenously and singly on the tips of conidiophores and are hyaline, continuous and smooth-walled. The spores are naviculiform or fusiform-elliptic, slightly apiculate at either end. The conidium is characterized by the presence of a thin membranous appendage which is developed on the free end. The appendage could be seen with some difficulty in unstained preparations but when stained with aqueous eosin or methylene blue or fast green it could be more clearly seen. Best results were obtained when spore smears were stained with Dorner's nigrosin in the same way as for bacterial negative mounts. The conidia are mostly $7{\cdot}2 \times 3{\cdot}4\,\mu$ ($3{\cdot}8 - 11{\cdot}8 \times 2{\cdot}0 - 4{\cdot}2$) average $7{\cdot}3 \times 3{\cdot}1\,\mu$; the appendage measuring $6{\cdot}4 \times 4{\cdot}8\,\mu$ ($3{\cdot}0 - 7{\cdot}2 \times 2{\cdot}0 - 6{\cdot}4$) average $6{\cdot}2 \times 4{\cdot}5\,\mu$.

The distinctive feature of the fungus is the membranous appendage of the conidium. The fungus bears some resemblance to *Koorchaloma madreeya* Subramanian (1953) in having the brush-like appendage of the spore, but differs from it in having no setæ in the sporodochium and in having irregularly ramose conidiophores. Therefore, a new

Table showing measurements of conidia, appendage and conidiophores of different isolates of Starkeyomyces

Herb M.U.B.L. No.	Conidium		Appendage		Conidiophore	
	Mostly (Range)	Average in μ	Mostly (Range)	Average in μ	Mostly (Range)	Average in μ
1390	7·2×3·4 (3·8–11·8×2·0–4·2)	7·3×3·1	6·4×4·8 (3·0–7·2×2·0–6·4)	6·2×4·5	7·2×2·4 (6·4– 9·6×2·0–3·2)	6·9×2·1
1391	7·8×3·2 (4·0–12·2×2·0–3·8)	7·6×3·1	7·2×6·4 (4·0–7·6×2·4–7·0)	6·9×5·9	9·6×2·8 (4·8–11·2×1·6–3·2)	9·2×2·5
1392	8·0×3·2 (4·0–12·0×1·6–4·0)	7·8×3·0	6·4×6·0 (2·8–8·0×2·0–7·0)	6·3×6·0	11·2×3·2 (7·2–14·0×1·6–3·6)	10·9×3·9
1393	8·1×3·4 (4·0–12·6×2·0–4·4)	7·8×3·2	7·2×6·8 (4·8–8·0×2·8–7·2)	6·8×6·4	8·0×3·2 (5·0– 9·6×2·0–3·2)	7·6×3·0
1394	7·8×4·0 (3·6–12·8×2·0–4·6)	7·6×3·8	5·6×4·8 (2·8–6·4×2·0–6·4)	5·3×4·6	9·6×2·8 (6·4–10·2×2·0–2·8)	9·5×2·6
1395	7·2×3·8 (3·4–12·0×2·0–4·8)	7·0×3·6	7·6×6·0 (3·2–8·0×1·6–6·4)	7·3×5·8	10·4×3·2 (5·2–11·0×1·6–3·2)	10·3×3·0
1396	8·0×4·0 (4·0–12·4×2·0–4·4)	7·8×3·8	6·0×5·6 (4·0–8·0×1·6–7·2)	5·8×5·3	8·0×2·8 (7·2– 9·6×2·0–3·2)	7·8×2·6
1397	8·4×4·0 (4·4–12·8×2·0–4·4)	8·1×3·9	6·8×6·8 (3·6–7·2×2·4–7·6)	6·5×6·3	10·8×3·2 (4·8–14·0×1·6–3·6)	10·5×3·1

genus is proposed to accommodate this fungus. The generic name is given in honour of Professor Dr. R. L. Starkey of the New Jersey Agricultural Experiment Station, Rutgers University, New Brunswick, New Jersey (U.S.A.), whose contributions to the rhizosphere microbiology are well known to soil microbiologists.

Starkeyomyces Agnihothrudu gen. nov.

Pertinet ad Fungos Imperfectos, ad Tuberculariaceas, Hyalosporas. Sporodochi lucide colorata, superficialia, integra. Conidiophori irregulariter ramosi, efformantes seriem hymenialem. Conidia hyalina, continua, acrogena, haud catenata, ornata appendice membranacea apicali. Species typica sequens.

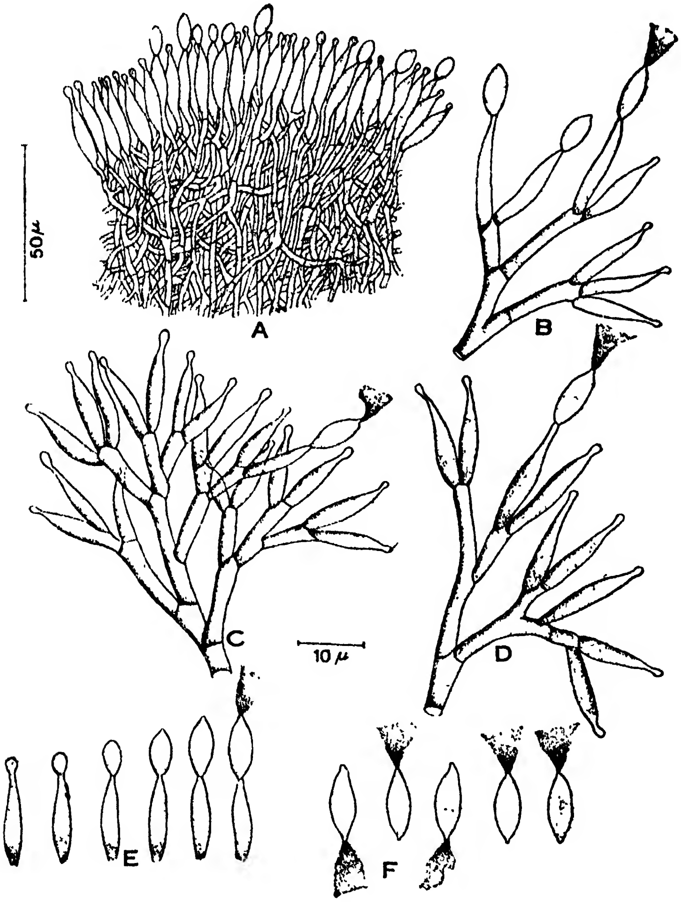

FIG. 1. *Starkeyomyces koorchalomoides* Agnihothrudu (Type, Herb. M.U.B.L. No. 1390). A. Section through a sporodochium. B, C and D. Irregularly branched conidiophores. E. Development of conidia. F. Mature conidia with appendage.

Starkeyomyces koorchalomoides Agnihothrudu sp. nov.—Sporodochia abundanter producta in mediis plurimis in laboratorio, alte viridia colore, separata vel coalescentia, superficialia, integra, circularia vel irregularia ambitu, usque ad 3 mm. diameter atque 100 μ alta. Mycelium sterile dense intertextum, producens irregulariter ramosos conidiophoros, quorum ultimi ramuli arcte juxtapositi efformant seriem hymenialem uniformem. Conidia hyalina, semel cellulata, acrogena, solitaria, haud catenata, navicularia vel fusiformi- elliptica tenuia atque levibus parietibus prædita, tenuiter apiculata in utroque apice, magnit. 7·2×3·4 μ (3·8–11·8×2·0–4·2), mediatate 7·3×3·1 μ, quorum singula appendice membranacea apicali prædita atque magnit. 6·4×4·8 μ (3·0–7·2×2·0–6·4) medietate 6·2×4·5 μ.

Typica cultura segregata e rhizosphæra *Cajani cajan* (Linn.) Millsp. in humo naturaliter infecto a *Fusario udo* Butler, in campo laboratorii botanici universitatis, in urbe Madras, a V. Agnihothrudu, die 4 aprilis 1953 et positus in M.U.B.L. sub-numero.

Starkeyomyces Agnihothrudu gen. nov.

Fungus imperfectus, Tuberculariaceæ, hyalosporæ. Sporodochia bright coloured, superficial, entire. Conidiophores irregularly ramose, forming a hymenial layer. Conidia hyaline, continuous, acrogenous, non-catenate, with an apical membranous appendage.

Starkeyomyces koorchalomoides Agnihothrudu sp. nov.—Sporodochia produced abundantly on many laboratory media, deep green in colour, separate or coalescing, superficial, entire circular or irregular in outline up to 3 mm. in diameter and 100 μ tall. Sterile mycelium thickly interwoven, producing irregularly ramose conidiophores the ultimate branches of which are closely juxtaposed to form a uniform hymenial layer. Conidia hyaline, one-celled, acrogenous, solitary, non-catenate, naviculiform or fusiform-elliptic, thin and smooth-walled, slightly apiculate at either end, measuring 7·2×3·4 (3·8–11·8 ×2·0–4·2) average 7·3×3·1 μ, each with a membranous appendage at the apex measuring 6·4×4·8 μ (3·0–7·2×2·0–6·4) average 6·2×4·5 μ.

Type culture isolated from the rhizosphere of pigeonpea [*Cajanus cajan* (Linn.) Millsp.] growing in soil naturally infested with *Fusarium udum* Butler, University Botany Laboratory campus, Madras, isolated by V. Agnihothrudu, 4th April 1953, Herb. M.U.B.L. No. 1390.

The following are other collections of the same fungus deposited in the Herbarium of Madras University Botany Laboratory. Soil from scrub jungle, Mount Abu (Bombay), coll. V. V. Krishnamurti on 2–6–1955, isolated on 15–6–1955, Herb. M.U.B.L. No. 1391, Kitchen Garden soil from Ahmedabad (Gujerat—Bombay), coll. V. V. Krishnamurti on 5–7–1955, isolated on 22–7–1955, Herb. M.U.B.L. No. 1392.

Rhizosphere soil of *Naregamia alata* W. & A. from Nilambur (Malabar-Madras), coll. V. Agnihothrudu on 12–5–1955, isolated on 20–5–1955, Herb. M.U.B.L. No. 1393. Rhizosphere soil of *Sphæranthus indicus* L. from Guruvayyur (Malabar-Madras), coll. V. Agnihothrudu on 8–5–1955, isolated on 23–5–1955, Herb. M.U.B.L. No. 1394.

Rhizosphere soil of seedlings of *Tectona grandis* L.f. from Topslip, Anamalais (Coimbatore-Madras), coll. V. Agnihothrudu, on 10–5–1955 isolated on 27–5–1955, Herb. M.U.B.L. No. 1395. Rhizosphere soil of *Nicotiana tabacam* L. from Vijayawada (Andhra), coll. V. Agnihothrudu on 9–12–1954, isolated on 1–1–1955, Herb. M.U.B.L. No. 1396. Garden soil from Bangalore (Mysore), coll. P. D. Varadarajan on 20–4–1955, isolated on 20–5–1955, Herb. M.U.B.L. No. 1397.

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The author is grateful to Professor Dr. T. S. Sadasivan, Director, University Botany Laboratory, Madras, for his encouragement and to Dr. C. V. Subramanian, for his suggestions and criticism in the preparation of this paper. He is also thankful to Rev. Fr. Dr. H. Santapau, for the Latin diagnosis, to Drs. V. V. Krishnamurti and P. D. Varadarajan, for samples of soils from Bombay and Mysore States respectively and to the Government of India for the award of a fellowship during the tenure of which most of this work was done.

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HITHERTO UNREPORTED HOSTS OF *DENDROPHTHŒ FALCATA* (L. F.) ETTINGS

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(Received for publication on August 8, 1955)

Dendrophthœ falcata is reported to parasitise a large number of dicotyledons and some gymnosperms. Recently the author (Singh, 1954) recorded 34 new hosts of this parasite and pointed out that earlier workers (Fischer, 1926; Srivastava, 1935; Sayeedud-Din and Salam, 1935; and Ezekiel, 1935) had already reported 157 other hosts. Mathur's (1949) record of two more hosts escaped the author's notice at that time.

Recent collections made from the forests of Dehra Dun and Saharanpur districts (including the Fruit Research Station), under the scheme 'Control and ultimate eradication of Bandha parasite in Uttar Pradesh', show 53 additional hosts. The total number of different species attacked by *Dendrophthœ falcata* has thus gone upto 246 indicating that the infection is on the increase. It is high time that the Government takes up a regular survey of the parasite to obtain a statistical data showing the damage caused to economically important plants.

The following list gives the names of newly recorded hosts, the intensity of infection, as well as their economic importance.

Abbreviations for intensity of infection: H, heavy; M, moderate; S, slight; V, very heavy; and for economic uses of hosts: D, dye; F, fruit trees; G, gum; Me, medicinal; T, timber; O, ornamental.

Supplementary list of new hosts of *Dendrophthœ falcata* (L.f.) Ettings.

No.	Family and name of host plant	Type of infection	Economic use of host plant
	Magnoliaceæ		
1	*Magnolia grandiflora* L. ..	S	O
	Anonaceæ		
2	*Miliusa velutina* Hk. F. & T. ..	V	T
	Capparidaceæ		
3	*Cratæva religiosa* Forst ..	H	Me, T

No.	Family and name of host plant		Type of infection	Economic use of host plant
	Guttiferæ			
4	*Garcinia xanthochymus* Hk. F.	..	S	F, G, O, Me. T
	Malvaceæ			
5	*Kydia calycina* Roxb.	..	M	Me, T
	Sterculiaceæ			
6	*Heritiera minor* Roxb.	..	V	D, T
7	*Sterculia alata* Roxb.	..	S	O, T
	Tiliaceæ			
8	*Grewia elastica* Royle	..	V	F, T
9	*Grewia oppositifolia* Roxb.	..	H	D, T
	Rutaceæ			
10	*Limonia acidissima* Linn.	..	M	T
11	*Murraya exotica* Linn.	..	S	Me, O
12	*Toddalia aculeata* Pers.	..	V	D, Me
	Sapindaceæ			
13	*Litchi chinensis* Sonner	..	S	F
14	*Litsæa chinensis* Lam.	..	M	T
15	*Litsæa polyantha* Juss.	..	V	Me, T
	Leguminosæ Papilionaceæ			
16	*Cassia nodosa* Ham.	..	M	O
17	*Cassia siamea* Lam.	..	M	O, T
18	*Desmodium gangeticum* DC	..	S	Me
19	*Millettia tetraptera* Kurz.	..	M	O, T
	Cæsalpiniaceæ			
20	*Bauhinia purpurea* Linn.	..	V	Me, T
21	*Bauhinia retusa* Ham.	..	V	G, Me
	Mimosaceæ			
22	*Acacia farnesiana* Wild.	..	M	G, Me
23	*Albizzia odoratissima* Benth.	..	V	G, Me, T
	Combretaceæ			
24	*Anogeissus acuminata* Wall.	..	M	T
25	*Anogeissus pendula* Edgew.	..	V	T

No.	Family and name of host plant	Type of infec. tion	Economic use of host plant
	Lythraceæ		
26	*Lagerstrœmia parviflora* Roxb.	M	G, O, T
27	*Lagerstrœmia apeciosa* Pers.	S	O, T
28	*Woodfordia floribunda* Salisb.	M	D, G, Me
	Samydaceæ		
29	*Cæsaria tomentosa* Roxb.	H	Me, T
	Rubiaceæ		
30	*Hymenodictyon excelsum* Wall	M	F, Me, T
	Sapotaceæ		
31	*Chrysophyllum olivæforme* Lam.	V	F, T
	Ebenaceæ		
32	*Diospyros kaki* Linn.	M	F
33	*Diospyros montana* Roxb.	H	Me, T
34	*Diospyros tomentosa* Roxb.	M	F, Me, T
	Oleaceæ		
35	*Nyctanthes arbor-tristis* Linn.	M	D, Me, O, T
36	*Olea cuspidata* Wall	H	Me, O, T
	Boraginaceæ		
37	*Cordia obliqua* Willd	V	Me, T
38	*Cordia vestita* Hk. F. & T.	S	Me, T
	Bignoniaceæ		
39	*Kigelia pinnata* DC	S	O
40	*Stereospermum suaveolens* DC	V	G, Me, O, T
41	*Tecomella undulata* Seem.	H	G, Me, O, T
	Verbinaceæ		
42	*Gmelina arborea* Linn.	M	F, Me, T
43	*Tectona hamiltoniana* Wall.	V	T
	Euphorbiaceæ		
44	*Sapium sebiferum* Roxb.	M	D, Me, T
	Urticaceæ		
45	*Celtis australis* Linn.	H	Me, T
46	*Ficus altissima* Bl.	M	T

No.	Family and name of host plant	Type of infection	Economic use of host plant
47	*Ficus palmata* Forsk. ..	M	F, Me, T
48	*Ficus rumphii* Bl. ..	S	F, Me, T
49	*Holoptelia himalayans* DC ..	M	Me
50	*Holoptelia integrifolia* Planch. ..	H	Me, T
51	*Morus alba* Linn. ..	V	F, Me
52	*Sterbulus asper* Lour. ..	S	Me
	Salicaceæ		
53	*Salix acmophylla* Boiss. ..	M	Me, T

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My thanks are due to Sri. J. N. Seth, Research Assistant and Sri. Kalu Ram, Specimen Collector, for the collection of the above hosts and to Mr. M. B. Raizada for identification of *Chrysophyllum olivæforme* Lam.

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SOIL CONDITIONS AND ROOT DISEASES

XVI. Colonization and Survival of *Macrophomina phaseoli* (Maubl.) Ashby in Trace Element Amended Soils*.

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Introduction

The beneficial role of trace elements in reducing infections by soil fungi has been, in recent years, a problem of keen interest. Evidence of zinc reducing the 'foot rot' of wheat was recorded by Millikan (1938) from Australia. Considerable check on the saprophytic activity of soil-borne Fusaria in trace element amended soils has been reported from this laboratory (Sarojini, 1950; Sulochana, 1952). So far there is no similar record regarding *Macrophomina phaseoli* (Maubl.) Ashby, the causative agent of cotton root rot. The following experiments were conducted to study the effect of certain trace elements on *M. phaseoli in vivo.*

Materials and Methods

Culture used.—A culture of *M. phaseoli* supplied by the Madras Government Mycologist, Coimbatore.

Soil used.—Root rot infested black cotton soil from Kovilpatti, Madras.

Colonization and survival of the fungus on cotton stubble.—Straw burial technique of Sadasivan (1939) as employed by Sarojini (1950) was adopted. Manganese, zinc and boron as manganese sulphate, zinc sulphate and boric acid were added to the soil in the form of solutions, the concentrations ranging from 2·5 to 80 mg. per 100 g. soil. After the required incubation period root pieces were surface-sterilized with calcium hypochlorite (Zachariah, 1953) and plated on Horne and Mitter's agar.

Experimental

Saprophytic activity of M. phaseoli *and trace element nutrition*

(1) *Survival.*—Effect of trace element amendment of the soil on the survival of *M. phaseoli* in artificially infected cotton root pieces buried in Kovilpatti soil was investigated. Manganese, zinc and boron at (i) 2·5, (ii) 5·0 and (iii) 10·0 mg. per 100 g. soil were added

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to Kovilpatti soil and the viability of the fungus tested at regular intervals.

TABLE I

Showing percentage viability of M. phaseoli *in cotton stubble in Kovilpatti soil amended with trace elements Manganese, Zinc and Boron*

Treatments	Period of survival in weeks										
	4	8	12	16	20	24	30	36	42	48	52
BORON :											
I	100	100	100	100	100	100	100	100	95	80	60
II	100	100	100	100	100	100	100	100	100	95	70
III	100	100	100	100	100	100	100	100	100	80	45
MANGANESE :											
I	100	100	100	100	100	100	95	85	85	70	70
II	100	100	100	100	100	100	100	100	90	90	70
III	100	100	100	100	100	100	100	100	80	80	80
ZINC :											
I	100	100	100	100	100	100	100	100	85	80	75
II	100	100	100	100	100	100	100	100	95	95	85
III	100	100	100	100	100	100	100	100	80	80	70
CONTROL :	100	100	100	100	100	100	100	95	75	70	60

The results presented in Table I show that the survival of the fungus was not affected by trace elements amendments. During the period of observation *M. phaseoli* was recovered from 100 per cent. of the cotton stubble both from the trace element amended and unamended soil for fairly long periods; this survival period varied from approximately 24 weeks to 42 weeks in the various treatments.

(2) *Colonization.*—The colonizing capacity of the fungus on dead host material buried in black cotton soil with and without trace elements was next determined. Manganese, zinc and boron were added to soil at (i) 5, (ii) 10, and (iii) 20 mg. per 100 g. soil. The colonization of the fungus was ascertained at intervals of 4 or 6 weeks for 24 weeks. The results are presented in Table II.

Boron.—Boron at all concentrations failed to suppress colonization of *M. phaseoli* at the initial stage of incubation; however, it checked

TABLE II

Showing percentage colonization of M. phaseoli *on cotton stubble in Kovilpatti soil treated with trace elements, Manganese, Zinc and Boron*

Treatments		Period of incubation in weeks				
		4	8	12	18	24
BORON :	I	70	40	30	40	..
	II	80	50	30	20	..
	III	60	30	20	20	..
MANGANESE :	I	70	60	70	70	40
	II	50	60	60	60	50
	III	50	40	20	30	20
ZINC :	I	60	30	20	10	..
	II	40	20	30	30	20
	III	40	30	25	35	15
CONTROL :		80	70	40	25	10

colonization on long incubation and after 24 weeks there was no colonization.

Manganese.—Application of manganese at 2·5 mg. per 100 g. soil favoured the colonization of the fungus throughout the experimental period. At the higher concentrations fungal colonization was inhibited at the early incubation period, *i.e.*, 4 and 8 weeks and later on colonization was favoured.

Zinc.—All concentrations of zinc depressed *M. phaseoli* colonization; nevertheless this effect was less pronounced on longer incubation at 5 and 10 mg. per 100 g. soil applications.

Effect of trace elements on the general soil flora

M. phaseoli once it established itself in the host tissue buried in soil was able to survive for a considerable period immaterial of the trace element applications to the soil. Indeed, the same soil treatments inhibited the colonization of *M. phaseoli* on dead host tissue, although it is a dominant colonizer of dead plant material freshly introduced into the soil. The saprophytic phase of a soil fungus is determined not only by its cellulose decomposing power and the nutrient supply but is also dependent on its capacity to survive microbial antagonism. How far the general microflora is stimulated by the trace element amendment of the soil was next studied.

Kovilpatti cotton soil was amended with manganese, zinc and boron and incubated at 50 per cent. of the water-holding capacity of the soil. After an incubation period of one month the fungi, bacteria and actinomycetes of these soils were quantitatively estimated by the dilution method of Waksman (1922). Levels of trace element applications were (i) 5 mg., (ii) 10 mg., (iii) 20 mg., (iv) 40 mg. and (v) 80 mg. per 100 g. soil. The results are presented in Table III.

TABLE III

Showing fungal, bacterial and actinomycetes numbers in Kovilpatti soil after 1 month's incubation with trace elements per g. of air-dry soil

Treatments	Rate of application in 100 g. soil	Fungi in thousands				in millions	
		Aspergilli	Penicillia	Other fungi	Total	Bacteria	Actinomycetes
BORON : ..	I	1000	100	362	1462	1·275	0·350
	II	650	50	275	975	1·8	0·325
	III	425	150	200	775	1·875	0·3
	IV	400	75	225	700	2·1	0·366
	V	225	25	225	475	2·275	0·425
MANGANESE :	I	725	162	137	1024	2·912	0·5125
	II	737	212	50	999	2·512	0·9
	III	700	250	50	1000	3·525	1·0
	IV	612	237	50	899	3·1375	1·0125
	V	500	287	50	837	3·067	0·7625
ZINC : ..	I	1187	537	150	1874	5·1	0·625
	II	1375	350	200	1925	4·9	0·85
	III	1012	387	112	1511	4·94	0·685
	IV	1025	300	162	1487	2·6	0·6
	V	1085	237	137	1459	2·9	0·2
CONTROL ..		500	118	150	768	2·175	0·425

Fungi.—Trace element amendments of the soil increased its fungal population, the lower concentrations of the elements, levels I and II being more favourable, with increase in the concentration of the trace elements, a corresponding decrease in the fungal flora was recorded; nevertheless, considerable variation in the response of the soil fungi to the different trace elements existed. The fungi responded best to zinc and least to boron. Further, boron at level V depressed the fungal flora, whereas zinc at the same concentration stimulated it.

Actinomycetes.—All the concentrations of boron applied to the soil decreased actinomycetes while all levels of manganese and levels I, II, III and IV of zinc increased it, manganese being more effective than zinc. Highest concentration of zinc (level V) inhibited actinomycetes population.

Bacteria.—Soil bacteria were depressed by boron amendment of the soil although an increase in boron supply increased the bacterial flora. Manganese at all concentrations and zinc at levels I, II and III stimulated the soil bacteria. Zinc at levels IV and V inhibited the bacterial population.

DISCUSSION

Sarojini (1950) demonstrated significant control of the survival and colonization of *Fusarium udum* by trace element amendments of the soil. Sulochana (1952) was able to correlate the saprophytic activity of *Fusarium vasinfectum* with the biological status of the soil treated with several trace elements. In the present investigation, boron, manganese and zinc supplied to Kovilpatti soil increased the soil microflora (Table III). However, the same treatments were able to control only the colonization of *M. phaseoli* on cotton stubble; the survival of the fungus was not affected by any of the soil treatments (Table I and II). This observation is justified by the fact that for colonization *M. phaseoli* is dependent on its hyphal growth which is susceptible to microbial antagonism, whereas the survival of the fungus for considerably long periods is rendered possible by means of its refractive sclerotia.

SUMMARY

The response of *M. phaseoli* to trace element addition was studied *in vivo.* Survival of *M. phaseoli* in infected host tissue was not affected by boron, manganese and zinc amendment of the soil. Colonization of *M. phaseoli* on dead host material was inhibited by boron and zinc amendments on long incubation of the soil. Manganese, zinc and boron favoured the increase of the general soil microflora.

ACKNOWLEDGEMENTS

I have great pleasure in expressing my indebtedness to Prof. T. S. Sadasivan, for the valuable guidance and criticisms throughout the course of this work. I am grateful to the Government of India, for the award of a Junior Research Fellowship during the tenure of which this work was carried out.

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HYPHOMYCETES—I

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In this series of papers on Hyphomycetes I propose to record, describe or discuss hyphomycetes in general, with special reference to those occurring in India.

1. **Annellophora indica** sp. nov.

The fungus forms well-defined brownish-black colonies on living leaves of *Photinia* sp. and each colony consists of a cluster of conidiophores arising from a pale brown stroma. The stromatic hyphæ are brown in colour, septate and mostly 3·4–4·3 μ thick. The conidiophores arise laterally from cells of the repent hyphæ of the stroma and are erect, straight or bent, simple, dark brown in colour, thick-walled, up to 4-septate, somewhat cylindrical, slightly paler and narrower towards the tip, 54–100 μ long, 6·8–7·7 μ broad at the base, 5·9–7·7 μ broad in the middle and 3·4–6·0 μ broad at the tip. The conidiophore septa are largely confined to the basal part of the conidiophore and the distance between septa varies from 10–50 μ. The most striking feature of the conidiophore is the presence of numerous circular ridges or annellations towards the upper part of the conidiophore indicating where dispersal of conidia had occurred previously followed by successive proliferation of the conidiophores through the scars of fallen conidia to produce further terminal conidia. Up to 19 such annellations have been observed in a single conidiophore, the space between successive annellations varying from 2·5–4·3 μ. The conidia are pale golden brown in colour, smooth, two-celled, often with one or more guttules in one or both cells, with a flat base, a broader flask-shaped basal cell and a narrow tapering apical cell, 28–40 μ long, 3·4–4·3 μ broad at the flat base, 6·8–8·5 μ where it is broadest, 2·5–3·4 μ broad at the tip, and produced acrogenously and singly at the tips of the conidiophores.

The conidia of this fungus have a close resemblance to those of species of the genus *Passalora*, e.g., *P. bacilligera* (Mont. & Fr.) Mont. & Fr. and *P. depressa* (B. & Br.) Sacc., but conidial formation in my fungus is strikingly different. The peculiar annellations on the conidiophores suggest that it is best classified under *Annellophora* Hughes (Hughes, 1951 *a*), notwithstanding the fact that my fungus has two-celled conidia. I am, therefore, placing it under *Annellophora* and since it differs from species of this genus so far known, I am proposing a new species for it.

Annellophora indica Subramanian sp. nov.

Coloniæ in foliis viventibus brunneo-nigræ, constantes e fasciculis compactis conidiophororum qui exsurgunt e strato hypharum repentium.

Hyphæ repentes brunneæ, ramosæ, septatæ, 3·4–4·3 µ latæ. Conidiophori simplices, erecti, recti vel incurvi, fusce brunnei, crassis parietibus præditi, usque quater septati, aliquantum cylindrici, tenuiter angustiores atque pallidiores ad apicem, 54–100 µ longi, 6·8–7·7 µ ad basim, 5·9–7·7 µ ad medium, 3·4–6·0 µ ad apicem lati, annulati pluribus jugis vel annulis 2·5–4·3 µ inter se distantibus ad mediam vel plus quam mediam partem superiorem. Conidia pallide aureo-brunnea, bicellulata, levia, basi lata atque plana, cellula basali latiori urceolata, cellula apicali angustiori, 28–40 µ longa, 3·4–4·3 µ lata ad basim planam, 6·8–8·5 µ ad partem latissimam, 2·5–3·4 µ ad apicem, producta singula acrogene ad apices conidiophororum.

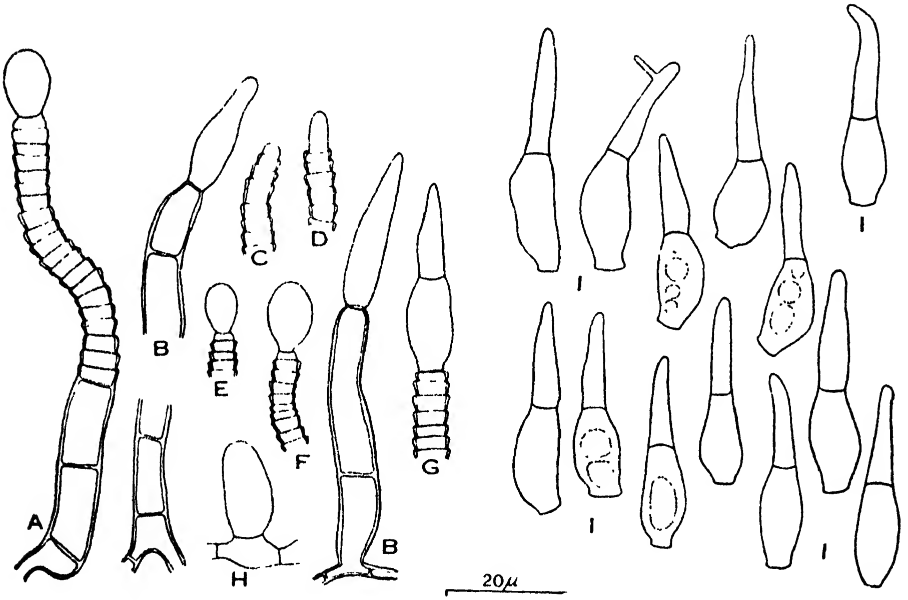

Fig. 1. *Annellophora indica* from type specimen, Herb. M.U.B.L. No. 1057. A–H, development of conidiophores and conidia; I, mature conidia.

Typus lectus in foliis viventibus *Photiniæ* cuiusdam speciei e familia Rosacearum, in loco Kodaikanal Hills, in dist. Madura, in Provincia Madras, die 12 decembris 1953, a K. Ramakrishnan et positus in herbario M.U.B.L. sub numero 1057.

2. **Excipularia narsapurensis** sp. nov.

This beautiful Tuberculariaceous fungus was collected by me recently from the Narsapur forests in the Hyderabad-Deccan and was found occurring on dead wood. The sporodochia are numerous and scattered on the substratum, entirely superficial, cup-shaped, black in colour, setose, 210–420 µ across and 98–140 µ tall excluding the setæ. The number of setæ per sporodochium is variable and up to 12 have been seen per sporodochium. The setæ are simple, brownish black to deep black, thick-walled, many- (up to 8-) septate, subulate, up to 280 µ long, up to 10·2 µ broad at the base, and up to 8·5 µ broad in the middle. The conidiophores are short, simple, cylindrical, sub-hyaline and 3–5 μ broad. The conidia are dark brown, fusiform, 6–8-septate, constricted at the septa, and broadest and darkest in the middle. The penultimate cells at either end of the conidium are paler in colour than the middle cells, and the basal and apical cells are paler still, being sub-hyaline. The conidia are produced acrogenously and singly from the tips of the conidiophores. They are 61–73 μ long, 20·4–22·1 μ where they are broadest, 7·6–9·4 μ broad at the tip, and 5·1–8·5 μ broad at the base.

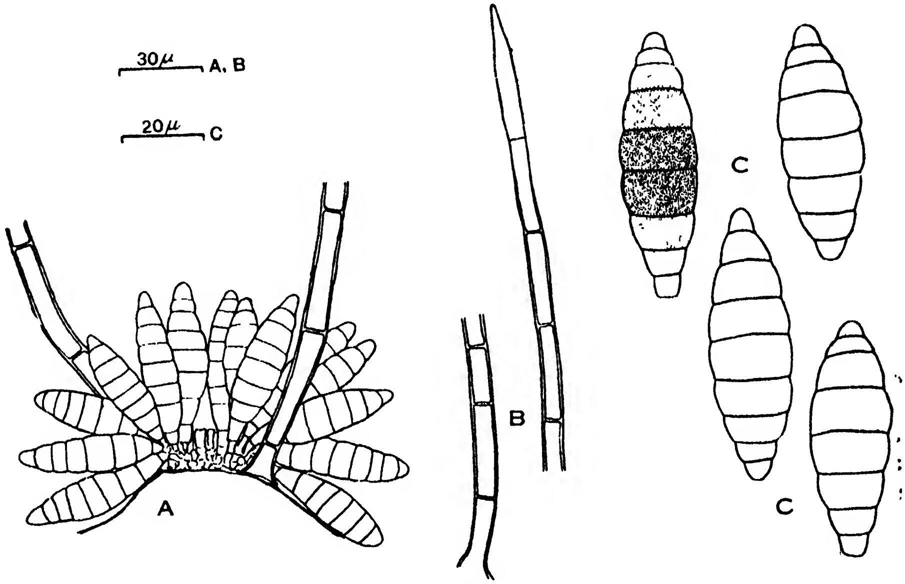

FIG. 2. *Excipularia narsapurensis* from type specimen, Herb. M.U.B.L. No. 1334. A, sporodochium showing setæ, conidiophores and conidia; B, seta; C, conidia.

This fungus belongs to the Tuberculariaceæ-Phæophragmeæ and is easily placed in the genus *Excipularia* Sacc. Two species of this genus are known, *viz.*, *E. fusispora* (B. & Br.) Sacc. [= *Excipula fusispora* B. & Br., 1859, in *Ann. nat. Hist.*, III, 359], the type species (Saccardo, 1884, p. 689) and *E. epidendri* P. Henn. (Hennings, 1905). The measurements of conidia, etc., in these two species are as follows:

		E. fusispora	*E. epidendri*
Sporodochia	..	70–120×70–120 μ	60–90 μ diam.
Setæ	..	60–90×3–4 μ	70–80×3–4 μ
Conidia	..	6–9-septate, 36–48×4–6·5 μ	3–4-septate, 12–30×4–5 μ

It is obvious that my fungus has much larger sporodochia, much onger setæ and much larger conidia than either of the above two pecies and I, therefore, propose to describe it as a new species.

Excipularia narsapurensis Subramanian sp. nov.

Sporodochia numerosa, dispersa in substratum, superficialia, nigra, cyathiformia, setosa, 210–420 μ diam., 98–140 μ alta (setis exclusis). Setæ usque duodenæ in singulis sporodochiis, simplices, brunneo-nigræ vel nigræ, crassis parietibus præditæ, plurisceptatæ (usque octies), subulatæ, usque ad 280 μ longæ, 10·2 μ latæ ad basim, 8·5 μ ad medium. Conidiophori breves, simplices, cylindrici, subhyalini, 3–5 μ lati. Conidia brunnea, fusiformia, 6–8-septata, constricta ad septa, 61–73 μ longa, 20·4–22·1 μ in parte latissima, 7·6–9·4 μ ad apicem, 5·1–8·5 μ ad basim, producta acrogene singula ad apices conidiophororum. Conidium latissimum atque coloris obscurioris ad medium; cellulæ penultimæ in utroque apice conidii pallidiores quam eae ad medium; cellulæ basales atque apicales utrinque pallidiores, *i.e.*, subhyalinæ.

Typus lectus in ligno quodam emortuo in loco Narsapur, in provincia Hyderabad-Deccan, die 22 augusti 1955 a C.V.S. et positus in herbario M.U.B.L. sub numero 1334.

3. *Exosporium arecæ* (B. & Br.) Petch, 1927, in *Ceylon J. Sci.* (*Ann. R. bot. Gdns Peradeniya*), **10**: 173–74.

The fungus forms black pulvinate colonies composed of closely aggregated conidiophores on the substratum, *viz.*, living leaves of *Areca catechu.* The conidiophores arise from a dark brown stromatic tissue composed of brownish black, branched, septate hyphæ which are 3–5 μ thick. The conidiophores are dark brown, simple, erect, straight or bent, cylindrical, septate and 224–504 μ long, The conidiophores are conspicuously verrucose and slightly thicker towards their tips than the rest of the conidiophore, being 10·2–13·5 μ wide at the tip; they are 7·6–9·4 μ wide below. The conidia are produced acrogenously and singly at the tips of conidiophores. They are obclavate, broadest at the second cell from the base, becoming progressively narrower above, 1–4-septate, constricted at the septa, dark brown, thick-walled, verrucose, 47·6–61·2 μ long, 18·7–22·1 μ where they are broadest, 3·4–9·4 μ broad at the tip and 3·4–5·1 μ broad at the point of attachment to the conidiophore. One or two of the cells immediately above the basal one of each conidium are the darkest, the other cells being paler in colour. This description is based on a study of Herb. M.U.B.L. No. 1388 (on living leaves of *Areca catechu*, Vittal, S. Kanara, Madras State, 28–8–1953, coll. T. S. Ramakrishnan). I have had occasion to examine the type specimen, *viz.*, Fungi of Ceylon, No. 833 sub. *Helminthosporium arecæ* B. & Br. on *Areca catechu* from Ceylon at the Commonwealth Mycological Institute, Kew (Herb. I.M.I. No. 7683 *ex* Herb. R.B.G., Kew). The conidia from the type measured 47–57 μ long and 20–23 μ thick where the conidia are broadest. I have been able to examine specimens pertaining to two other records of this fungus from India, *viz.*, on *Areca catechu*, Sirsi, Bombay, June 1913, coll. & det. G. S. Kulkarni (Herb. M.U.B.L. No. 813 *ex* Herb. Crypt. Ind. Orient. No. 12246) and on the same host, Assam, coll. J. N. Sen, November 1927 (Herb. M.U.B.L. No. 812 *ex* Herb. Crypt. Ind. Orient. No. 12248), both collections being labelled "*Brachysporium arecæ* (B. & Br.) Sacc." Indeed, during my visit to the C.M.I., Kew, in 1950, I found I.M.I. 7683 referred to above disposed under *Brachysporium arecæ*.

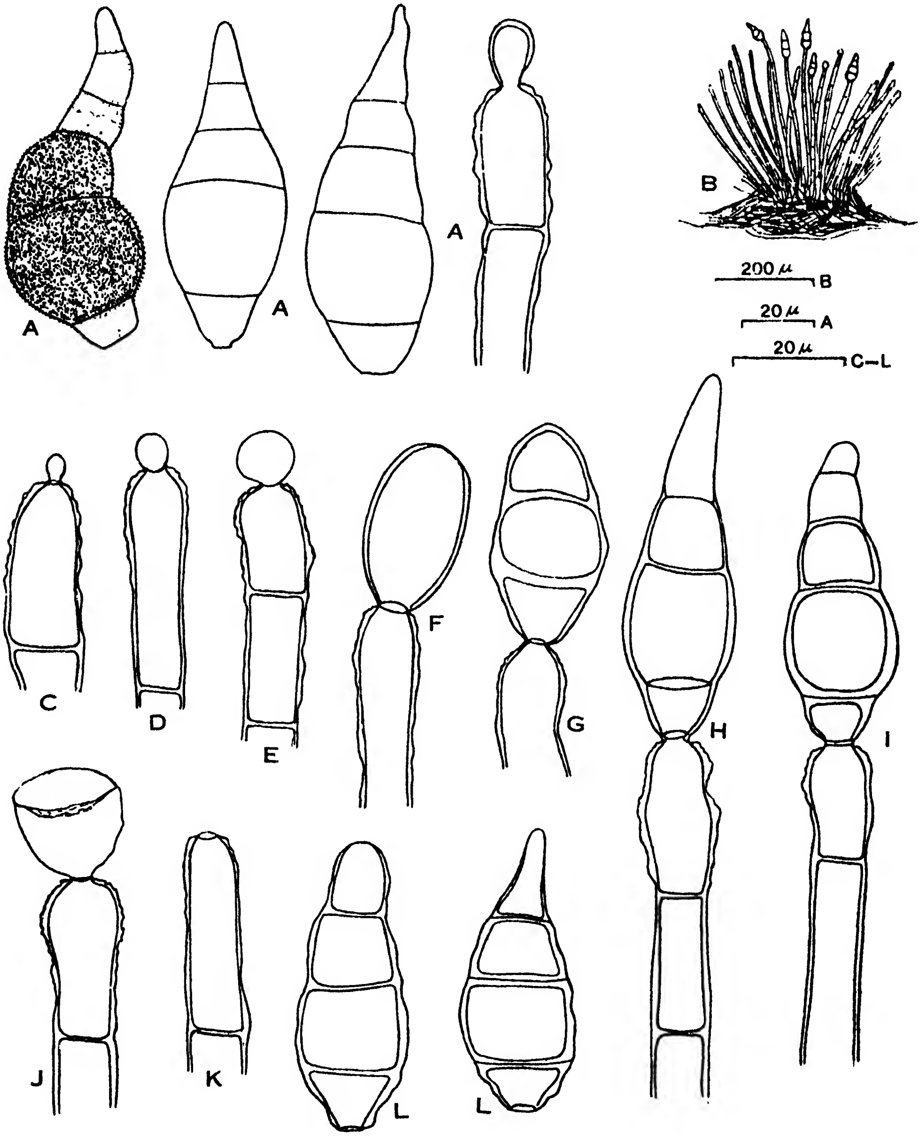

Fig. 3. *Exosporium arecæ*; A, showing three conidia and part of a conidiophore from type specimen, Herb. I.M.I. No. 7683; B–L, from Herb. M.U.B.L. No. 1388. B, a cluster of conidiophores; C–I, development of conidia; J–K, tips of conidiophores showing detachment of conidia; L, conidia.

After a study of the above specimens, which includes the type, I am in complete agreement with Petch's (1927) disposition of the fungus under *Exosporium*. It is not congeneric with *Brachysporium* *obovatum* (Berk.) Sacc., the lectotype species of the generic name *Brachysporium* Sacc. (Hughes, 1951 *c*).

It would also appear that the fungus has received two other names in literature: *Exosporium pulchellum* Sacc. (Saccardo, 1931, p. 994–95) and *E. eximium* Sacc. (Saccardo, 1931, p. 994). *E. pulchellum* was described in 1916 (in Notæ Myc. XX, in *Nuovo G. bot. ital.*, V, **23**, p. 215) and was collected on decaying leaves of *Areca catechu* from the Philippines; and *E. eximium* was described in 1918 (in Notæ Mycol. XXIV, in *Bull. Orto bot. Napoli*, **1928**, p. 526), also on dead leaves of *Areca catechu*, collected from the botanical garden, Singapore. Comparative measurements of the sporodochia, etc., of these two species (from Saccardo, 1931, pp. 994–95) are given below:

	E. pulchellum	*E. eximium*
Sporodochia ..	Black, 500–700 μ diam.	Black, 400–500 μ diam.
Conidiophores ..	220–350 × 6–8 μ	300–350 × 7–9 μ
Conidia ..	3-septate, 48–50 × 16–16·5 μ	3–4-septate, 40 × 16 μ

The conidia of *E. eximium* were described as: "conidiis in quoque conidiophoro subquinis, obclavatis, basi tenuato-truncatis, sursum acutato-subcuspidatis, ... constrictis, ..., cellula ima minima subhyalina, secunda castaneo-atra, tertia dilute castanea, apicali subhyalina, episporio et conidiophoris lenissime asperulis." The description of the conidia of *E. pulchellum* was as follows: "conidiis breviter fusoideo oblongis, subrectis, apice obtuse tenuatis, basi longiuscule apiculatis, ..., ad septa leniter constrictis, levibus, ..., fuligineis, loculis binis centralibus saturatioribus." I have not seen specimens authentic for these names, but from the descriptions quoted above, the two species appear to me to be identical. Further, they appear to be identical with *Helminthosporium arecæ* B. & Br.

As a summary to the foregoing discussion, I give below a nomenclator:

Exosporium arecæ (B. & Br.) Petch, 1927, in *Ceylon J. Sci.* (*Ann. R. bot. Gdns Peradeniya*), **10**: 773–74; Ramakrishnan, T. S., & Sundaram, N. V., 1954, *Indian Phytopath.*, **7**: 64–65.

=*Helminthosporium arecæ* B. & Br., 1875, *J. Linn. Soc.* (*Bot.*), **14**: 98.

=*Brachysporium arecæ* (B. & Br.) Sacc., 1886, in *Sylloge Fungorum*, **4**: 429.

=*Exosporium pulchellum* Sacc., 1916, in Notæ Mycol. XX, *Nuovo G. bot. ital.*, V, **23**: 215; Saccardo, 1931, *Sylloge Fungorum*, **25**: 994.

=*Exosporium eximium* Sacc., 1918, in Notæ Mycol. XXIV, *Bull. Orto. bot Napoli*, 1918, p. 26; Saccardo, 1931, in *Sylloge Fungorum*, **25**: 994.

4. **Exosporium coonoorense** sp. nov.

This fungus was recently collected by me from the Nilgiris and was found to occur on dead stems surrounded by leaf litter in moist

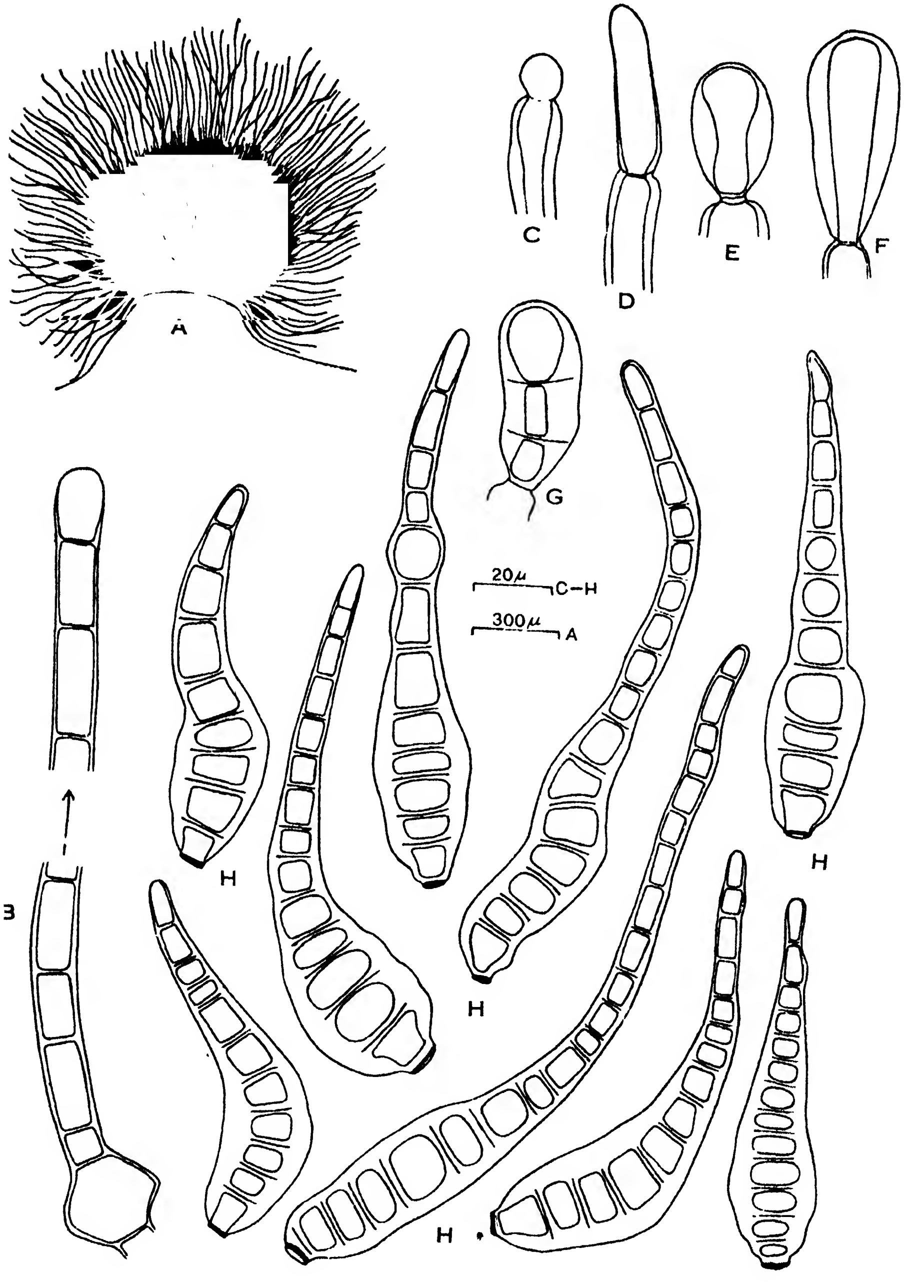

FIG. 4. *Exosporium coonoorense* from type specimen, Herb. M.U.B.L. No. 1336. A, a sporodochium; B, a single conidiophore; C–G, development of conidia; H, mature conidia.

situations. The colonies are black, consist of compact clusters of numerous conidiophores, and are up to 1120 μ across and up to 910 μ tall. The conidiophores arise from a cushion-like stromatic base. The conidiophores are simple, brown, somewhat cylindrical, erect, straight, bent or flexuous, thick-walled, up to 770 μ long, many-septate, with a swollen basal cell up to 25 × 25 μ in size, up to 12 μ thick immediately above the swollen basal cell, 12–14 μ thick in the middle, and 11–14 μ thick at the apex which is blunt and rounded. The conidiophores are darker in colour towards the base and paler above. The conidiophore septa are usually up to 42 μ apart or often less. The conidiophores sometimes have one or more swellings and these are about 18–22 μ thick. The conidia are produced singly and acrogenously at the tips of conidiophores. They are typically obclavate, broadest towards the base, becoming much narrower and tapering above, brown, verrucose, 10-20-septate, thick-walled. straight or often curved variously, 90–200 μ long, 22-27 (-33) μ where they are broadest and 5–7 μ broad at the apex. Each conidium has a prominent scar 5–8 μ broad at the base, indicating the point of attachment to the conidiophore. The tips of the conidia are hyaline to sub-hyaline and blunt and rounded. The conidia appear to be produced as blown out ends of conidiophores.

The simple conidiophores arising in clusters from a basal stroma and the production of phæophragmospores singly and acrogenously from the tips of conidiophores indicate that the fungus is an *Exosporium*. It appears to be distinct from species of this genus so far known and is therefore being classified as a new species.

Exosporium coonoorense Subramanian sp. nov.

Coloniæ atræ, constantes e fasciculis compactis plurium conidiophororum, usque ad 1120 μ diam., 910 μ altæ. Conidiophori surgentes e basi stromatica pulvinariformi, simplices, aliquantum cylindrici, erecti, recti, curvati vel flexuosi, brunnei, crassis parietibus præditi, pluries septati, ornati cellula basali tumescente usque ad 25 μ crassa et alta, usque ad 12 μ crassi immediate supra cellulam basalem tumescentem, 12–14 μ crassi ad medium, 11–14 μ crassi ad apicem, obscurioris coloris ad basim, pallidiores supra, usque 770 μ longi; conidiophororum septa 42 μ inter se distantia vel proximiora. Conidia obclavata, latissima ad basim, evadentia multo angustiora atque fastigata supra, recta vel sæpe curvata varie, brunnea, crassis parietibus prædita, verrucosa, 10–20-septata, 90-200 μ longa, 22–27 (–33) μ lata ad partem latissimum, 5–7 μ lata ad apicem, singula ornata cicatrice basali prominenti 5–8 μ lata, producta singula acrogene ad apices conidiophororum.

Typus lectus in culmis emortuis in loco Sim's Park, ad Coonoor, in districtu Nilgiris, in provincia Madras, die 23 mensis septembris anno 1955, a C.V.S. et positus in herbario M.U.B.L. sub numero 1336.

5. **Helicoceras longisporum** sp. nov.

This fungus was collected on living leaves of *Celtis serotina* from the Nilgiris. The fungus forms chocolate brown epiphyllous effuse colonies on the living leaves. The repent hyphæ are sub-hyaline to golden brown, branched, septate, and 1·7–5·1 μ thick. The conidiophores are short and arise laterally or apically from cells of the repent hyphæ. The conidiophores are short and somewhat globose, or elongated and sub-cylindrical, erect or decumbent, straight, bent or flexuous, 0–5-septate, 8·5–44·2 μ long and 5·9–7·7 μ broad. The short globose to sub-globose conidiophores are concolorous with the

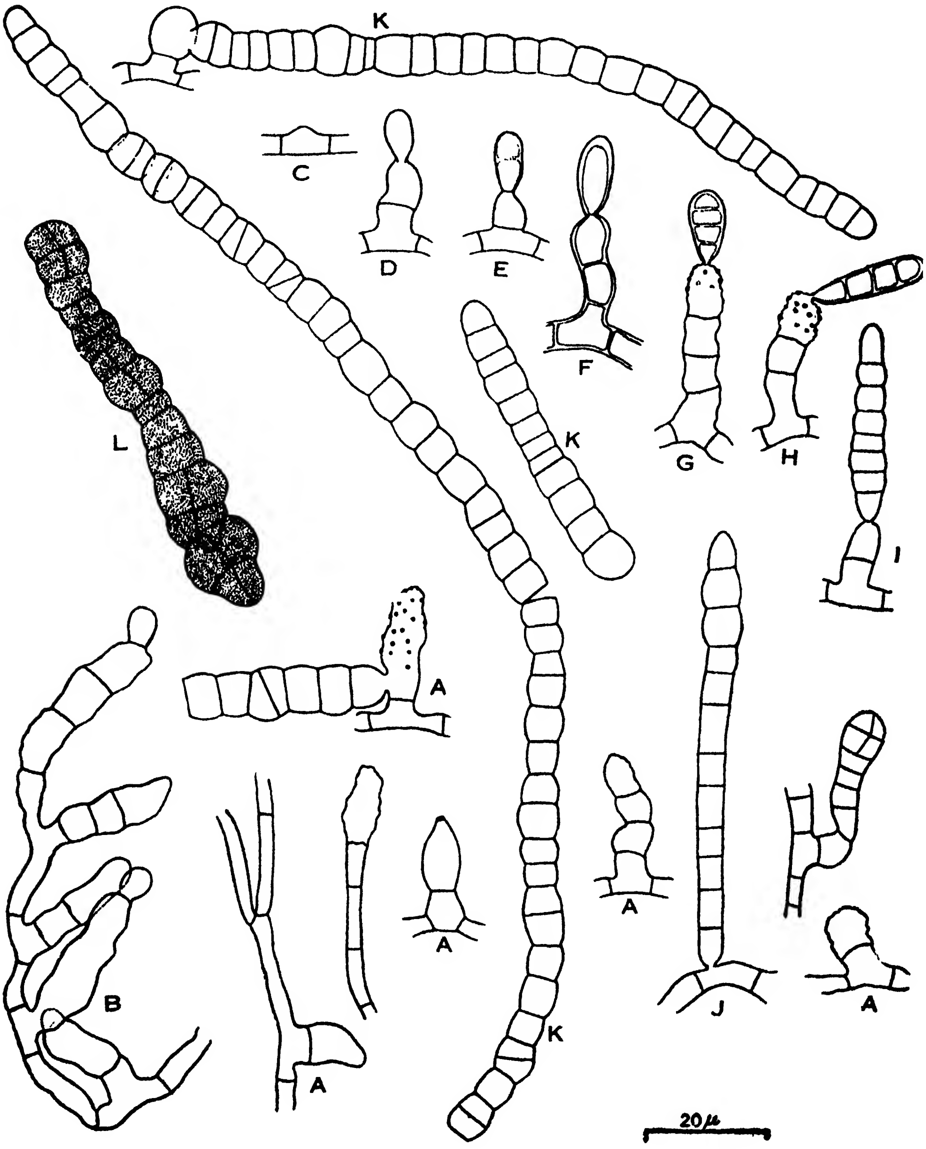

FIG. 5. *Helicoceras longisporum* from type specimen, Herb. M.U.B.L. No. 1382. A–B, conidiophores; C–I, development of conidiophores and conidia; J, production of one conidium laterally from a cell of a vegetative hypha; K, mature phragmospores; L, a mature dictyospore.

repent hyphæ. The elongate cylindric conidiophores are darker in colour, being brown, and have wavy and slightly verrucose walls. The conidia are borne acrogenously at the tips of the conidiophores or often from more than one point on the conidiophore. The conidia are long, brown in colour, somewhat cylindrical, often curved, many times transversely septate and constricted at the septa. The individual cells of the phragmo-conidia are mostly broader than longer, the distance between transverse septa of the conidia varying from 3·4–8·5 μ. One or more cells of the conidia may have diagonal or longitudinal septa. The conidia are 150–280 μ long, 6·8–12·0 μ thick where they are broadest and 5·1 9·4 μ broad elsewhere. In a few cases the conidia have been seen to be produced directly and laterally from cells of the repent hyphæ.

It will be clear from the above description that the fungus belongs to the genus *Helicoceras* Linder (Linder, 1931, pp. 2–3). The host genus on which the present fungus has been collected is the same as that on which the description of the type species is based, *viz.*, *Celtis*. The type species is *H. celtidis* (Biv.-Bernh.) Linder, and this species has been collected on a number of species of *Celtis*. On the basis of a study of several European and other specimens of this fungus, Linder (1931, p. 4) gave the following description for the fungus: "Mycelium light fuscous to fuscous, branched, septate, penetrating through the host tissues. Conidiophores as short branches of the mycelium, simple, little differentiated. Conidia fuscous, curved, circinate, or once coiled, more conspicuously coiled in dried material, multiseptate, some cells occasionally diagonally or longitudinally septate, constricted at the transverse septa, 50–100×5–8 μ, the cells shorter than wide." I had at first disposed my fungus under *H. celtidis*, but the conidia are mostly twice as long and slightly thicker than in *H. celtidis*. Indeed, the conidia in my fungus are much longer than those of the four species of *Helicoceras* so far known (see Moore, 1955) and my fungus is, therefore, described here as a new species.

Helicoceras longisporum Subramanian sp. nov.

Coloniæ epiphyllæ, badiæ, effusæ. Hyphæ repentes subhyalinæ vel aureo-brunneæ, ramosæ, septatæ, 1·7–5·1 μ crassæ. Conidiophori surgentes lateraliter vel terminaliter e cellulis hypharum repentium, breves, aliquantum subglobosi, atque eiusdem coloris ac hyphæ repentes, vel tenuiter elongati, subcylindrici atque pallide brunnei vel brunnei, erecti vel decumbentes, recti, curvati vel flexuosi, 0–5-septati, 8·5–44·2 μ longi, 5·9–7·7 μ lati. Conidia producta singula acrogene ad apices vel pleurogene ex una alterave parte conidiophori, brunnea, longa, aliquantum cylindrica, sæpe curvata vel flexa, sæpissime transverse septata, constricta ad septa, 150–280 μ longa, 6·8–12·0 μ ad partem latissimam, 5·1–9·4 μ lata alibi, cellulis nonnullis diagonaliter vel longitudinaliter septatis, cellulis omnibus latioribus quam longioribus.

Typus lectus in foliis viventibus *Celtis serotinæ* Pl. e familia Ulmacearum, in loco Sim's Park, in Coonoor, Dist. Nilgiris, in provincia Madras, die 25 septembris anni 1955, a C.V.S. et positus in herbario M.U.B.L. sub numero 1382.

Two other species of *Helicoceras* are known from India: *H. celtidis* (Thirumalachar and Lacy, 1951, as *Gyroceras celtidis*) and *H. oryzæ* Linder and Tullis (Ramakrishnan and Subramanian, 1952, p. 23).

6. **Helicomina indica** sp. nov.

This fungus was collected by me from Castle Rock in the Bombay State during a visit in 1954 and occurred on living leaves of an unidentified leguminous plant. The colonies on the leaves simulate sooty spots. The conidiophores are simple, erect, straight or bent, mostly 3- but up to 5-septate, somewhat cylindrical, brown in colour, darker towards the base and paler above, arising from a pale brown hypophyllous stroma, and occurring in compact clusters. The conidiophores have wavy walls towards the tips, are up to 144 μ long, 5·1–7·7 μ broad at the base, 3·4–6·0 μ broad in the middle and 4·2–6·0 μ broad at the tip. The conidia are sub-hyaline to pale brown in colour, straight, curved, bent or curled variously, usually up to 5-septate, cylindrical in the middle and becoming narrower towards either end, each with a somewhat mamillate base and a broadly or narrowly rounded smooth tip, smooth, produced singly and acrogenously at the tips of conidiophores, 20·4–57·8 × 5·7–10·2 μ. Some conidia have been found to have a button-like or somewhat elongated apical outgrowth.

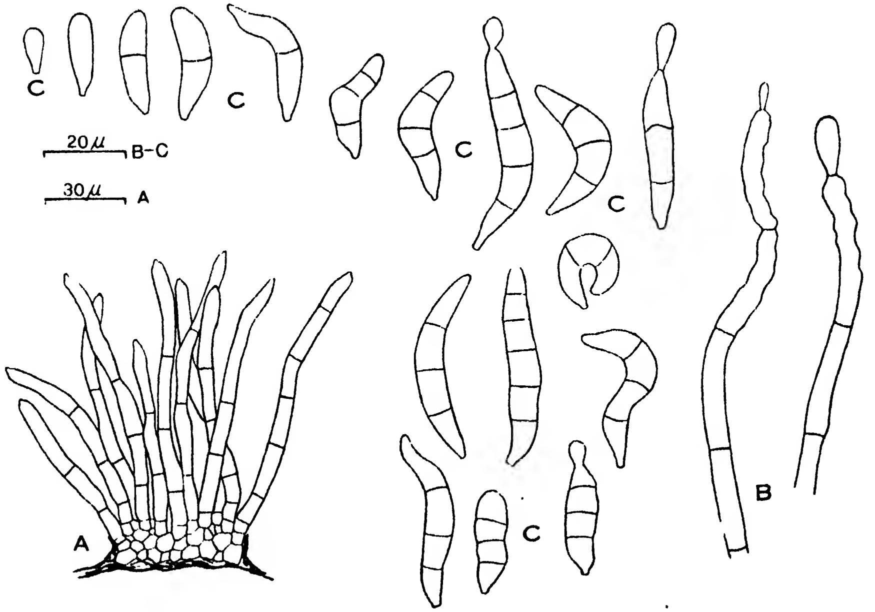

FIG. 6. *Helicomina indica* from type specimen, Herb. M.U.B.L. No. 1217. A, a cluster of conidiophores; B; conidiophores showing the production of conidia; C, conidia.

This fungus belongs to the Dematiaceæ-Phragmosporæ (Helicosporæ ?) and appears to possess the characteristics described by Olive (1948) for the genus *Helicomina*. This genus, so far as I am aware, is monotypic and the type species, *H. caperoniæ* Olive was collected on living leaves of *Caperonia castanaefolia* (L.) St. Hil. (Euphorbiaceae) from Louisiana. The conidiophores of *H. caperoniæ* were described as 2–12-septate and 92–329 × 4–6·6 μ, and the conidia as 1–7-septate, mostly 3-septate, and 17·4–40 × 4·5–6·3 μ. My fungus has morphologically a close similarity to Olive's, but the conidia appear to be larger and I, therefore, consider it best to keep my fungus separate and am describing it as a new species.

Helicomina indica Subramanian sp. nov.

Coloniæ in foliis viventibus fuligineæ, constantes e fasciculis conidiophororum surgentium e stromate hypophyllo. Conidiophori simplices, erecti, recti vel incurvi, nonnihil cylindrici, marginibus undulatis ad apicem, usque quinquies septati, brunnei, obscurioris coloris ad basim, pallidiores supra, usque ad 144 μ longi, 5·1–7·7 μ ad basim, 3·4–6·0 μ ad medium, 4·2–6·0 μ ad apicem lati. Conidia subhyalina vel pallide brunnea, recta, incurva vel varie curvata, usque quinquies septata, cylindrica ad medium, fastigata ad utrumque apicem, singula ornata basi aliquantum mamillata atque apice anguste vel late rotundato, levia, producta singula acrogene ad apices conidiophororum, 20·4–57·8 × 5·7–10·2 μ.

Typus lectus in foliis viventibus plantæ cuiusdam e Leguminosis, in loco Castle Rock, in provincia Bombay, die 29 decembris 1954 a C.V.S. et positus in herbario M.U.B.L. sub numero 1217.

7. *Helminthosporium guareicola* Stevens, 1918 (March), in *Bot. Gaz.*, **65**: 241 (as 'guareicolum'); Saccardo, 1931, *Sylloge Fungorum*, **25**: 832; Hughes, S. J., 1953, *Mycol. Pap.*, **50**: 25–26.

   -*Helminthosporium flagellatum* Yates, 1918 (November), in *Philipp. J. Sci.*, **13**: 383; Saccardo, 1931, *Sylloge Fungorum*, **25**: 827.

   -*Helminthosporium spirotrichum* Saccardo, 1921, in *Boll. Orto bot. Napoli*, **6**: 61.; Saccardo, 1931, *Sylloge Fungorum*, **25**: 826.

This fungus is a hyperparasite and was recently collected on Meliolineæ on living leaves of an unidentified angiosperm from Castle Rock in the Bombay State. The conidiophores occur in closely aggregated clusters, and arise laterally from cells of the repent hyphæ. They are simple, erect, straight, bent or curved, somewhat cylindrical, dark brown in colour, thick-walled, many-septate, 240–532 μ long, 6·8–10·2 μ thick at the base, and up to 8·5 μ thick above. The most noteworthy feature of the conidiophore is its marked zigzag appearance when viewed from the side. The zigzag appearance is the result of successive production of conidia regularly to the left and to the right. As indicated by Hughes (1953), the conidiophores may occasionally produce 2–3 zigzag fertile portions, each separated by a short cylindrical region and the planes of the separated regions of geniculation may be different. The conidia are acrogenous and are produced singly at the tip of the conidiophore. They are somewhat fusiform to obclavate, flat- and broad-based, broadest in the middle or nearer the base, becoming progressively narrower above, having tapering and smoothly

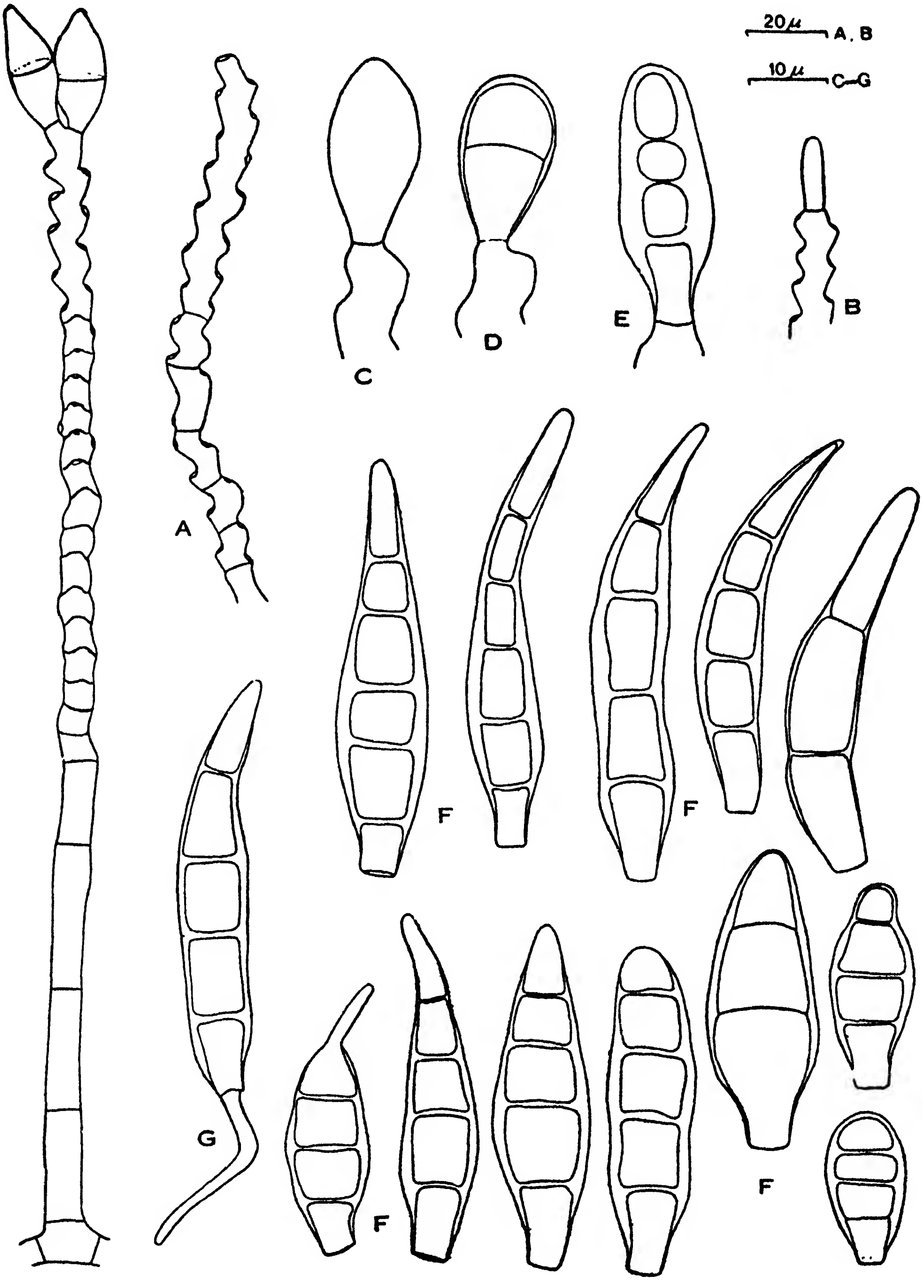

FIG. 7. *Helminthosporium guareicola* from Herb. M.U.B.L. No. 1218. A, conidiophores with conidia; B–E, development of conidia; F, mature conidia; G, germinating conidium.

rounded tips or bluntly rounded ends, thick-walled, golden to dark brown in colour, smooth-walled, usually 3–4- but up to 5-septate, and not constricted at the septa. They are 28·8–68·4 μ long, 4·2–6·0 μ broad at the base, 8·5 15·3 μ where they are broadest, and 2·5–6·8 μ broad at the tip. Conidial germination takes place through the apical or the basal cell.

Only one collection has been made: parasitic on Meliolineæ, occurring on living leaves of unidentified angiosperm, Castle Rock, (Bombay State), 29-12-1954, coll. K. Ramakrishnan, Herb. M.U.B.L. No. 1218.

8. **Lomachashaka kera** gen. et sp. nov.

The fungus forms scattered sporodochia which are waxy in appearance. They are superficial, light green in the centre with a white fringe, circular or oval in outline when viewed from above, cup-like when viewed from the sides, 210–350 μ across, and 80–100 μ tall. The white fringe characteristic of the sporodochia is composed of numerous unbranched, thin-walled, hyaline, septate, erect, straight, bent or flexuose, sterile hairs, surrounding the central sporiferous part of the sporodochium. These sterile hairs may be up to 200 μ long and 1·6-2·5 μ thick throughout their length. The conidiophores arise from a stratum of hyaline, septate, vegetative hyphæ and form a closely arranged hymenium above. The conidiophores are hyaline, thin-walled, cylindrical, and terminate in one or two phialides each. The phialides are 13–19 μ long and 1–3 μ broad. The conidia are produced acrogenously and singly from the tips of the phialides. They are fusiform with a mamillate base, one-celled, hyaline, each with two

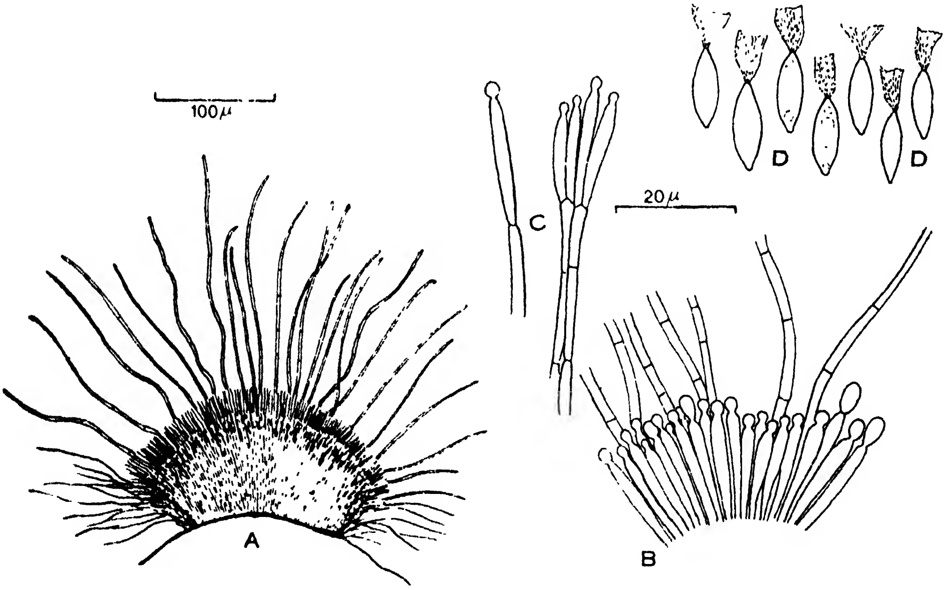

FIG. 8. *Lomachashaka kera* from type specimen, Herb. M.U.B.L. No. 955. A, a sporodochium; B,C, phialide-like tips of conidiophores; D, conidia.

to four guttules and an apical appendage. This appendage is brush-like, obconical in shape, mucoid, 4·9–6·6 μ tall, and 4·9–6·6 μ where it is broadest. The conidia are mostly 11·6×3·3 μ, but their size varies from 9–14×2–4 μ.

The most characteristic features of the fungus just described are: (i) the cup-like sporodochia fringed with numerous simple, hyaline, septate, sterile hairs and (ii) the one-celled conidia with the characteristic apical appendage. The conidia are very similar to those of *Koorchaloma madreeya* Subram. (Subramanian, 1953), but the present fungus differs from *K. madreeya* in having hyaline, thin-walled sterile *hairs* around the sporodochium instead of dark brown, thick-walled *setæ* which are typical of *K. madreeya*. It has also a close resemblance to *Starkeyomyces koorchalomoides* Agnihotrudu (Agnihotrudu, 1956); but the latter has sporodochia which lack setæ or hairs. I know of no genus of the Tuberculariaceæ in which my fungus may be placed. Accordingly, I am proposing a new genus to accommodate my fungus and am naming it *Lomachashaka kera*, the generic and specific names being derived from Sanskrit: the generic name from लोम (*lōma* = hair) and चषक (*chashaka* = cup), indicative of the cup-like sporodochium fringed by hairs; and the specific epithet from केर (*kera* = the coconut palm), from the host plant on which the fungus was collected.

Lomachashaka Subramanian gen nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Tuberculariaceas, Hyalosporas.

Sporodochia superficialia, cyathiformia, ciliata plurimis capillis simplicibus, septatis, hyalinis atque sterilibus. Conidiophori simplices, hyalini, cylindrici, septati, desinentes in phialides. Conidia hyalina, semel cellulata, singula ornata appendice apicali unica obconica evanescenti mucoidea, acrogene et singulariter producta ex apicibus phialidum.

Fungus imperfectus, Moniliales, Tuberculariaceæ, Hyalosporæ.

Sporodochia superficial, cup-like, fringed with numerous simple, septate, hyaline, sterile hairs. Conidiophores simple, hyaline, cylindrical, septate, terminating in phialides. Conidia hyaline, one-celled, each with a single apical, obconical, evanescent, mucoid appendage, produced acrogenously and singly from the tips of phialides.

Type species

Lomachashaka kera Subramanian sp. nov.

Sporodochia superficialia, pallide viridia in medio, albide fimbriata, circularia vel ovalia ambitu supra, cyathiformia, 210–350 μ diam., 80–100 μ alta; fimbriæ albidæ constantes ex plurimis capillis, qui sung simplices, hyalini, septati, parietibus tenuibus præditi, erecti, recti vel curvati vel flexi et steriles, dimetientes 200 μ longit. et 1·6–2·5 μ crassit. Conidiophori dense aggregati ad efformandum hymenium, surgentes e strato hypharum (quæ sunt hyalinæ, septatæ atque vegetativæ), hyalini, simplices, tenuibus parietibus præditi, cylindrici, septati, desinentes in unam duasve phialides; phialides vero 13–19 μ longæ, 1–3 μ latæ. Conidia producta acrogene atque singulariter ad apices phialidum, hyalina, in massa pallide viridia, fusiformia, basi mamillata, semel cellulata, singula ornata duplici vel quadruplici guttula atque appendice apicali, 11·6×3·3 (9–14×2–4 μ). Appendix mucoidea, evanescens, obconica, 4·9–6·6 μ alta. 4 9–6·6 μ lata ad partem latissimam.

Typus lectus in foliis emortuis *Cocos nuciferæ* Linn. in campo Laboratorii Botanici Universitatis die 28 mensis octobris anni 1953 a C.V.S. et positus in herbario M.U.B.L. sub numero 955.

9. **Paathramaya sundara** gen. et sp. nov.

This interesting stilbaceous fungus was recently collected by me from the Narsapur forests in the Hyderabad (Deccan) State, and was found growing on dead stems. The fungus forms numerous scattered, dark to blackish-brown synnemata, each with a fan-shaped, sub- or hemi-spherical or irregularly globose capitate head consisting of closely aggregated free ends of conidiophores and conidia produced on them. Each synnema has an erect stalk composed of numerous, closely parallel, unbranched, septate, sub-hyaline to pale brown hyphæ which appear dark in mass. The stalk of each synnema is sub-cylindrical, 360–750 μ long, 112–280 (–532) μ thick at the base, 35–140 (–322) μ thick in the middle, and 84–182 (–420) μ thick immediately below the head. The head is concolorous with the stalk, is fan-shaped in relatively young fructifications, but somewhat hemispherical or irregularly sub-globose when mature, and consists of closely aggregated free ends of conidiophores. The heads are 266–532 (–1260) μ across and 168–280 (–700) μ tall. The conidiophores are unbranched, few-septate, sub-hyaline individually but brownish in mass, non-septate in the upper part which alone is fertile, thick-walled with wavy margins, somewhat cylindrical, of variable length, the length of the fertile part being up to 210 μ, 10·2–13·6 μ broad in the fertile region, and up to 6·8 μ broad below. Each conidiophore terminates in a conspicuous cup-like protuberance subtended by a constriction and has also many (up to about 20 per conidiophore) similar cup-like protuberances arising from scattered points laterally all over the fertile part of the conidiophores. The acrogenous and pleurogenous cup-like structures are concolorous with the conidiophore; the former measure 6·8–8·5 ×5·1–6·8 μ and the latter 5·1–8·5×5·1–8·5 μ. The conidia are produced singly at the tips of the acrogenous and pleurogenous cup-like protuberances. The conidia are one-celled, dark brown, oval in shape, almost always with a prominent guttule, smooth and thick-walled, non-catenate, and 20–29×17–21 μ.

The acrogenous and pleurogenous cup-like structures produced on the conidiophores and the production of smooth phæospores singly from the tips of these cup-like structures are the most noteworthy features of the fungus just described and, as far as I am aware, this has not been described for any genus of the Stilbaceæ-Phæosporæ so far known. The genus *Basidiella* Cooke has been considered as a repository for my fungus; but the type species *B. sphærocarpa* was described (Cooke, 1878) as producing roughened phæospores singly at the tips of minute spicules on the conidiophores. I, therefore, propose

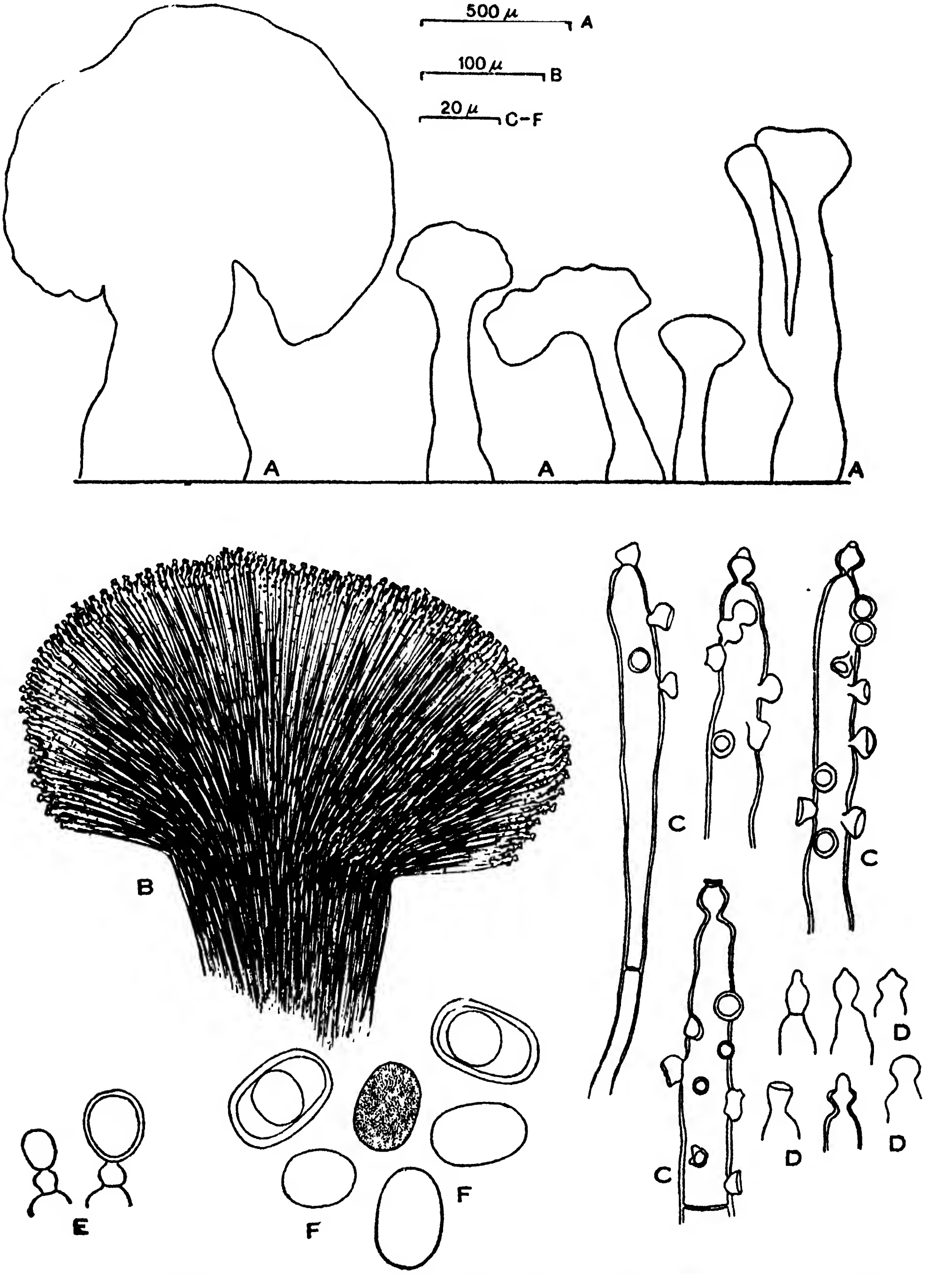

FIG. 9. *Paathramaya sundara* from type specimen, Herb. M.U.B.L. No. 1328. A, young and mature synnemata; B, fertile apex of a synnema; C, tips of conidiophores showing the cup-like protuberances at the tips of which conidia are produced; D, the apex of conidiophores; E, apex of conidiophores showing attachment of conidia; F, young and mature conidia.

a new genus to accommodate my fungus and I am naming it *Paathramaya sundara*, the generic and specific names being derived from Sanskrit: the generic name from पात्र (*paathra* -- vessel, cup) and मय (*maya* -- full of, with many), indicative of the many cup-like structures of the conidiophore; and the specific name from सुंदर (*sundara* -- beautiful).

Paathramaya Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Hyphomycetas, Phæostilbæas, Amerosporas.

Synnemata erecta, simplicia, cylindrica, brunnea, conidiophoris capitatis, dense aggregatis in capitula hemisphærica vel globosa. Conidiophori simplices, sub-hyalini vel pallide brunnei, septati, ad apices fertiles, efformantes conidia singula ad apices tuberum acrogenorum atque pleurogenorum et cyathiformium. Conidia brunnea, unicellulata, haud catenata.

Fungus imperfectus, hyphomycete, Phæostilbeæ, Amerosporæ.

Synnemata erect, simple, cylindrical, brown, with capitate, hemispherical to globose head of closely aggregated conidiophores. Conidiophores simple, sub-hyaline to pale brown, septate, fertile towards the apex, producing conidia singly at the tips of acrogenous and pleurogenous cup-like protuberances. Conidia brown, one-celled, non-catenate.

Type species

Paathramaya sundara Subramanian sp. nov.

Synnemata dispersa in substratum, fusca vel nigro-brunnea, singula ornata pediculo atque capitulo capitato concolore. Stipes erectus, rectus vel curvatus, subcylindricus, 360–750 μ longus, 112–280 (–532) μ crassus ad basim, 35–140 (–322) μ crassus ad medium, 84–182 (–420) μ crassus sub ipso capite, constans plurimis hyphis dense aggregatis, non-ramosis, septatis, subhyalinis vel pallide brunneis. Capitula hemisphærica vel irregulariter subglobosa, 266–532 (–1260) μ in diam., 168–280 (–700) μ alta, constantia ex apicibus liberis dense aggregatis conidiophororum. Conidiophori simplices, subcylindrici, singuli subhyalini sed brunnei in massa, fertiles atque non-septati ad apicem, septati infra, crassis parietibus prædíti, marginibus undulatis, longitudinis variabilis, 10·2–13·6 μ lati ad partem fertilem, usque ad 6·8 μ lati infra (parte fertili usque ad 210 μ longa), singuli ornati uno tubere acrogeno atque usque 20 tuberibus cyathiformibus pleurogenis. Tubera acrogena 6·8–8·5×4·1–6·8 μ, pleurogena vero 5·1–8·5 μ diam. Conidia producta singula ad apices tuberum acrogenorum et pleurogenorum cyathiformium, unicellulata, ovata, fusce brunnea, ut plurimum una guttula prominenti et parietibus levibus atque crassis ornata, haud catenulata, 20–29×17–21 μ.

Typus lectus in ligno quodam emortuo in loco Narsapur, in provincia Hyderabad Deccan die 22 mensis augusti, anni 1955, a C.V.S. et positus in herbario M.U.B.L. sub numero 1328.

10. **Prathoda saparva** gen. et sp. nov.

Another interesting Stilbaceous fungus was also collected by me from the Narsapur forest area in the Hyderabad State, occurring on dead stems in moist situations. A description of the fungus is given below:

The fungus forms numerous dark synnemata on the substratum, occurring singly and scattered, or in small groups. Under a hand lens each stalk of a synnema appears to bear a crown of radiating hyphæ or fungal elements which are somewhat paler in colour. The synnemata are simple, sometimes branched once or repeatedly, erect, straight or bent, 770–980 μ tall and each synnema terminates in one or more obconical clusters of loosely arranged radiating hyphæ (conidiophores) producing conidia. The stalks of the synnemata are somewhat sub-cylindrical, are composed of closely aggregated parallel hyphæ which are unbranched, septate and pale brown in colour, 70–210 μ thick at the base and 56–84 μ thick in the middle. The closely aggregated parallel hyphæ of the stalk spread out towards the tip into one or more groups of loosely compacted clusters of conidiophores and this apical obconical crown of free conidiophore ends is paler in colour than the stalk and is 280–350 μ across and 224–378 μ tall. The conidiophores are simple, very rarely branched, of variable length, pale brown above, dark brown below, thick-walled, smooth, many-septate, constricted at the septa, geniculate, with cylindrical or barrel-shaped cells which are up to 17 μ long; cylindrical cells are 3·4–9·4 μ broad; barrel-shaped cells are 5·1–9·4 μ broad; and the conidiophore tips are 5·1–6·8 μ broad. The conidia are produced acrogenously and singly at the tips of the conidiophores. Successive formation of conidia from the same conidiophore takes place in two ways: (i) a new conidium initial may be formed immediately below the scar of the first formed conidium and when this is repeated a typical geniculate conidiophore results; (ii) the conidiophore may proliferate through the scar of the first formed conidium, grow for a short length and produce another conidium acrogenously and when this process is repeated a conidiophore with many intercalary swellings results. Both types of conidial formation may be found in one and the same conidiophore. The conidia are typical scolecospores of the *Cercospora* type, hyaline to sub-hyaline, long, whip-like, many- (up to 15-) septate, broadest immediately above the basal cell and becoming narrower and almost filiform above, and constricted at the septa in the lower part of each conidium. The conidia are 182–294 μ long. The lowermost cell of the conidium is 6·8 μ broad. The conidium is 8·5–10·2 μ thick where it is broadest and 2·5–3·4 μ broad above where it is filamentous and of uniform thickness.

The fungus clearly belongs to the Stilbaceæ, and its most noteworthy feature is the possession of many-celled conidia which are typical scolecospores. The only genus of the Stilbaceæ known to possess scolecospores is *Pterulopsis* Wakefield and Hansford (*apud* Hansford, 1943, p. 64), but the type species of this genus (*P. dummeri*) produces whitish synnemata and has one-celled hyaline scolecospores

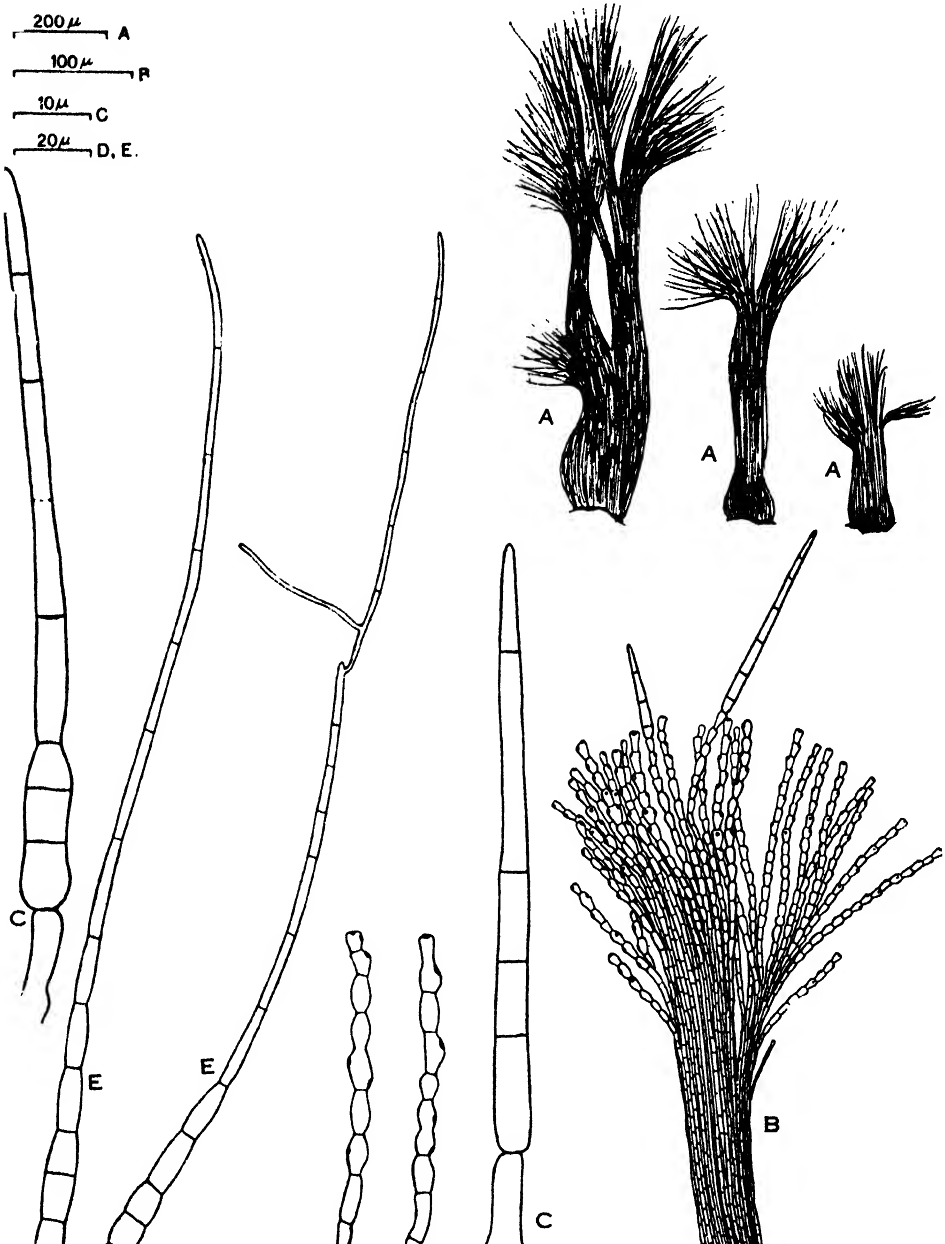

FIG. 10. *Prathoda saparva* from type specimen, Herb. M.U.B.L. No. 1325. A, young and mature synnemata; B, fertile apical part of a synnema; C, conidiophore tips showing attachment of young conidia; D, apical portions of conidiophores showing geniculations; E, two mature conidia, of which one has germinated.

and is placed in the Hyalo-Scolecosporæ. My fungus is obviously not a *Pterulopsis*, since the former belongs to the Phæostilbeæ and has many-septate scolecospores. I am, therefore, proposing a new genus for it and am naming it *Prathoda saparva*, the generic and specific names being derived from Sanskrit: the generic name from प्रतोद (*prathōda* = a long whip), from the resemblance of the scolecospores to a long whip; and the specific epithet from सपर्व (*saparva* = divided), suggestive of the septate nature of the conidia.

Prathoda Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Hyphomycetas, Phæostilbeas, Scolecosporas.

Synnemata erecta, fusce brunnea, simplicia vel ramosa, una alterave aggregatione conidiophororum apicali ornata. Conidiophori simplices vel ramosi, brunnei, septati, geniculati. Conidia hyalina vel subhyalina, longa, scolecospora, pluriseptata, producta singula atque acrogene ex apice conidiophororum; productio successiva conidiorum per incrementum conidiophororum per cicatricem conidii prævii, vel per incrementum renovatum prævii conidii immediate infra cicatricem.

Fungus imperfectus, hyphomycete, Phæostilbeæ, Scolecosporæ.

Synnemata erect, dark brown, simple or branched with one or more apical clusters of conidiophores. Conidiophores simple or branched, brown, septate, geniculate. Conidia hyaline to sub-hyaline, long, scolecosporous, many-septate, produced singly and acrogenously from the tips of conidiophores. Successive production of conidia by growth of conidiophore through scar of previous conidium or by renewed growth from just below scar of previous conidium.

Type species

Prathoda saparva Subramanian sp. nov.

Synnemata plura, singula vel aggregata super substratum, fusca, simplicia, aliquando semel vel pluries furcata, erecta, recta vel curvata, desinentia in unam pluresve catervas obconicas fasciculorum laxe aggregatorum hypharum (conidiophororum) quæ conidiis ortum dant, 770–980 μ alta. Stipites subcylindrici, constantes e hyphis dense aggregatis, parallelis, non-ramosis, septatis, pallide brunneis, 70–210 μ crassi ad basim, 56–84 μ crassi in medio. Fasciculis apicalis radians conidiophororum 280–350 μ diam., 224–378 μ altus. Conidiophori simplices, raro ramosi, longitudinis variabilis, fusce brunnei infra, pallide brunnei supra, crassis parietibus præditi, leves, pluriseptati, constricti ad septa, geniculati, cylindricis vel doliiformibus cellulis ornati usque ad 17 μ longi. Cellulæ cylindricæ 3·4–9·4 μ latæ; doliiformes vero usque 5·1–9·4 μ latæ; conidiophororum apices 5·1–6·8 μ crassi. Conidia hyalina vel subhyalina, longa, scolecospora, usque ad quindecies septata, latissima immediate supra infimam cellulam atque gradatim angustiora evadentia sursum, fastigata in caudam filiformen crassitudinis uniformis, 182–294 μ longa, acrogene producta atque singula ex apicibus conidiophororum; infima cellula conidii 6·8 μ lata. Conidium 8·5–10·2 μ

latum in parte latissima, 2·5–3·4 μ in parte filiformi crassitudinis uniformis. Productio successiva conidiorum per incrementum conidiophororum per cicatricem conidii prævii vel per incrementum renovatum prævii conidii immediate infra cicatricem.

Typus lectus in culmo quodem emortuo in loco Narsapur, in provincia Hyderabad-Deccan, die 22 mensis augusti, anni 1955, a C.V.S. et positus in herbario M U.B.L. sub numero 1325.

11. *Spegazzinia tessarthra* (Berk. & Curt.) Sacc., 1886, *Sylloge Fungorum*, **4**: 758; Damon, S. C., 1953, *Bull. Torrey bot. Cl.*, **80**: 162; Hughes, S. J., 1953, *Mycol. Pap.*, **50**: 62–64.

Sporidesmium tessarthrum Berk. & Curt., 1869, *J. Linn. Soc.* (*Bot.*), **10**: 355.

Spegazzinia ornata Sacc., 1880, *Rev. mycol. Toulouse*, **2**: 140; 1886, *Sylloge Fungorum*, **4**: 758.

Tetrachia quadrigemina Berk. & Curt. ex Cooke, 1884, *Grevillea*, **12**: 97.

Triposporium cristatum Pat., 1888, *Bull. Soc. mycol. Fr.*, **4**: 125; Saccardo, 1892, *Sylloge Fungorum*, **10**: 739.

Spegazzinia tucumanensis Speg., 1896, *Rev. Fac. Agron. La Plata*, **19**: 256; Saccardo, 1899, *Sylloge Fungorum*, **14**: 1132.

Spegazzinia brasiliensis Speg., 1919, *Bol. Acad. nac. Ciencas*, **23**: 538; Saccardo, 1931, *Sylloge Fungorum*, **25**: 997.

The fungus forms black pulverulent colonies of variable shape and size on the substratum. Two types of conidia are produced: the spiny and the smooth.

The spiny conidia are dark brown in colour and composed of four cells adpressed in one plane. They are 17–26 μ broad, 15–26 μ tall and 13–16 μ thick, excluding the spines. Each conidium bears a number of pale brown to sub-hyaline, irregular, straight or curved spines up to 12 μ long and 1–2 μ thick at the base. The conidiophore is inserted towards the inner angle of one of the four cells of the conidium in such a way that the plane of the four cells of the conidium is at right angles to the conidiophore. The conidiophores bearing these spiny conidia may be long macroconidiophores or short microconidiophores. The macroconidiophores are brown, simple, thick-walled, non-septate, erect, straight, bent or flexuous, 80–150 μ long, up to 4·2 μ thick at the tip and 1–2 μ thick elsewhere. The microconidiophores are similar to the macroconidiophores but much shorter, being 25–60 μ long. The conidiophores arise from a conspicuous swollen conidiophore mother cell 5·1–7·7 μ tall and 4·2–5·1 μ thick. This swollen cell is produced laterally from cells of the repent hyphæ which are 1–3 μ thick, sub-hyaline, septate and branched.

The smooth conidia are dark brown, disc-shaped and flattened in a vertical plane, cruciately divided by oblique septa into four equal somewhat triangular cells, constricted at the septa, attached to the conidiophore by the broad side of one of the four cells, 12–17 μ long and wide and 8–9 μ thick. Invariably, each conidium has a short, thin pedicel indicating the point of attachment to the conidiophore; the pedicel is up to 5 μ broad, up to 2 μ tall, and is sub-hyaline. The conidia are produced on extremely short conidiophores about 3 μ long and 5 μ thick.

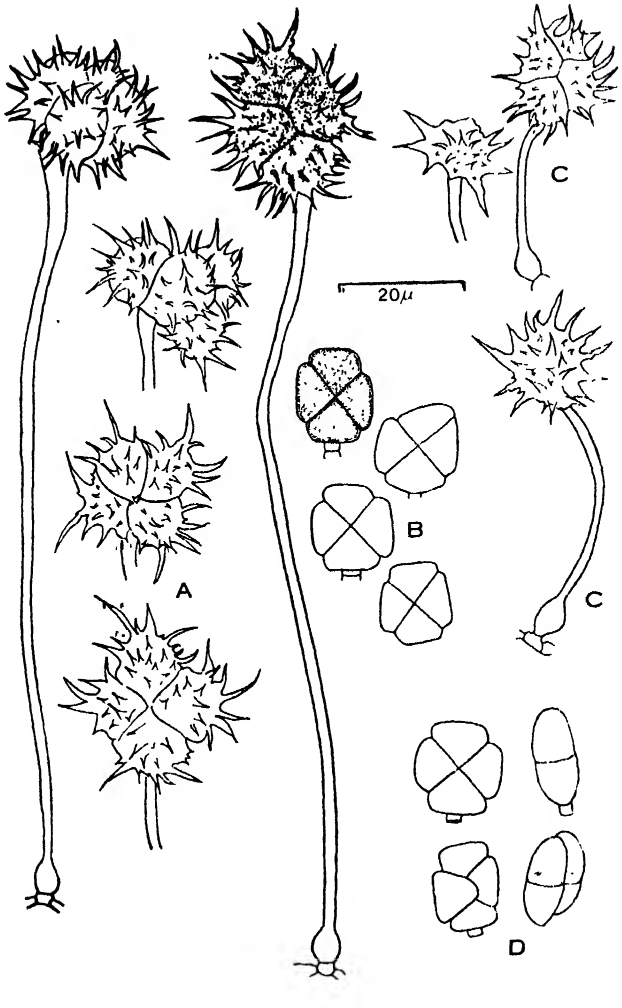

FIG. 11. *Spegazzinia tessarthra*. A, B, spiny and smooth conidia from Herb. M.U.B.L. No. 1383; C, D, the same from Herb. M.U.B.L. No. 1387.

Two collections of this fungus have been seen: on dead culms of grass, Sim's Park, Coonoor (Nilgiris District, Madras State), coll. C.V.S., 23–9–1955 (Herb. M.U.B.L. No. 1387); 25–9–1955 (Herb. M.U.B.L. No. 1384).

An earlier report of this fungus from India is that of Chona and Munjal (1950) who collected it on dead leaves of *Cynodon dactylon* at New Delhi and recorded it as *S. ornata* Sacc.

12. **Spegazzinia sundara** sp. nov.

The fungus forms black, pulverulent colonies of variable size on the substratum. The sporodochia are of variable size, and consist of closely aggregated clusters of numerous conidiophores and conidia. Two types of conidia are produced: the spiny and the smooth.

Spiny conidia and conidiophores.—The spiny conidia are of variable shape and size, dark brown in colour, and may be 1–4-celled. They are borne singly and acrogenously at the tips of conidiophores. Each conidium is ornamented all over with many spines which are up to 8·5μ long and 2·5μ wide. The one-celled conidia are sub-globose to ovoid and measure 10–12μ in diameter, excluding the spines; the two-celled ones measure 20 × 12μ and the four-celled ones 25·5–30·6 × 15·3–23·8μ. The conidial septa are oriented as in the case of *Spegazzinia tessarthra*, but there is greater cleavage so that the conidia appear deeply lobed. The conidiophores are simple, long and filamentous, erect, straight or flexuous, pale brown, non-septate, (21)–79–137μ long, 2–3μ broad at the apex, and 1–2μ broad below.

Smooth conidia and conidiophores.—The smooth conidia are dark brown in colour, disc-like and flattened in a vertical plane, cruciately divided into four somewhat equal cells, deeply constricted at the septa, having irregularly lobed edges, 18·7–25·5μ long and wide and 9–10μ thick. In most cases the basal cell of the conidium is somewhat conical, the apical cell is obconical and the two middle cells which are found in the same plane are separated by a narrow vertical septum; the apical and the basal cells are separated by the two middle cells. Rarely, the conidia may have fewer cells or sometimes up to 7 cells, but these may be considered abnormalities. The conidia are produced acrogenously and singly at the tips of conidiophores and are attached to the conidiophores by the broad ends of their basal cells. The conidiophores are simple, of uniform thickness throughout or possessing one or more constrictions, non-septate, sub-hyaline to pale brown, erect, straight or flexuous, thin and filamentous, (16)–21–69μ long, 3·4–5·1μ broad at the apex, and 1–3μ thick at the base.

Two collections in the Herb. M.U.B.L. are being assigned to this taxon, *viz.*, No. 1362 and No. 585. The description given above is based on a study of No. 1362. No. 585 has both types of conidia: the spiny ones are 2–4-celled, 13·6–20·4μ long, 11·9–17·0μ across (excluding the spines), the spines being up to 4·2μ long and 1·7μ thick; they are borne on conidiophores which are 61–162μ long. The smooth conidia measure 13·6–17·0×11·9–15·3μ and are about 10μ thick; they are similar to those of No. 1362, are slightly smaller and the lobing of the four cells is less conspicuous, but nevertheless is present. Further, these conidia appear to be produced on very short, inconspicuous conidiophores.

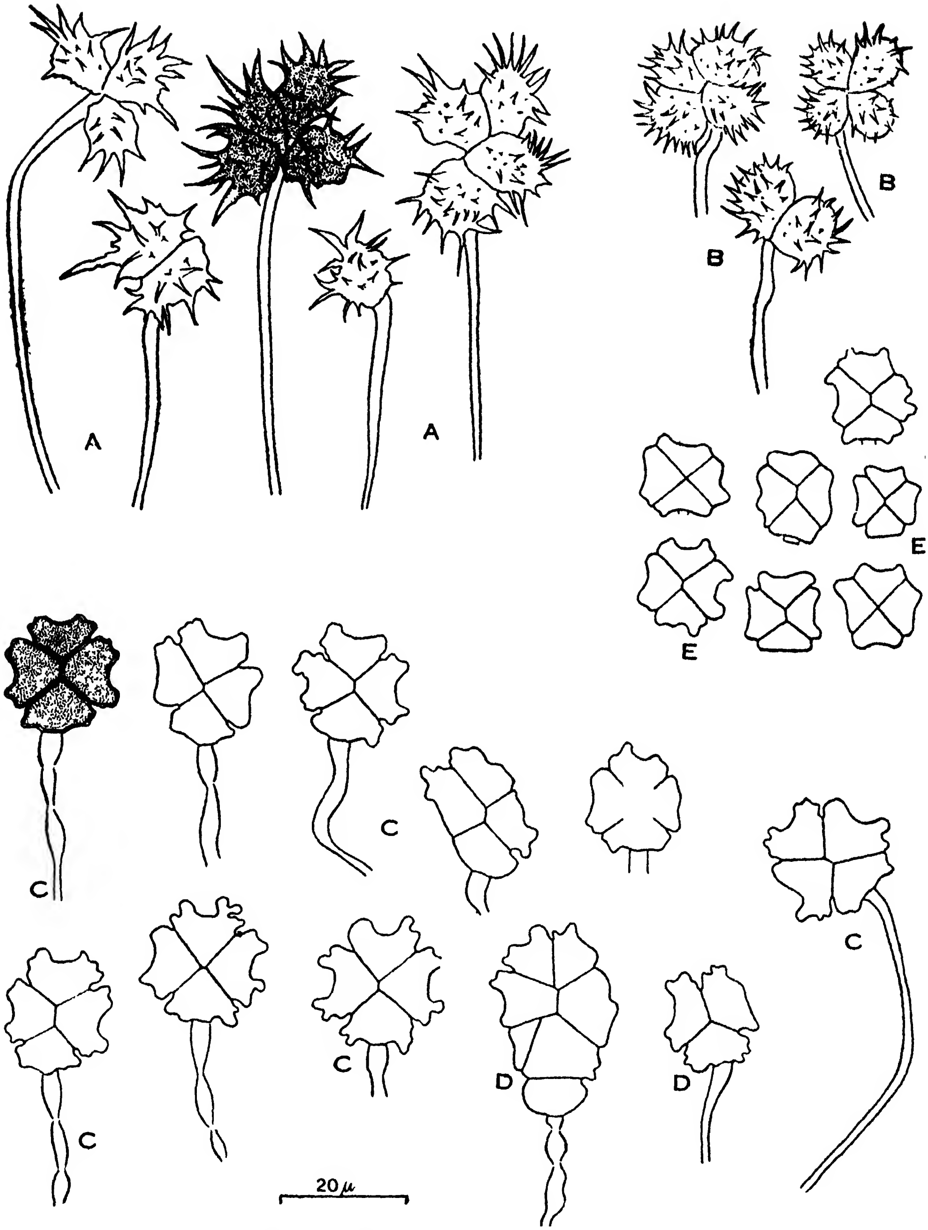

FIG. 12. *Spegazzinia sundara.* A, B, spiny conidia; C, E, normal smooth conidia; D, abnormal smooth conidia. A, C, D, from type specimen, Herb. M.U.B.L. No. 1362; B, E, from Herb. M.U.B.L. No. 585.

It will be obvious from the above description that my fungus is quite distinct from *Spegazzinia tessarthra* in having highly lobed smooth conidia and their larger size compared to the smooth conidia of *S. tessarthra.* On the basis of these differences, I propose to describe my fungus as a new species of *Spegazzinia.*

Spegazzinia sundara Subramanian sp. nov.

Sporodochia nigra, pulverulenta, magnitudinis variabilis. Conidia duplicis formæ: spinosa et levia.

Conidia spinosa magnitudinis et formæ variabilis, fusce brunnea, 1-4-cellulata, producta singula acrogene ad apices conidiophororum; spinulæ usque ad 8·5 μ longæ, 2·5 μ crassæ; conidia unicellulata subglobosa vel ovoidea, 10-12 μ diam. (spinulis exclusis); conidia bicellulata 20 × 12 μ; conidia 4-cellulata vero 25·5–30·6 × 15·3–23·8 μ. Conidiophori supportantes conidia spinosa simplices, longi, filiformes, erecti, recti vel incurvi, non-septati, pallide brunnei, (21)-79–137 μ longi, 2-3 μ lati ad apicem, 1-2 μ lati infra.

Conidia levia brunnea, discoidea et complanata in plano verticali, cruciformiter divisa in 4 cellulas plus minusve aequales (cellula basal conica, cellula apicali obconica, duplici cellula media separata per septum breve verticale), alte constricta ad septum, marginibus irregulariter lobatis, 18·7-25·5 μ longa et lata, 9-10 μ crassa, infixa conidiophoro per marginem latum cellulæ basalis. Conidiophori supportantes conidia simplices, filiformes, crassitudinis uniformis, vel semel bisve constricti, non-septati, subhyalini vel pallide brunnei, erecti, recti vel flexuosi, (16)-21-69 μ longi, 3·4-5·1 μ lati ad apicem, 1-3 μ crassi ad basim.

Typus lectus in quadam planta bambusina emortua, in campo "Corporation Zoo", in urbe Madras, die 9 mensis septembris anni 1955 a C.V.S. et positus in herbario M.U.B.L. sub numero 1362; lectus etiam in foliis emortuis *Ananas sativæ* Schult. f., in Chingavanam, T.C. State, die 8 mensis octobris 1951, a K. Ramakrishnan et positus in herbario M.U.B.L. sub numero 585.

Recently, Hughes (1953, p. 65) described a new variety of *Spegazzinia tessarthra*, *viz.*, v. *deightonii* from the Gold Coast and it was characterised as follows: "A typo ita differt: conidia 8-cellulata." This new variety *deightonii* is sufficiently distinct from *S. tessarthra* as to merit specific rank. Accordingly, I propose' to. accord specific rank to this variety:

Spegazzinia deightonii (Hughes) Subramanian comb. nov.

Basonym.—*Spegazzinia tessarthra* (Berk. & Curt.) Sacc. var. *deightonii* Hughes, 1953, *Mycol. Pap.*, **50**: 65.

Type.—On *Saccharum officinarum*, Gold Coast (Colony), Takoradi, 10–5–1949, Herb. I.M.I. 38568 (*b*).

13. **Sporidesmium nilgirense** sp. nov.

This interesting fungus was collected on dead bamboo (*Bambusa nana* Hort.) from the Government Gardens, Ootacamund (Nilgiris), during a visit in 1953. The colonies on the substratum are dark brown and effuse. The repent hyphæ are sub-hyaline to pale brown, branched, septate and 2–4 μ broad. The conidiophores arise laterally from cells of the repent hyphæ or on short one-celled lateral branches therefrom. They are simple, short, somewhat cylindrical, erect, straight or bent, brown, 3–5-septate, up to 90 μ long and 5·9–8·5 μ broad. The conidia are produced acrogenously and singly at the tips of the conidiophores. They are elongate-obclavate, broadest immediately above the base,-

becoming progressively narrower and finally tapering to somewhat uniform thickness above, many times transversely septate and constricted at the septa. Each conidium has a flat base 4·2–5·1 μ broad where it is attached to the conidiophore. The conidia are 70–210 μ long, 11·9–15·3 μ where they are broadest and 4·2–6·8 μ broad at the tips. They are dark brown, may be slightly paler in colour towards the apex and are straight, bent or curved.

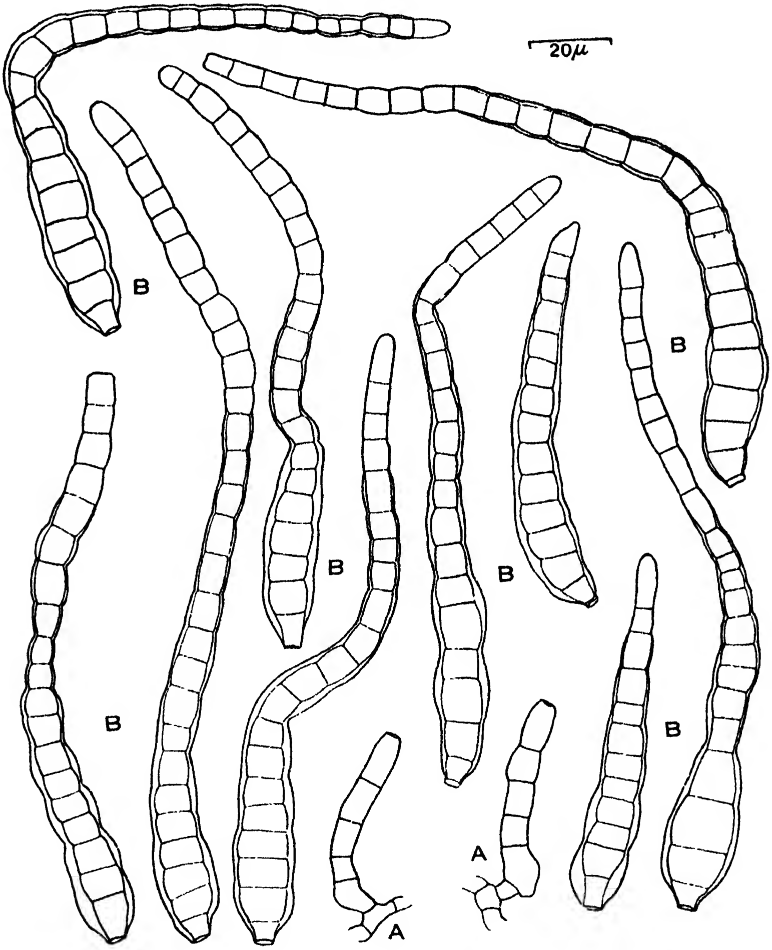

FIG. 13. *Sporidesmium nilgirense* from type specimen, Herb. M.U.B.L. No. 1031. A, conidiophores; B, mature conidia.

I consider that the fungus just described is best placed in the genus *Sporidesmium* and since it appears to differ from species of this genus so far known, I am describing it as a new species.

Sporidesmium nilgirense Subramanian sp. nov.

Coloniæ fusce brunneæ, effusæ. Hyphæ repentes subhyalinæ vel pallide brunneæ, ramosæ, septatæ, 2–4 μ latæ. Conidiophori surgentes lateraliter e cellulis hypharum repentium vel e ramulis brevibus unicellulatis lateralibus hypharum repentium, simplices, breves, aliquantum cylindrici, erecti, recti vel curvati, brunnei, 3–5-septati, usque ad 90 μ longi, 5·9–8·5 μ lati. Conidia elongato-obclavata, latissima supra ipsam basim, progressive evadentia angustiora atque tandem desinentia supra in partem uniformiter crassam, fusce brunnea colore, tenuiter pallidiora ad apicem, recta, curvata vel flexa, sæpissime transverse septata, constricta ad septa, 70–210 μ longa, 11·9–15·3 μ ad partem latissimam, 4·2–6·8 μ lata ad apicem, singula conidia ornata basi plana 4·2–5·1 μ lata.

Typus lectus in culmis emortuis *Bambusæ nanæ* Hort. in "Government Gardens", in loco Ootacamund, in dist. Nilgiris, provincia Madras, die 9 mensis decembris anni 1953, a T. S. Sadasivan et positus in herbario M.U.B.L. sub numero 1031.

14. *Stigmina maculata* (Cooke) Hughes, 1952, *Mycol. Pap.*, **49**: 11.

Clasterosporium maculatum Cooke, 1876, *Grevillea*, **4**, No. 31, 117; Saccardo, 1886, *Sylloge Fungorum*, **4**: 392.

? *Exosporium fici* Payak & Thirum. (*nomen nudum*) *apud* Payak, 1953, *Sci. & Cult.*, **18**: 343.

A collection of this fungus was made from the Mysore State during a visit in 1953. The fungus forms dark brown, irregular colonies on living leaves and the colonies consist of clusters of conidiophores arising from immersed stromata. The conidiophores are somewhat cylindrical, simple, erect, straight or bent, often somewhat broader towards the base, dark brown below, paler above, with hyaline tip, up to 3-septate, 28–55 μ long and 5·1–6·0 μ wide. The basal cell of the conidiophore may be up to 12 μ broad. The conidia are produced acrogenously and singly at the tips of conidiophores. They are mostly sub-cylindrical to obclavate, with a broad and flat base, broadest towards the middle or nearer the base, gradually or somewhat suddenly tapering above into a narrow elongate apex, dark brown in colour but becoming paler towards the tip which is sub-hyaline, smooth, up to 7-septate, not constricted at the septa, 30–75 μ long, and 5·1–8·5 μ thick where they are broadest. The conidia are 3·4–6·0 μ thick at the base.

Habit.—On living leaves of *Ficus* sp., Chamundi Hills, Mysore, coll. K.R. & C.V.S., 11–10–1953, Herb. M.U.B.L. No. 919.

The fungus appears to be identical with the type collection of *Clasterosporium maculatum* Cooke, "on leaves of *Ficus cordifolia*, India, coll. Hobson [616]", as re-described and figured by Hughes (1952, pp. 11–13), notwithstanding the fact that the conidia in the type collection were stated to be mostly 8–9 (mostly 9)-septate, whereas in my fungus they are not more than 7-septate. I have followed Hughes in classifying the fungus under *Stigmina.*

Payak (1953) recently reported *Exosporium fici* Payak & Thirum. n.sp. on living leaves of *Ficus bengalensis* from Poona, Bombay State.

No description was given. I have not seen a specimen either; but it is not unlikely that Payak's fungus is the same as *Stigmina maculata.*

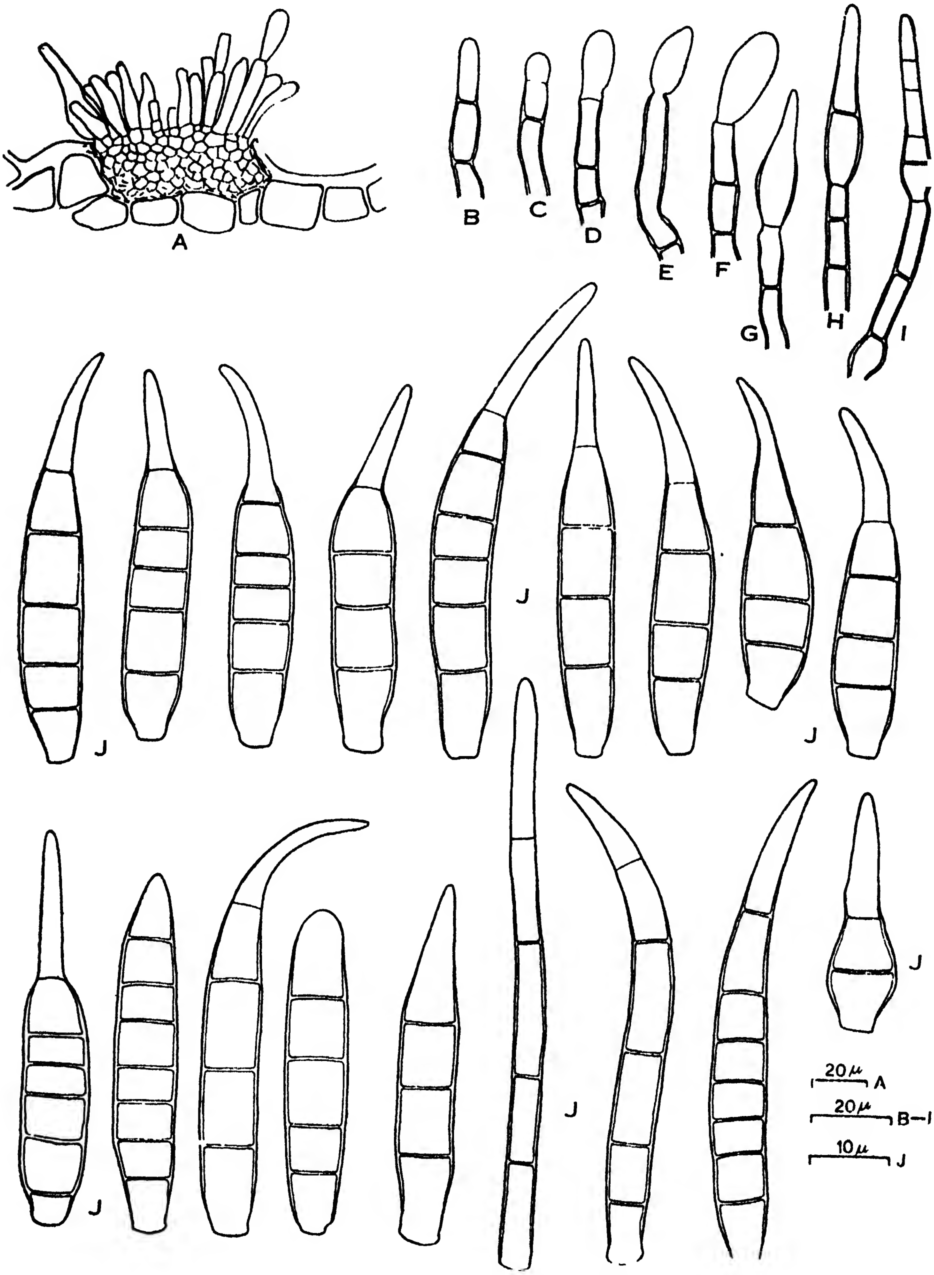

FIG. 14. *Stigmina maculata* from Herb. M.U.B.L. No. 919. A, a cluster of conidiophores; B–I, development of conidia; J, mature conidia.

It is noteworthy that the type collection of *Clasterosporium maculatum* is from Kolapore, Bombay State (Butler and Bisby, 1931).

15. *Stigmina palmivora* (Sacc. *apud* Trelease) Hughes, 1952, *Mycol. Pap.*, **49**: 13.

Exosporium palmivorum Sacc. *apud* Trelease, 1898, *Rep. Mo. bot. Gdns.*, **9**: 159; Saccardo, 1902, *Sylloge Fungorum.* **16**: 1106; Butler, E. J. & Bisby, G. R., 1931, *Sci. Monogr. Coun. agric. Res. India*, **1**: 145.

A collection of this fungus, occurring on living leaves of *Phœnix* sp., was recently made from the Nilgiris. The fungus causes leaf spots which are angular or rounded, pale brown to brownish-black and of variable size. Each spot has clusters of conidiophores bearing conidia. The conidiophores arise from a stromatic base which is immersed in the host tissue. They are short, simple, cylindrical, brown, up to 15 μ long and 5·1–6·8 μ broad at the tip, and straight or slightly bent. The conidia are produced acrogenously and singly at the tips of the conidiophores. They are fusoid-clavate, with a rounded apex and a lower portion tapering gradually to a flat scar, straight, bent or curved, pale to dark brown, thick-walled, verrucose, up to 13-septate, 72–108 μ long, 5·1–6·8 μ broad at the base, 8·5–10·2 μ where they are broadest, and 4·3–6·8 μ broad at the tip.

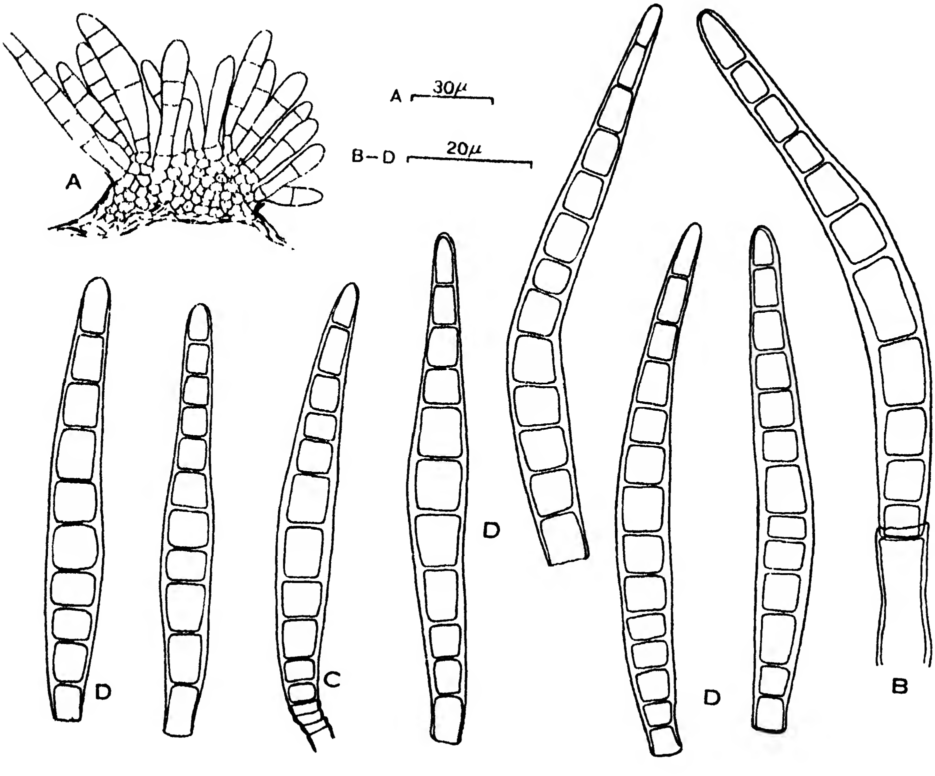

Fig. 15. *Stigmina palmivora*, from Herb. M.U.B.L. No. 991. A, a cluster of conidiophores; B, C, showing attachment of conidia to conidiophores; D, mature conidia.

Only one collection has been made: on living leaves of *Phœnix* sp., Sim's Park, Coonoor (Nilgiris District, Madras State), 8-12-1953, coll. T. S. Sadasivan and C. V. S., Herb. M.U.B.L. No. 991.

16. **Tharoopama trina** gen. et sp. nov.

The fungus forms conspicuous scattered, superficial, erect synnemata on the substratum, *viz.*, dead culms of grass occurring in moist leaf litter. Under a hand lens, each synnema is seen to have a short, simple, brownish-black stalk and an apical head which is ash gray in colour and may be globose, oval or somewhat irregular in outline. The synnemata are 740–1470 µ tall and the apical heads up to 1190 µ in diameter. The structure of the fungus as revealed by microscopic examination is as follows: The synnema has a dark brown stalk which is somewhat cylindrical, simple, swollen at the base, and composed of numerous pale olivaceous brown, unbranched, septate, parallel hyphæ up to 4 µ thick closely aggregated together. The stalks are 504–1050 µ long, 84–140 µ thick at the base and 42–70 µ thick above. Usually, well over half the upper portion of each stalk is fertile and in this region the individual hyphæ of the synnema progressively become free and diverge from the main stalk to form the conidiophores. The fertile portion of the stalk is usually 350–910 µ long and the diameter of the fertile part including the much branched conidiophores is 460–1190 µ. The conidiophores, which are the free ends of the hyphæ of the synnema, are brown in colour, but progressively become paler and finally hyaline towards the tips. They are 84–350 µ long, diverging at varying angles with reference to the main stalk of the synnema, straight, bent or curved, septate (the distance between septa varying from 14–29 µ), 3–8 µ thick, and branched. Conidiophore branches are produced laterally from cells of the main conidiophore, mostly immediately below septa and confined to one side of the conidiophore. These branches may be formed at right angles to the main conidiophore or else may form an acute angle with the latter. Secondary and tertiary branches may be porduced in the same way. In cases where more than one lateral branch arise from the sub-apical cell of the main conidiophore or a branch, or from any other cell of the conidiophore or its branches, a resemblance to a verticil is seen, but they are not true verticils. Indeed, the branching described above reminds one of the conidiophores of *Hansfordia* spp. recently described by Hughes (1951 *b*). The ultimate branches, which alone bear conidia, are hyaline, subcylindrical, one-celled, 14–33 µ long and 3–4 µ wide. The conidia are produced acrogenously and singly from the tips of the ultimate one-celled branches and successive production of conidia from the same conidiophore by renewed growth immediately below the scar of the fallen conidium gives the tips of ultimate branches a geniculate appearance. The geniculations may not be seen in young synnemata in which conidial production has just started, but are conspicuous in older ones. The conidia are globose with a basal apiculus, hyaline, smooth, one-celled, and 3–4 µ in diameter.

The fungus just described is easily placed in the Moniliales-Phæostilbeæ, but I know of no genus in which it can be accommodated.

The nature of the conidiophore, its branching, the geniculate character of the ultimate branches and the one-celled conidia are suggestive of *Hansfordia* spp. (Hughes, 1951 *b*). My fungus, however, is not a

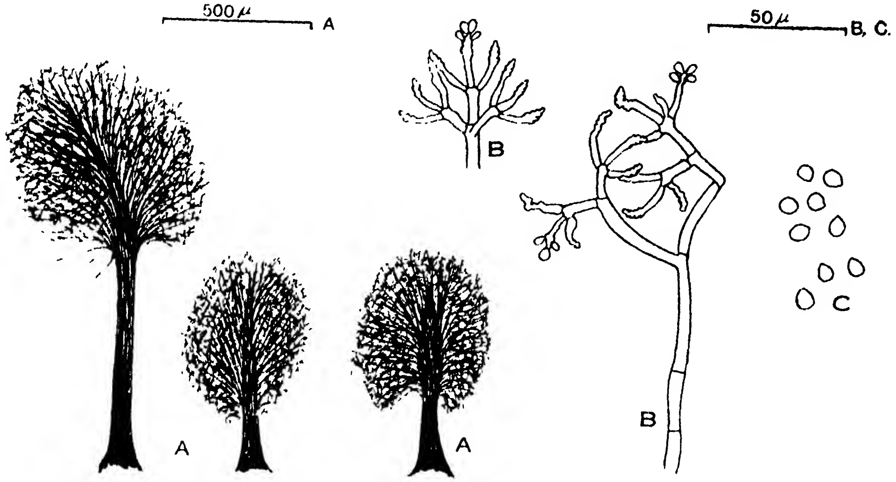

FIG. 16. *Tharoopama trina* from type specimen, Herb. M.U.B.L. No. 1416. A, synnemata; B, portions of conidiophores showing their branching and the production of conidia; C, mature conidia.

simple Dematiaceous one but forms distinct and conspicuous synnemata. I am, therefore, proposing a new genus for its accommodation and naming it *Tharoopama trina*. The generic and specific names are derived from Sanskrit: the generic name from तरु (*tharu* = tree) and उपम (*upama* = like, resembling), suggestive of the tree-like appearance of the synnemata; the specific name from त्रिण (*trina* = grass), from the substratum (grass) on which it was collected.

Tharoopama Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Stilbaceas, Phæostilbeas, Amerosporas.

Synnemata superficialia, erecta, stipite atque capitulo bene definitis. Stipes erectus, subcylindricus, fertiles supra, constans e hyphis dense aggregatis, parallelis, haud ramosis, septatis, brunneis. Singulæ hyphæ synnematum progressive liberæ evadunt in parte fertili stipitis atque ex stipite divergunt ad efformandos conidiophoros. Conidiophori subhyalini vel brunnei, septati, semel furcati vel bis terve. Ramuli tantum finales fertiles, semel cellulati, geniculati ad apicem. Conidia acrogene producta singulariter ad apices ramulorum terminalium vel ex successivis punctis crescentibus novis, quæ immediate sub cicatrice conidii lapsi surgunt, hyalina, globosa, semel cellulata.

Fungus imperfectus, Moniliales, Stilbaceæ, Phæostilbeæ, Amerosporae.

Synnemata superficial, erect, with well-defined stalk and head. Stalk erect, subcylindrical, fertile above, composed of closely aggregated parallel, unbranched, septate, brown hyphæ. Individual hyphæ of synnema progressively becoming free in the fertile part of stalk, diverging from the stalk to form conidiophores. Conidiophores subhyaline to brown, septate, branched once, twice or thrice. Ultimate branches alone fertile, one-celled, geniculate towards the apex. Conidia produced acrogenously and singly at the tips of ultimate branches or from successive new growing points arising from immediately below the scar of a fallen conidium, hyaline, globose, one-celled.

Type species

Tharoopama trina Subramanian sp. nov.

Synnemata dispersa in substratum, conspicua, superficialia, erecta, 740–1470 μ alta, stipite atque capitulo bene definitis, capituli diametro 460–1190 μ. Stipes nonnihil cylindricus, simplex, ad basim tumescens, constans e plurimis hyphis (quæ sunt olivaceo-brunneæ, non-ramosæ septatæ, usque ad 4 μ crassæ, dense aggregatæ), 504–1050 μ longus, 84–140 μ crassus ad basim, 42–70 μ crassus supra. Ut plurimum dimidium superius stipitis vel plus quam dimidium fertile, hyphis singulis synnematis in hac parte progressive liberis evadentibus atque divergentibus ex stipite principali ad efformandos conidiophoros. Pars fertilis stipitis 350–910 μ longa. Conidiophori brunnei, progressive evadentes pallidiores atque tandem hyalini ad apices, 84–350 μ longi, divergentes ex stipite synnematis ad angulos varios, recti, curvati vel flexi, septati, 3–8 μ crassi, ramosi. Conidiophororum ramuli primarii, secundarii et tertiarii, producti lateraliter ex cellulis conidiophori ut plurimum immediate sub septis, atque ut plurimum ad unum latus conidiophori vel ramulorum restricti. Ramuli terminales hyalini, subcylindrici, semel cellulati, 14–33 μ longi, 3–4 μ lati, geniculati ad apices. Conidia producta acrogene atque singulariter ex apicibus ramulorum terminalium vel ex successivis punctis crescentibus immediate sub cicatrice conidii lapsi, globosa, apiculata, hyalina, semel cellulata, lævia, 3–4 μ diam.

Typus lectus in culmis emortuis cuiusdam graminis (an *Cynodontis dactyli* ?) in stramento foliorum humido, in campo Laboratorii Botanici Universitatis, Madras, die 9 mensis novembris anni 1955, a C. V. S. et positus in herbario M.U.B.L. sub numero 1416; lectus etiam in leguminibus emortuis *Cæsalpiniæ pulcherrimæ* Sw. in stramento foliorum humido eodem loco die 10 mensis novembris anni 1955 ab eodem auctore et positus in herbario M.U.B.L. sub numero 1419.

From a study of literature, I find that a fungus closely resembling *Tharoopama trina* has been previously described by Penzig and Saccardo (1904), *viz.*, *Trichosporium arborescens* (Saccardo, 1906, p. 573). *T. arborescens* is not a *Trichosporium*. It cannot even be a *Hansfordia*, as suspected by Hughes (1951 *b*, p. 24). Penzig and Saccardo described their fungus as follows: "Cæspitosum, latum, brunneogriseum; hyphis filiformibus prælongis, 5 μ cr., liberis v. fasciculato-connexis, atro-fuligineis, sursum iterato et crebro ramosis, paniculam amplam formantibus, ramis ultimis pallidioribus attenuatis, conspicue tortuosis denticulatisque; conidiis sphæricis, diu minutis pallidis, dein fuligineis, 9·5 10μ diam., levibus, ex denticulis orientibus. Hab. in foliis marcescentibus, in horto Bogoriensi. Javæ—Pulcra species ad *Streptotrichem* et *Botrytidem* accedens et ob hyphas sæpe densiuscule fasciculatas etiam ad *Graphium* nutans.—A *T. fusco* differt ramis crebrioribus, conidiis sphæricis, etc." Penzig and Saccardo's figure of *T. arborescens* is also reproduced herewith in Plate IV, Figs. 3, 4. I have not seen a specimen, but from a study of Penzig and Saccardo's description and figure, it appears to me that *T. arborescens* resembles *Hansfordia* spp. in the branching of the conidiophore and the production of conidia, etc., but differs from the latter in having the conidiophores aggregated to form distinct and conspicuous synnemata. Indeed, Penzig and Saccardo's remarks on their fungus (which is reproduced above) and the suggested affinity to *Graphium*, the reference in their description to "hyphis liberis v. fasciculato-connexis", and their figures all indicate that the fungus is best accommodated in the Stilbaceæ. Further, from the description it would appear that its systematic position in the Stilbaceæ would be under the Phæostilbeæ. A critical comparison of *Tharoopama trina* with Penzig and Saccardo's description and figure of *Trichosporium arborescens* indicates that both species are congeneric. *T. arborescens*, however, has much larger conidia than *Tharoopama trina* and may, therefore, be considered specifically distinct from the latter. Accordingly, *Trichosporium arborescens* is being transferred to *Tharoopama*:

Tharoopama arborescens (Penzig and Saccardo) Subramanian comb. nov.

Basonym. Trichosporium arborescens Penzig & Saccardo, 1904, *Icones fungorum javanicorum*, p. 101, plate lxix, 3; Saccardo, 1906, *Sylloge Fungorum*, **18**: 575.

17. *Umbellula terrestris* (Timonin) Morris, 1955, *Mycologia*, **47**: 602.

Spicularia terrestris Timonin, 1940, *Canad. J. Res.*, C, **18**: 314.

A collection of this interesting fungus was made by Professor Sadasivan and myself from the Nilgiris in 1953. The fungus forms effuse, somewhat bluish-green growth on the substratum. The repent vegetative hyphæ are brown, branched, septate and up to 6μ broad. The conidiophores arise laterally from cells of the repent hyphæ. They are unbranched and simple, erect, mostly straight, septate, dark brown with the apical cell alone being sub-hyaline, slightly tapering towards the tip, terminating in a verticil of up to about 16 simple, hyaline, sterigma-like branches of more or less equal length, each of which in turn terminates in a somewhat globose or sub-globose tip bearing many (about 25–30 is usual) conidia produced singly on minute, short pegs. The conidia are oblong-ovate, two-celled, subhyaline to pale greenish-brown (bluish-green in mass), smooth-walled, not constricted at the septa, and with a somewhat mamillate basal scar indicating the point of attachment. The measurements of the various parts of the conidiophore and conidia are:

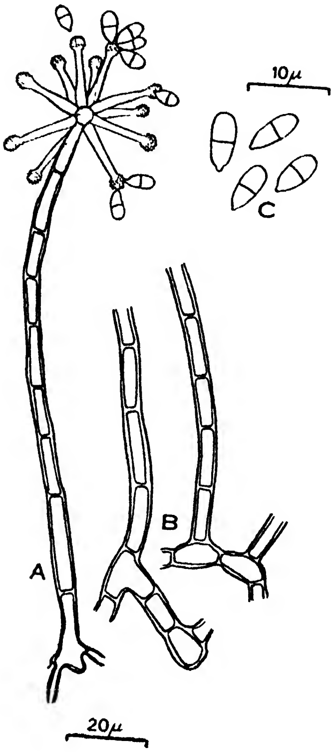

FIG. 17. *Umbellula terrestris* from Herb. M.U.B.L. No. 1050. A, conidiophore and conidia; B, basal portion of conidiophores; C, mature conidia.

Main stipe of the conidiophore.—Length up to 180 μ; breadth at the base 4·2–8·5 μ; breadth at the middle 6·0–7·7 μ; apical cell of the stipe 15·3–25·5 × 3·4 μ; distance between septa of the stipe up to 24 μ; sterigma-like branch 11·9–18·7 × 2·5–3·4 μ; diameter of globose tip of sterigma-like branch 3·4–5·1 μ.

Conidia.—6·8–7·7 × 2·5–3·4 μ.

Habit.—On dead stem, Coonoor (Nilgiris Disrtict, Madras State), 8–12–1953, coll. T. S. S. & C. V. S., Herb. M.U.B.L. No. 1050.

18. *Wiesneriomyces javanicus* Koorders, 1907, *Verh. Akad. Wet. Amst.*, **13** : 246, fig. 57; Saccardo, 1913, *Sylloge Fungorum*, **22**: 1496–97.

=*Chætosira javanica* (Koorders) Clem., Clements, F. E., and Shear, C. L., *The Genera of Fungi*, p. 403.

A collection of this pretty fungus was recently made from the University Botany Laboratory campus, Madras. The fungus forms scattered sporodochia on the substratum. The sporodochia are dark in colour, cup-like, mostly with a narrow, short stipe, setose, 210–280 μ tall, 126–378 μ wide where they are broadest and 28–98 μ wide at the base. The setæ are dark brown, slightly paler towards the apex, simple, erect, mostly bent in characteristic manner so as to have an inner concavity with reference to the sporodochium, long, up to 10-septate, the distance between septa being 14–51 μ, swollen and 7–11 μ thick at the base, 4·8 7·2 μ wide above, subulate with a somewhat pointed or blunt tip, and 126–266 μ long. Each sporodochium has

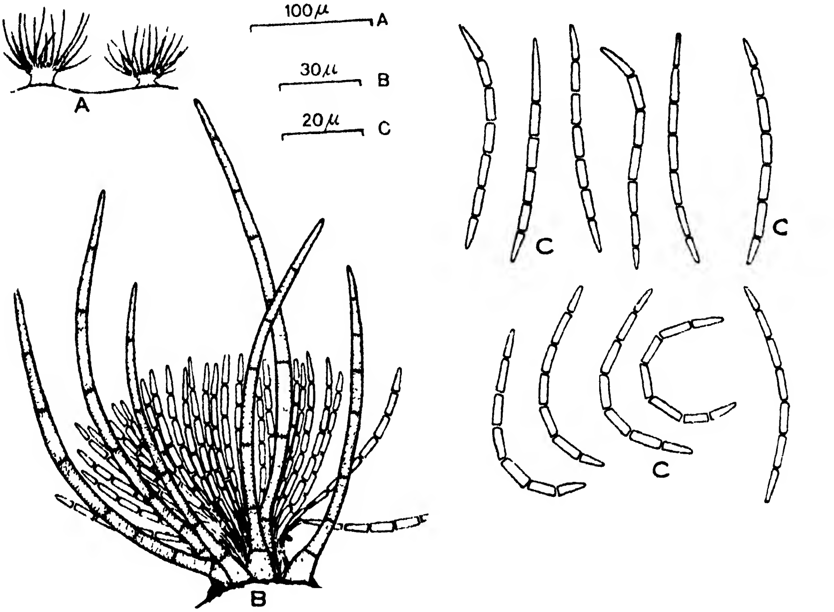

Fig. 18. *Wiesneriomyces javanicus* from Herb. M.U.B.L. No. 1418. A, B, aporodochia; C, conidia.

a varying number of setæ and up to 35 have been seen per sporodochium. The conidiophores arise from a dark brown stromatic base and are closely aggregated parallel to each other forming a hymenium surrounded by the sterile setæ. The conidiophores are simple, erect, cylindrical, non-septate, hyaline, 10–18 μ long and 2–3 μ broad. The conidia are produced singly and acrogenously at the tips of the conidiophores. They are hyaline to sub-hyaline, 5–7 (–11)-septate, somewhat filiform, being broadest in the middle, becoming slightly narrower towards the base and towards the apex, somewhat pointed at the apex, straight, slightly bent, falcate or curved, 49·3–69·7 μ long, and 2·5–3·4 μ wide where they are broadest. Each conidium at maturity often fragments into its individual cells or 2-more-celled pieces. The one-celled segments from the middle portion of the conidia are cylindrical and 7·6–17·0 μ long. The apical segments of the conidia are usually shorter, being 5·9–10·2 μ long.

Habit.—On dead leaves of *Cæsalpinia pulcherrima* Sw., in moist leaf litter, University Botany Laboratory campus, Madras, 9–11–1955, coll. K. Ramakrishnan, Herb. M.U.B.L. No. 1418.

My collection agrees largely with that figured and described by Koorders (1907) from Java and has, therefore, been assigned to *W. javanicus.* It would appear that this is the first time the fungus has been collected again since it was described by Koorders in 1907.

Clements and Shear (1931) have placed this genus under the Tuberculariaceæ-Amerosporæ, but I believe that the conidia are phragmospores which break up into 1-more-celled bits. Indeed, the fragmentation of the phragmospores into such bits may be considered a unique feature of the genus.

As pointed out by Bisby (1949, p. 14), "*Chætosira* is an invalid change, by Clements, of *Wiesneriomyces*", and the combination, *Chætosira javanica* (Koorders) Clements is invalid for the same reason.

SUMMARY

Most of the hyphomycetes treated in this paper are from India. Four new genera are described: *Lomachashaka* (Tuberculariaceæ, Hyalosporæ) with the type species *L. kera* on dead leaves of *Cocos nucifera*, from Madras; *Paathramaya* (Stilbaceæ, Phæostilbeæ, Amerosporæ) with the type species *P. sundara* on dead stems, from Narsapur, Hyderabad-Deccan; *Prathoda* (Stilbaceæ, Phæostilbeæ, Scolecosporæ) with the type species *P. saparva* on dead stems, also from Narsapur; and *Tharoopama* (Stilbaceæ, Phæostilbeæ, Amerosporæ) with the type species *T. trina* on dead culms of grass, from Madras. *Trichosporium arborescens* Penzig & Saccardo, described from Java, is transferred to the new genus *Tharoopama*, as a second species.

Seven new species of hyphomycetes are described, also from India: *Annellophora indica*, on living leaves of *Photinia* sp., from Kodaikanal Hills; *Excipularia narsapurensis*, on dead wood, from Narsapur; *Exosporium coonoorense*, on dead stems, from Coonoor, Nilgiris; *Helicoceras longisporum*, on living leaves of *Celtis serotina*, also from Coonoor; *Helicomina indica*, on living leaves of a leguminous plant, from Castle Rock, Bombay State; *Spegazzinia sundara*, on dead bamboo, from Madras; and *Sporidesmium nilgirense*, on dead *Bambusa nana*, from Ootacamund, Nilgiris.

Spegazzinia tessarthra (B. & C.) Sacc. var. *deightonii* described by Hughes from the Gold Coast, Africa, is raised to specific rank. On the basis of a study of the type collection of *Helminthosporium arecæ* B. & Br. (Fungi of Ceylon No. 833) and of Indian collections of this fungus, it is concluded that Petch's disposition of this fungus under *Exosporium* is correct. *Exosporium pulchellum* Sacc. and *E. eximium* Sacc. are considered synonyms of *E. arecæ* (B. & Br.) Petch. *Helminthosporium guareicola* Stevens, *Umbellula terrestris* (Timonin) Morris and *Wiesneriomyces javanicus* Koorders are reported for the first time from India. Three other fungi mentioned are: *Spegazzinia tessarthra* (B. & C.) Sacc. and *Stigmina maculata* (Cooke) Hughes, the former being reported for the first time from the Madras State, and the latter from the Mysore State; and *Stigmina palmivora* (Sacc. *apud* Trelease) Hughes, from the Nilgiris.

ACKNOWLEDGMENTS

I am deeply indebted to Professor T. S. Sadasivan, for much encouragement and to the Rev. Fr. Dr. H. Santapau, for kindly translating the generic and specific diagnoses into Latin; to Prof. V. Raghavan, for suggesting the new generic names in Sanskrit; to the Government Mycologist, Agricultural Research Institute, Coimbatore, and to the Head of the Division of Mycology, Indian Agricultural Research Institute, New Delhi, for specimens; and to the Director, Commonwealth Mycological Institute, Kew, England, for generous facilities provided for studies during my stay there in 1950-51. I thank the Ministry of Education, Government of India, for a grant-in-aid for travel which enabled me to collect several fungi reported in this paper.

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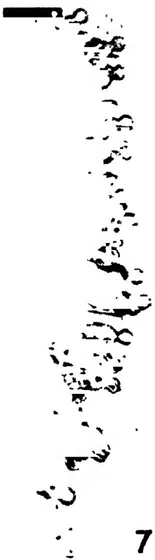

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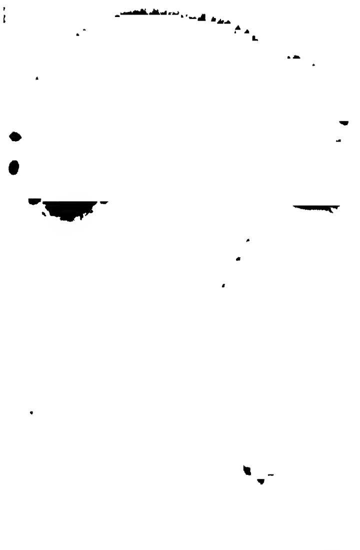

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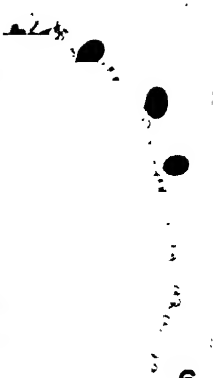

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EXPLANATION OF PLATE

Figs. 1 2. *Tharoopama trina*. Fig. 1. A synnema. Fig. 2. Part of conidiophores showing branching and production of conidia. Figs. 3–4. *Tharoopama arborescens*, reproduced from Penzig and Saccardo (1904). Fig. 3. A habit sketch showing the aggregation of conidiophores to form a synnema. Fig. 4. Showing the branching of the conidiophores and the production of conidia. Figs. 5–7. *Paathramaya sundara*. Fig. 5. A synnema. Figs. 6–7. Part of the fertile region of the synnemata showing the tips of conidiophores, the cup-like protuberances and the attachment of conidia. Figs. 8–9. *Prathoda saparva*. Fig. 8. Synnemata. Fig. 9. Apical fertile parts of synnemata showing the attachment of conidia to free ends of conidiophores and the phragmoscolecospores. Figs. 1, 8, × 75; Figs. 2,7, 9, × 320; Fig. 5, × 100; Fig. 6, × 200.

THE CLAVARIACEAE OF THE MUSSOORIE HILLS—I

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(Received for publication on August 6, 1955)

The Panjab University Botany Department has been undertaking a Botanical Excursion each year to the Mussoorie Hills, under the leadership of Prof. P. N. Mehra, to make a comprehensive study of the Cryptogamic Flora of that region. The taxonomic study of the Clavariaceæ is a part of the Fungal Flora under that programme.

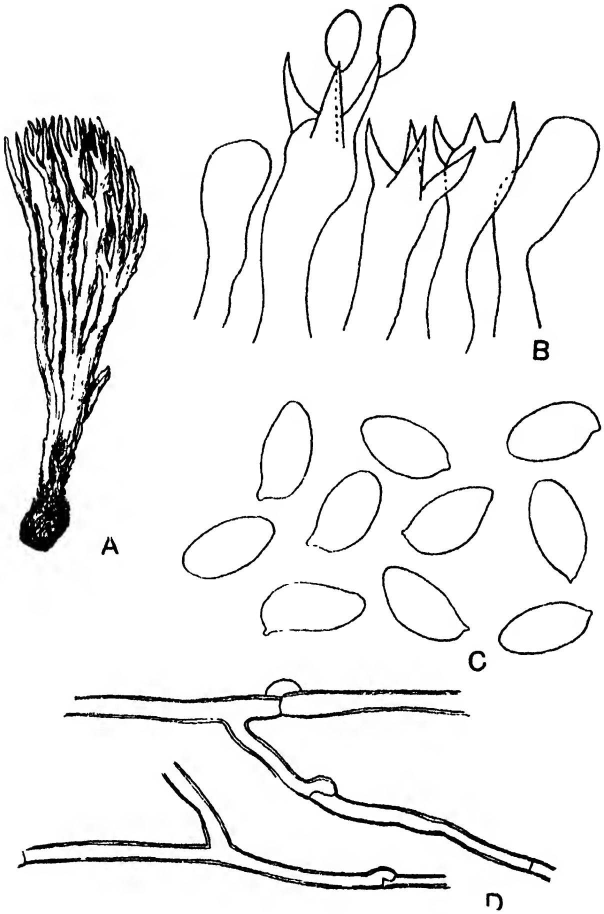
This interesting and most beautiful group of fungi has remained neglected so far in India. There have been only isolated reports of species by different people at different times. Thus until now only less than two dozen Clavarias have been reported and most of these are not adequately described. The present is the first attempt to study Indian Clavarias on a comprehensive scale. The classification recently proposed by Corner (1950) in his Monograph of Clavaria and Allied Genera has been followed in the present study.

This paper deals with the taxonomy of seven Clavarias which fall under 6 species and 1 form. One of these species belongs to the Thelephoroid Series while 5 species including 1 variety and 1 form belong to the Ramaria Series. All of these are new records for India. *Ramaria fumigata* (Pk.) Corner var. *gigantea* is proposed as a new variety. All these species are deposited in the Herbarium of the Panjab University.

Thelephoroid Series

1. *Aphelaria pusio* (B.) Corner

Fructifications gregarious, erect, small sized, flattened, with or without a trunk, branched, somewhat leathery and tough, whitish, 3·5–5 × 1–1·8 cm. Trunk, when present, 0·5–1·8 cm. long and up to 0·3 cm. broad. Branching dichotomous above and appearing polychotomous below due to very close dichotomy, branches unequal, flattened, fastigiate, in alternating planes, sometimes fused together. Apices concolorous and acute. Flesh concolourous. *Hymenium* spread all over except the trunk, up to 79 μ in width. *Basidia* clavate, subhyaline, 9–12 μ broad. Sterigmata 3–4, stout, and massive. *Basidiospores* subhyaline, oblong-ellipsoid, pip-shaped, smooth, thin-walled, aguttate when young, overmatured spores multiguttulate, guttules vague, 10·3–15·5 × 6–7·7 μ. *Hyphæ* monomitic, hyaline, narrow, branched, slightly thick-walled, septate, septa at long intervals, clamped, clamps abundant but not at all septa, 2·3–3·8 μ broad, hyphal cells up to 150 μ long, or even longer (Text-Fig. 1, A-D).



Text-Fig. 1. *Aphelaria pusio* (B.) Corner. A. Fructification, ×1. B. Basidia, ×880. C. Basidiospores, ×880. D. Slightly thick-walled hyphæ, ×330.

Collected on soil under oak forest, Kempty Road, Mussoorie, September 3, 1953, **25**.

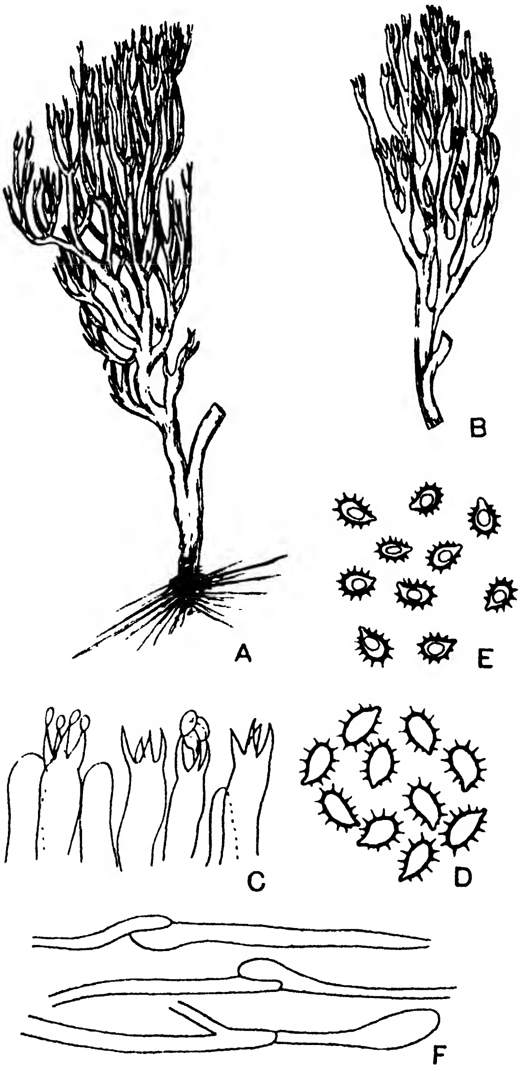
The fructifications of the present collection are slightly smaller but much more branched than those of *A. pusio* (B.) Corner (Corner, 1953). However, the size of the fruit body and degree of branching is often only a matter of age.

Ramaria Series

2. *Ramaria flaccida* (Fr.) Ricken

Fructifications humicolous or lignicolous, gregarious, rarely solitary, medium sized, rarely large sized, radial, slender, flaccid, trunk absent, sometimes present, profusely branched, fleshy, smooth, glabrous, brown, dirty brown, or dirty yellowish brown, up to 7 cm. tall and up to 5 cm. broad, rarely up to 10 cm. tall and up to 6 cm. broad. Trunk, when present, slender, up to 1·7 cm. long and up to

3 mm. broad. Branching dichotomous, branches slender, unequal, in alternating planes, sometimes very small or ligulate, often fused with one another, ligulate or adventitious branches present all over the fructifications or confined to the basal part and they may also divide dichotomously and become bushy. Primary branches slender, only up to 2·5 mm. broad, ultimate branchlets thin, small, in equal or unequal pairs, sometimes minute and ligulate, very minute or 3–20 mm. long. Apices concolorous, acute, fertile. Flesh lighter coloured. Taste and smell inparticular. Numerous rhizomorphic mycelial threads



Text-Fig. 2. *Ramaria flaccida* (Fr.) Ricken.—A. Fructification of collection n. 28, ×1. B. A part of fructification n. 27, ×1. C. Basidia, ×880. D. Basidiospores cf n. 27×1880. E. Similar and less conspicuouly marked spores of n. 28, ×880. F. Clamped hyphæ, ×30.

given out from the base of the fructification. *Hymenium* spread all over except the lighter coloured base, compound, with numerous embedded spores usually in clusters of four, 70–105 μ thick. *Basidia* clavate, 4–7 μ broad. Sterigmata four, slightly incurved, 3–6 μ long. *Basidiospores* brown, ellipsoid, papillate, profusely echinulate, wall dark, aguttate, 4–7×3–4 μ (see also Table I). *Hyphæ* monomitic, hyaline, branched, thin-walled, septate, septa at long intervals, not inflated, or sometimes slightly inflated, considerably swollen into sac-like structures at places near the ends or at the septa, clamped, clamps prominent, 2–8 μ broad (Text-Fig. 2, A-F).

Collected on humus under oak forest, The Park, Mussoorie, August 31, 1953, **26.** On dead leaves and dead twigs under oak forest, Chakrata Toll, Mussoorie, August 16, 1953, **27.** On dead pine needles under pine forest, The Park, Mussoorie, August 11, 1953, **28.** On humus under oak forest, Dhobi Ghat, Mussoorie, August 7, 1953, **29.**

Collections n. 27 and n. 29 are more typical of *Ramaria flaccida* (Fr.) Ricken than n. 26 and n. 28. The fructifications of n. 29 are the largest being up to 10 cm. tall and up to 6 cm. broad. Having seen a great many collections of *R. flaccida*. Corner (Personal correspondence, 1955) states that the fruit body of this species may grow up to 10 cm. high, or more, though commonly it is small.

Fructifications of n. 26 are solitary, flattened, sooty black, and with palmate branching. According to Corner (Personal correspondence, 1955) the palmate, or flattened branching of n. 26 is unusual (for *R. flaccida*) but occurs in some other species, *e.g.*, *Ramaria palmata* (Pers.) Quél., which is merely *Ramaria gracilis* (Fr.) Quél., with flattened branching.

Fructifications of n. 28 occur on pine needles and possess slightly smaller and less prominently marked spores. According to Corner (Personal correspondence, 1955) the small spores (see Table I) and habit on coniferous needles indicate *Ramaria myceliosa* (Pk.) Corner, but n. 28 may be only *R. flaccida*, because n. 26 and n. 29 seem to have as small spores. He is not sure if the two species (*R. myceliosa* and *R. flaccida*) are separable.

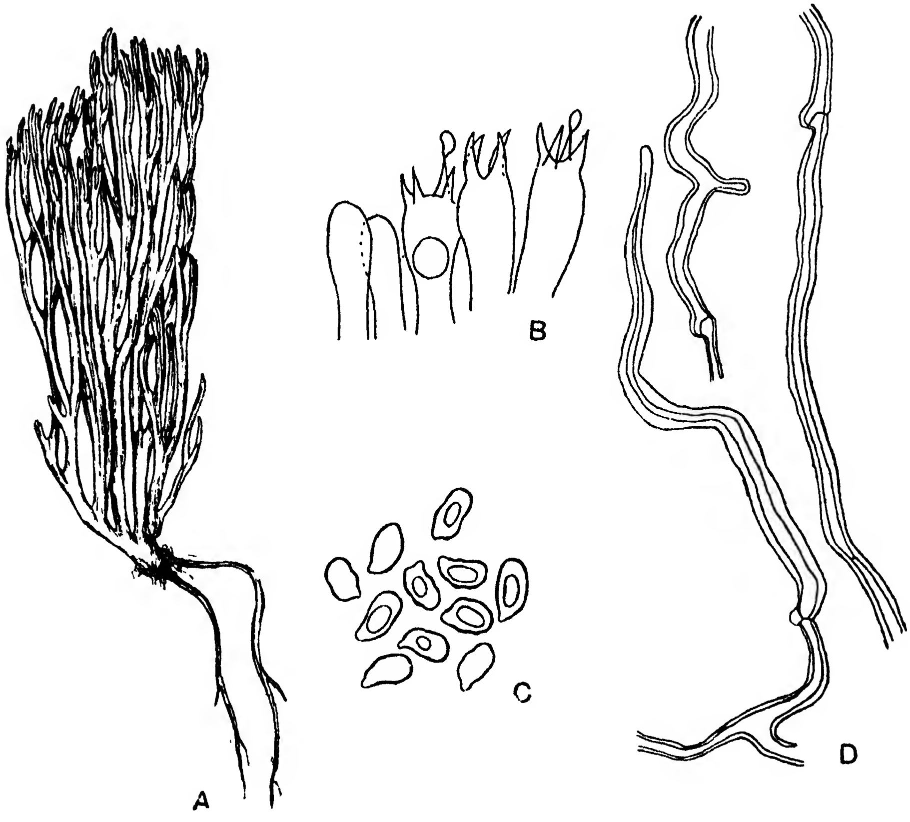
TABLE I

Spore-size in the four collections of Ramaria flaccida

Collection number	Spore size
26	4·6–6·4×2·5–3·8 μ
27	5·4–7 ×2·5–3·5 μ
28	4 –5·4×3–4 μ
29	4·6–6 ×3–4 μ

3. *Ramaria stricta* (Fr.) Quél. var. *concolor* Corner

Fructifications lignicolous, gregarious, cæspitose, erect, medium sized, radial, without a trunk, profusely branched, fleshy, smooth, glabrous, dark brown, or pinkish brown to violaceous brown, up to 8·5 cm. tall and up to 5 cm. broad. Branching more or less polychotomous below and dichotomous above, branches crowded, often fused together, unequal, in alternating planes, internodes long, primary branches up to 3 mm. broad, ultimate branchlets very thin or slender, from very small to 0·6-1·3 cm. long. *Apices* cream coloured to yellowish, or concolorous, acute. Flesh concolorous. Taste and smell inparticular. Numerous long rhizomorphic mycelial strands given out from the bases of fructifications. *Hymenium* spread all over except the white submerged base, thickening, stratose, with abundant embedded spores, up to 345 μ broad. *Basidia* clavate, subhyaline to pale brown, 7–9 μ broad. Sterigmata 4, rarely 2–3, stout, slightly incurved, 3·5-7 μ long. *Basidiospores* light brown, broadly ellipsoid, papillate, rough, or almost smooth, wall dark, aguttate or uniguttate, guttule large and filling $\frac{1}{3}$-$\frac{1}{2}$ of the spore cavity, rarely 2–3 guttulate, 7–10·5×4–6·7 μ. *Hyphæ* monomitic, hyaline, slightly to moderately thick-walled, sometimes much thickened, thickening 0·5-1·6 μ, branched, not inflated, septate, septa at long intervals, clamped, H-pieces present,



TEXT-FIG. 3. *Ramaria stricta* (Fr.) Quel. var. *concolor* Corner. A. Fructification, ×1. B. Basidia, ×880. C. Basidiospores, ×880. D. Thick-walled and clamped hyphæ, ×380.

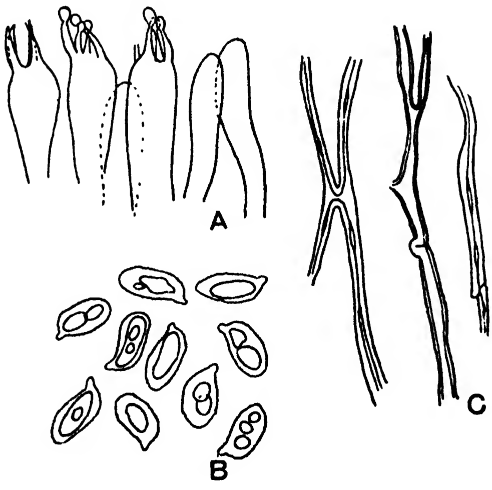
highly convoluted and interwoven, often swollen at ends or near septa, 2–12 μ broad, up to 16 μ broad at the swollen regions (Text-Fig. 3, A-D).

Collected on rotting stumps and logs of trees in oak forest, The Park, Mussoorie, August 13, 1953, **30.** On humus amid mosses and on dead leaves of *Quercus incana* Roxb. under oak forest, The Park, Mussoorie, August 9, 1953, **31.**

According to Corner (Personal correspondence, 1955) violaceous tints, as we have observed in collection n. 31, may develop in the species *R. stricta.*

4. *Ramaria stricta* (Fr.) Quél. var. *concolor* Corner
"Dark Coloured Form"

Fructifications lignicolous, solitary, erect, medium sized, radial, without a trunk, profusely branched, fleshy, smooth, glabrous, sooty black, up to 7 cm. tall and up to 5·8 cm. broad. Branching polychotomous below, dichotomous above, branches unequal, in alternating planes, compact, fused together at places, primary branches up to 4 mm. broad, ultimate branchlets minute, only up to 3 mm. long, in pairs, or look crowded and cristate due to very close and irregular dichotomy. Branches lighter coloured above. Apices lighter coloured or cream coloured and blunt. White rhizomorphic branches given out from the base of the fructifications. Flesh concolorous. Taste and smell inparticular. *Hymenium* spread all over, compound, stratose, 140–175 μ thick. *Basidia* clavate, brown or pale brown, 6·3–7·4 μ broad. Sterigmata 4, 3·5–7 μ long. *Basiodiospores* light or pale brown



TEXT-FIG. 4. *Ramaria stricta* (Fr.) Quel. var. *concolor* Corner "Dark coloured form."—A. Basidia, ×880. B. Basidiospores, ×880. C. Considerably thick walled and clamped hyphæ, ×380.

to brown, ellipsoid, papillate, rough or inconspicuously verrucose, warts not distinct, wall dark, aguttate or with 1–3 or more vague guttules, 7–11×3·5–5 μ, abundantly embedded in the compound hymenium. *Hyphæ* monomitic, subhyaline, branched, septate, septa at long intervals, clamped, 2·58–8·6 μ broad, thick-walled (skeletal), wall 0·86–5·16 μ thick, thickening often highly pronounced so as to obliterate whole of the lumen (Pl. V, Fig. 1; Text-Fig. 4, A-C).

Collected on fallen dead pine needles, The Park, Mussoorie, September 2, 1953, **32.**

This collection resembles *Ramaria stricta* (Fr.) Quél. var. *concolor* Corner in all respects except that its fructifications are very dark and sooty black. Therefore, as suggested by Corner (Personal correspondence, 1955) this collection n. 32 is regarded as a dark coloured form of the variety *concolor* Corner.

5. *Ramaria subbotrytis* (Coker) Corner

Fructifications solitary, erect, large sized, radial, without a trunk, profusely branched, fleshy, smooth, glabrous, deep scarlet red or deep pinkish red when young, colour fading at maturity, up to 10 cm. tall and up to 10 cm. broad. Base stubby, thick, lighter coloured. Branching polychotomous below but dichotomous above, branches compact, unequal, in alternating planes, primary branches up to 1 cm. broad, ultimate branchlets small to minute, thin. Apices obtuse or blunt, in pairs, or crowded together and looking cristate due to close dichotomy, concolorous. Flesh concolorous. Taste and smell inparticular. *Hymenium* spread all over, compound, up to 74 μ broad. ***Basidia*** clavate or elongated, light brown or subhyaline, 5–7·4 μ broad. Sterigmata 4, long, straight or slightly incurved, 3·5–5·3 μ long. ***Basidiospores*** light violet or light brownish violet when in a mass, brown or sooty brown individually under the microscope, narrowly ellipsoid, papillate, wall dark, rough to almost smooth, aguttate, abundantly embedded in the compound hymenium, 7–9·8×3·5–4 μ. *Hyphæ* monomitic, hyaline or subhyaline, thin-walled, inflated, may be slightly constricted at the septa, septate, septa at shorter intervals, secondary septa absent, clamps absent, 3·5–14 μ broad, hyphal cells 67–121 μ long (Text-Fig. 5, A-D).

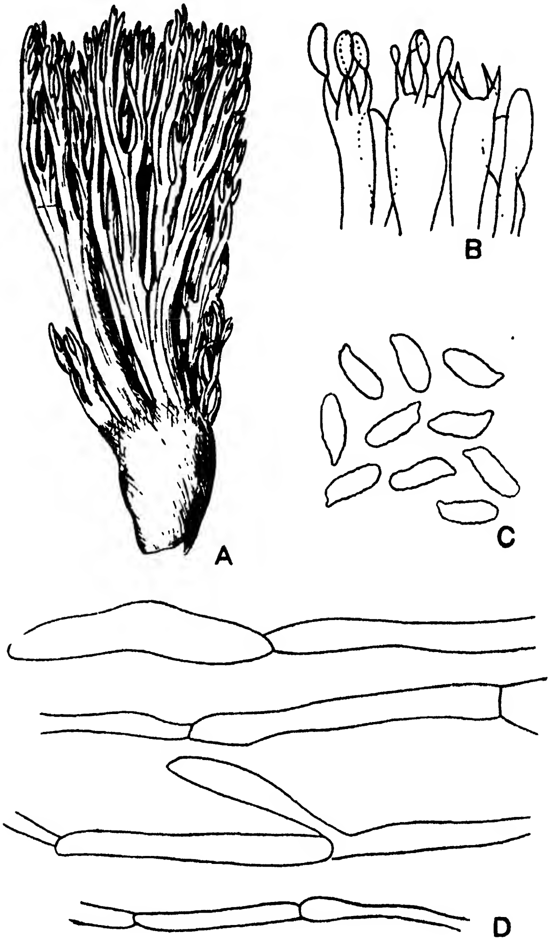
Collected on soil under oak forest, Chakrata Toll, Mussoorie, August 6, 1953, **33.**

This species is easily recognized from the red colour, the small and narrow spores, and the absence of clamps.

6. *Ramaria fumigata* (Pk.) Corner var. *gigantea* var. nov.

Usque 21·5 cm. alta, carne color immutatus, sporis 10·5–14 ×4·2–6·3 μ, hyphis fibulis præditis. Terrestris, Chakrata Toll, Mussoorie, India, August 20, 1953, **34.**

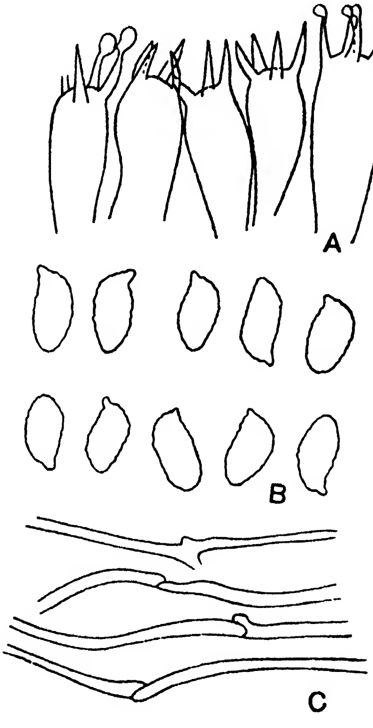
Up to 21·5 cm. high, flesh not changing colour on bruising, spores 10·5–14×4·2–6·3 μ, hyphæ provided with clamps.



Text-Fig. 5. *Ramaria subbotrytis* (Coker) Corner.—A. Fructification, ×1. B. Basidia, ×880. C. Basidiospores, ×880. D. Inflated hyphæ, ×380.

Collected on soil, Chakrata Toll, Mussoorie, India, August 20, 1953, **34**.

Fructifications gregarious or solitary, erect, large sized, massive, radial, trunk present, profusely branched, fleshy, smooth, glabrous, violet coloured throughout, colour fading in over-matured specimens to fuliginous ochraceous but the tips remain violet for a longer time, up to 21·5 cm. tall and up to 10 cm. broad. Trunk as undifferentiated stubby basal part of the fructification, up to 5·8 cm. broad. Branching polychotomous below and dichotomous above, branches crowded to compact, unequal, in alternating planes, primary branches up to 1 cm. broad, ultimate branchlets minute, blunt and crowded together due to close dichotomy. Flesh white to cream coloured, not changing colour on bruising. Taste and smell inparticular. Internodes are generally long but they may be short in some specimens. *Hymenium* spread all over, compound, up to 88 μ broad. *Basidia* clavate, pale brown, 8–10·5 μ broad. Sterigmata 4, slightly incurved, 3·5–7 μ long. *Basidiospores* light brown to brown or sooty brown, dark brown to sooty when in a mass, narrowly ellipsoid to broadly ellipsoid, papillate, rough to almost smooth, wall dark, aguttate or with one or more vague guttules, 10·5–14×4·2–6·3 μ. *Hyphæ* monomitic, subhyaline, branched, sometimes antler-like short branches also observed, not inflated or only slightly so, thin-walled septate, septa at long intervals, clamped, 1·8–7 μ broad (Pl. V, Fig. 2; Text-Fig. 6, A-C).



TEXT-FIG. 6. *Ramaria fumigata* (Pk.) Corner var. *gigantea* var. nov.—A. Basidia, ×880. B. Basidiospores, ×880. C. Clamped hyphæ, ×380.

Collected on soil under oak forest, Chakrata Toll, Mussoorie, August 20, 1953, **34.**

This collection comes near to *Ramaria fumigata* (Pk.) Corner but it differs from the latter in the following important respects:—

	Present collection		*R. fumigata*
1.	Up to 21·5 cm. tall.	1.	5–12 cm. tall.
2.	Primary branches upto 1 cm. broad.	2.	Primary branches only 2–3 mm. broad.
3.	Not rufescent on bruising.	3.	Rufescent on bruising.

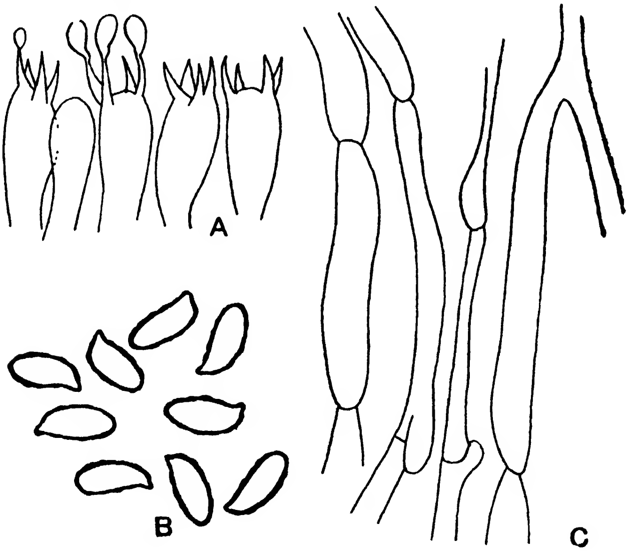
4. Spores aguttate or with 1 to more vague guttules.	4. Spores uniguttate.
5. Hyphæ clamped.	5. Hyphæ not clamped.
6. Spores 10·5–14×4·2–6·3 μ	6. Spores 8·5–12·5×3·7–5·5 μ.

As also suggested by Corner (Personal correspondence, 1955), the collection n. 34 is regarded here as a new variety on the basis of its very large fructifications, the larger spores, the absence of colour change of the flesh, and the presence of clamps on the hyphæ. The name var. *gigantea* is proposed because of its larger size and slightly larger spores.

7. *Ramaria obtusissima* (Pk.) Corner

"Rough Spored Form"

Fructifications solitary, erect, large sized, radial, trunk present, profusely branched, fleshy, smooth, glabrous, cream coloured, deep coloured below and lighter coloured at the top, up to 14 cm. tall and up to 11 cm. broad. Trunk narrow, up to 2 cm. long and 1 cm. broad. Branching dichotomous, branches rather lax, unequal, in alternating planes, internodes long below but shorter above, primary branches like the trunk and up to 0·9 cm. broad, ultimate branchlets very small to 3 mm. long, in pairs, or crowded together and look cristate due to close dichotomy. Apices obtuse or blunt, concolorous. Flesh whitish. Taste bitter, smell inparticular. *Hymenium* spread all over except the trunk, compound, 73–112 μ broad. *Basidia* clavate, light brown, 7–10·5 μ broad. Sterigmata 2–4, 3·5–7 μ long. *Basidiospores* light brown, ellipsoid, papillate, slightly rough, wall dark, aguttate, abundantly



TEXT-FIG. 7. *Ramaria obtusissima* (Pk.) Corner "Rough spored form". A. Basidia, ×880. B. Basidiospores, ×880. C. Inflated and clamped hyphæ, ×380.

embedded in the compound hymenium, 10·5–15×4·0–6·0μ. *Hyphæ* monomitic, hyaline to subhyaline, branched, thin-walled, inflated, hyphæ may be swollen at ends, ends of the hyphal cells gliding over one another, clamps present, septate, septa at short to long intervals, hyphal cells 3·5–15μ broad and from 32μ to very long (Pl. V, Fig. 3; Text-Fig. 7, A-C).

Collected on soil under oak forest, Chakrata Toll, Mussoorie, August 6, 1953, **35**.

The spores of this collection are slightly rough and wider than *Ramaria obtusissima* (Pk.) Corner which has characteristically smooth and narrowly-cylindrical spores (10–15×3·5–5μ). Accordingly, collection n 35 is put under the "rough spored form" of this species.

ACKNOWLEDGMENTS

The writers are deeply indebted to Mr. E. J. H. Corner, F.R.S., of the Botany School, Cambridge, England, for help in the identification of the species and Prof. P. N. Mehra for valuable criticism and encouragement. They are also thankful to Mr. Balram Khanna for making illustrations of the fructifications apart from the photographs.

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EXPLANATION OF PLATE

FIG. 1. *Ramaria stricta* (Fr.) Quél var. *concolor* Corner "Dark Coloured Form".

FIG. 2. *Ramaria fumigata* (Pk.) Corner var. *gigantea* var. nov.

FIG. 3. *Ramaria obtusissima* (Pk.) Corner "Rough Spored Form".

2

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3

ON TWO NEW SPECIES OF *TERMINALIOXYLON* SCHÖNFELD FROM THE TERTIARY OF SOUTH ARCOT DISTRICT, MADRAS

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Introduction

The present paper deals with two new species of *Terminalioxylon* Schönfeld, collected by the author in 1952 from near Murttanqi (also known as Mortandra) and Tiruchhitambalam, about 5 and 7 miles W.N.W. of Pondicherry respectively, in South Arcot District, Madras. The fossiliferous localities can be reached from Tindivanam on the Southern Railway. Both Mortandra and Tiruchhitambalam are on the bus route from Tindivanam to Pondicherry. Besides silicified trunks which dominate the landscape, hardly any other organic remains are found at these areas; the only other fossils to be met with here are of some gasteropods.

The whole area is a plain, dotted with hillocks not more than 100 feet in height, with ridges, caves and ravines. The hillocks are formed of Cuddalore sandstones. The silicified trunks occur firmly embedded in these sandstones, but a considerable number of them have been loosened by weathering and lie scattered freely on the ground (Pl. VI, Fig. 1).

The Cuddalore sandstones to which the fossil trunks belong are formed of argillaceous and silicified sandstones with lumps and veins of chert. These sediments lie along the east coast and overlie various coastal deposits of Mesozoic age. A variously coloured and mottled loose textured sandstone is the principal component of these rocks. The age of the Cuddalore sandstones is believed to range from the Eocene to Pliocene (Sahni, 1931). Krishnan (1949) regards the Cuddalore sediments to be of Miocene and according to Wadia (1953) a great part of this series is believed to be of Pliocene age and the other parts to be of still younger age.

From the same fossiliferous localities the author briefly reported previously (Ramanujam, 1953, 1954 *a*) dicotyledonous trunks belonging to various other families like Guttiferæ, Dipterocarpaceæ, Celastraceæ, Anacardiaceæ, Leguminosæ, Sonneratiaceæ, and Euphorbiaceæ, and very recently (Ramanujam, 1954 *b*) has described in detail the anatomy of two fossil trunks belonging to the family Leguminosæ showing similarities in particular to the genera *Cæsalpinia* and *Acacia*. The author is not aware of any published records of fossil trunks from India resembling the modern genus *Terminalia* belonging to the family Combretaceæ, consequently the present report of the occurrence of such fossil trunks in the Tertiary rocks of South Arcot District is the first of its kind from India.

MATERIAL AND METHODS

The specimens collected are from large trunks generally 1–2 feet in diameter and 3-5 feet in length. The fossils are finely silicified and range in colour from greyish to deep brown. For each wood studied several transverse, tangential and radial sections were made. The sections were generally thinly ground, but at times somewhat thicker sections proved to be useful for studying the gross structures of the fossils. The examination of the polished transverse surface of the wood in reflected light was of paramount help in studying the distribution of the vessels and the xylem parenchyma. The thin sections were examined as a rule under glycerine, but where there was no danger of their becoming transparent they were mounted in canada balsam. The sections usually were not stained as the natural stain of the petrifaction made the tissues fairly prominent. Comparisons were made as far as possible with the modern specimens.

Terminalioxylon Shönfeld

Terminalioxylon speciosum sp. nov.

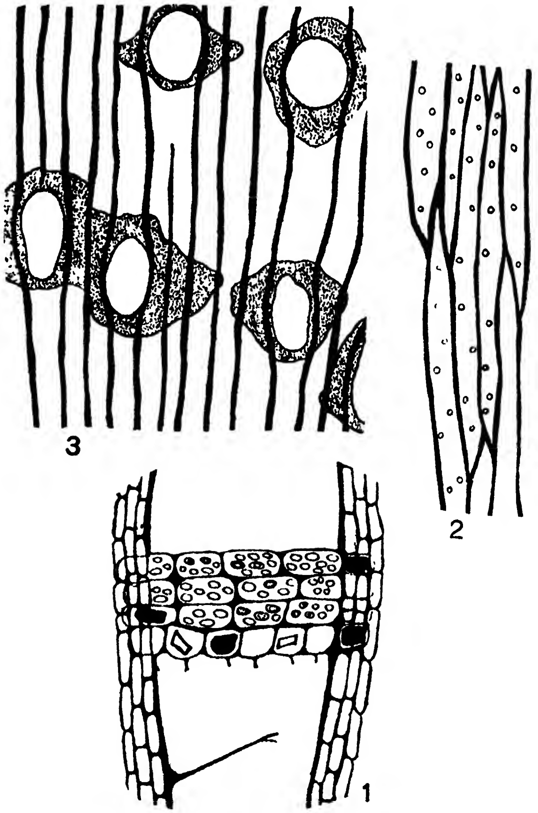
The species is represented by about 12 pieces of silicified wood. The figured specimen measures 10×5 cm. The wood shows very good preservation.

No growth rings are seen either by the naked eye or under the microscope. The vessels are diffuse and can be seen by the unaided eye as light coloured dots against the grey background of the fossil. They are solitary and arranged without any definite pattern. They are medium to large, comparatively thin-walled and oval to rounded in the cross-section. The vessels frequently deflect the xylem rays. The majority of the vessels are abundantly tylosed, but the tyloses are sometimes masked by dark contents which fill the vessels. The vessel-segments are medium, and truncate or sometimes attenuately tailed at one or both ends. The perforations are exclusively simple, horizontal or slightly oblique. The intervessel pits are numerous and in general are fairly large, circular to elliptic in outline, prominently bordered and vestured (Pl. VI, Fig. 2). Their distribution is usually alternate, although in certain parts of the facets an opposite alignment may be retained. The vessel-ray pitting is more or less similar to the intervessel pitting. The vessel-ray pits, however, tend to be slightly larger than the corresponding intervessel pits; they are 3–8 per cell and arranged irregularly (Text-Fig. 1). The vessel-parenchyma pits are bordered and alternate; they are rounded to flattened with circular apertures.

The fibres are well preserved. As seen in transverse sections they are arranged in more or less regular radial rows which are frequently interrupted by the paratracheal parenchyma. They are squarish to rectangular in outline as seen in cross-sections. The fibres are distinctly libriform and medium in length. They are always aseptate.

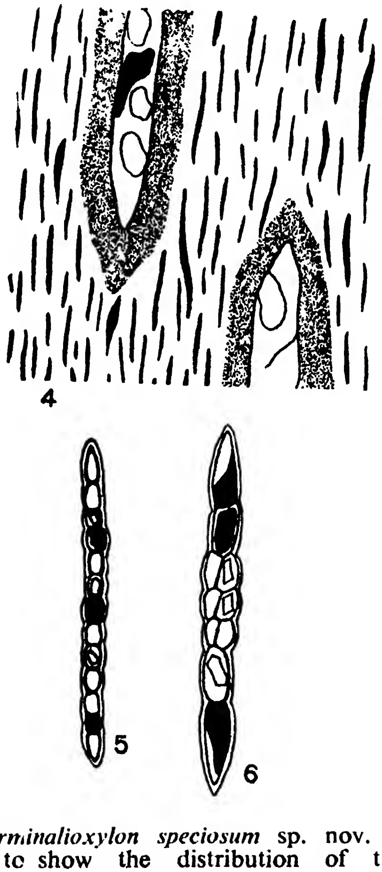
Interfibre pits are few, simple and circular; these pits are usually very minute and inconspicuous (Text-Fig. 2).

On the whole the xylem parenchyma is abundantly developed. It is visible to the naked eye in the immediate vicinity of the vessels as light coloured patches. It is of two types: (1) paratracheal and (2) apotracheal. The paratracheal parenchyma is represented by 2–6 cells thick vasicentric to aliform sheaths (Text-Fig. 3; Pl. VI, Figs. 3, 4). The aliform parenchyma at times tends to become confluent. The distribution of the apotracheal parenchyma is purely diffuse, consisting of either single cells or groups of cells numbering 1–3 scattered irregularly among the fibres; from fibres they can be easily distinguished by their larger size and thin-walled nature. The parenchyma cells in general are oval to round and are occasionally filled with some dark brown contents. Pits to the parenchyma cells are invariably simple, circular to elliptical and numerous (Text-Fig. 3).



TEXT-FIGS. 1–3. *Terminalioxylon speciosum* sp. nov. Fig. 1. Vessel-ray pitting. ×200. Fig. 2. Pits to the fibres, ×200. Fig. 3. Semi-diagrammatic cross-section to show the distribution of the parenchyma (stippled), ×45.

The rays are numerous and very closely spaced; they appear on the polished transverse and tangential surfaces of the fossil wood as fine lines under the hand lens. The rays are evenly distributed (Text-Fig. 4). They are 1–2 seriate. The uniseriate rays are predominant and the biseriate ones occur fairly commonly (Pl. VI, Fig. 5). In height the rays range from 2–25 cells. They are weakly heterogeneous with 1–2 marginal rows of square or vertical cells (Text-Figs. 5, 6). The uniseriate rays often contain almost entirely of either procumbent or vertical cells. A very important feature of the xylem rays is the presence of crystalliferous cells in them, each cell containing a single large crystal. The crystals are found mostly in the procumbent cells, but they occur frequently in the vertical cells also (Text-Figs. 5, 6). In addition to the crystals a dark coloured deposit fills most of the ray cells. Pits to the tangential walls of the ray cells is not observed.



Text-Figs. 4–6. *Terminalioxylon speciosum* sp. nov. Fig. 4. Semi-diagrammatic tangential section to show the distribution of the xylem rays, ×45. Fig. 5. A uniseriate ray, ×200. Fig. 6. A biseriate ray. Note the crystalliferous cells, ×200.

Comparison with the living species.—The fossil wood from Mortandra shows the following important features that are of very great help in its identification: (1) vessels medium to large, solitary, (2) vestured pitting of the vessels, (3) aseptate, libriform fibres, (4) parenchyma abundant, paratracheal and diffuse, and (5) 1–2 seriate weakly heterogeneous rays, with cells containing single crystals. The presence of these characters necessitates one to compare the fossil with the members of the families like Anacardiaceæ, Urticaceæ, Leguminosæ, and Combretaceæ (Gamble, 1922; Pearson and Brown, 1932; Metcalfe and Chalk, 1950). Anacardiaceæ and Urticaceæ have some genera which show a superficial resemblance with our fossil, but these families markedly differ from the fossil in the nature of the xylem rays and the intervessel pitting which, in these two families, is not vestured.

In Leguminosæ some species of *Acacia* and *Albizzia* show resemblances to the fossil in the distribution of the xylem parenchyma, and to some extent in the nature and arrangement of the vessels. But they fundamentally differ in other important characters. Thus in both these genera the rays are much different, being wider, always homogeneous and without crystalliferous cells. The parenchyma in *Acacia* and *Albizzia*, is crystalliferous. Besides, in both these genera, the vessels are not tylosed and the intervessel pits are minute and inconspicuous.

In its vestured intervessel pits, and crystalliferous ray cells coupled with the other important characters, the present fossil shows the greatest resemblance with the members of the Combretaceæ. There are several species, particularly those of *Terminalia*, which show many similarities with our fossil. The following species of *Terminalia* were compared *viz*., *T. tomentosa*, *T. catappa*, *T. belarica*, *T. paniculata*, and *T. oblongata*. From a study of the wood anatomy of these species it is seen that the generic resemblances of the South Indian fossil with *Terminalia* are very strong and unmistakable. This is shown by a close similarity between the two in characters such as the size, shape and arrangement of the vessels, in the nature of the pitting on the various types of cells, in the nature and distribution of the xylem parenchyma, and last but not the least in the structural details of the xylem rays.

Comparison with the fossil species.—In 1936 Rode described a dicotyledonous wood *Dryoxylon mohgaœnse*, from Deccan Intertrappean series showing according to him, its nearest affinity to the members of Combretaceæ. Since this is all what is represented by Combretaceæ in the Indian rocks so far, a detailed comparison has been made with Rode's species. Our fossil differs from *Dryoxylon mohgaœnse*, in more than one respect. Thus in the South Indian fossil xylem parenchyma is abundantly represented as against the very scanty parenchyma of the latter, growth rings are absent as against the fairly distinct growth rings of *D. mohgaœnse*, and the xylem rays contain crystalliferous cells as against their complete absence in the Deccan Intertrappean species.

Schönfeld in 1947 described two species of fossil woods from the Tertiary of Columbia resembling the modern species of *Terminalia*. These are *Terminalioxylon naranjo* and *T. porosum*. Both these species despite possessing many features similar to our fossil are, however, easily distinguishable from it. In *Terminalioxylon naranjo* besides paratracheal parenchyma short tangential strips of apotracheal parenchyma are always present; secondly the rays are nearly always uniseriate. In our fossil there are no tangential strips of apotracheal parenchyma and the biseriate rays are fairly common. In *Terminalioxylon porosum*, in contrast with the South Indian fossil, the vessels are much bigger and frequently distributed in radial groups of 2–9; moreover the rays in the Columbian species are very high (5–80 cells high).

The present fossil wood as it differs from the hitherto described species in one or another important character has been given a new specific name, *Terminalioxylon speciosum*.

Diagnosis.—A diffuse porous wood.

Growth rings not present.

Vessels distinct to the naked eye, solitary, radial groups not seen. Diffuse, 10–12 per square mm., oval to round. Medium to large, 180–270 μ in diameter. Majority abundantly tylosed. Vessel-segments medium, 250–750 μ long, truncate or sometimes attenuately tailed at one or both ends. Perforations simple, horizontal or slightly oblique. Intervessel pits fairly large, prominently bordered, vestured, circular to elliptic in outline; usually alternate. Vessel-ray pitting similar to intervessel pitting; vessel-ray pits 3 8 per cell, arranged irregularly. Vessel-parenchyma pits bordered, alternate, rounded to flattened with circular apertures.

Fibres libriform.' Medium, 1100–1300 μ in length, 18 μ in diameter. Arranged in regular radial rows frequently interrupted by paratracheal parenchyma. Squarish to rectangular in cross-section. Aseptate.

Parenchyma abundant. Paratracheal and apotracheal. Paratracheal in 2–6 cells thick vasicentric to aliform sheaths; sometimes aliform sheaths tend to become confluent. Distribution of apotracheal parenchyma diffuse, either in single cells or groups of 1–3 cells scattered irregularly among the fibres. Parenchyma cells oval to round 25–40 μ in diameter, often filled with dark brown contents. Pits simple, circular, numerous per cell.

Xylem rays numerous, 15–20 per mm. evenly distributed. 1–2 seriate, Uniseriate rays predominant, biseriate rays fairly common. 2–25 cells high, weakly heterogeneous with 1 2 marginal rows of square or vertical cells. Most of the ray cells contain a single crystal; usually procumbent cells crystalliferous, sometimes vertical cells too contain single crystals.

Holotype.—No. 4973. The type specimen and the slides are kept in the Museum of Birbal Sahni Institute of Palæobotany, Lucknow.

Localities.—Mortandra and Tiruchhitambalam.

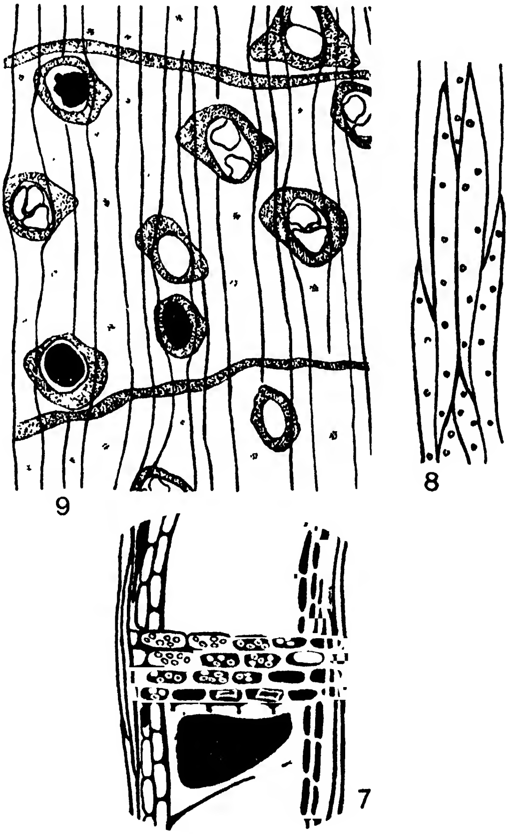
Terminalioxylon Felixi sp. nov.

The fossil is represented by about 5 small silicified wood pieces greyish in colour with light yellow or brown patches here and there.

This wood is similar in general characters to the one previously described, but differs from it in certain features of specific value.

The growth rings are rather indistinct, but the lines of demarcation between them can be seen clearly due to the presence of narrow bands of initial parenchyma.

The vessels are diffuse and appear to the naked eye as whitish dot-like structures against the grey background of the fossil. They are mostly solitary and circular, but radial groups of 2–3 are seen occasionally. When in radial groups the vessels are flattened at the points of contact. They are medium in size, and frequently tylosed. The vessel-segments are medium and truncate. The perforations are simple and horizontal or slightly inclined. The intervessel pits are fairly large, bordered, alternate and distinctly vestured. The pits are either rounded or flattened. The vessel-ray pits are bordered, rounded or tangentially stretched, 2–6 per cell arranged irregularly; the pit apertures are circular or, more or less, lenticular (Text-Fig. 7). The vessel-parenchyma pits are numerous, bordered and rounded to elliptical with circular apertures.



Text-Figs. 7–9. *Terminalioxylon Felixi* sp. nov. Fig. 7. Vessel-ray pitting ×200. Fig. 8. Pits to the fibres, ×200. Fig. 9. Semi-diagrammatic cross-section to show the distribution of the parenchyma (stippled). ×45.

The fibres are libriform. They are considerably thick-walled and usually medium in length. They are in general distributed in radial seriations as seen in cross-sections and squarish to polygonal in outlines. The fibres as a rule are aseptate. The pitting to the fibres is very distinctly seen in tangential sections; the pits are simple, rather small, and circular (Text-Fig. 8).

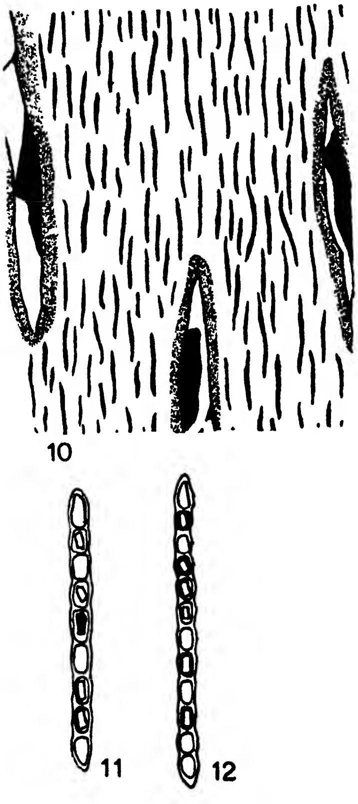
The parenchyma in contrast with *Terminalioxylon speciosum* is limited in amount. It is paratracheal and apotracheal and is visible to the naked eye as buff-coloured patches. The paratracheal parenchyma is represented by vasicentric to aliform sheaths, 1–3 cells thick (Text-Fig. 9; Pl. VII, Fig. 8). The aliform sheaths in this species never become confluent. The apotracheal parenchyma consists of narrow, 1–3 cells thick initial bands (Text-Fig. 9; Pl. VII, Fig. 7), and also as diffuse cells or groups of cells. The initial bands of apotracheal parenchyma appear to the naked eye as growth marks. According to Chowdhury (1936, 1953) parenchyma bands occurring in between growth rings are distinguishable into two types: (1) terminal, representing parenchyma formed at the end of the season's growth, and (2) initial, which means parenchyma formed at the beginning of the season's growth. The difference between these two types lies in the size, and shape of their cells. "As a rule, the terminal type is radially flattened and rectangular in shape, while the initial shows variation in shape, from rectangular to triangular but for the most part widest radially" (Chowdhury, 1936). On the basis of this difference the parenchyma bands in the South Indian fossil wood appear to be of the initial type and not terminal. The parenchyma cells in general are round to oval, and are empty. Pits to the parenchyma cells are seen very clearly in the tangential sections; the pits are always simple, circular and rather small.

The xylem rays appear as extremely fine lines under the hand lens. They are numerous and distributed evenly throughout (Text-Fig. 10). In contrast with the previous species they are here almost exclusively uniseriate (Pl. VII, Fig. 9), and rays showing the biseriate condition are very sporadic. The rays are 2–20 cells high and are usually homogeneous (Pl. VII, Fig. 11); rarely they are weakly heterogeneous with a single row of marginal vertical cells. When homogeneous the rays contain either entirely procumbent cells or vertical cells. The ray cells in general contain a single crystal (Text-Figs. 11, 12; Pl. VII, Fig. 10). These crystalliferous cells are more or less conspicuous in the tangential sections. In addition to the crystals the ray cells sometimes contain a dark brown deposit.

Comparison with the fossil species.—Terminalioxylon Felixi differs from *Terminalioxylon speciosum*, in the former's (1) smaller vessels, (2) relatively less parenchyma, in the form of initial bands and vasicentric to aliform sheaths, and (3) almost exclusively uniseriate xylem rays which are usually homogeneous.

The present species when compared to *Terminalioxylon naranjo* and *T. porosum* (Schönfeld, 1947) described from the Tertiary of Columbia, shows several marked differences. It differs from both the

South American species in possessing smaller vessels, and limited amount of parenchyma. In both *T. naranjo* and *T. porosum*, the aliform parenchyma at many places becomes confluent, while in our specimen confluent parenchyma is absent. The above fossil woods from Columbia have no initial parenchyma, although short strips of apotracheal parenchyma are seen in *Terminalioxylon naranjo*. Our fossil, however, resembles *T. naranjo*, in the xylem rays. In *T. porosum*, the rays although similar to our fossil in other characters, are very high (5–80 cells).



Text-Figs. 10–12. *Terminalioxylon Felixi* sp. nov. Fig. 10. Semi-diagrammatic tangential section to show the distribution of the uniseriate xylem rays, ×45. Figs. 11, 12. Uniseriate rays. Note the crystalliferous cells, ×45.

The present fossil wood is named after Felix, as *Terminalioxylon Felixi*, who is one of the pioneer workers on fossil dicotyledonous woods. Felix, incidentally redescribed Schleiden's *Peuce Schmidianum*, from Tiruvakkarai village which is very near to Mortandra and Tiruchhitambalam in South Arcot District, and has also given a short geological sketch of the fossiliferous localities at and near about Tiruvakkarai (Felix, 1882).

Diagnosis.—A diffuse porous wood.

Growth rings rather indistinct.

Vessels visible to the naked eye as whitish dot-like structures. Diffuse 10-16 per square mm. Mostly solitary, circular, occasionally in radial groups of 2-3. Medium sized, 130–250 μ in diameter. Frequently tylosed. Vessel-segments medium, 300–800 μ, truncate. Perforations simple, horizontal or slightly inclined. Intervessel pits fairly large, bordered, distinctly vestured, alternate, rounded or flattened. Vessel-ray pits bordered, rounded or tangentially stretched, 2–6 per cell, arranged irregularly; pit apertures circular, or more or less lenticular. Vessel-parenchyma pits numerous, bordered, rounded to elliptical, apertures circular.

Fibres libriform. Medium, 1100–1350 μ in length, 14 μ in diameter. Arranged uniformly in radial seriations, squarish to polygonal as seen in cross-section. Aseptate. Pits to fibres simple, small, circular.

Parenchyma in limited amount. Paratracheal and apotracheal. Paratracheal mostly in 1-3 cells thick vasicentric to aliform sheaths; sheaths never become confluent. Apotracheal parenchyma consists of (1) 1-3 cells thick initial bands placed in between the growth rings, and (2) diffuse cells or groups of cells, 1-4 in number. Parenchyma cells round to oval, 20-30 μ in diameter, mostly empty. Pits numerous, simple, circular.

Xylem rays numerous, 15-30 per mm. Evenly distributed. Almost exclusively uniseriate, 2-20 cells high. Generally homogeneous, rarely weakly heterogeneous with a single marginal row of vertical cells. Generally a single crystal fills up the individual ray cells.

Holotype.--No. 4976. The type specimen and the slides are kept in the museum of Birbal Sahni Institute of Palæobotany, Lucknow.

Locality.—Mortandra.

SUMMARY

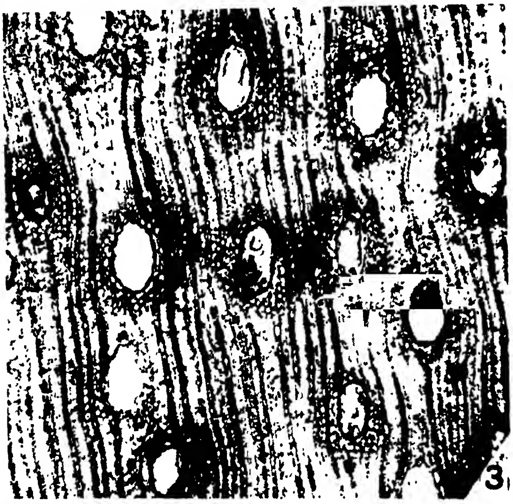
Two new species of fossil woods resembling the modern genus *Terminalia* have been described for the first time from India, from the Tertiary rocks of South Arcot District, Madras.

Terminalioxylon speciosum is characterised by uniformly distributed, solitary, usually tylosed vessels, fairly large, vestured and alternate intervessel pits, aseptate libriform fibres, vasicentric to aliform often locally confluent abundant paratracheal parenchyma and diffuse apotracheal parenchyma, and 1–2 seriate weakly heterogeneous xylem rays with cells containing single crystals.

Terminalioxylon Felixi contains indistinct growth rings, solitary or radial groups of 2–3 evenly distributed vessels, fairly large, distinctly vestured and alternate intervessel pits, aseptate, libriform fibres, limited parenchyma in narrow vasicentric to aliform sheaths, and initial bands between the faint growth rings, and lastly almost exclusively uniseriate, generally homogeneous xylem rays with crystalliferous cells.

ACKNOWLEDGEMENTS

The author is highly indebted and grateful to Dr. R. V. Sitholey, for his valuable guidance, and critical perusal of the manuscript.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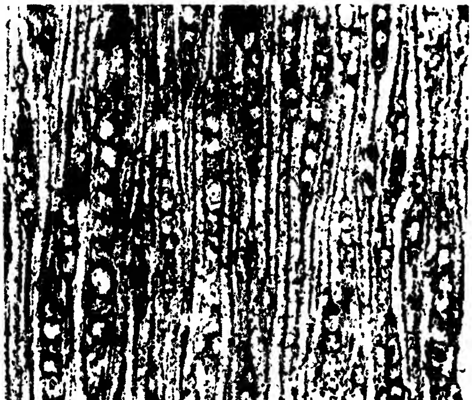


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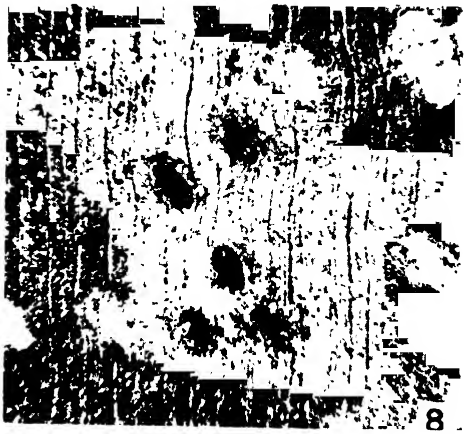
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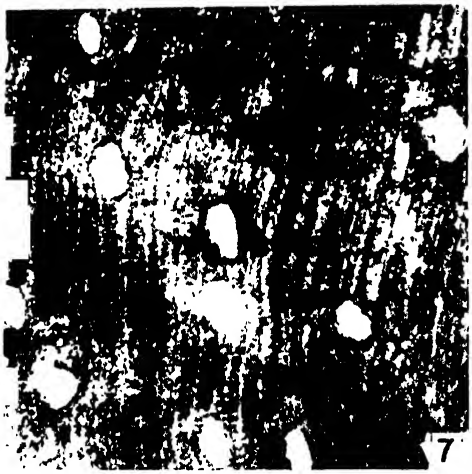
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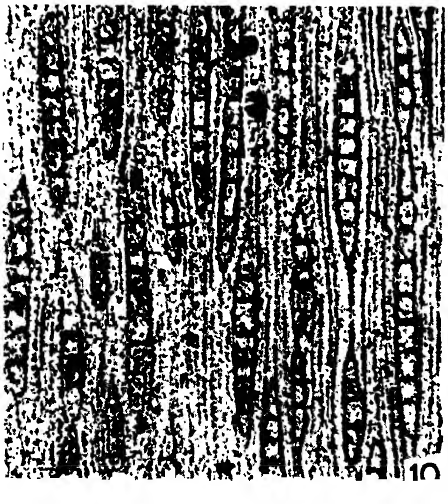
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EXPLANATION OF THE PLATES

(All the photomicrographs are from untouched negatives)

PLATE VI

FIG. 1. A general view of the fossiliferous locality near Mortandra.

FIGS. 2–5, *Terminalioxylon speciosum* sp. nov.

FIG. 2. Intervessel pitting, ×200.

FIG. 3. Cross-section showing the distribution of the parenchyma, ×50.

FIG. 4. Cross-section showing the vasicentric and diffuse parenchyma, ×50.

FIG. 5. Tangential section to show the general nature of the xylem rays, ×50.

PLATE VII

FIG. 6. *Terminalioxylon speciosum* sp. nov.

FIG. 6. Radial section showing the weakly heterogeneous rays, ×50.

FIGS. 7–11. *Terminalioxylon Felixi* sp. nov.

FIG. 7. Cross-section showing the initial bands of the apotracheal parenchyma, ×50.

FIG. 8. Cross-section showing the vasicentric to aliform parenchyma, ×50.

FIG. 9. Tangential section to show the general nature of the xylem rays. Note the tyloses in the vessels, ×50.

FIG. 10. Tangential section slightly enlarged to show the crystalliferous cells in the xylem rays (*c*), ×50.

FIG. 11. Radial section to show the homogeneous nature of the rays, ×50.

SAPUCCHAKA, A NEW GENUS OF THE HEMISPHAERIALES

By K. Ramakrishnan

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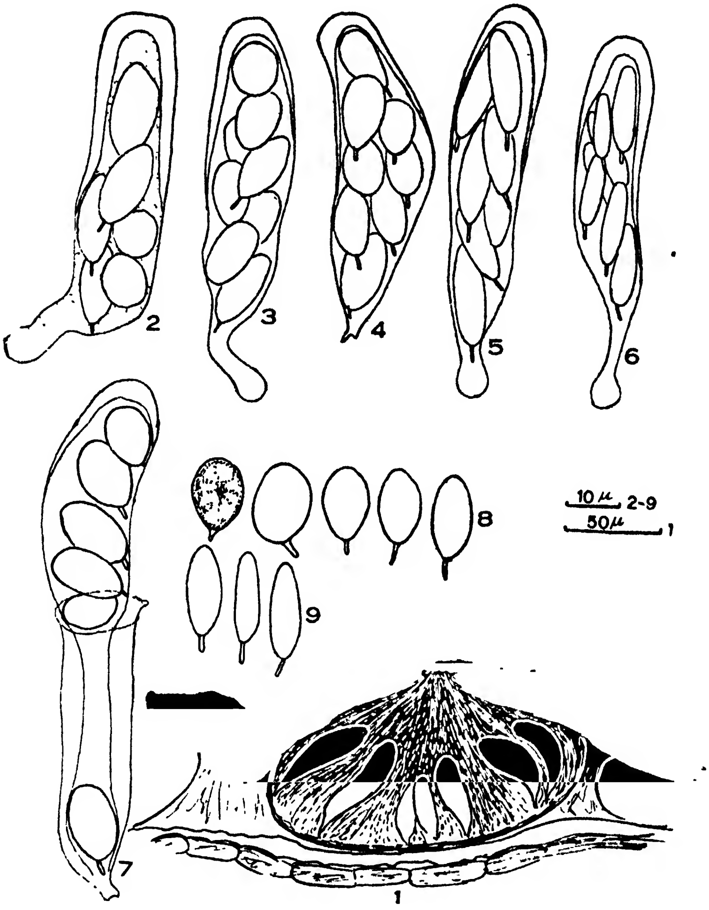
(Received for publication on November 30, 1955)

The fungus which forms the subject of this paper was found growing on dead twigs of *Quisqualis indica* Linn., at the University Botany Laboratory campus, Madras. A description of the fungus is given below.

The fungus forms black, somewhat circular or oval ascomata on the surface of the twig. The ascomata are entirely superficial without any free mycelium. The ascomata which measure ½–1 mm. in diameter may coalesce and form irregular patches. There is a clear ostiole-like opening at the centre which is slightly bulged out. The shield is made up of dark brown pseudoparenchymatous cells except at the margins where these cells are arranged radially. A cross-section shows that the ascomata are thyriothecia, each such thyriothecium enclosing a single locule and a single hymenium. The hymenium is made up of asci and paraphyses-like interthecial threads. The asci and the interthecial threads arise from a layer of thin-walled, subhyaline cells which form the lower wall of the thyriothecium. The asci are stout, broadly club-shaped, with a rounded or flattened apex and a narrow foot at the base. They measure $70–93 \times 15–22\,\mu$. The ascus is bitunicate with a thick inner and a thin outer wall. The ascospores form the most characteristic and interesting feature of the fungus. These are 8 in each ascus and are arranged in two irregular rows. They are hyaline, one-celled and ovoid in shape and measure $16–21 \times 8–13\,\mu$. Each ascospore is provided with a short, basal appendage which is hyaline and of uniform thickness or tapering from a slightly broadened base. This appendage seems to be made of the same material as the ascospore wall. The appendage is not mucoid and is not dissolved by lactic acid when mounted in this medium.

In addition to these ovoid ascospores certain other narrower and elongated, fusiform ascospores were also found in the material. These spores were also provided with the basal appendage. An ascus either contained the ovoid ascospores exclusively or the elongated ascospores; the two were not found mixed together in the same ascus. It is not clear whether the elongated ascospores were degenerate ones. Their protoplasm did not show any signs of disintegration.

The structure of the ascomata clearly shows that the fungus belongs to the Microthyriaceæ of the Hemisphæriales. The only genus of the Microthyriaceæ with caudate ascospores is *Caudella* Sydow (Stevens and Ryan, 1939). In this fungus, however, the ascospores are two-celled and the ascomata are aparaphysate. There is free mycelium present. The present fungus, therefore, has to be accommodated in a new genus. It is named *Sapucchaka* (from the Sanskrit, *Pucchaka* = a short tail).



FIGS. 1–9. *Sapucchaka madreeya.* Fig. 1. Section of a thyriothecium (diagrammatic). Figs. 2–4. Asci containing ovoid ascospores. Figs. 5–6. Asci containing narrow ascospores. Fig. 7. A dehisced ascus. Fig. 8. Ovoid ascospores. Fig. 9. Narrow ascospores.

Sapucchaka gen. nov.

Pertinent ad Ascomycetas. Hemisphæriales, Microthyriaceæ.

Mycelio nullo; ascomata superficialia, dimidiata, nigra, circularia; scutum radiale ad margines, ornatum foramine ostioli simili in centre; loculus unus in unoquoque ascomate, includens hymenium unicum, quod constant ex ascis atque filamentis paraphysis similibus; asci bitunicati; ascosporæ octo in singulis ascis, semel cellulatæ, hyalinæ, singulæ, ornatæ appendice brevi basali caude simili.

Sapucchaka madreeya sp. nov.

Mycelio nullo; ascomata superficialia, dimidiata, nigra, circularia vel irregularia per coalescentiam, 0·5–1 mm. diameter, ornata foramine claro in centro ostioli simili; scutum constans ex cellulis fusce brunneis, pseudoparenchymaticis, quae ad margines radialiter sunt dispositæ; hymenium ornatum unico vallo ascorum surgenti e serie basali ascomatis; series basalis constans e minutis cellulis subhyalinis; asci robusti, late clavati, bitunicati, rotundati vel complanati ad apicem superiorum, breviter pediculati ad basim, 70–93 × 15–22 μ; ascosporae irregulariter distichæ, hyalinæ, semel cellulatæ, ovoideæ, 16–21 × 8–13 μ; singulæ ascosporæ ornatæ brevi appendice recta caude simili; appendix uniformiter crassa per totam longitudinem, vel crassior ad basim, fastigiata ad apices, 4·8 × 1·6 μ; paraphyses angustæ, filiformes, inter ascos dispositæ.

Typus lectus in ramis emortuis *Quisqualis indicæ* Linn., in campo laboratorii botanici universitatis, in urbe Madras, die 4 mensis novembris, anni 1955 a K. Ramakrishnan, et positus in herbario M.U.B.L. sub-numero 1414.

I thank Prof. T. S. Sadasivan for much encouragement, the Rev. Fr. Dr. H. Santapau, S.J., for kindly translating the diagnoses into Latin and Prof. V. Raghavan for suggesting the Sanskrit name of the fungus.

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NATURAL REGENERATION IN *POGONATUM* PALIS

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(Received for publication on July 18, 1955)

While collecting materials for the study of the life-history of *Pogonatum* Palis, one of the Polytrichaceæ, certain young specimens of *P. perichætiale* (Mont.) Jæg. growing on the leaves of the same species were seen. On further examination it was found to be a common feature. It was thought to be of interest to study the growth of plants from the leaves and to know which part of the leaf gives rise to plants.

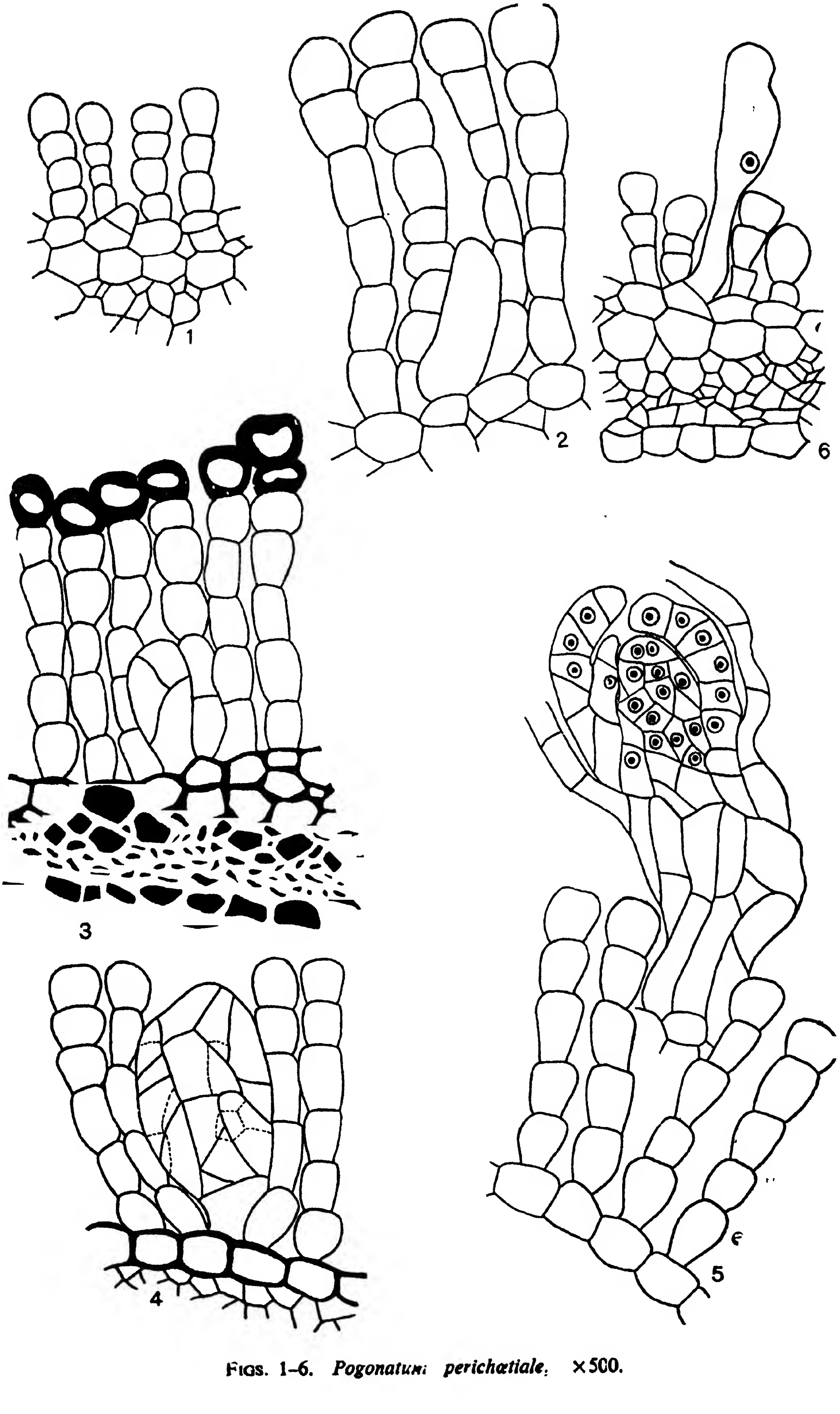
The material was collected from Depot Road, Mussoorie (Western Himalayas) and was fixed in Formalin-acetic-alcohol. Sections were cut from 8–10 μ thick and stained with Safranin and Fast green.

On most of the leaves only a single mature plant is seen but the leaves with more than one plant, *i.e.*, two, three or even four are also quite common. On a single leaf several plant initials, *i.e.*, buds are formed to start with but in most cases only one plant grows to maturity. The cells of the upper surface of the leaf, *i.e.*, cells which produce and bear lamellæ on them, assume meristematic activity. A cell enlarges and cuts off another cell which lies in the space between the two adjacent lamellæ (Fig. 1). This cell in turn enlarges considerably (Fig. 2) and divides by three oblique walls to cut off an apical cell (Fig. 3). The apical cell is developed by the first few divisions, so that the plant has got direct union with the surface of the leaf and no protonema in the usual sense of the term is developed. The apical cell cuts off segments and further development takes place to form a mature plant (Figs. 4 and 5). The origin of the leaf from the segments of the apical cell is not clear even in very young plants growing on leaves due to the condensed growth at the apex.

Sometimes the enlarging cell formed by the first division extends above, becomes linear and projects above the lamellæ (Fig. 6). This extending cell may even branch sometimes but it has never been observed to produce a young plant.

Regeneration from the lower portion of the stem has also been observed in a specimen.

It is not possible to say which portion of the leaf regenerates more effectively as studied by other authors in some other mosses in cultures because the present study has been made from naturally occurring regeneration. In this case an extensive protonema as described by Kachroo (1954) in *Physcomitrium pyriforme* Brid. and by Meyer (1942–43) in *Physcomitrium turbinatum* (Michx.) Brid. (in both cases in cultures) does not develop and when it does develop to a certain extent it does



FIGS. 1–6. *Pogonatum perichætiale.* ×500.

not produce a new plant. In this study it is seen that the cell which has to give rise to the plant divides immediately so that that plant has got direct union with the surface of the leaf as described by Gemmal (1953) in *Atrichum undulatum* (Hedw.) P. Beauv. This gives a better fixation and the growing plant may be drawing food from the leaf upon which it grows.

Our thanks are due to Prof. P. N. Mehra for going through the manuscript and making some useful suggesticns.

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PROBABLE FACTORS RESPONSIBLE FOR FORMATION OF SPOROGONIA IN *MANNIA INDICA* ST. AND *ASTERELLA PATHANKOTENSIS* KASH.

By P. Kachroo

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(Received for publication on September 12, 1955)

Among bryophytes studies on physiology have been mainly confined to mosses. Garjeane (1932) in a paper on Physiology (*cf.* Verdoorn, 1932) reviews the literature on the subject from 1900 onwards. 'Vakblad voor Biologen' 1920, Nr. 4 lists biologic literature from 1903–20. Servetaz (1922) first made a pure culture of mosses and the importance of such cultures was stressed upon by Pringsheim (1924).

The present communication is a preliminary note on the factors influencing the formation of female receptacle and sporogonia on the ventral shoots of *Mannia indica* and *Asterella pathankotensis.* The species were collected *en masse* with adherent soil (pH 8·5) from Pathankot and Hoshiarpur (Punjab) during February-March, 1950 and later cultivated as such in wooden boxes on canal soil (pH 7·0 approximately) in the Panjab University Botany Laboratory at Amritsar.

The experiments were performed on 225 plants. Sterilised canal soil in Petri dishes was employed for cultures which were kept at room temperature.

Experimental

(*a*) The apical portions of the thalli were cut and grown separately. The remaining portion of the thallus was allowed to grow; some male receptacle-bearing parts were segmented in such a way as to have two portions—one with male receptacle and the other without it.

(*b*) The ventral shoots were removed from the thalli and grown separately. These were removed at different stages of development as follows:—

(i) Very young ventral shoots with no indication of female receptacle.

(ii) Young ventral shoots showing the initiation of female receptacle.

(iii) Young ventral shoots with visible receptacle.

In the above experiments the apical portions of the vegetative thalli continued growth primarily due to the presence of apical cell. From the longitudinally segmented equal portions of the apical segment each showed capacity for shoot formation. Even two shoots were formed from the same region but it could not be determined whether one or more cells were involved in their formation. The fragmented maleless portions rarely formed lateral shoots.

The male cushion-bearing fragments did not form vegetative shoots from their basal regions.

The ventral shoots already developing with the unsegmented male fragments behaved normally with regard to sporogonia formation; where the female receptacles were evident the sporogonia were formed in the normal manner, when these were just dot-like in appearance the sporogonia formation was rare or absent.

The growth of the stalk of the female receptacle appeared to be related to the development of the sporogonia, since when the sporogonia attain maturity there is no increase in the length of the stalk.

In the very young ventral shoots where probably the receptacle development had not started, fruiting was absent and vegetative shoots were formed instead.

The parent thalli without the male cushion continued to live and formed vegetative shoots. In no case did these produce fresh sexual shoots. On dissecting them along the mid-rib vegetative shoots were only produced along their margins and even from the notch of the ventral shoots, but never from the midrib region.

The extent of fruiting by the fragmented portions is shown below:—

Portion used	Frequency of fruiting			Total No. of plants or fragments
	Frequency %	Rare %	Very rare %	
1 Apex with male receptacle	98	..	..	160 fragments
2 Ventral shoots with just visible female receptacle	..	30–40	5	160 shoots
3 Ventral shoots with visible female receptacle	90	..	5 due to injury	150 ,,
4 Ventral shoots without formation of female receptacle	..	..	..	200 ,,
5 Ordinary vegetative shoots	100	..	..	75 ,,
6 Same under continued humid conditions	..	..	12	75 ,,

It will be seen from the above that: frequency of fruiting was maximum in the ordinary vegetative shoots and less so in the segmented male cushions and ventral shoots with visible female receptacles. It was minimum in ventral shoots with the initiation of female receptacles and very rare in the vegetative shoots growing under extreme moist conditions.

The growth of the plants as observed under cultural conditions is of the following order:—

(i) the vegetative shoots show indefinite growth under humid conditions;

(ii) the stalked female receptacles on the detached ventral shoots form sporogonia earlier (*economy of time*);

(iii) the vegetative shoots formed by the fragments bearing male cushion show comparatively slower growth; and

(iv) the very young ventral shoots show little or no growth.

CONCLUSIONS

The midrib of the parent thallus is continuous with the midrib of the ventral shoots; the stalk of the female receptacle is actually terminating the midrib of the ventral shoots; the antheridial cushion is also in direct contact with the midrib; on removing the male cushion-bearing region of the thallus the female receptacle on the ventral shoots, hitherto small or absent, do not form sporogonia but vegetative shoots instead; the already developing female receptacles behave normally and form sporogonia and spores *comparatively* earlier than the controls and in cases where the receptacles are in their primordial stages the frequency of fruiting is rare.

It thus appears that the male cushion controls in some way the fruiting of the species. It is possible that it acts as a stimulus in initiating the sexual development in the notch of ventral shoot and the midrib conveys this stimulus. The fact that the ventral shoots removed from the decapitated thallus do not form female receptacles (even though near the male-cushion fragments and normal thalli) supports the probable influence of the presence of the male cushions on the initiation of the female receptacles.

The formation of the vegetative shoots from the margin is due to wound stimulus.

I am grateful to Prof. P. N. Mehra for laboratory facilities and for his interest in me and my work, to Prof. A. C. Joshi for encouragement.

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SOME ABNORMAL CONES OF *EQUISETUM DEBILE* ROXB.

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Milde (1865) in his monograph on *Equisetum* described some proliferated cones of *Equisetum maximum* and gave them a verietal status. Later on Ridley (1884) did not approve of this status being given to these monstrosities which according to him were due probably to accidental circumstances. Subsequently Bower (1904), Goebel (1918), Allen (1928), Kashyap (1930) and Tschudy (1939) also described such abnormalities in various species of the genus. Kashyap (1930) described three specimens of *Equisetum debile* each having two cones separated by two sterile leaf-sheaths and claimed such a condition to be unknown in any other species of the genus.

In November 1954 during a visit to a stand of *Equisetum debile* on the banks of Kali Nadi near Saini village, about eight miles from Meerut, I also came across some abnormal specimens. They differ from Kashyap's specimens in their gross structure and the structure of their components. One of the specimens was found to have the cone divided into two segments by a narrow transverse constriction having a fertile sheath comparable to an annulus, another specimen showed a short proliferated shoot, and a third one with a long proliferated shoot above the cone.

It may be worthwhile to describe these specimens in some detail.

In the first specimen the lower fertile portion is somewhat abnormal in this respect that its annulus is fertile and bears some sporangia on it, a condition reported in some normal cones of certain species (*cf.* Smith, 1938). Above the annulus there are four whorls of sporangiophores* of which the lower three have 'discs' laterally compressed and the fourth has 'discs' which are somewhat rounded or oval. From the centre of each 'disc' of fourth or the last whorl there comes out a small spiny projection (Fig. 1). In this whorl each 'disc' has only two sporangia and is attached to a flattened horizontal stalk by its lower margin, (Figs. 1-3). After a narrow constriction there follows the upper portion of the cone having a distinct fertile annulus similar to that of the lower portion. In this portion the 'discs' are not hexagonal but somewhat circular with lobed margins. They become smaller towards the top of the cone. The sterile leaf-sheath below the annulus of the cone has nine acuminate teeth (Fig. 1).

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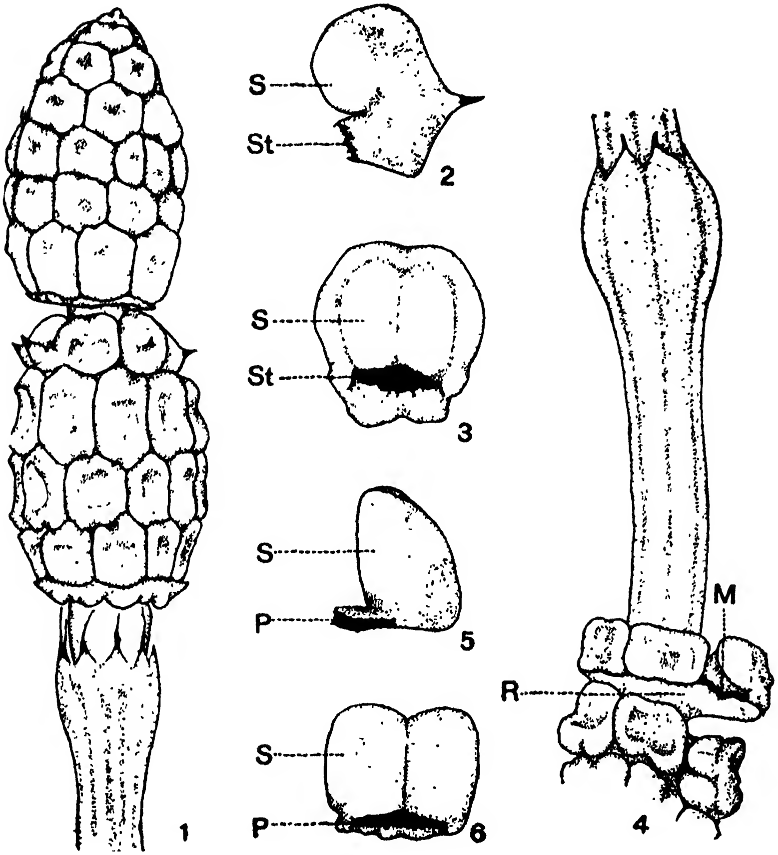
* Tschudy (1939) has discovered some correlation between the leafy character of the sporangiophore and the number of sporangia, and as a result of this he arrives at the conclusion that the sporangiophore should better be regarded as a sporophyll than anything else.



Figs. 1–6. *Equisetum debile*. Fig. 1. Abnormal cone with a median constriction. Figs. 2–3. Sporangiophore of the fourth whorl of the same in lateral and adaxial views respectively. Fig. 4. Upper part of the cone with long proliferation showing the 'discs' attached to the margin of the 'rim'. Figs. 5–6. Sporangiophore of the last whorl of the same in lateral and adaxial views respectively. *M*, margin of the 'rim' from where the 'disc' has been removed; *P*, place of attachment of the 'disc' to the 'rim'; *R*, 'rim'; *S*, sporangia; *St*, stalk of the sporangiophore.

In the second case the cone has a small proliferation at its top. The annulus is fertile as in the first specimen, and above it there are three whorls of sporangiospores. Whereas the lower two whorls are normal with hexagonal 'discs', the third whorl has 'discs' that are somewhat laterally compressed. The sterile leaf-sheath below the annulus is nine-toothed with acuminate ends. Above the cone is a small shoot with three small internodes and nodes bearing normal sterile leaf-sheaths each having seven unequal teeth.

In the third case the stalk of the cone is very delicate as compared to stalk of normal cones, the annulus is fertile with distinct sporangia on the upper surface. There are only two whorls of sporangiophores, lower whorl with 'discs' somewhat square in shape, and upper one having laterally elongated 'discs'. The 'discs' of the second or the last whorl are peculiar in having no slender stalk but their lower margins are fused all along their length to the margin of a 'rim' (Figs. 4–6). The sterile sheaths below the cone have got six teeth with acuminate ends (except the sterile sheath just below the annulus of the cone which has bluntly pointed teeth and forms a saucer-shaped structure). A proliferated shoot is also present above the cone with three long internodes and normal sterile leaf-sheaths each with six bluntly pointed teeth.

Grateful thanks are due to my respected teacher Dr. V. Puri, for guidance and encouragement. I am also thankful to Mr. Y. S. Murty, for valuable help.

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EMBRYOLOGY OF THE PASSIFLORACEÆ

I. Gametogenesis and Seed Development of *Passiflora calcarata* Mast.

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The Passifloraceæ included by Engler and Prantl (1925) in the order Parietales comprise eleven genera of which the genus *Passiflora* has 400 species most of them being distributed in the tropics and a few in sub-tropical Asia. Gamble (1919) reports one species of *Passiflora* and two of *Adenia* in South India. Recently, Chakravarty (1949) has made a review of the Indian Passifloraceæ. He has reported 25 species of *Passiflora* and seven of *Adenia*. *Passiflora calcarata* Mast. is an introduced plant now growing wild in many parts of South India.

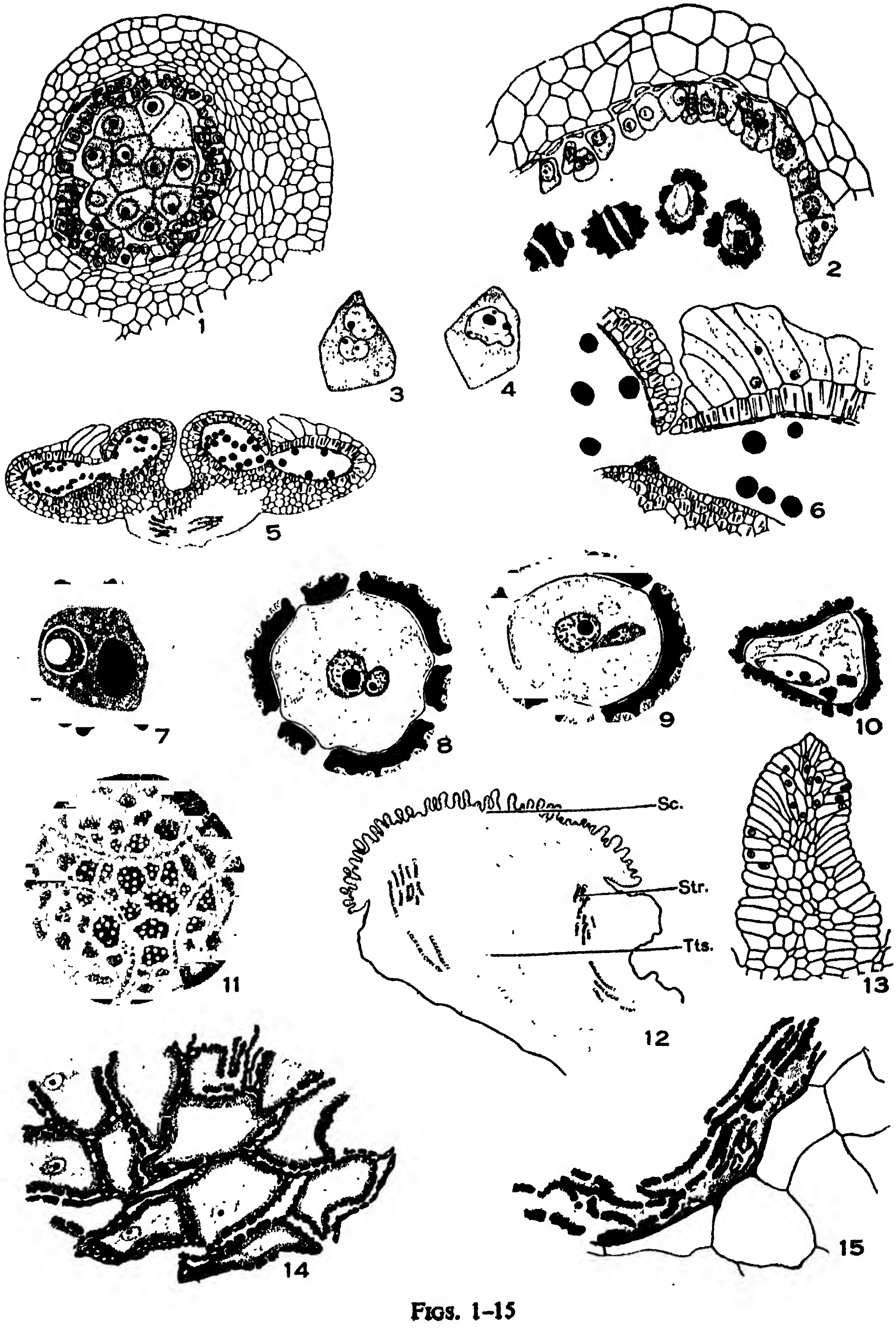
Previous work on the embryology of the Passifloraceæ is meagre. Schnarf (1929, 1931) has reviewed the embryological features of this family. Some observation on the peculiar behaviour of the pollen tube in *Passiflora adenophylla* has been made by Cook (1909). In a comprehensive survey of seed-coat structure of angiosperms, Netolitzky (1926) has referred to the seed-coat and aril of *Adenia venenata*, *Passiflora holoserecea* and *P. hirsuta*. The present investigation deals with the development of gametophytes and seed of *Passiflora calcarata* Mast.

Abbreviations

A, aril; *Ce*, cellular endosperm; *Cot*, cotyledon; *Cs*, chalazal vascular strand; *Ct*, chalazal tissue; *Emb*, embryo; *Fs*, funicular strand; *Fu*, funiculus; *Ii*, inner integument; *In*, ingrowths; *N*, nucellus; *Ne*, nuclear endosperm; *Oi*, outer integument; *Ppt*, persistent pollen tube; *Sc*, stigmatic crest; *Str*, stylar tracheids; *Tts*, transmitting tissue.

Observations

Microsporangium and male gametophyte.—The microsporangium in transverse section has a group of microspore mother cells surrounded by a glandular tapetum (Fig. 1). The anther wall comprises the epidermis, endothecium, two to three middle layers and the tapetum (Figs. 1, 2). In later stages, the middle layers get crushed and the endothecium develops fibrous thickenings (Figs. 5, 6). Such thickenings are also seen in some cells of the connective (Fig. 5). The epidermal cells of the outer loculi get very much enlarged near the region of dehiscence (Figs. 5, 6). The tapetal cells are glandular, binucleate and biseriate at certain regions (Fig. 1). Their nuclei often show tendencies of repeated fusion (Figs. 3, 4). At the shedding stage the pollen grains are two celled (Figs. 8, 9). They show heavy reticulate thickenings (Figs. 7–11).



Figs. 1–15

FIGS. 1-15. Fig. 1. Transverse section of a young anther lobe showing spore mother cells, tapetum and the wall, ×50. Fig. 2. A portion of anther at a later stage with epidermis, wall layers, tapetum and microspores, ×50. Fig. 3. Tapetal cell with free nuclei, ×216. Fig. 4. Same with a single nucleus formed by the fusion of free nuclei, ×216. Fig. 5. T.s. of anther at the time of dehiscence, note the fibrous thickenings and also the enlarged epidermal cells at the region of dehiscence. ×6. Fig. 6. Same at the region of dehiscence enlarged, ×13. Fig. 7. Section of uninucleate microspore, ×216. Fig. 8. Section of two-celled microspore showing six germinal areas, ×216. Fig. 9. Same at a later stage, ×216. Fig. 10. Section of distorted pollen grain with a hypertrophied nucleus and two darkly stained bodies, ×216. Fig. 11. Surface view of the entire pollen grain showing reticulate sculpturing of exine, ×216. Fig. 12. Longisection of tip of the style showing stigmatic crest with multicellular outgrowths, ×6. Fig. 13. A multicellular outgrowth. ×50. Fig. 14. Abnormal distorted pollen grains in the anther locule, ×100. Fig. 15. Same, grains pushed to a side of the anther locule. ×100.

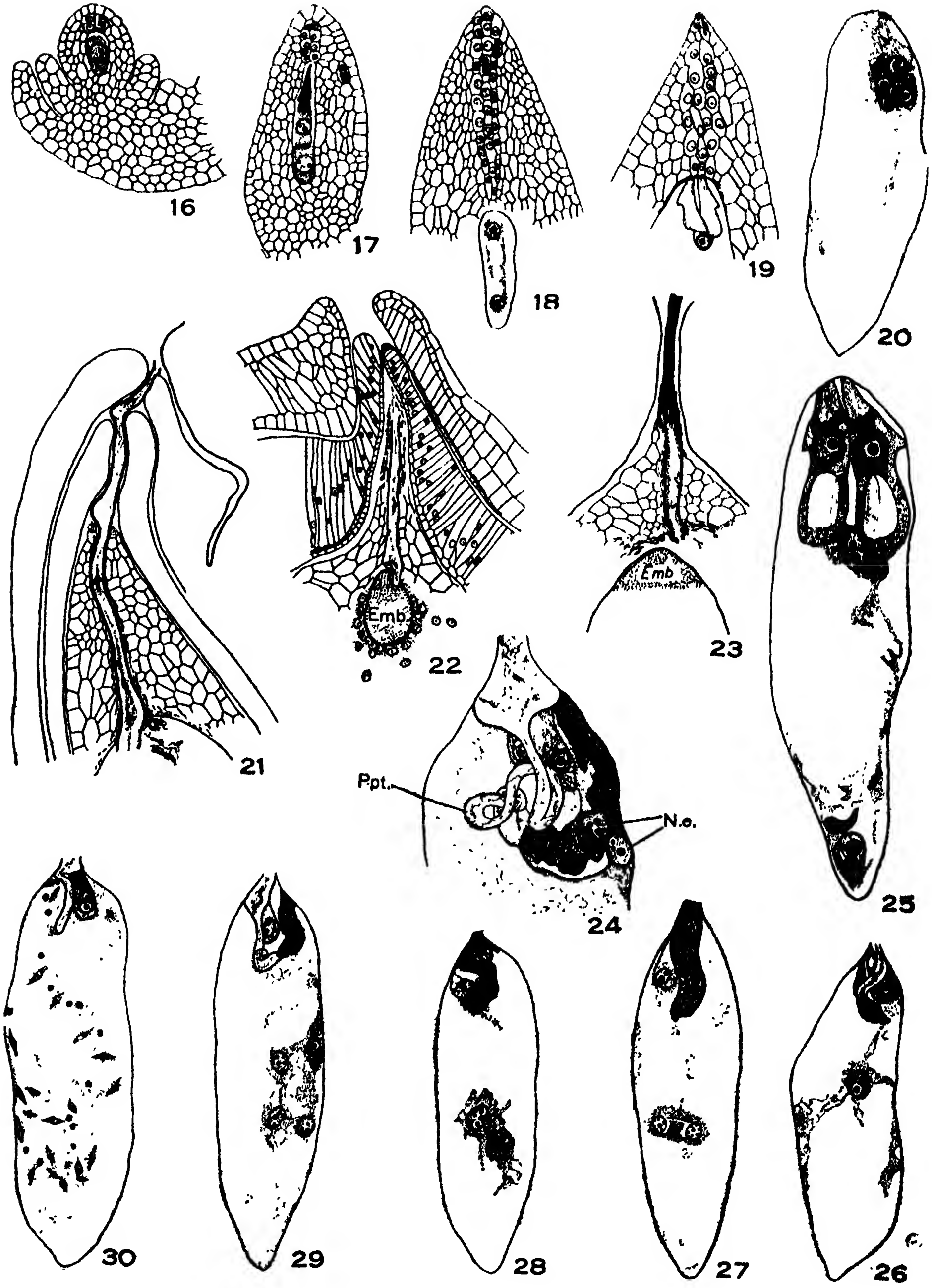
Several cases of degeneration of pollen grains are noticed. They present a distorted appearance (Fig. 14) and are pushed towards the wall of the anther (Fig. 15). Such pollen grains become prominently vacuolate and have hypertrophied nuclei which stain very lightly (Figs. 13-15).

Megasporangium and female gametophyte.—The ovules are crassinucellate, bitegmic and are borne on parietal placentæ. A few ovules in the locule of the ovary remain orthotropous. The ovular primordia develop from the placenta as small projections. The integumental initials are laid down at the time of archesporial differentiation. Soon they develop further and the ovules take an anatropous bend. The micropyle is organised by the two integuments (Fig. 21). The nucellar cells divide actively till the two-nucleate stage of the female gametophyte (Figs. 16–19). Some of them at the micropylar end are elongated and contain dense cytoplasm. During post-fertilization stages, the nucellus becomes irregular in outline due to the development of ingrowths from the seed-coat (Fig. 43).

At the tetrad stage of megaspores, the nucellar cells at the chalazal region of the ovule become conspicuously stained. During seed development this becomes differentiated into the chalazal tissue into which the vascular strand branches freely. A few cells of this region in contact with the lower end of the endosperm become slightly elongated (Figs. 31–38, 43, 43 *e*).

The archesporium is hypodermal and it divides transversely forming the upper primary parietal cell and the lower megaspore mother cell. The parietal cell by further divisions forms the parietal tissue. The megaspore mother cell undergoes meiosis and a linear tetrad of megaspores is formed (Fig. 17), of which the upper three degenerate and the lowermost develops into the embryo sac (Figs. 18, 25) of the Polygonum type (Maheshwari, 1948). The synergids are hooked and show filiform apparatus. The egg is situated between and often below them. The ephemeral antipodal cells are situated at the attenuated chalazal end of the embryo sac.

Many instances of degeneration of megaspore tetrads and embryo sacs are observed and the former appear as dark deeply stained masses.



FIGS. 16–30. Fig. 16. L.s. of ovule showing the integuments, parietal cells and megaspore mother cell, ×50. Fig. 17. Nucellus showing a linear tetrad of megaspores of which the upper two have degenerated, ×50. Fig. 18. Same at a later stage showing a few layers of radially elongated nucellar cells and two-nucleate embryo sac, ×50. Fig. 19. Nucellus at the mature embryo sac stage, ×50.

Fig. 20. An abnormal embryo sac with aggregation of six free nuclei at the micropylar end, × 100. Fig. 21. L.s. of ovule at the region of micropyle showing the irregular micropyle and pollen tube, × 50. Fig. 22. Same at a later stage with scanty nucellus, persisting pollen tube and developing embryo, × 50. Fig. 23. Same at a still later stage, × 50. Fig. 24. A case showing convolutions of pollen tube, × 100. Fig. 25. Mature embryo sac, × 100. Fig. 26. Stage in double fertilization, × 50. Figs. 27–30. Stage in development of endosperm, × 50.

In an abnormal embryo sac six nuclei are seen aggregated at the micropylar end (Fig. 20).

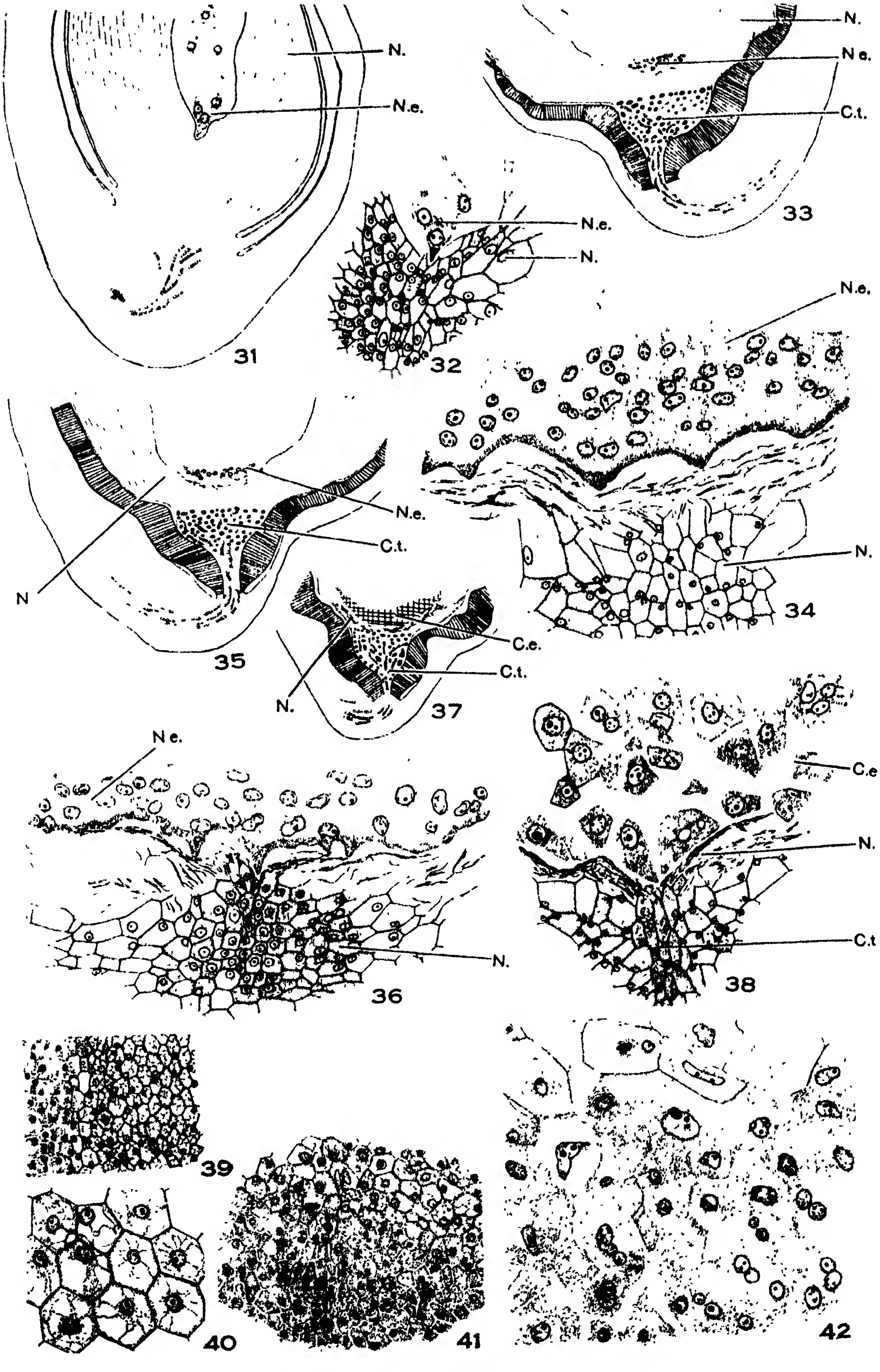
Stigma, Pollen tube and Fertilization.—The tricarpellary ovary has three stylar branches, each ending in a globose stigma. In a sectional view of the solid style, the transmitting tissue spreads over the stylar tip and develops conical outgrowths to form the receptive structure (Fig. 12). The former can be differentiated from the stylar tissue. The outgrowths of the stigmatic crest (Figs. 12, 13) facilitate in the retention of the pollen grains.

The pollen tube emerges out of one of the furrows in the equatorial region and penetrates into one of the multicellular outgrowths of the stigmatic crest. Then it reaches the ovarian cavity through the transmitting tissue of the style. The pollen tube is quite prominent and makes its entry through the irregular micropyle into the embryo sac, destroying on its way the radiating cell layers of the nucellus (Fig. 21). It has a thick wall and persists during later stages of seed development (Figs. 21–33). In some of them the presence of cytoplasm is quite evident (Figs. 21-24). Many cases of pollen tube convolutions have been observed near the micropylar end of the embryo sac (Fig. 24).

Double fertilization has been observed (Fig. 26). The pollen tube, as it enters into the embryo sac, destroys one of the synergids. It bursts open at the tip liberating darkly stained substances (Fig. 24) and the male nuclei, one of which fuses with the egg and the other with the secondary nucleus (Fig. 26).

Endosperm.—The primary endosperm nucleus by repeated divisions forms a large number of nuclei (Figs. 27–30). These aggregate in a dense mass of cytoplasm at the chalazal region (Figs. 34, 43). A similar accumulation of nuclei is also noticed around the developing embryo (Fig. 22). In early stages of endosperm development, the nuclei in chalazal portion become conspicuous. This portion of endosperm closely abuts on the nucellus between the chalazal tissue and the lower region of the embryo sac (Figs. 35, 36). Later, as development proceeds, it comes into direct contact with the chalazal tissue (Figs. 36, 38).

Cytokinesis around the free endosperm nuclei results in an endosperm tissue. It encroaches on the remaining nucellus and finally becomes irregular in outline (Fig. 51). The endosperm cells towards the periphery appear like meristematic cells and are deeply stained (Fig. 39). In the middle they are vacuolate and hexagonal (Figs. 39, 40). At the chalazal end they contain hypertrophied nuclei and are plurinucleate. In a few cells nuclear fusions are noticed (Figs. 41,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Figs. 31–42.

FIGS. 31–42. Fig. 31. L.s. of chalazal portion of a young seed showing massive nucellus and free nuclear endosperm with the cytoplasm penetrating into the adjacent nucellus, ×48. Fig. 32. Portion of the same at the chalazal region enlarged, ×109. Fig. 33. L.s. of chalazal portion of an older seed showing chalazal tissue and also a portion of nucellus digested by the nuclear endosperm, ×11. Fig. 34. Enlarged portion of the same, ×108. Fig. 35. L.s. of chalazal portion of a still older seed; ×11. Fig. 36. Same enlarged, ×108. Fig. 37. L.s. of a fairly mature seed showing cellular endosperm, degenerated nucellus and persistent chalazal tissue, ×7. Fig. 38. Same enlarged to show details, ×100. Fig. 39. Portion of endosperm in the middle region showing peripheral meristematic-like cells and hexagonal cells towards the centre, ×23. Fig. 40. Enlarged sketch of the central vacuolate hexagonal endosperm cells, ×67. Fig. 41. Chalazal portion of endosperm under low power showing nuclear activity, ×23. Fig. 42. Portion of same enlarged to show hypertrophied nuclei and various stages of nuclear fusion, ×67.

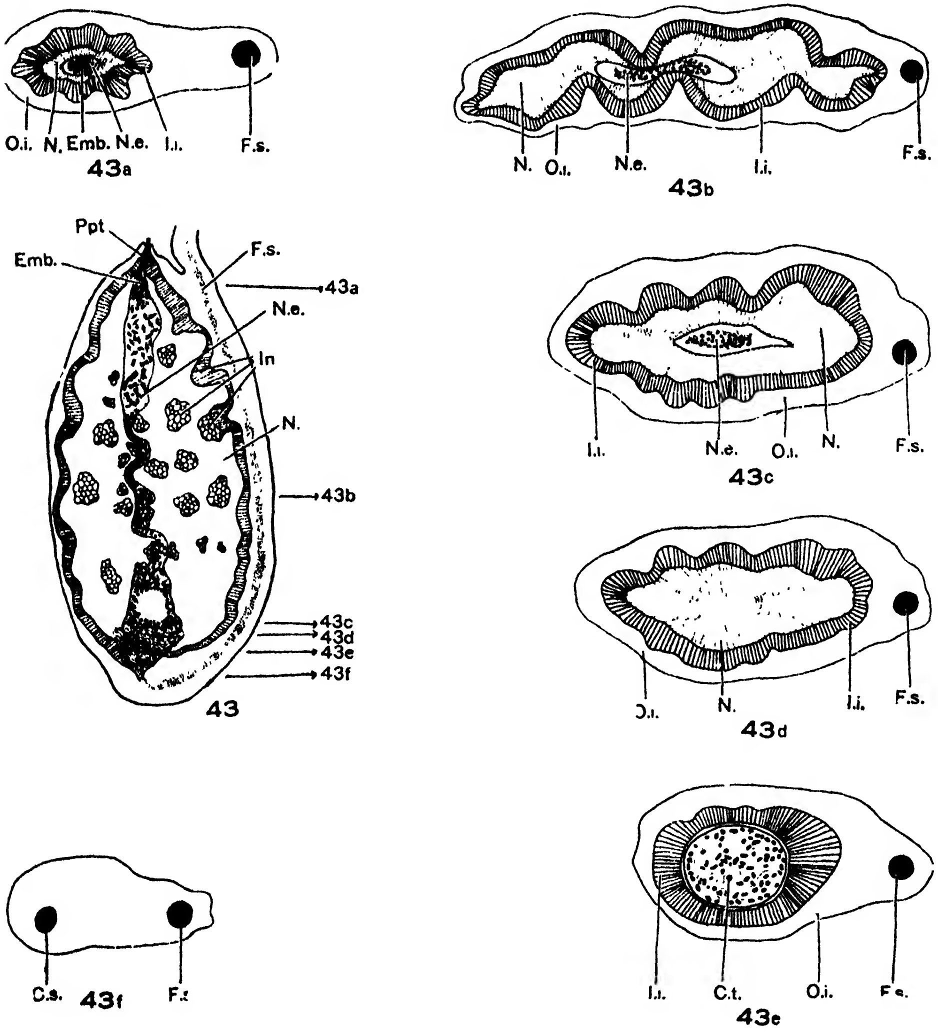
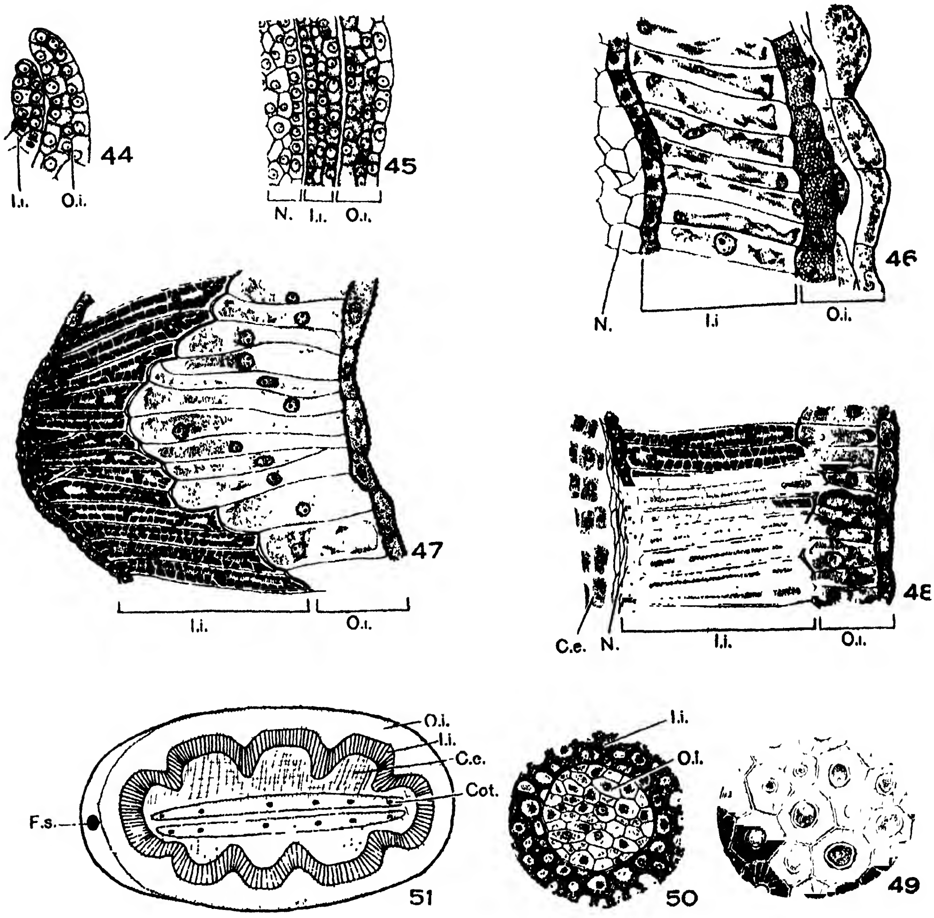


FIG. 43

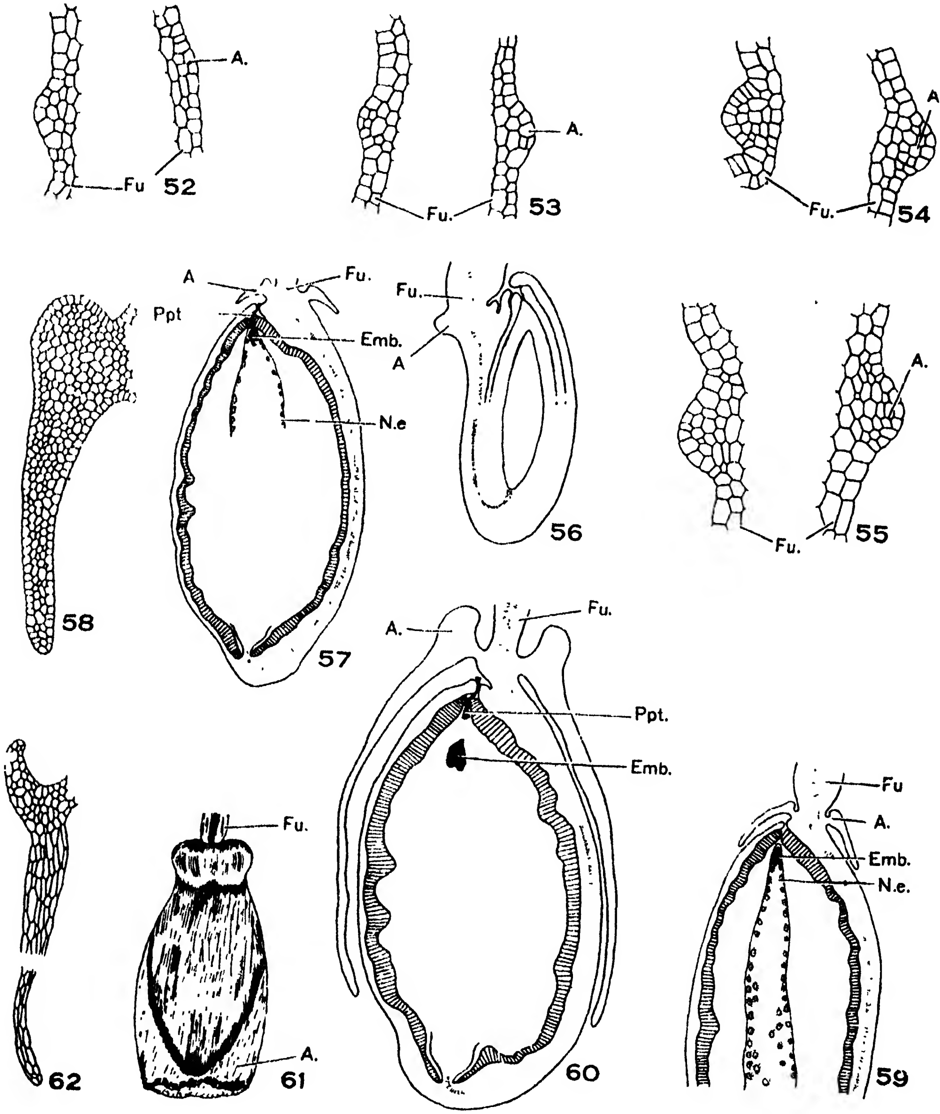
FIG. 43. L.s. of a fairly old seed showing irregular embryo sac with free endosperm nuclei; note also the integumental ingrowths, ×6. Figs. 43 *a–f*. Transverse sections of the seed at different levels as indicated in Fig. 43, ×9.



FIGS. 44–51. Fig. 44. L.s. of inner and outer integuments, ×67. Fig. 45. Later stage showing three layered inner and outer integuments, ×67. Fig. 46. Section of the seed-coat with disintegrating middle layer in each of the two integuments, ×40. Fig. 47. Section of the well-developed seed-coat at the region of the ingrowth, ×40. Fig. 48. Section of the seed-coat, ×40. Fig. 49. T.s. of lignified region of the integument to show simple and ramified pits, ×67. Fig. 50. T.s. of ingrowth showing the central outer integument surrounded by the sclerotic cells, ×33. Fig. 51. Diagrammatic transverse section of the mature seed showing ingrowths, cellular endosperm and cotyledons of the embryo.

42). During later stages of seed development the growing embryo consumes a portion of the surrounding endosperm.

Seed-coat.—The seed-coat is organised by the two integuments. The inner integument to start with is two layered and later by the periclinal division of the inner layer becomes three layered (Figs. 44, 45). The outer integument is also three layered (Fig. 45). The middle layers of both the integuments get crushed during seed-coat organisation (Figs. 46, 48). In the mature seed the outermost layer of the



Figs. 52–62. Figs. 52–60. Stages showing development of aril. Fig. 61. Diagrammatic sketch of the seed with the enveloped aril. Fig. 62. L.s. of a portion of the aril showing multilayered base and two to four layered tip. Figs. 52–55, ×44. Fig. 56, ×13. Fig. 57, ×3. Fig. 58, ×23. Figs. 59–60, ×3. Fig. 62, ×6.

outer integument has its outer wall echinulately thickened (Figs. 47, 48). The innermost layer consists of radially stretched cells (Figs. 47, 48).

The outermost layer of the inner integument becomes prominently elongated and lignified with both simple and ramiform pits (Figs. 47–49). The cells of the innermost layer are brownish and deeply stained (Figs. 47, 48).

The seed-coat develops ingrowths all round its inner surface (Figs. 43, 51). The inner integument is pushed in by the radial elongation of the cells of the innermost layer of the outer integument (Figs. 47, 50). The degree of radial elongation of the cells is not uniform throughout. So, this results in a wavy appearance on the inner surface of the seed-coat. These ingrowths which appear like ruminations do not extend deep into the seed.

Aril.—The seeds are arillate (Fig. 61). At about the tetrad stage of megaspores, the initials of the aril arise on the funiculus, just above the micropylar region of the anatropous ovule (Fig. 52). During its development some epidermal cells of the funiculus near the micropyle become conspicuous. Later, these divide periclinally to form a collar all round the funiculus (Figs. 52–56). The collar does not develop further till the stage of fertilization (Fig. 56). However, after fertilization, it shows pronounced development. It soon grows over the micropyle and completely encloses the seed (Figs. 57–60). In a longitudinal section the aril is about two to four layered at its tip and multilayered at the base (Figs. 58, 62). Its thin-walled cells are filled with plenty of oil, starchy material and yellow red chromoplasts. The persistent aril which is whitish to start with becomes brownish pink later. It completely envelops the brownish black seed, except at the chalazal end where it is open.

DISCUSSION

While discussing the systematic position of the Cactaceæ (see Maheshwari, 1950, p. 364), the absence of division in the nucellar epidermis in the Passifloraceæ has been taken as one of the striking differences between these two families. However, in the present form, the nucellar epidermis divides periclinally adding a little to the mass of nucellar tissue.

The occurrence of persistent pollen tubes in the developing seeds has been reported in several angiosperms (Maheshwari and Johri, 1950; Venkata Rao, 1952). Venkata Rao (1952) attributes a haustorial function to such persisting pollen tubes in some Malvaceæ. According to him "the persistence without any collapse of the pollen tube with tough wall lined internally by a thin layer of cytoplasm and the presence of its rupture end at the base of the embryo are sufficient evidence to show the liaison behaviour of the persistent pollen tube conveying food material from the inner integument to the developing embryo". He also brings evidence of the crushed layers of the inner integument during the development of the seed. The persisting pollen tube of *Passiflora calcarata* has a fairly thick wall enclosing scanty cytoplasmic contents and does not get crushed by the adjacent tissues in the developing seeds. Though it shows the presence of cytoplasm there is no indication of its activity. So, it has no haustorial or liaison function and a similar view has already been expressed by Maheshwari and Johri (1950).

The nuclear endosperm becomes cellular at a later stage. Dense aggregation of endosperm nuclei is seen in the chalazal region and also around the embryo. The chalazal endosperm tissue is distinguished from the rest by its larger cells and hypertrophied nuclei. Some of these cells are plurinucleate and show nuclear fusions. In the remaining endosperm, the cells along the periphery appear like meristematic cells, and those in the centre are vacuolate and hexagonal. The endosperm finally displaces the nucellus and its cells are filled with oily, starchy and proteinaceous contents.

The seed-coat of *Passiflora calcarata* is organised by the two integuments and in structure and development it recalls some of the features of *Adenia venenata*, *Passiflora holoserecea* and *P. hirsuta* (Netolitzky, 1926). In all these forms the number of layers in the outer and inner integuments is more or less the same. The seed-coat in *Adenia venenata* is peculiar in possessing lacunæ and there are no lignified layers in the inner integument at any stage of development (Netolitzky, 1926). But, in the species of *Passiflora* investigated so far, a lignified layer develops in the inner integument (Netolitzky, 1926). In *P. holoserecea*, the innermost layer of the inner integument gets crushed during the development of the seed-coat (Netolitzky, 1926). But, in *P. calcarata*, this layer, in particular, persists with brownish colouration. Further, in this form the cuticle develops echinulate thickenings; but, Netolitzky (1926) reports a simple cuticle for *P. holoserecea* and *P. hirsuta*.

In *Passiflora calcarata* the wedge-like ingrowths are developed from the seed-coat and are very prominent in the middle region of seed. They show a superficial resemblance to ruminations. A detailed account of these ruminations in a few Annonaceæ has been described by Corner (1949). According to him the ruminations are composed of foldings of inner integument into which extend portions of outer integument. But, in a few other cases, either the outer or the inner takes part in the organisation of ruminations. Development of such ruminations has also been recorded in a few other angiosperms (Voigt, 1888; Swamy, 1949; Sastri, 1954; Venkata Rao, 1955). The ingrowths of *Passiflora calcarata* become hardened by the deposition of lignin and a similar type of lignification is seen in some layers of cells in the ruminations of Annonaceæ (Corner, 1949). In Degeneriaceæ and Magnoliaceæ, however, the wedged-ruminations become stony due to the hardening of cell contents (Swamy, 1949). Dahlgren (1922) has described four types ruminations based on the correlation between the development of the nucellus, endosperm and seed. The ingrowths or the so-called ruminations of *Passiflora calcarata* correspond to the Spigelia type of Dahlgren, so far as the time of organisation of ingrowths is concerned. They are completely formed when the nucellus is still present and the endosperm is nuclear.

The aril in *Passiflora calcarata* arises from the funiculus in the form of a collar very near the micropyle, by the active division of a group of epidermal and some hypodermal cells. It grows over th micropyle enveloping the seed, but remains open at the chalazal end

SUMMARY

Developmental stages of microsporangium and male gametophyte, megasporangium and female gametophyte of *Passiflora calcarata* Mast. are described. Double fertilization has been observed. The endosperm is nuclear to start with but, later becomes cellular. Its structure and behaviour are described. The seed-coat is organised by both the integuments. The structure of seed-coat and formation of ingrowths are explained in detail. Aril development is followed.

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ON FACTORS INFLUENCING FRUIT-SET AND STERILITY IN ARECANUT (*ARECA CATECHU* LINN.)

I. Studies on Pollen Grains

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Introduction

The arecanut (*Areca catechu* Linn., Palmæ) which is one of the most important of tropical fruits as a masticatory, is cultivated in the hot damp regions of Asia. In India arecanuts are grown extensively in Assam, Bengal, Bombay, Madras and the West Coast. Many different types of arecanut palms have been distinguished on the basis of the size of the fruits, majority being included in the single species, *A. catechu*. However, no comprehensive investigation on the different aspects of the life-history of this plant has been made except by Beccari (1919), Sands (1926), Milsum (1938) and Nambiar (1949) on the morphology and floral structure.

The plants are monœcious, male and female flowers occurring in the same spadix. A full grown spadix produces on an average of about 2,000–3,000 male flowers and 250–550 female flowers, the former constituting the panicle of the spadix and the latter occupying the basal region. It is generally observed that all the female flowers that are borne on the spadix do not yield fruits, a considerable majority of them falling off prematurely. The extent of sterility caused by such flower fall in the different plantations in Assam has been found to vary from 35–55 per cent. As the extent of sterility is high, the causes thereof are being investigated. The present work is based on observations made during two consecutive seasons in the different plantations.

One criterion used in classifying the palms is the size of the fruit and on this basis the different types are broadly separated into five groups: (i) Big oblong, (ii) Big round, (iii) Small oblong, (iv) Long and (v) Apex round fruits. There are, however, many variations in size in between the different types, intermediate types being not uncommonly found.

MATERIAL AND METHODS

In order to investigate this loss in fruit-set, the male flowers of the different types were examined to determine if sterility is associated with the nature and behaviour of the pollen grains. Maheshwari (1950) has emphasised the importance of pollen grains in relation to fruit-set in plants while Wodehouse (1935) and Erdtman (1952 *a*, *b*) have stressed the importance of morphological characters of pollen grains in taxonomy.

Inflorescences bearing the male flowers of the different types were collected from various localities at Gauhati. Fresh panicles were brought to the laboratory in the morning and pollen preparations were made in methyl-green glycerine jelly according to Wodehouse (1935). Preparations of two types from Jorhat, namely, 'apex round' and 'long', were made in the field itself and the slides were subsequently examined in the laboratory. The measurements of the grains were made with an ocular micrometer.

The causes of failure of germination of the pollen grains, in different types of arecanuts, resulting in lack of fertilization, have been studied in detail by determining the extent of germination of the pollen grains and the rate of elongation of the pollen tubes in different media. The effect of changes in the composition of the medium by using different types of carbohydrates such as sucrose, glucose, lævulose, maltose and starch was studied. The aqueous extracts of crushed stigmas of different types of arecanuts were also used. Germination counts were made in duplicate cultures at 28° C. by the hanging drop technique and in each case more than 100 counts were made to determine the extent of germination. The length of the pollen tubes was measured from time to time with an ocular micrometer.

EXPERIMENTAL

Fruit-set and sterility.—Estimates were made on the fruit-set and sterility in the different palms according to their types of fruits. The number of female flowers generally produced on the spadix and the number of fruits usually borne in the bunch were counted to determine the extent of fruit-set and sterility in each instance (Table I); figures for each type are based on the average of at least 20 bunches. The trees in the plantations are marked. The period intervening between flowers that have been observed and the fruits that have been formed in 5–7 months, was noted.

It will be seen from the above that fruit-set varies from 46–66 per cent. of the number of female flowers produced. Flower fall appeared to be related to the size of the fruits, the bigger sized fruits showing higher sterility than smaller types of fruits.

Morphology of pollen grains.—In all the types mature pollen grains show a similar morphology in having a reticulate exine (Fig. 1 *a*), a thin hyaline intine and a sharply defined oval furrow oriented parallel to the polar axis containing a small central germ pore-like structure

TABLE I

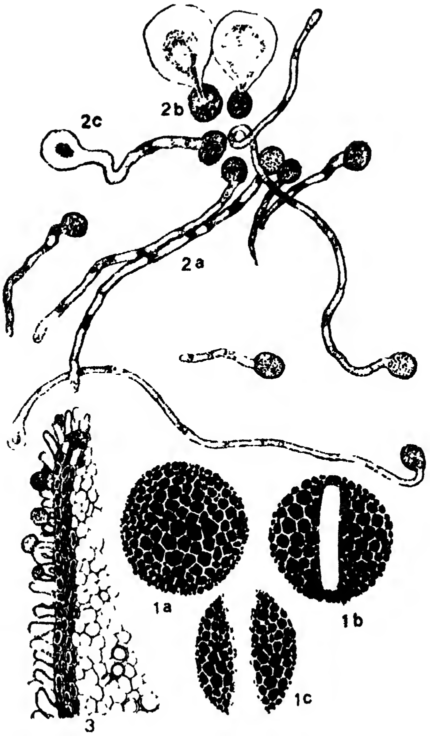
Extent of fruit-set and sterility in the different types of arecanuts

Locality	Type	No. of female flowers	No. of fruits	Extent of fruit-set %	Extent of sterility %
Charrapunji ..	Big oblong	446	220	49	51
	Small oblong	503	278	55	45
Dawki ..	Big oblong	460	237	52	48
	Big round	452	228	50	50
	Small oblong	419	252	60	40
Gauhati ..	Big oblong	502	260	52	48
	Big round	422	227	54	46
	Small oblong	488	289	59	41
Jorhat ..	Big oblong	394	192	49	51
	Apex round	469	282	60	40
	Long	420	254	60	40
	Small oblong	407	249	61	39
Nowgong ..	Big oblong	350	160	46	54
	Big round	428	221	52	48
	Small oblong	406	266	66	34
Palasbari ..	Big oblong	480	245	51	49
	Big round	469	234	50	50
	Small oblong	492	270	55	45
Sibsagar ..	Big oblong	522	287	55	45

(Fig. 1 *b*). The grains conform to the monocolpate type of Wodehouse (1935) or monosulcate of Erdtman (1952 *b*). The fertile grains were more or less spherical, but the sterile ones varied from ellipsoidal to sharply defined oval structures (Fig. 1 *c*). The sterile, crumbled or empty grains were of the same size as the fertile ones, but they could easily be distinguished by feeble staining reactions with methyl-green glycerine jelly. There were minor variations in size in the grains of the different types. The average range in size of the fertile and sterile grains was respectively 29·5–34·0 μ and 29·0–31·5 μ.

The anthers of the male flowers produce fertile pollen as well as sterile or imperfect grains. The extent of sterility is high, varying from 3·0–100·0 per cent. in the different types examined.

Pollination and flower fall.—In many plants premature flower fall is probably influenced to a great extent by the failure of pollination or by certain physiological factors or by both. Fruit-set is dependent on the normal development of the male and female reproductive units and the successful pollination of the stigmas affecting fertilization of the ovule. The high percentage of sterile grains in arecanuts indicates that one of the possible factors of sterility may be failure of pollination and subsequent failure of fertilization in some of the pollinated flowers. An attempt was, therefore, made to see if there is any defect in the normal course of events leading to fertilization and ultimate development of the fruit.



FIGS. 1–3. Fig. 1. Pollen grains. (*a*) Surface view of fertile grain showing reticulate exine. (*b*) Same showing furrow and 'germ pore'. (*c*) Sterile grain, × 350. Fig. 2. Germinating pollen grains. (*a*) Normal germination after 24 hours. (*b*) Pollen grains germinating into vesicles in high concentrations of medium. (*c*) Formation of vesicles at the tip of tubes, × 65. Fig. 3. Section through the mature stigma showing the elongated receptive cells and germinating pollen grains, × 15.

The male phase in arecanut palm begins immediately after the spadix frees itself from the spathe (Sands, 1926). The male flowers commence to open indiscriminately on the spadix; this phase continues for 2–4 weeks till all the male flowers are exhausted. At the close of the male phase, the green petals of the female flowers lengthen and change their colour to yellowish white. The petals slightly open at the tips and soon after, the receptive trifid stigmas are open to pollination. The female phase generally lasts for 4–5 days and during this period the flowers remain open all through, exposing their receptive stigmatic surfaces. The surface of the stigma is constituted of a special kind of thick-walled palisade-like cells which are closely packed in the young flowers but become elongated during maturity of the flower leaving interspaces in between them for the reception of the pollen grains (Fig. 3). Scrapings taken from the stigmas on consecutive days after opening of the female flowers showed that only a small percentage of them were pollinated.

The pollinated flowers which are successfully fertilized develop into mature fruits within 5–7 months. However, during the course of 20–30 days after opening of the spadix, there is invariably falling off of certain proportions of female flowers, which are not so far being investigated. Table II shows the types of fallen flowers and their number in each collection from random samples.

TABLE II

Number of fallen flowers in each type

No. of collections	Total No. of flowers examined	Closed flowers	Slightly open flowers	Fully open flowers	Old flowers
1	184	36	13	118	17
2	85	4	16	61	4
3	191	13	19	152	7
4	128	..	10	117	1
5	89	..	..	80	9
6	66	..	2	61	3
7	144	5	28	102	9
8	63	3	9	42	9
9	58	2	9	45	2
10	111	3	3	92	13
11	88	3	5	71	9

It is apparent from the results that the majority of fallen flowers in the 11 samples observed were fully open with receptive stigmas. About 7 per cent. of them were old with the stigmas projecting considerably outside the perianth lobes. A small percentage of the fallen flowers were young and closed and abscised from the pedicels before there could be any chances for pollination. Some of the flowers though of a similar nature, were with their perianth lobes slightly open.

The flowers were further examined to find out whether they were pollinated, and if pollinated fertilization had occurred. The stigmas were examined by teasing and staining with methyl-green glycerine jelly and in some instances with lactic acid for clearing and then staining in acid fuchsin and light green. The results show that in the first and second groups pollination is not evident, whereas in the fully open flowers about 5 per cent. revealed the presence of pollen grains on the stigmas and in the old flowers only about 40 per cent. showed the presence of pollen grains on the stigmas. However, the pollen tubes were observed only in 15 per cent. of the pollinated open flowers and

12 per cent. of the pollinated old flowers. It is possible that only short tubes were produced. It is thus clear that a number of flowers remain unpollinated in nature and subsequently wither; this is further supported by the fact that the number of stigmatic surfaces with germinating pollen grains was somewhat low.

The pollinated flowers were sorted out and further examined to find out whether the ovules had been fertilised. The ovules, after carefully removing the outer fibrous integuments, were fixed in formalin-acetic-alcohol and embedded. Sections were cut 10–15 μ thick and stained in iron-hæmatoxylin, and safranin and light green. The sections of the female gametophytes showed that the egg apparatus was in a state of degeneration and there was no trace of the pollen tube. It is thus evident that fertilization had not occurred in the fallen flowers. It is possible that the failure of pollen grains to successfully germinate on the stigmas and produce sufficiently long tubes is one of the reasons for the failure of fertilization.

Germination of pollen grains.—The extent of germination and the average length of the pollen tubes during the first 24 hours of germination of the pollen grains of big oblong, big round and small oblong types are given in Table III; results are plotted in Figs. 4 and 5.

The pollen grains germinate readily in nutrient media, the percentage of germination depending on the medium employed, its concentration and the type of grain used. The highest rate of germination was observed in a big oblong type with sucrose—0·75–1·0 per cent., sucrose-gelatin—0·75–1·0 per cent., glucose—0·5–0·75 per cent., lævulose—0·1–1·0 per cent., maltose—0·25–0·5 per cent. and starch—0·5–1·0 per cent. The length of the pollen tubes in the different types varied from 15–600 μ according to the types of nutrient used. Pollen grains in high concentrations of media (2–10 per cent.) produced, however, big vesicles (Fig. 2 *b*). The percentage of germination in crushed aqueous stigmatic extracts showed no appreciable variation (60–80 per cent.) and the length of the pollen tubes did not in any concentration exceed 320 μ in 24 hours. The growth in length of the tubes was found to be related to the concentration of the medium up to a certain limit after which it decreased (Fig. 5). The increase in length of the tubes was observed up to 72 hours after which there was no further increase. In some cases growth of the tubes during or after the first 24 hours of sowing was followed by formation of vesicles at the tips (Fig. 2 *c*).

In another experiment the effect of varying the sowing period after the pollen grains have matured on the rate of germination of the pollen grains and elongation of the pollen tubes of different types of arecanuts was studied. Mature pollen was collected in watch-glasses and on slides from freshly opened flowers and stored in the laboratory at 88 per cent. R.H. and 28° C. Hanging drop cultures were made after

TABLE III

Extent of germination of the pollen grains and length of pollen tubes of the different types in 24 hours in different media

Type	Big oblong						Big round						Small oblong					
Media	S	SG	G	L	M	ST	S	SG	G	L	M	ST	S	SG	G	L	M	ST
Amount in gms. per 100 c.c. of the medium									Percentage of germination									
0·1	6	20	22	25	20	20	5	25	20	50	25	3	15	15	5	10	25	12
0·25	13	30	75	..	60	35	7	35	23	20	32	8	22	20	40	15	28	18
0·5	30	45	92	..	20	82	15	45	35	18	40	23	28	22	42	25	28	36
0·75	40	48	72	..	15	82	17	48	15	15	40	28	48	50	55	25	..	39
1·0	85	85	50	..	8	72	12	30	12	3	20	26	42	22	30	50	..	29
2·0	35	80	30	..	5	50	5	12	2	3	20	20	20	20	30	25	..	9
5·0	25	50	20	..	5	25	5	1	2	3	18	8	12	20	15	25	..	3
10·0	22	25	18	..	5	25	5	..	..	..	10	2	5	20	5	20	..	3
									Length of pollen tubes in μ									
0·1	51	35	150	120	60†	150†	20	60†	20	20	25	15	100	120	20	60†	100	90
0·25	60	42	400	..	75	172	25	60	300	60	200	23	150	300	20	120†	60	120†
0·5	210	100	600	..	90	600	25	90	600	60	350	250	200	500	200	400†	60	500†
0·75	210	180	120	..	120*	500†	36	90	100	120	500	390	500	355	200	500†	..	520†
1·0	210	500†	120	..	25*	500	36	60	100	15*	120	402†	450†	350	100	500†	..	530†
2·0	60	450†	50	..	25*	40	32†	30	15	15*	120	120*	200†	36*	100	60*	..	30*
5·0	50*	200	30	..	15*	35*	15*	30*	15	15*	50*	60*	50*	30*	100	60*	..	30*
10·0	40*	45*	20	..	15*	35*	15*	..	..	..	40*	15*	50*	30*	60	60*	..	15*

* Grains germinating into big vesicles.

† Tip of pollen tubes enlarging into vesicles during or after 24 hours of germination.

S = Sucrose; SG = Sucrose + 1% Gelatin; G = Glucose; L = Lævulose; M = Maltose; ST = Starch.

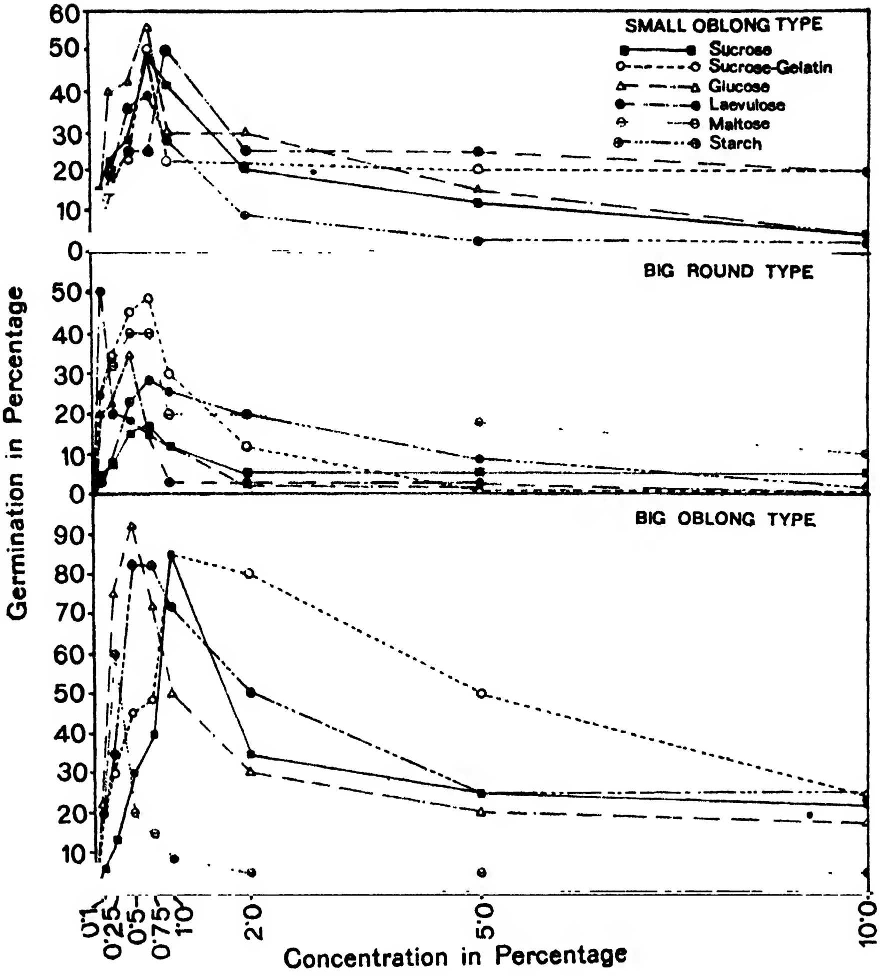


FIG. 4. Percentage of germination of pollen grains in different concentrations of media.

every one hour; the percentage of germination and the growth in length of the tubes were noted after 24 hours (Table IV and Fig. 6).

It is seen that the viability of the pollen grains after maturity extended up to 9 hours. The sowing of grains during only the first few hours showed the best results, optimum being at 2–3 hours.

The effect of temperature on the extent of germination of the pollen grains and the rate of growth of pollen tubes was also studied in

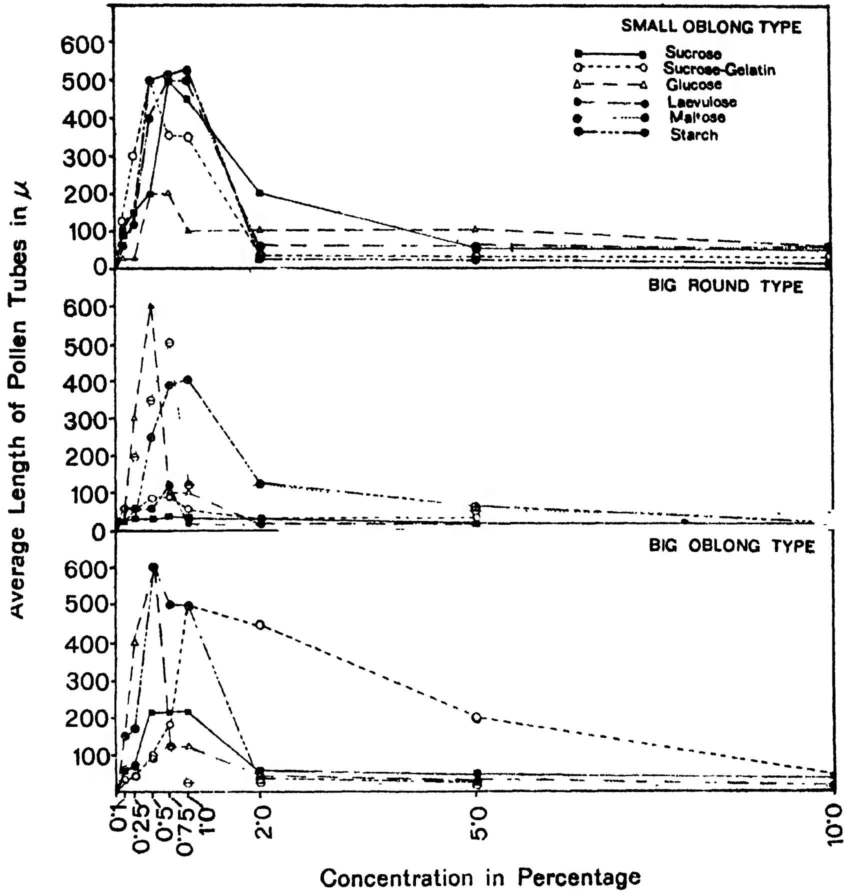


FIG. 5. Rate of growth of pollen tubes in different concentrations of media.

1·0 per cent. sucrose, 1·0 per cent. sucrose-gelatin, 0·5 per cent. glucose, 0·1 per cent. lævulose, 0·25 per cent. maltose and 0·5 per cent. starch at 15° C., 20° C., 28° C., 30° C. and 35° C. The extent of germination and the rate of growth of the pollen tubes were measured after 24 hours and are shown in Table V.

The optimum temperature was found to be at 28° C. whereas temperatures of 15° C., 20° C., 30° C. and 35° C. were inhibitory to successful germination of pollen grains.

TABLE IV

Extent of germination and length of pollen tubes of grains sown after being stored for different periods in hours

Type	Nature of observation	Time in hours									
		Control*	1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	6 hr.	7 hr.	8 hr.	9 hr.
Big oblong	% of germination	20	50	70	72	60	28	14	6	3	..
	Length of pollen tubes in μ	20	20	220	550	230	20	20	20	10	..
Big round	% of germination	10	22	30	40	40	32	10	8	..	..
	Length of pollen tubes in μ	25	100	210	420	420	200	100	82	..	..
Small oblong	% of germination	21	23	29	38	43	42	32	18	6	..
	Length of pollen tubes in μ	60	66	120	220	510	510	266	200	20	..

* Control Fresh pollen.

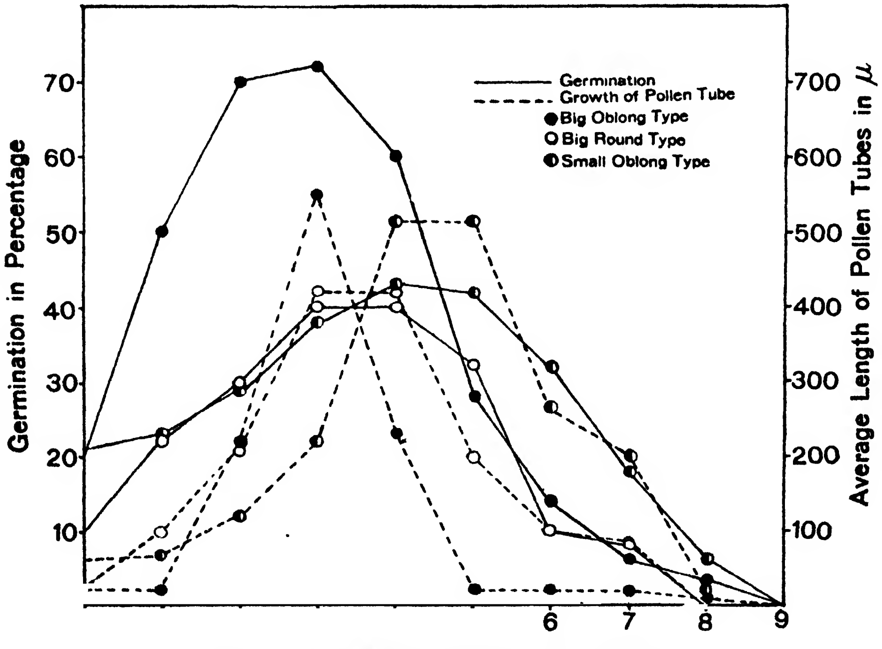


FIG. 6. Effect of storage of pollen grains on the extent of germination and average length of pollen tubes.

TABLE V

Percentage of germination and length of pollen tubes after 24 hours at different temperatures

Media	15° C.		20° C.		28° C.		30° C.		35° C.	
	%	μ	%	μ	%	μ	%	μ	%	μ
Sucrose ..	..	..	30	60	60	421	30	60	..	..
Sucrose-gelatin ..	5	15*	33	75	60	392	36	130	..	..
Glucose ..	..	..	10	30*	75	576	40	220	..	..
Lævulose ..	10	20*	15	40*	20	223	18	100	..	..
Maltose ..	10	20*	10	60	16	138	10	30*	..	..
Starch ..	20	20*	25	100*	65	568	20	60*	..	..

* Pollen grains germinating into vesicles.

DISCUSSION AND CONCLUSIONS

Some of the main conclusions reached above are as follows:—

It has generally been observed that in arecanut palms there has been considerable extent of sterility resulting in low yield of fruits. An estimate is given here of the extent of sterility of the various types of *Areca catechu* grown in Assam, as well as the factors which influence pollination. Sterility is probably due to: (i) maturity of the male and female flowers with considerable lag of time in between the phases, (ii) presence of sterile pollen grains in the male flowers, (iii) failure of pollen grains to germinate, (iv) length of the pollen tubes being inadequate to reach the ovule resulting in failure of fertilization, (v) longevity of the pollen grains limited to a few hours and the degree of receptivity of the stigma most favourable being when the flowers are slightly open, and (vi) effect of temperature on the germination of pollen grains.

It may be noted that the time lag in the maturity of the male and female flowers is a natural adaptation to prevent self-pollination. Sands (1926), however, indicates the possibility of pollination from the male flowers of the spadix opening successively in the same palm.

The percentage of sterile pollen grains in the male flowers in different types of arecanuts is considerably high. Such a high sterility is generally characteristic of hybrids and the question whether the different types of arecanuts are really morphologically different or merely unstable hybrids requires further investigation.

In the formation of fruits the lodging of the pollen grains on the stigma under natural conditions and its subsequent germination leading to fertilization of the ovule are important factors. It has been observed that not more than 75 per cent. of the female flowers actually receive pollen on their stigmatic surfaces. Naik and Rao (1943) and Mukherjee (1951) working on the blossom biology of mangoes have made similar observations. The main problem, however, is not in regard to the lodging of the pollen grains on the stigmas and their capacity to germinate but in the active growth of the pollen tubes inside the sytlar canal leading to fertilization of the ovule. The failure of pollen tubes to fertilize the ovules may be due to: (i) maximum length of the pollen tube being inadequate to reach the ovule, (ii) medium of the stylar canal failing to promote optimum growth of the pollen tubes, and (iii) bursting of the pollen tubes inside the stylar canal or formation of vesicles at the tip of the tubes. In this connection it is worthwhile to note that the length of the style varied from 0·8–1·3 cm. in the different types and the maximum length attained by the pollen tubes in cultures under optimum conditions is rather incompatible with the length of the style. Furthermore, evidence has already been given of the frequent occurrence of vesicles at the tip of pollen tubes in cultures. However, the observations based on experiments *in vitro* are necessarily different from conditions *in vivo*, but it has not been possible to determine the nature of growth of the pollen tube in the stylar canal. The ephemeral nature of the pollen grains and the degree of receptivity of the stigmas are also factors that determine successful pollination and fertilization. In the case of arecanuts, pollen grains lose their viability within 8–9 hours after dehiscence; stigmas in mature flowers also exhibit rapid loss of receptivity. It has been further found that certain nutrient solutions favour production of long tubes and successful germination of the pollen grains. The effect of nutrients may serve as a basis for further studies on specific stimuli or auxins that may be responsible for quicker initiation of germination and active growth of the pollen tubes than hitherto obtained, because there is evidence that even the stylar extracts do not increase sufficiently the extent of germination of the pollen grains and length of the pollen tubes.

It is evident, therefore, that failure of pollination and fertilization primarily accounts for a considerable proportion of the fallen flowers in arecanut palms. Approximately 15 per cent. of the flowers wither and abscise before there could be any chances of pollination. The factors which influence the abscission of the young flowers are still, however, imperfectly understood.

SUMMARY

1. The fruit-set and sterility in different types of arecanuts of Assam have been studied; only 46–66 per cent. of the female flowers set fruits and mature.

2. Pollen grains of different types of arecanuts are morphologically similar, but the anthers exhibit varying degrees of sterility.

3. The fall of female flowers during premature stages is due to failure in pollination and fertilization.

4. The extent of germination of the pollen grains and the rate of growth of the pollen tubes have been studied under different conditions.

ACKNOWLEDGEMENT

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ADDITIONS TO OUR KNOWLEDGE OF RUSTS OF HYDERABAD—II

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Introduction

The material for the paper was mostly collected from Narsapur Forest Reserve, situated at a distance of 36 miles from Hyderabad City. This part of the country is typical of the Telangana side. Much of the open country contains the thorn forest or scrub jungle, common mostly on laterite and on rocky soil, but nearing Narsapur, one sees luxuriant tree vegetation. The forest consists of mixed deciduous species, considerably thicker and containing a good deal of *Tectona grandis* Linn., *Buchanania latifolia* Roxb., *Dalbergia latifolia* Roxb., and many species of *Albizzia.*

Aecidium barleriæ sp. nov.

Rust spots circular, yellowish; pycnia not observed; æcia, hypophyllous, in groups, bright yellow, subepidermal, peridiate, measuring 150–240 × 132–198 μ; peridial cells polygonal, hyaline, thick-walled, verrucose, 18–28 × 14–22 μ; æciospores catenulate, subglobose or polygonal, with orange contents, 16–24 × 8–12 μ.

Habitat.—On living leaves of *Barleria cuspidata* Heyne (Acanthaceæ), private gardens, Hyderabad-Dn., 22–8–1955, Coll. Miss Videhi Iyengar, O.U.B. 'Hy' No. 19.

Maculæ circulares, luteolæ: pycnia haud observata; æcia hypophylla, aggregate, lucide lutea, subepidermalia, peridiata, magnit. 150–240 × 132–198 μ; cellulæ peridiales polygonales, hyalinæ, crassis parietibus præditæ, verrucosæ, 18–28 × 14–22 μ; æciosporæ catenulatæ, subglobusæ vel polygonales, contentis aurantiacis, 16–24 × 8–12 μ.

Typus lectus in foliis viventibus *Barleriæ cuspidatæ* Heyne e familia Acanthacearum, in hortis privatis, in loco Hyderabad-Dn. die 22 mensis augusti 1955 a Videhi Iyengar, et positus in O.U.B. 'Hy' sub-numero 19.

This rust does not seem to have been reported before on this host. Hence it is described as a new species.

Aecidium ocimi P. Henn.

Saccardo, P. A., *Syll. Fung.*, **11**: 218, 1911.

Only æcia were present.

Habitat.—On living leaves of *Ocimum canum* (Labiatæ), University Campus, 25–8–1955, Leg. P.R. O.U.B. 'Hy' No. 20.

Aecidium ocimi P. Henn. has not so far been reported from India. An *Aecidium* collected by McRae from Koilpatti on *Ocimum canum* was identified by Sydow (1914) as *A. ocimi* P. Henn. and listed as such by Butler and Bisby (1930). However, in 1917 Sydow made the same specimen the basis of his new species *Aecidium leiocarpum* Syd. *A. ocim* P. Henn. is therefore, being recorded from this country for the first time here.

Melampsora euphorbiæ-gerardianæ W. Mueller

Saccardo, P. A., *Syll. Fung.*, **23**: 232, 1925; Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*, No. **1**: 60, 1930.

Only telia were present.

Habitat.—On the living leaves of *Euphorbia* sp. (Euphorbiaceæ), University Campus, 12-5-1954, Leg. M.A.S. and P.R. O.U.B. 'Hy' 21.

Hemileia vastatrix Berk. and Br.

Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*, No. **1**: 59, 1930.

Both uredia and telia were present.

Habitat.—On the living leaves of *Coffea arabica* L. (Rubiaceæ), Botanic Gardens, Osmania University, Leg. P.R. and M.A.S. O.U.B. 'Hy' No. 22.

Puccinia polygoni-amphibii Pers.

Saccardo, P. A., *Syll. Fung.*, **17**: 394, 1905.; Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*, No. **1**: 71, 1930.

Only telia were present.

Habitat.—On living leaves of *Polygonum* sp. (Polygonaceæ), Mannanoor Forest, 22-12-1954, Leg. P.R. O.U.B. 'Hy' No. 23.

Puccinia shiraiana Syd.

Saccardo, P. A., *Syll. Fung.*, **16**: 300, 1902.; Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*,. No. **1** 76, 1930; Thirumalachar, M. J., in *Mycologia*, **39**: 231-48, 1947.

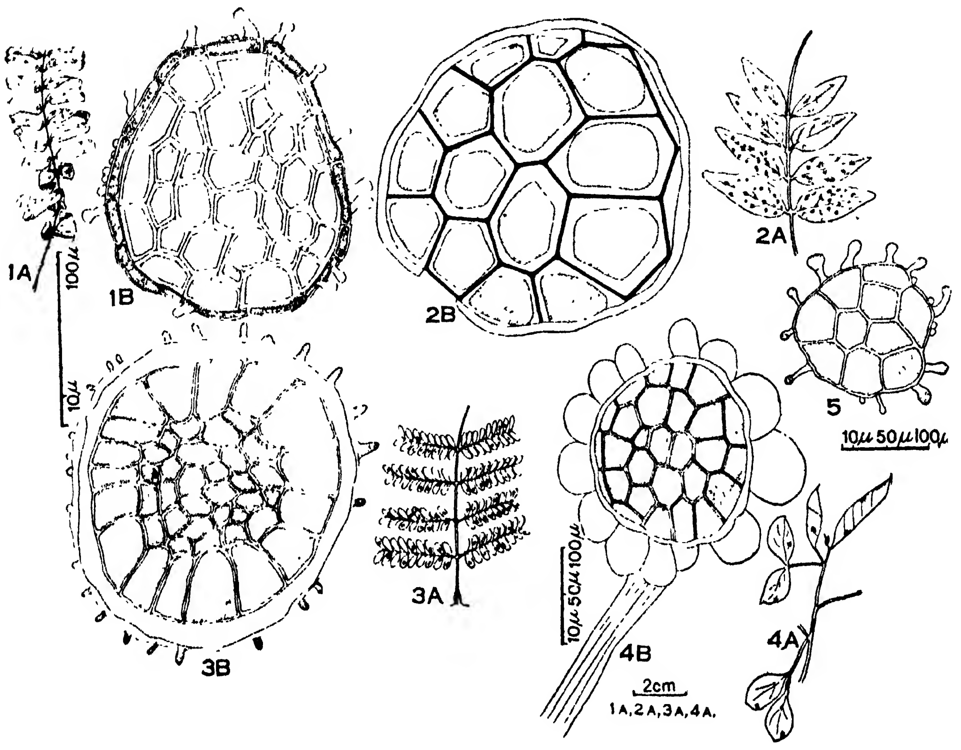
Aecia and telia were present.

Habitat.—On living leaves of *Justicia* sp. (Acanthaceæ), Narsapur Forest, 5-12-1954, Leg. P.R. O.U.B. 'Hy' No. 24.

Ravenelia sayeedii sp. nov.

Pycnia and æcia unknown; Telia mostly hypophyllous, black, subepidermal, erumpent, scattered, infection spots up to 0·6 mm. in diameter; teliospore heads almost spherical, chestnut brown, 50-90 μ in diameter, with 3-4 spores in cross-section; teliospores one-celled, measure 24-40 × 16-28 μ; cysts absent; pedicel hyaline, compound, decidious, very short.

Habitat.—On living leaves of *Sophora glauca* Lesch., (Papilionaceæ), Mannanoor Forest, 28-12-1953, Leg. P.R. O.U.B. 'Hy' No. 25.



Figs. 1-5. Fig. 1. (*a*) Leaf of *Albizzia odoratissima* showing the telia of *Ravenelia japonica*, (*b*) Telial heads of *R. japonica*. Fig. 2. (*a*) A part of the leaf of *Sophora glauca* showing the telia of *Ravenelia sayeedii*, (*b*) Telial head of *R. sayeedii*. Fig. 3. (*a*) A part of the leaf of *Albizzia amara* showing the telia of *Ravenelia albizziæ-amaræ*, (*b*) Telial head of *R. albizziæ-amaræ*. Fig. 4. (*a*) A part of the twig of *Cassia absus* showing the telia of *Ravenelia berkeleyi*, (*b*) Telial head of *R. berkeleyi*. Fig. 5. Telial head of *Ravenelia ornata*.

Pycnia atque æcia ignota. Telia ut plurimum hypophylla, nigra, subepidermalia, dispersa; infectionis maculæ usque ad 0·6 mm. diam. Teliosporarum capitula fere sphærica, castaneobrunnea, 50–90 μ diam., ornata 3–4 maculis in sectione transversali; teliosporæ unicellulatæ, magnit. 24–40 × 16–28 μ; cystis absentibus, pediculo hyalino, composito, deciduo, brevissimo.

Typus lectus in foliis viventibus *Sophoræ glaucæ* Lesch., e familia Papilionacearum, in silva Mannanoor, die 28 mensis decembris anni 1953, a P.R. et positus in O.U.B. 'Hy' sub-nemero 25.

There seems to be no record of this rust occurring on the present host. Hence it has been described as a new species and named after Prof. M. Sayeeduddin, well-known taxonomist in Angiosperms.

Ravenelia albizziæ-amaræ Baccarini.

Saccardo, P. A., *Syll. Fung.*, **23**: 707, 1925; Mundkur, B. B. and Thirumalachar, M. J., Revisions of and additions to Indian Fungi, I, *Mycol. Pap.*, **16**: 27, 1946.

Only telia were present.

Habitat.—On living leaves and fruits of *Albizzia amara* Boiv. (Mimosaceæ), Narsapur Forest (Hanumanthapuram), 5–12–1954, Leg. P.R. O.U.B. 'Hy' No. 26.

Ravenelia berkeleyi Mundkur and Thirumalachar.

Mundkur, B. B. and Thirumalachar, M. J., in Revisions of and additions to Indian Fungi, I, *Mycol. Pap.*, **16**: 27, 1946.

Both uredia and telia were present.

Habitat.—On living leaves, stems and fruits of *Cassia absus* L., (Cæsalpinaceæ), Narsapur Forest, 5–12–1954, Leg. P.R. O.U.B., 'Hy' No. 27.

Ravenelia hobsoni Cke.

Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*, No. **1**: 76, 1930.

Only telia were present.

Habitat.—On living leaves of *Pongamia glabra* Vent. (Papilionaceæ), on the banks of the canal, Lingampalli, Hyderabad-Deccan, 10–12–1953, Leg. M.A.S. and P.R. O.U.B. 'Hy' No. 28.

Ravenelia japonica Diet and Syd.

Saccardo, P. A., *Syll. Fung.*, **16**: 336, 1902; Mundkur, B. B., in *Sci. Monogr. Coun. agric. Res. India*, No. **12**: 23, 1938.

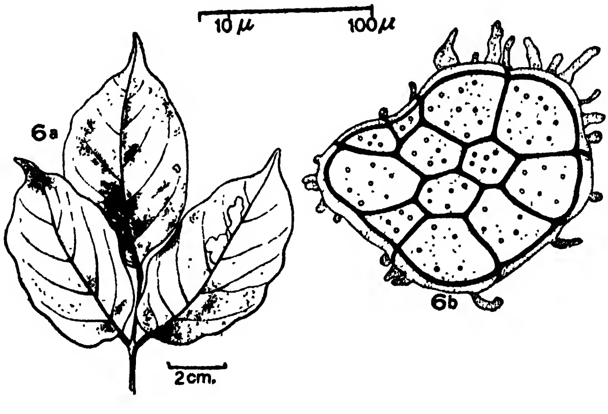


Fig. 6. (*a*) Leaf of *Pongamia glabra* showing the telia of *Ravenelia hobsoni*, (*b*) Telial head of *Ravenelia hobsoni*.

Both uredia and telia were present.

Habitat.—On living leaves and fruits of *Albizzia odoratissima* Wall. (Mimosaceæ), Narsapur Forest, 22-6-1955, Leg. P.R. and M.A.S. O.U.B. 'Hy' No. 29.

Ravenelia emblicæ Syd.

Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*, No. **1**: 76, 1930.

Only telia were present.

Habitat.—On living leaves and fruits of *Phyllanthus emblica* Linn. (Euphorbiaceæ), Botanic Gardens, Osmania University, 20-8-1954, Leg. P.R. and M.A.S. O.U.B. 'Hy' No. 30.

The rust has been hitherto reported to occur on the leaves only.

Ravenelia mitis Syd.

Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*, No. **1**: 77, 1930.

Only telia were present.

Habitat.—On living leaves of *Tephrosia purpurea* Pers. (Papilionaceæ), University Campus, 20-8-1954, Leg. P.R. O.U.B. 'Hy' No. 31.

Ravenelia ornata Syd.

Saccardo, P. A., *Syll. Fung.*, **21**: 738, 1912.; Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*, No. **1**: 77, 1930.

Both uredia and telia were present.

Habitat. On living leaves of *Abrus precatorius* Linn. (Papilionaceæ), Botanic Gardens, Osmania University, 5-6-1954, Leg. M.A.S. O.U.B. 'Hy' No. 32.

This rust has been reported previously on *Abrus pulchellus* Wall., The present host seems to be new.

Uromyces mucunæ Rabenh.

Butler, E. J., and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*, No. **1**: 83. 1930.

Only telia were present.

Habitat.—On living leaves of *Mucuna* sp. (Papilionaceæ), Narsapur Forest, 26-12-1954, Leg. P.R. and M.A.S. O.U.B. 'Hy' No. 33.

Uromyces hobsoni Vize.

Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India*, No. **1**: 82, 1930; Thirumalachar, M. J., *Phytopathology*, **29**: 785, 1939.

Pycnia, æcia and telia were present.

Habitat.—On living leaves, petioles, stem and flowers of *Jasminum grandiflorum* L. (Oleaceæ), Narsapur Forest and private gardens, Hyderabad-Deccan, 22–8–1955, Leg. M.A.S. and P.R. O.U.B. 'Hy' No. 34.

SUMMARY

The present paper records 16 species of rusts, *viz.*, *Aecidium barleriæ*, *Aecidium ocimi*, *Melampsora euphorbiæ-gerardianæ*, *Hemileia vastatrix*, *Puccinia polygoni-amphibii*, *Puccinia shiraiana*, *Ravenelia sayeedii*, *R. albizziæ-amaræ*, *R. berkeleyi*, *R. hobsoni*, *R. japonica*, *R. emblicæ*, *R. mitis*, *R. ornata*, *Uromyces mucunæ* and *U. hobsoni*, occurring on various angiosperms collected from the vicinity of Hyderabad and Narsapur Forest. Out of these the rusts, *Ravenelia sayeedii* on *Sophora glauca* and *Aecidium barleriæ* on *Barleria cuspidata*, are new species. *Abrus precatorius* is reported as an additional host for *Ravenelia ornata.*

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SYDOW, H. & P. 1917. Novæ fungorum species—XV. *Ibid.*, **15**: 143–48.

OBSERVATIONS ON INTER-RACIAL RICE HYBRIDS

The *japonica-indica* Rice Hybridisation

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Introduction

The genus *Oryza sativa* Linn. is divided into two main races, *viz.*, (1) forma *japonica* and (2) forma *indica*. The *japonicas* are characterised by short stature, stiff straw, long panicle, non-lodging habit and possess what is known as 'the response to high fertility'. The *indica* forms are tall and lodge even under normal manurial conditions and are poor responsers to high fertilization. In order to combine the useful genes of these two forms, the *japonica-indica* rice hybridisation programme was launched by the F.A.O. at the Central Rice Research Institute, Cuttack, India, and the F_1 hybrid seeds were sent to participating countries and Indian States for study and selection from the first segregating generation onwards. It is generally believed that a large number of gene mutations and gene rearrangements within the chromosomes have accumulated in the *japonicas*, on account of their cultivation in entirely different agro-climatic conditions (Jones and Longley, 1941) which largely accounts for the sterility in the hybrids. As a detailed study of the F_2 progenies for various characters offers the earliest opportunity for estimating the value of crosses, an attempt is made here to present the results of observations on the *japonica-indica* rice hybrids.

Materials and Methods

The following F_1 seeds were received from the Central Rice Research Institute, during the year 1953-54. (1) Rikuu 132×141 B.K., (2) Norin 18×36 B.K. and (3) Norin 18×141 B.K. Seedings raised from well manured beds were transplanted singly when they were 20 days old, with a spacing of one foot between plants and between rows, at a fertility level of 40 lb. N and 20 lb. P_2O_5 per acre, applied in the form of ammonium sulphate and single superphosphate, respectively, after an initial green manuring of 1,000 lb. per acre. The parent plants, *japonica* and *indica* types, were also grown side by side, with the hybrid population and a comparison was made between them for their performance. Observations on plant height, flowering dates, number of productive tillers, paddy colour and presence of awn, were made on individual hybrid progenies. Hybrid plants selected for F_3 generation were studied for adaptability to heavy manuring under a fertility level of 80 lb. N and 40 lb. P_2O_5 per acre.

OBSERVATIONS

(*a*) *General* (*Qualitative*)

The first segregation *japonica-indica* rice hybrids segregate for various characters. In some of the progenies was noticed varying intensities of vegetative colouration like light and dark green. None of the progenies showed any tendency for lodging, though some of the *indica* parents, raised side by side, lodged at full maturity. In a similar study on *japonica-indica* crosses, Rajagopalan (1955) observed segregation for vegetative colouration as well as for lodging.

(*b*) *Quantitative*

The various quantitative characters studied in the population are presented in Tables I, II and III.

TABLE I

Showing the characters of the parents in the japonica-indica *rice crosses*

No.	Plant characters	japonicas	indicas
1	Height in cm. ..	68—75	120—130
2	Flowering duration (from sowing to ear-emergence) in days ..	75—80 (late August flowering)	120—25 (late Oct. flowering)
3	Number of productive tillers	15—20	8—10
4	Paddy (in husk) colour ..	Straw	Straw (36 BK) Brown (141 BK)
5	Presence of awn ..	Awnless	Tipped (36 BK) Awnless (141 BK)
6	Rice grain (Kernel) colour ..	White	White

(i) *Plant height.*—Height measurements show that *japonica* parents range from 68–75 cm. while *indica* parents measure 120-130 cm. (Table I). The F_2 progenies of these parents show a wide range in height within the parental limits. Table II shows that in all the crosses studied, there is a preponderance of intermediate types except in the case of Rikuu 132 × 141 B.K. The table also shows that *indica* types are recovered in greater percentage than *japonica* types, in all the crosses.

(ii) *Flowering duration.*—*Japonicas* flower by about late August and their flowering duration is about 75–80 days (Table I), while *indicas* take about 120–125 days to flower from the date of sowing. Hybrid population of these two forms show that the flowering duration may be inherited in a simple Mendelian ratio (Norin 18 × 36 B.K. and Norin 18 × 141 B.K.) or the inheritance may be multi-factorial transgressing either sides of the parental limits (Rikuu 132 × 141 B.K.). Table II shows that, in the inheritance of flowering duration in the latter cross (Rikuu 132 × 141 B.K.), there is a tendency for a shift towards

TABLE II

Showing the segregation of characters in the F_2 progenies japonica-indica *rice hybrids*

No.	Characters	Rikuu 132 × 141 B.K. No. of progenies conforming to					Norin 18 × 36 B.K. No. of progenies conforming to			Norin 18 × 141 B.K. No. of progenies conforming to		
			japonica type	Intermediate	*indica* type		*japonica* type	Intermediate	*indica* type	*japonica* type	Intermediate	*indica* type
1	Height ..		654 (25·72)	911 (35·82)	978 (38·49)		298 (26·68)	437 (39·00)	384 (34·33)	49 (19·84)	114 (46·15)	84 (34·00)
2	Flowering duration	76 (2·99) (Earlier than Rikuu)	348 (13·68)	1442 (56·70)	535 (21·04)	142 (5·59) (later than 141 B.K.)	268 (23·94)	..	851 (76·46)	68 (27·53)	..	179 (72·46)
							Chi = 0·539, P = 0·50 – 0·40			Chi = 1·352, P = 0·30 – 0·20		
3	Production of fertile tillers		854 (33·58)	787 (30·98)	902 (35·47)		288 (25·73)	659 (58·89)	172 (15·37)	36 (14·57)	117 (47·37)	94 (38·06)
4	Paddy colour		2441 (95·98)	..	102 (4·02)		All normal straw-coloured			199 (80 56)	..	48 (19·44)
5	Presence of awn		2499 (98·27)	17 (0·65)	27 (1·06)		948 (84·71)	128 (11·43)	43 (3·84)	215 (87·06)	14 (5·68)	18 (7·29)
			(Awnless)	(Tipped)	(Awned)		(Awnless)	(Tipped)	(Awned)	(Awnless)	(Tipped)	(Awned)

N.B.—Characters of the F_1 hybrids of these parents were not known as the crosses were done at the Central Rice Research Institute, Cuttack. Figures in brackets show the percentage of population.

later flowering (than late parent, 141 B.K.) which exceeds earlier flowering by about twice the number (than early parent, Rikuu 132).

(iii) *Production of fertile tillers.*—Number of productive tillers in the *japonicas* vary between 15–20 while *indicas* produce about 10 tillers (Table I). F_2 hybrids of these types show a wide range of variation in the capacity for tillering (Table II).

(iv) *Paddy colour.*—*Japonicas* are all straw coloured, while paddy colour of 141 B.K. is brown and 36 B.K. is straw coloured, similar to that of *japonicas*. In Rikuu 132×141 B.K. and in Norin 18×141 B.K., a few of the progenies show brown coloured paddy, though a majority of the hybrids conform to the *japonica* group.

(v) *Awn character.*—All the parents involved in the cross are awnless except 36 B.K., one of the *indica* parents, where the lemma show the rudiments of awn as a slight tip (Table I). It is an interesting feature to note that in all the crosses, awn character expresses itself, though the percentage is small (Table II). 'Tipped' to 'Fully-awned' hybrids were noticed in the population. Similar findings were also recorded by Rajagopaln (*loc. cit.*) in the hybrids, when the parents did not possess this 'awn' character.

TABLE III (*a*)

Showing the percentage of spikelets formed, spikelets empty and flowering duration in the cross

Rikuu 132×141 B.K.

No.	Total No. of spikelets formed.	Total No. of empty spikelets	Percentage non-setting	Flowering duration in days
1	240	84	35·00	93
2	238	90	37·82	101
3	148	45	30·41	96
4	211	115	54·50	104
5	286	143	50·00	110
6	159	68	36·48	111
7	223	34	15·25	97
8	146	77	52·74	105
9	306	93	30·39	99
10	183	74	40·44	103
11	169	75	44·34	111
12	239	133	55·65	106
13	148	75	50·68	89
14	106	42	39·62	94
15	263	155	58·93	107
16	86	17	19·77	111
17	147	42	28·65	99
18	183	12	6·57	102
19	229	81	35·37	112
20	293	214	73·03	108

Mean non-setting of spikelets = 41·19%.

(vi) *Setting of spikelets.*—In a number of hybrid progenies was noticed empty spikelets, the percentage varying from 0–100. Fully sterile progenies were not uncommon and very rarely were fully fertile hybrids met with. The data presented in Table III (*a–c*) show that, in a random count of about 50 hybrid progenies, non-setting of spikelets ranges from 6·56 98·09 per cent. Rajagopalan (*loc. cit.*) found that empty spikelets ranged from 21·0–32·3 per cent. in the different crosses. Roy and Subramanyam (1954) while studying the growth performance of *japonica* rice varieties under Indian conditions, found that the percentage of non-setting of spikelets in Rikuu 132, Norin 36 and Norin 18 was 88, 48 and 27 respectively. In view of the low setting of spikelets in two of the *japonica* varieties used as parents, an attempt was made to estimate whether high non-setting of spikelets in Rikuu 132 and Norin 36, had any relation to the non-setting of the spikelets in the hybrids and it was found that there was no relation between the parent and hybrid spikelet settings (Table III, *a–c*).

TABLE III (*b*)

Showing the percentage of spikelets formed, spikelets empty and flowering duration in the cross

Norin 18×36 B.K.

No	Total No. of spikelets formed	Total No. of empty spikelets	Percentage non-setting	Flowering duration in days
1	210	42	20·00	101
2	304	85	27·96	98
3	196	22	11·23	104
4	178	92	51·69	110
5	264	140	53·03	109
6	169	61	36·09	103
7	208	40	19·23	106
8	176	97	55·12	98
9	168	65	38·69	108
10	308	100	32·47	111
11	268	230	85·82	109
12	212	105	49·53	89
13	169	64	37·87	101
14	214	46	21·49	99
15	194	118	60·83	101
16	311	135	43·41	89
17	118	39	33·51	98
18	174	68	39·81	103
19	309	40	12·95	106
20	268	165	61·57	105

Mean non-setting of spikelets = 40·83%.

The data (Table *a–c*) show that in the common parents, *viz.*, Rikuu 132×141 B.K. and Norin 18×141 B.K., the F_2 progenies of the latter show a higher percentage of non-setting than the former, while the progenies of Norin 18×36 B.K. show a mean of 40·83 per cent. non-setting similar to that of Rikuu 132×141. It is also clear from the data that there is no relation between non-setting of spikelets and maturity of the hybrids.

TABLE III (*c*)

Showing the percentage of spikelets formed, spikelets empty and flowering duration in the cross

Norin 18 × 141 B.K.

No.	Tolal No. spikelets formed	Total No. of empty spikelets	Percentage non-setting	Flowering duration in days
1	329	215	65·35	101
2	367	294	80·11	98
3	268	176	65·67	104
4	179	111	62·01	89
5	298	283	94·97	96
6	311	206	66·23	103
7	168	89	69·22	110
8	368	254	59·98	107
9	211	183	86·73	104
10	314	299	95·23	101
11	366	359	98·03	98
12	179	86	48·04	99
13	311	210	67·52	99
14	378	265	70·11	104
15	293	180	61·43	107

Mean non-setting of spikelets = 77·51%.

It is of interest to mention that in all the three crosses studied, the parents have white-grained rice, while some of the hybrid progenies of these parents showed coloured grains. No detailed study could, however, be undertaken on this aspect. Similar results were also obtained by Rajagopalan (*loc. cit.*) in the progenies whose parents did not show this grain colour.

F_3 progenies raised under a fertility level of 80 lb. N and 40 lb. P_2O_5 showed that in general the performance of the hybrids was better with respect to seed setting and tillering. The hybrids stood this heavy manuring well without lodging.

SUMMARY

F_2 generation of *japonica-indica* rice hybrids show segregation with respect to many characters like plant height, flowering duration, etc. Some of the interesting features were the expression of 'awn' character and the presence of coloured grains in the progenies where the parents involved did not show these characters. Raising the hybrids in the succeeding generations under increased fertility levels is likely to give better results for selection of types combining these two forms.

ACKNOWLEDGEMENT

The authors place on record their sense of gratitude to Dr. N. Parthasarathy, F.N.I., Director, Central Rice Research Institute, Cuttack, for kindly supplying us the hybrid materials for study at the F_2 stage in this Institute.

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SOME UNREPORTED FERNS OF BIHAR

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While making collections of ferns from different parts of Bihar some were found that have not been reported earlier from this area either by Beddome (1892), Haines (1921–25) or by Mooney (1950). It is, therefore, thought proper to record their occurrence in Bihar. A short description of their morphological characters from the actual specimens and their distribution according to Beddome have also been noted down. For the help in the identification of the specimens the author is thankful to the Superintendent, Indian Botanic Gardens, Calcutta, and especially to its Curator, Dr. S. K. Mukerji. In placing the specimens in their respective families, Copeland's (1947) classification has been followed.

Class FILICINEÆ

Order FILICALES

Family *PTERIDACEÆ*

1. *Dennstædtia appendiculata* (Wall. ex Hook.) J. Sm.—Terrestrial; frond bipinnate, pinnules pinnatifid; veins forked and free as well as simple; rachis hairy; sori round and marginal, each sorus being supplied with a single veinlet; indusium present and formed by the fusion of the true indusium and a minute tooth looking like a cup-shaped or bivalvate structure. Collected from Purnea in October 1953.

Distribution.—Senchal above Darjeeling, 8,500 feet; Lachen Valley, in Sikkim, Nepal; Kumaon Gori Valley, 5,500 feet; Banks of Vishnugunga, above Panchkisar, 8,000–9,000 feet.

Family *ASPIDIACEÆ*

2. *Athyrium drepanopterum* (Kze.) A. Br.—Terrestrial; frond pinnate, pinnæ nearly cut to the rachis into crenate lobes; veins forked and free; stipe scaly at the base; sori oblong, along the veins and generally on one side of the vein, sometimes on both sides; indusium present and flap like. Collected in October 1952 from Parasnath Hills at a height of 3,000–3,500 feet.

Distribution.—*A. drepanopterum* is the valid name of *Aspidium eburneum* Wall. which according to Beddome is a synonym of *Lastrea cana* J. Sm. whose distribution according to him is Himalayas near Simla, Sikkim, Yakla, 8,000 feet elevation.

3. *Athyrium macrocarpum* (Bl.) Bedd.—Terrestrial; frond pinnate, lower pinnæ half cut to the rachis, upper pinnæ show crenate margin;

veins forked and free; stipe scaly at the base; sori oblong, along the veins and only on one side of them; indusium present and flap like. Collected in October 1952 from Parasnath Hills at the height of 3,000–3,500 feet.

Distribution.- South India, very common on the Western Mountains, above 3,000 feet; Ceylon; Himalayas, Gurwhal and Bhotan, 2,000-9,000 feet; Khasya; Burma and Malaya Peninsula.

Family POLYPODIACEŒ

4. *Drynaria propinqua* (Wall. ex Mett.) J. Sm.—Epiphytic; frond simple, dimorphic--the scale (bract), sessile leaves for humus collection (Nayar and Kachroo, 1953) and the normal green frond deeply pinnatisect, segments arranged alternately and with broad base and gradually tapering apex, margin obscurely crenate; venation reticulate with included and variously directed free veinlets; stipe scaly below, scales brown in colour with hairy margin; sori round, in two rows one on each side of the midrib of a leaf segment; indusium absent. Only the normal, green, fertile, pinnatisect frond was collected in October 1952 from Parasnath Hills at 3,000–4,000 feet.

Distribution. - Himalayas from Gurwhal to Bhotan, 2,000–7,000 feet; Khasya, very common; Burma; Malaya Peninsula and Java.

The author is thankful to Prof. R. P. Roy, for seminar and laboratory facilities.

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THE HYDROPHYTES OF CUTTACK

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Introduction

Cuttack City is situated between the 20·48′ N. latitude and 85·56′ E. longitude. The climate is tropical and the average annual rainfall is 43 inches. It is a city consisting of 23 square miles. Three sides of the city are surrounded by two big rivers, *i.e.*, the Mahanadi and its branch the Kathjuri. The ground level of the city is almost the same as that of the river beds. The general soil of the city is sandy loam and alluvial at some places. There are a large number of ponds and ditches inside the city. Some of those are used for bathing, fish culture, etc., but a good number of them remain unused by human beings. One canal known as Taldanda canal starts from the Mahanadi river and passes through the city. There is also another small canal which passes through the heart of the city. These canals and most of the ditches and ponds dry up in the summer. These are the main grounds for development of water plants in the city. The growth of innumerable hydrophytes has drawn the attention of many botanists. A systematic work on these aquatic plants has not yet been done by any worker. Haines (1925) or Prain (1903) have not discussed anything regarding the flora of Cuttack. Now as the Botanical Survey of the State has started, much attention has been focussed on these water plants. All of them are not undesirables but on the other hand some of them are useful. The present work gives detailed information regarding the aquatic flora of Cuttack City as far as practicable.

Observations

Aquatic plants generally include plants of various conditions; such as, true aquatics, which are free-floating; submerged or emerged ones, which grow just on the border-line between water and land surfaces; and plants which generally thrive in aquatic conditions. Although aquatic plants grow in an uniform condition and are not much affected by temperature, depth of water, etc., generally some remarkable variations can be noticed due to some factors, *viz.*, transparency or muddiness of water, pH of water and chemical behaviour of the substratum.

The ponds and other sources of aquatic plants were visited in different seasons of the year and plants were collected in their flowering stages. A systematic list is given below showing the name of the plants and the family to which they belong with their flowering seasons and habits. It has been considered convenient to follow the same order as Haines in his *Botany of Bihar and Orissa* for ready reference. The collected specimens are preserved in the Herbarium of the Botany Department of Ravenshaw College, Cuttack.

ENUMERATION OF THE PLANTS

	Name of the plants	Habit	Flowering season
	Nymphæaceæ		
1.	*Nymphæa rubra* Roxb.	Floating	Sept.–Dec.
2.	*N. esculenta* Roxb.	do.	Oct.–Jan.
3.	*N. stellata* Willd.	do.	March–Sept.
4.	*Nelumbium speciosum* Willd... ..	do.	Feb.–March
	Papilionaceæ		
5.	*Aeschynomene aspera* L.	Emerged	Sept.–Dec.
	Mimosaceæ		
6.	*Neptunia oleracea* Lour.	Floating	July–Sept.
	Halorrhagidaceæ		
7.	*Myriophyllum tuberculatum* Roxb. ..	Floating	Sept.–Dec.
	Onagraceæ		
8.	*Jussiaea repens* L.	Floating	Oct.–Dec.
9.	*Trapa bispinosa* Roxb.	do.	July–Aug.
	Umbelliferæ		
10.	*Centella asiatica* (Linn.) Urb. ..	Emerged	Nov.–Jan.
	Gentianaceæ		
11.	*Limnanthemum cristatum* Griseb. ..	Floating	Jan.–Dec.
	Convolvulaceæ		
12.	*Ipomoea reptans* L.	Floating	Jan.–Dec.
	Scrophulariaceæ		
13	*Limnophila heterophylla* Benth. ..	Emerged	Oct.–Jan.
14.	*L. gratioloides* Br.	do.	Oct.–Feb.
	Lentibulariaceæ		
15.	*Utricularia stellaris* L.f.	Submerged	Oct.–Jan.
	Acanthaceæ		
16.	*Asteracantha longifolia* Nees. ..	Emerged	Oct.–Jan.
	Alismaceæ		
17.	*Alisma plantago* L.	Emerged	Oct.–Jan.
18.	*Sagittaria sagittifolia* L.	do.	Nov.–Jan.

	Name of the plants	Habit	Flowering season
	Naiadaceæ		
19.	*Aponogeton monostachyon* L. ..	Submerged	Jan.-Dec.
20.	*Potamogeton indicus* Roxb.	do.	Sept.-Jan.
	Hydrocharitaceæ		
21.	*Hydrilla verticillata* Casp.	Submerged	July-Sept.
22.	*Vallisneria spiralis* L.	do.	Jan.-May
23.	*Ottelia alismoides* Pers.	do.	July-Dec.
	Araceæ		
24.	*Pistia stratoites* L.	Floating	Oct.-Jan.
	Lemnaceæ		
25.	*Lemna polyrrhiza* L.	Floating	Oct.-Jan.
	Cyperaceæ		
26.	*Cyperus articulatus* L.	Floating	April-July
27.	*Scirpus articulatus* L.	Emerged	Dec.-Jan.
	Gramineæ		
28.	*Sacciolepis myosuroides* Comb. ..	Emerged	Aug.-Nov.
29.	*Panicum repens* L.	do.	July-Dec.
	Pontederiaceæ		
30.	*Monochoria hastata* Solm.	Emerged	Jan.-Nov.
31.	*M. vaginalis* Presl.	do.	Jan.-Aug.
32.	*Eichornia crassipes* Solm.	do.	March-July
	Marsiliaceæ		
33.	*Marsilia quadrifoliata* L.	Floating	Oct.-March

DISCUSSION

This is a very preliminary work and the investigation of the flora of Cuttack is in rapid progress. Though Haines (1925), Prain (1903), Mooney (1950) and Bal (1942) have done some work regarding certain parts of Orissa states, they have not discussed much about the flora of Cuttack or the costal districts. Now the main aim of our work is to list all these plants of Orissa not only for the study of Botany but also to discover rare, economical and medicinal plants. Now that the Botanical Survey of India has started, we hope that our work will also fall within the plans of the B.S.I.

SUMMARY

Preliminary work has been done to find out the hydrophytes of the Cuttack. It has been found that the number of aquatic

monocotyledonous is greater than that of the aquatic dicotyledonous and families like Hydrocharitaceæ, Cyperaceæ, Gramineæ and Pontederiaceæ are dominating.

ACKNOWLEDGMENT

This is a part of the work done in connection with the Botanical Survey of Orissa entrusted to Prof. B. Samantarai by the Board of Scientific and Industrial Research, Orissa. Our thanks are due to the said Board for financial help and to Prof. B. Samantarai for kind supervision and encouragement. We are also grateful to Mr. C. M. Bastia of this Department for his encouragement.

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THE CLAVARIACEÆ OF THE MUSSOORIE HILLS—III

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This paper is intended to record more Clavariaceæ from the Mussoorie Hills as a part of the study of the Cryptogamic Flora of that region (Thind and Anand, 1956; Corner, Thind and Anand, 1956*). Of the seven Clavarias described, one belongs to the Clavariadelphus-series, and six belong to the Clavaria-series. *Clavariadelphus mirus* (Pat.) Corner, *Clavulinopsis aurantio-cinnabarina* (Schw.) Corner and *Clavulinopsis alcicornis* (Zoll. et Mor.) Corner are new records for India. *Clavulinopsis biformis* (Atk.) Corner var. *elongata* var. nov. and *Clavulina bessonii* (Pat.) Corner var. *incarnata* var. nov. are described here as new varieties. All the specimens are deposited in the Herbarium of the Punjab University.

The classification as proposed by Corner, 1950, in his *Monograph of Clavaria and Allied Genera*, has been followed in the present study.

CLAVARIADELPHUS-SERIES

15. *Clavariadelphus mirus* (Pat.) Corner

Fructifications gregarious, solitary, rarely sub-cæspitose, erect, large-sized, radial, trunk indistinct, simple, tough, smooth, glabrous, light brown or camel-brown coloured, lower portion being light dull yellow, up to 22·5 cm. tall and up to 1·5 cm. broad at the top and up to 0·9 cm. broad at the base. Trunk indistinct, lighter coloured, light dull yellow, narrower than the clubs above, smooth. Clubs simple, very rarely forked only once at the top, solid, cylindrical below while usually flattened and longitudinally rugulose in the upper part, younger specimens usually cylindrical even in the upper portion. Apices concolorous, fertile, blunt, rounded, often flattened, and swollen. Flesh cream coloured or pale yellow, turning vinaceous brown on bruising and not so on mere exposing. Taste bitter, smell inparticular. *Hymenium* spreading all over except the basal dull yellowish stem-like portion, thickening, up to 87 μ broad. *Basidia* clavate, light brown, 8–12 μ broad. Sterigmata mostly 4, sometimes 2–3, massive, large, straight or incurved, 7·4–11·2 μ long. *Basidiospores* subhyaline, broadly ellipsoid, obovate or pyriform, papillate, papilla up to 1·2 μ long, smooth, aguttate, 8·6–10·8×7–8·6 μ. *Hyphæ* monomitic, hyaline, thin-walled, branched, usually inflated but some narrow and uninflated, septate, septa at long intervals, clamped, clamps abundant and present almost at all septa, 1·7–10·5 μ broad, hyphal cells very long (up to 206 μ or more) (Pl. VIII, Fig. 1; Text-Fig. 1, A–B).

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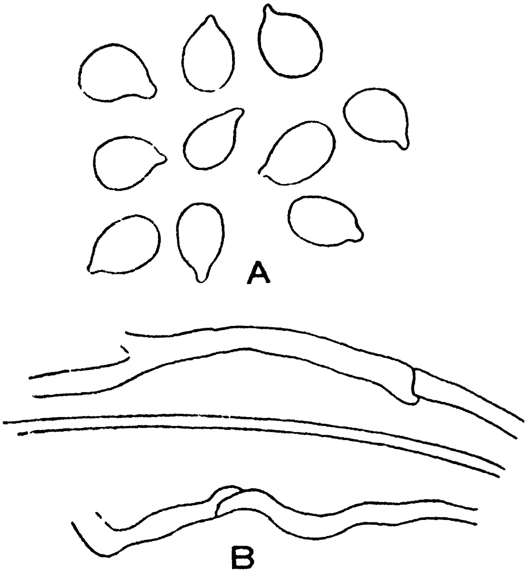
* Five new species and two new varieties of Clavarias are described in this paper.



TEXT-FIG. 1. *Clavariadelphus mirus* (Pat.) Corner. A, Basidiospores, ×880 ; B, Clamped hyphæ, × 380.

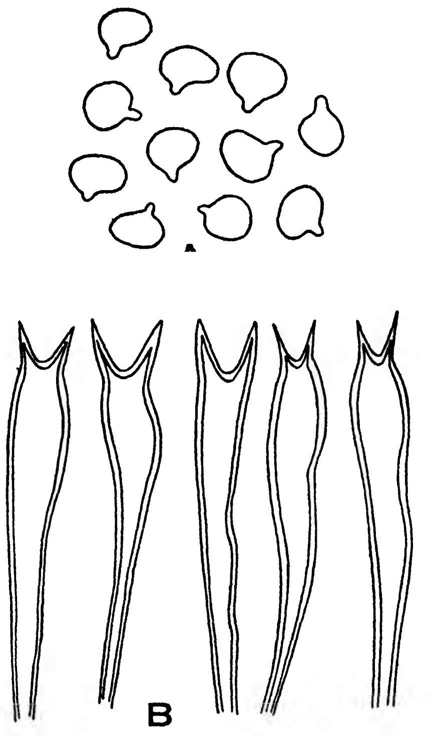
Collected on soil under Oak Forest (*Quercus incana* Roxb.), Dhobi Khud, Mussoorie, August 28, 1953, **46**.

The species is clearly related to *Clavariadelphus pistillaris* (Fr.) Donk but differs in the tall narrow shape and brown colour of the fruit bodies and the short wide spores.

CLAVARIA-SERIES

16. *Clavulinopsis fusiformis* (Fr.) Corner

Fructifications solitary, cæspitose, erect, medium-sized, radial, trunk present, simple, fleshy, smooth, glabrous, orange at the top, fading to yellow lower down, and finally white in the region of trunk, the whole cæspitose cluster up to 6·5 cm. tall and up to 3·5 cm. broad, individual clubs up to 6·5 cm. tall and up to 0·4 cm. broad. Trunk cylindrical, not grooved, one-third of the length of clubs, clearly demarcated by its white colour. Young clubs cylindrical, mature clubs become grooved and often flattened, a single groove running along the middle of the club, mature clubs slightly hollow within. Apices acute, concolorous. Flesh paler concolorous. Taste and smell inparticular. *Hymenium* spread all over except the white trunk, thickening, up to 95 μ thick. *Basidia* clavate with a long tapered base, often becoming thick-walled and persisting in the hymenium, subhyaline, with large globules, 5–11 μ broad. Sterigmata mostly 2, large, stout and straight, 4·5–10·6 μ long. *Basidiospores* subhyaline, obovate, papillate, papilla usually eccentric, smooth, aguttate, a single large greenish-yellow guttule observed in some cases, 4·2–7·4×6·2–9·8 μ, papilla 1–2 μ long. *Hyphæ* monomitic, hyaline, thin-walled, usually parallel, sparsely branched, usually inflated, some narrow hyphæ are uninflated, septate, septa at short intervals, some hyphæ, especially the narrow ones, secondarily septate, clamps absent, narrow uninflated hyphæ 3·5–5·2 μ broad and with cells up to 95 μ long, broader inflated hyphæ 7–16 μ broad and with cells up to 52 μ long, often much shorter (Pl. VIII, Fig. 2; Text-Fig. 2, A–B).



TEXT-FIG. 2. *Clavulinopsis fusiformis* (Fr.) Corner. A, Basidiospores, ×880; B, Long tapered and thick-walled basidia, ×880.

Collected on soil under Oak Forest, The Park, Mussoorie, August 25, 1953, **47**.

Except for the absence of clamps and the presence of predominantly 2-spored basidia the present fungus closely resembles *Clavulinopsis fusiformis* (Fr.) Corner. The present fungus is the only one lacking clamps among more than a hundred species of the genus *Clavulinopsis* Van Ov. reported so far. The absence of clamps in this case may be connected with the predominantly 2-spored (? haploid) state of the fruit body.

This fungus also closely resembles *Clavulinopsis amœna* (Zoll. et Mor.) Corner but is easily distinguished from the latter by the possession of a large (1–2 μ long) apiculus to the spore.

The presence of predominantly 2-spored basidia and the absence of clamps would indicate that this fungus belongs to the genus *Clavulina* Schroet. However, as in *Clavulinopsis*, the basidia in this fungus possess long-tapered base and the straight sterigmata and often become thick-walled and persist in the hymenium. *Clavulina*, on the other hand, has a subcylindric basidium, eventually becoming septate, and curved sterigmata.

17. *Clavulinopsis biformis* (Atk.) Corner var. *elongata* var. nov.

Usque 9 cm. longa, solitaria vel gregaria vel cæspitosa, sordide alba: sporis 4·3-5 × 3-3·5 μ, I-guttulatis: hyphis fibulatis: terrestris, Chakrata Toll, Mussoorie, India, September 2, 1953, **48**.

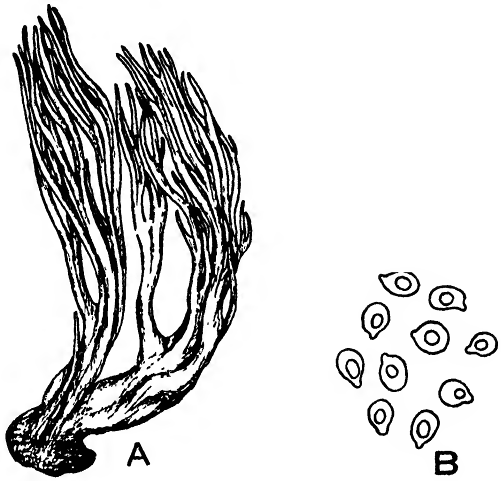
Up to 9 cm. long, solitary, gregarious, sometimes cæspitose, dirty white; spores 4·3-5 × 3-3·5 μ, uniguttate: terrestrial, Chakrata Toll, Mussoorie, India, September 2, 1953, **48**.

Fructifications solitary, gregarious, sometimes cæspitose, erect, medium-sized, radial, trunk present or absent, profusely branched, firm-fleshy, pubescent below, smooth and glabrous above, dirty white, up to 9 cm. tall and up to 3 cm. broad. Trunk when present up to 3·5 cm. long, pubescent, cylindrical, like the primary branches and of the same width. Branching profuse, starting right from the base or from a distance of 3·5 cm., dichotomous, branches unequal, in alternating planes, often fused together, primary branches up to 3 mm. broad, ultimate branchlets in unequal pairs and up to 1 cm. long. Apices concolorous and acute to rounded. Flesh concolorous. Taste and smell inparticular. *Hymenium* spread all over except the basal pubescent portion, thickening strongly but is largely sterile except on the young branches, up to 103 μ broad. *Basidia* small, clavate, 28–35 × 4·7-6 μ. Sterigmata 4, slightly incurved, 3–5 μ long. *Basidiospores* subhyaline to hyaline, small, obovoid to subglobose, papillate, smooth, uniguttate, guttule small, filling about one-fourth of the spore cavity, 4·3-5 × 3–3·5 μ. *Hyphæ* monomitic, hyaline, thin-walled, branched, mostly inflated but narrow ones uninflated, septate, septa at short intervals in the inflated hyphæ and at longer intervals in the narrow ones, clamped, clamps common, H-connections present, inflated hyphæ 5·2-10·3 μ broad while narrow uninflated hyphæ 1·7–5·2 μ broad, hyphal cells of inflated hyphæ up to 146 μ long, those of narrow uninflated hyphæ up to 361 μ long (Text-Fig. 3, A–B).

Collected on humous soil under Oak Forest, Chakrata Toll, Mussoorie, September 2, 1953, **48**.

The hymenium of this fungus thickens strongly but is largely sterile except on the young branches.

This fungus resembles *Clavulinopsis biformis* (Atk.) Corner in all respects except that its fruit bodies are up to 9 cm. tall in contrast to 4 cm. as the maximum length recorded so far for the fruit bodies of *C. biformis*. Therefore, it is made a variety of *C. biformis* on the basis of its large fruit bodies, as has also been suggested by Corner (personal correspondence, 1955). The varietal name *elongata* is proposed here to indicate the large fruit bodies.



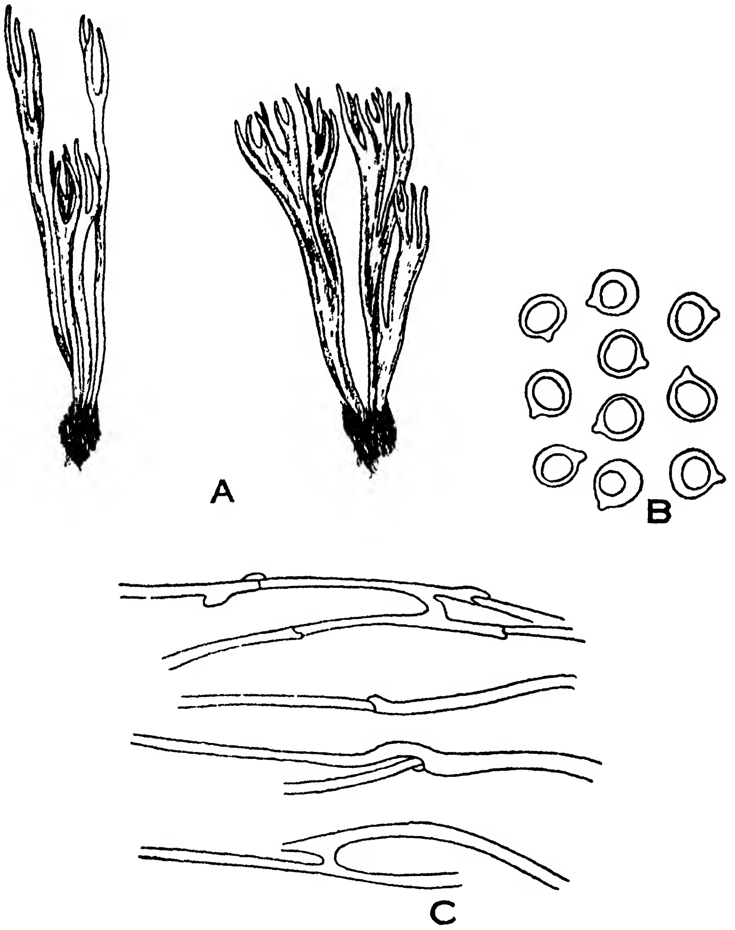
TEXT-FIG. 3. *Clavulinopsis biformis* (Atk.) Corner var. *elongata* var. nov. A, Fructification, ×1; B, Basidiospores, ×880.

18. *Clavulinopsis corniculata* (Fr.) Corner

Fructifications gregarious, cæspitose, erect, medium-sized, radial, trunk usually present, sometimes absent, sparsely branched, fleshy, smooth, glabrous, dull ochraceous, up to 7 cm. tall, the whole cæspitose cluster up to 3 cm. broad, individual fructifications up to 0·5 cm. broad. Trunk radial or flattened and grooved, narrower than the fructifications above, concolorous, up to 5 cm. long and up to 0·3 cm. broad. Branching sparse, from 1–4 times, dichotomous, may start right from the base when trunk is absent. Branches unequal, divergent, or divaricate with wide lunate axils, in alternating planes, primary branches often flattened and grooved, upper ones usually cylindrical, internodes long, ultimate branchlets in pairs, slightly incurved, 1–10 mm. long. Apices concolorous and acute. Flesh lighter coloured. Taste slightly bitter, smell inparticular. Numerous rhizomorphic mycelial strands given out from the base of fructifications; several separate mycelial hyphæ also given out from the base. They are septate, abundantly clamped, slightly darker and slightly thickened. *Hymenium* spread all over including the trunk, thickening, up to 79 μ broad. *Basidia* clavate,. 6–8 μ broad. Sterigmata mostly 4, slightly incurved, 4–10 μ long. *Basidiospores* subhyaline, globose, papillate, papilla 1–1·2 μ long, smooth, uniguttate, guttule from small to large filling one-half or more of the spore cavity, 4–7 μ broad. *Hyphæ* monomitic, hyaline, branched, thin-walled, mostly slender, narrow and uninflated, septate, septa at long intervals, clamped, H-connections present but sparse, 1·8–7 μ broad, hyphal cells very long (Text-Fig. 4, A–C).

Collected on soil under Oak Forest, Chakrata Toll, Mussoorie, August 30, 1953, **49**.

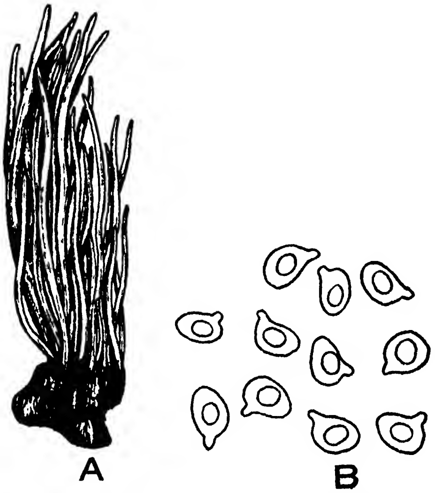
The species is recognized by the yellow fruit bodies with sparse branches, divaricate with wide lunate axils and globose uniguttate spores (4–7 μ wide).



Text-Fig. 4. *Clavulinopsis corniculata* (Fr.) Corner. A, Two fructifications, ×1; B, Basidiospores, ×880; C, Hyphæ clamped and with H-connections, ×380.

19. *Clavulinopsis aurantio-cinnabarina* (Schw.) Corner

Fructifications gregarious, densely cæspitose, erect, small-sized, slender, radial, trunk present, simple, fleshy, smooth, glabrous, deep orange red, up to 5·5 cm. tall, the cæspitose clusters up to 2 cm. broad, individual clubs very thin, mostly 0·5–2 mm. broad, some old ones very much flattened with the flattened side up to 5 mm. broad but the edge being only about 1 mm. thick. Trunk indistinct, paler concolorous, may be narrower than the club above or not, up to 2 cm. long. Clubs cylindrical, slender, mature and old ones may become flattened and grooved, apices concolorous, subacute or rounded. Flesh deep orange red, not fading. Taste and smell inparticular. *Hymenium* spread all over except the trunk, up to 68 μ thick, small, granular crystal-like bodies abundantly present in the hymenium. *Basidia* clavate, orange coloured, 4·2–7 μ broad. Sterigmata mostly 4, sometimes 2–3, incurved, 3·7–7 μ long. *Basidiospores* paler orange coloured, obovate to subglobose, papillate, papilla 1–2 μ long, smooth, uniguttate, guttule filling about one-third of the spore cavity, 7–7·4×4·2–7 μ. *Hyphæ* monomitic, orange coloured, both narrow and slightly broad, thin-walled, uninflated, broader ones slightly inflated, septate, septa at short to longer intervlas, at longer intervals in narrow hyphæ and at short intervals in broader hyphæ, clamped, narrow hyphæ usually very much convoluted while broader ones usually straight, 1·8–7 μ broad (Text-Fig. 5, A–B).



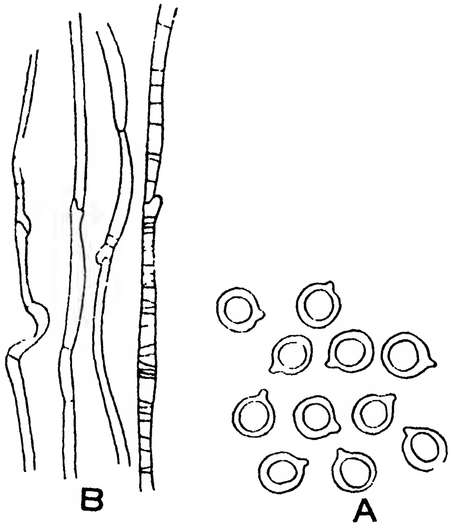
TEXT-FIG. 5. *Clavulinopsis aurantio-cinnabarina* (Schw.) Corner. A, Fructification, ×1; B, Basidiospores, ×880.

Collected on soil under Oak Forest, Chakrata Toll, Mussoorie, August 20, 1953, **50**.

The species is easily known from the simple, deep orange red fructifications, pale orange, subglobose to obovoid, uniguttate spores (7–7·4×4·2–7 μ), orange coloured hyphæ, and hymenium with many small crystals.

20. *Clavulinopsis alcicornis* (Zoll. et Mor.) Corner

Fructifications solitary, cæspitose, erect, small-sized, radial, trunk usually present, much branched, fleshy, smooth, glabrous, yellowish buff coloured, up to 5 cm. tall and up to 3·5 cm. broad. Trunk up to 1 cm. long and up to 4 mm. broad, radial, sometimes lacking. Branching dichotomous, branches lax, unequal, in alternating planes, internodes long. Each fructification branches at the most 3–5 times and the branches become thinner and thinner upward as is usual of other Clavariaceæ. Primary branches up to 4 mm. broad, ultimate branchlets long, 0·2–3·9 cm. long, usually in pairs like a pair of tongs but also found solitary. Apices acute, concolorous. Flesh lighter coloured. Taste and smell inparticular. *Hymenium* spread all over, up to 88 μ broad. *Basidia* clavate, 7–9 μ broad. Sterigmata 4, slightly incurved, 3·5–8·8 μ long. *Basidiospores* globose, papillate, papilla 1–1·5 μ long, hyaline to subhyaline, smooth, uniguttate, guttule almost completely filling up the spore cavity, 5·3–6·9 μ in diameter. *Hyphæ* monomitic, hyaline to subhyaline, brown in a mass, thin-walled or slightly thick-walled, septate, secondary septa observed in several hyphæ, secondary septa profusely developed or sparse, not inflated but swollen and beaded at places. Hyphæ often irregular in outline varying from merely wavy to deeply constricted so as to give a beaded appearance, swollen in the region of beads as well as in the portion with wavy margin. Hyphæ are clamped, clamps present on every primary septum, 1·8–6 μ, or more in diameter (Pl. VIII, Fig. 3; Text-Fig. 6, A–B).



TEXT-FIG. 6. *Clavulinopsis alcicornis* (Zoll. et Mor.) Corner. A, Basidiospores, ×880.; B, Secondarily septate and clamped hyphæ, ×380.

Collected on soil under Oak Forest, Dhobi Khud, Mussoorie, August 18, 1953, **51**.

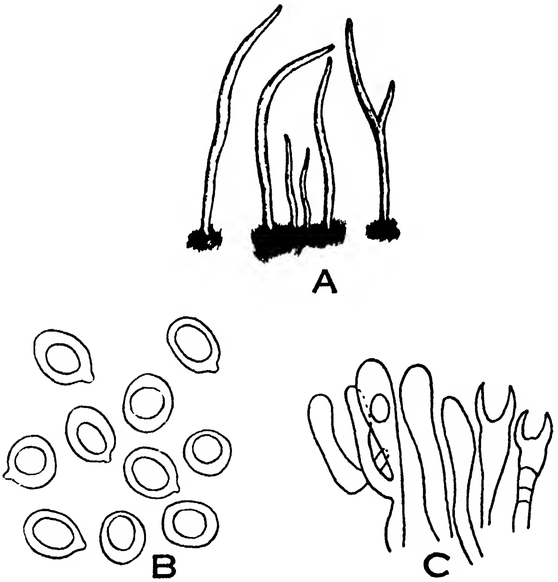
The species shows close resemblance to *Clavulinopsis corniculata* (Fr.) Corner but is easily differentiated by the more numerous branches, and the secondarily septate, irregular often wavy to beaded hyphæ.

21. *Clavulina bessonii* (Pat.) Corner var. *incarnata* var. nov.

Usque 1·6×0·1 cm., simplicia, raro monoramosa, stipitate, incarnata: stipite—2×0·8 mm., pallide-incarnata: sporis 7–7·4 μ, 1-guttatis: hyphis fibulis prædítis: terrestris, Dhobi Khud, Mussoorie, India, September 19, 1953, **52**.

Up to 1·6×0·1 cm., simple, rarely branched only once, trunk present, pink: trunk—2×0·8 mm., lighter pink coloured, spores 7–7·4 μ in diameter, uniguttate: hyphæ provided with clamps: terrestrial, Dhobi Khud, Mussoorie, India. September 19, 1953, **52**.

Fructifications gregarious, erect, small-sized, radial, slender, trunk present, simple, or rarely branched only once, fleshy, smooth, glabrous, pink up to 1·6 cm. tall and up to 1 mm. broad. Trunk up to 2 mm. long and up to 0·8 mm. broad, lighter pink coloured. Clubs are usually bent, or sometimes straight. Apices blunt and concolorous. Taste and smell inparticular. *Hymenium* spread all over except the lighter coloured trunk, thickening, up to 81 μ broad. *Basidia* clavate, subhyaline, contents granular, secondarily septate after spore discharge, 3·5–7 μ broad. Sterigmata 2, incurved, 5·3–7 μ long. *Basidiospores* hyaline, globose to subglobose, papillate, smooth, uniguttate, guttule large, filling nearly three-fourth of the spore cavity, 7–7·4 μ in diameter. *Hyphæ* monomitic, hyaline, thin-walled, branched, somewhat inflated, septate, septa at short intervals and hence hyphæ small-celled, clamped, clamps abundant and nearly at all septa, may look like cells gliding over one another, hyphal cells 3·5–8·8×17·5–70 μ (Text-Fig. 7, A–C).



TEXT-FIG. 7. *Clavulina bessonii* (Pat.) Corner var. *incarnata* var. nov. A, Simple and rarely branched fructifications, ×2; B, Basidiospores, × 880; C, Basidia, becoming secondarily septate after spore discharge, ×880.

Collected on soil amid mosses under an Oak Forest, Dhobi Khud, Mussoorie, September 19, 1953, **52**.

This fungus closely resembles *Clavulina bessonii* (Pat.) Corner, except that its fruit bodies are pink in contrast to the white fruit bodies of *C. bessonii*. Accordingly, this fungus is made a pink-coloured variety (var. *incarnata* var. nov.) of *C. bessonii*, as has also been suggested by Corner (personal correspondence, 1955).

ACKNOWLEDGEMENTS

The writers are deeply indebted to Mr. E. J. H. Corner, F.R.S., of the Botany School, Cambridge, England, for valuable criticism and help in the identification of the species of Clavarias and Prof. P. N. Mehra for providing facilities and encouragement. They are also thankful to Mr. B. Khanna, for making illustrations of some of the fructifications.

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EXPLANATION OF PLATE

FIGS. 1-3. Fig. 1. *Clavariadelphus mirus* (Pat.) Corner. Fig. 2. *Clavulinopsis fusiformis* (Fr.) Corner. Fig. 3. *Clavulinopsis alcicornis* (Zoll. et Mor.) Corner.

FIGS. 1-3

K. S. Thind and G. P. S. Anand

THE GAMETOPHYTES OF *LYCIUM EUROPÆUM* LINN.

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(Received for publication on December 13, 1955)

Introduction

Lycium europæum is a spinous shrub found in Merwara and Rajasthan, India. Although it belongs to Solanaceæ, in floral structure, it resembles Convolvulaceæ. Its morphological study has been undertaken with the belief that it may show some transitory features connecting Solanaceæ and Convolvulaceæ.

Hofmeister (1858) described the mature embryo-sac in *Hyoscyamus orientalis*, *Scopolina atropoides* and *Salpiglossis picta*. Jönsson (1881) studied the development of embryo-sac and found that in *Saracha jaltomato* the megaspore mother cell forms a linear tetrad of megaspores, the innermost of which develops into an eight-nucleate 'Polygonum type' of embryo-sac. The same type of development has been described in a number of plants of this family (Guignard, 1882; Souèges, 1907; Palm, 1922; Svensson, 1926; Banerji, 1931; Bhaduri, 1932; Goodspeed, 1947; and Walker, 1955). Contrary to the above, Nanetti (1912) and Young (1923) found that the embryo-sac development follows that of 'Lilium-type' in *Solanum muricatum* and *S. tuberosum* respectively and Modilewski (1935) reports a bisporic eight-nucleate 'Scilla-type' of embryo-sac in *Nicotiana glauca.*

Material and Methods

The material for this study was collected from Adarsh Nagar Hills and Foy Sagar Road, Ajmer, and fixed in formalin-acetic-alcohol and acetic-alcohol. Immature buds were placed in the fixing fluid as such while the tips of the older buds were trimmed to ensure better fixation. In the case of open flowers the sepals, petals and occasionally the stamens were removed and only the ovaries were fixed. The customary processes of dehydration and infiltration were followed. Transverse and longitudinal sections, 8–12 microns in thickness, were cut and stained in safranin and fast-green. The earlier developmental stages up to two-nucleate embryo-sac were obtained in transverse sections. Later stages, however, were found in the longitudinal sections, 10–12 microns in thickness. This is due to the changes in the orientation of the ovule during its development.

Microsporogenesis and Male Gametophyte

The five epipetalous initials of the stamens arise as blunt processes. These undifferentiated masses of cells soon become bilobed, each lobe bearing a pair of loculi. The anther is basally attached to its filament.

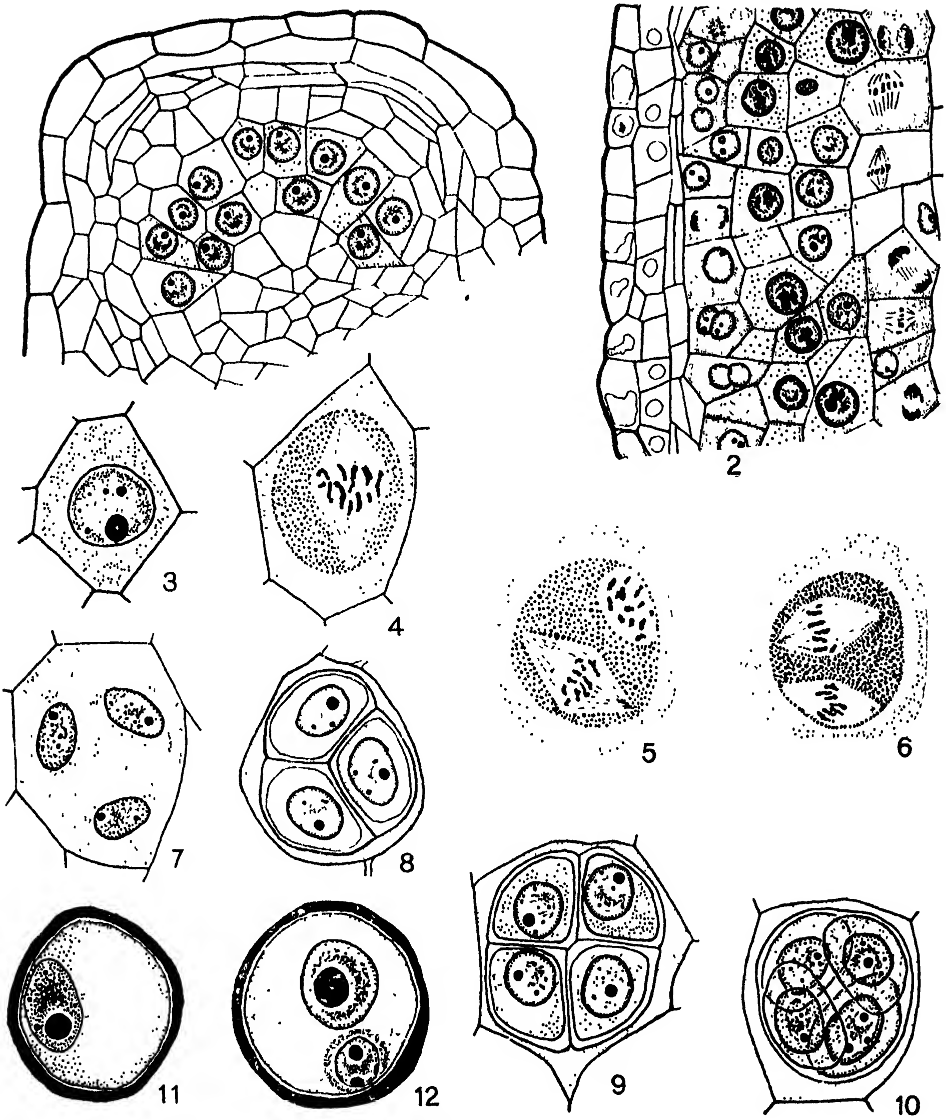
Unlike the genus *Solanum* where the anther opens by apical pores, the mature anther dehisces by longitudinal slits.

The archesporium differentiates as a plate of hypodermal cells which divide periclinally to form primary parietal cells and primary sporogenous cells. The former divide anticlinally and periclinally to form four-wall layers (Fig. 1) the innermost of which functions as tapetum, the sub-epidermal layer acts as the endothecium and the remaining two form the middle layers (Fig. 2). The primary sporogenous cells divide further and ultimately differentiate as microspore mother cells (Fig. 2).

The endothecium is uniseriate; towards the connective, however, it is many seriate. The protoplast of the epidermal cells shrink at the shedding time of the pollen grains and their outer tangential walls develop cuticular dentations. The inter-locular tissue in each lobe disorganises resulting in the line of dehiscence in the form of a longitudinal slit.

The innermost layer of the parietal tissue differentiates as the glandular tapetum (Fig. 2). About the time the mother cells are in the resting stage, the tapetal cells become completely filled with dense cytoplasm and stain densely. The nuclear division in the tapetum takes place by normal mitosis and the tapetal cells become bi-nucleate (Fig. 2). Later as the tapetal cells enlarge a large vacuole appears in the cytoplasm. The tapetum is absorbed during the formation and maturation of the pollen grains. Its remnants, however, persist for some time, completely disappearing at the shedding stage of the pollen grains. The tapetal cells derived from the anther tissue towards the connective are more conspicuous in size (Fig. 2).

The sporogenous tissue is arc-shaped in each lobe (Fig. 1). The mother cells develop gelatinous sheaths around them, inside their original cell wall. The first meiotic division produces a dyad and the second, a tetrad of microspores (Figs. 3 6). Different types of microspore tetrads result (Figs. 8 10) due to the differences in the orientation of the spindles at the second meiotic division. There is not much synchronization in the divisions of mother cells of a loculus during the meiotic divisions. Cytokinesis takes place by furrows which appear at the periphery and grow inward till they meet at the centre, dividing the protoplast into four microspores (Fig. 7). The microspores separate and development of the exine takes place. A vacuole develops inside the pollen grain which displaces the nucleus towards the wall (Fig. 11). The pollen grains are smooth-walled, spheroidal and tri-forate. The division of the microspore nucleus results in a vegetative and a generative cell (Fig. 12). The pollen grains are shed at the two-celled stage. It has been observed in smears that before division the generative cell becomes very much elongated and is accommodated in the pollen grain in the form of a sickel-shaped body. In the pollen tube, however, it becomes almost straight. Instances were also noted therein, where the pollen tubes from different pollen grains coiled around each other. This suggests that the pollen grains had germinated *in situ.*



FIGS. 1–12. Fig. 1. T.S. of part of anther showing microspore mother cells. Fig. 2. L.S. of anther showing microspore mother cells, tapetum and wall layers. Fig. 3. Microspore mother cell. Figs. 4–6. Meiosis I and II, note metaphasic spindles with different orientations in Figs. 5 and 6. Fig. 7. Cytokinesis in microspore mother cell by furrowing. Figs. 8–10. Tetrahedral, isobilateral and decussate tetrads. Fig. 11. Uninucleate pollen grain. Fig. 12. Bi-celled pollen grain. Figs. 1, 2, ×63. Figs. 3–12, ×766.

The vertical section of the glandular stigma has been observed to be abundantly filled with densely staining and sufficiently long pollen tubes.

OVULE

The ovary is bilocular and its carpellary margins meet only incompletely in the centre. A bulky placenta is absent and there are not many ovules, showing thereby resemblance with Convolvulaceæ.

The development of the ovule conforms to the type found in most of the Sympetalæ. It initiates its development at the time when the microspore mother cells are being formed. The ovular papillæ arise as minute protuberances and as they grow, the more pronounced growth on one side results in their anatropic form. The ovule is tenuinucellate and unitegmic (Figs. 15, 17); a single vascular strand extends through the funiculus up to the chalaza.

The hypodermal archesporial cell differentiates very early along with the primordia of the integument (Fig. 13). The integument is 2–3 cells thick at the time when the mother cell is distinguishable. Prior to heterotypic division, it becomes 4–5 cells thick and at the dyad stage begins to arch over the nucellus forming a micropyle, 4–5 cells long. Frequently the degeneration of the dyad and the tetrad has been noted, which probably is due to an insect biting the flower. The ovules in an injured ovary almost always show the signs of degeneration of the sporogenous tissue. Later the micropyle becomes a long narrow and curved canal (Figs. 17–19).

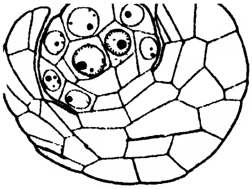
The embryo-sac during its development, beginning at the micropylar end, completely absorbs the nucellus (Figs. 20, 24, 26), leaving a few degenerated masses, which stain darkly towards the chalazal region. The inner integumentary epidermis assumes a tapetum-like appearance rather early (Fig. 18). Its cells become radially elongated and have glandular contents, prominent nuclei and nucleoli. The cells of this endothelium remain always uninucleate. The presence of integumentary tapetum enclosing the embryo-sac is a characteristic feature of the Solanaceæ (Bhaduri, 1935 and Souèges, 1907), and is found in most of the Sympetalæ. As the embryo-sac enlarges in dimensions, the cells at the chalazal end become gradually absorbed (Figs. 24, 26). A hypostase could not be observed at the chalazal end (*cf.* Walker, 1955).

A weakly developed glandular obturator is organized from the epidermal cells of the placenta.

MEGASPOROGENESIS

As in most of the Sympetalæ, the archesporium directly functions as the megaspore mother cell (Fig. 14) and is distinguishable from the rest of the cells by its dense cytoplasm and a prominent nucleus. A pair of archesporial cells of integumentary origin has been reported in addition to the hypodermal archesporial cell by Bhaduri (1932) in *S. melongena*.

The nucleus of the young megaspore mother cell prior to its division occupies a more central position. The mother cell elongates and divides. The metaphasic spindle lies in the centre of the cell (Figs. 15,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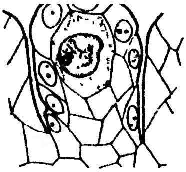
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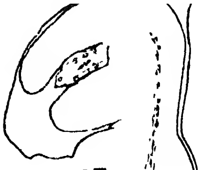
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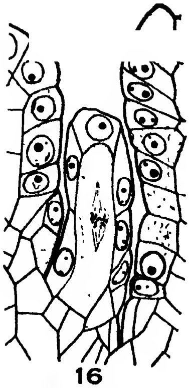
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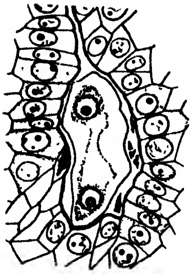
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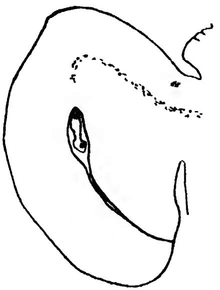
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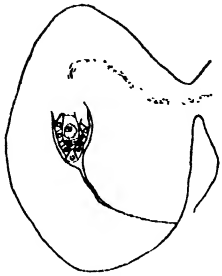
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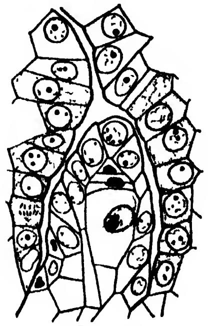
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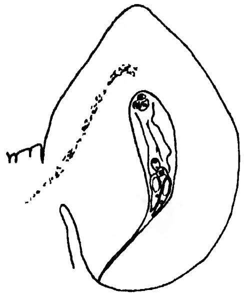
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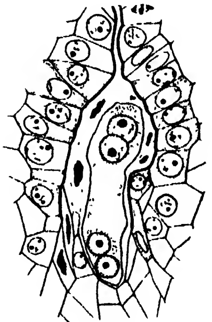
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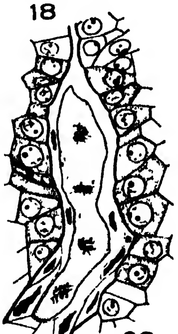
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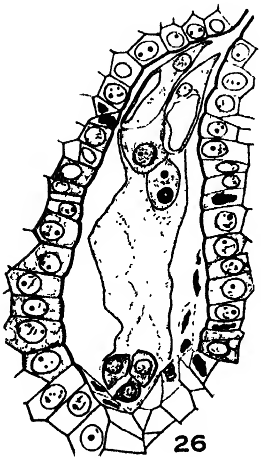
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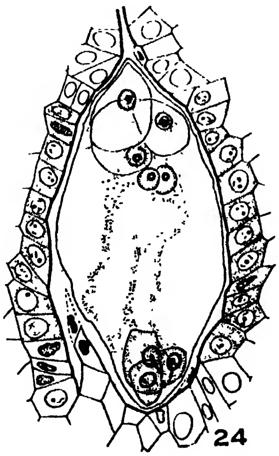
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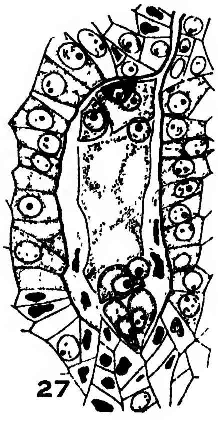
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FIGS. 13-27. Fig. 13. Young ovule showing two enlarged cells in the nucellus. Fig. 14 Megaspore mother cell. Fig. 15. Ovule showing megaspore mother cell in metaphase. Fig. 16. Same, a portion magnified. Fig. 17. Massive integument and chalazal functioning megaspore. Fig. 18. Same, a portion magnified with endothelial cells. Fig. 19. Ovule with two-nucleate embryo-sac. Fig. 20. Same, a portion magnified showing disintegrated nucellar cells. Fig. 21. Ovule with four-nucleate embryo-sac. Fig. 22. Four-nucleate embryo-sac. Fig. 23. Same, dividing. Fig. 24. Mature embryo-sac. Fig. 25. Ovule, embryo-sac with fused polars. Fig 26. Same, magnified. Fig. 27. Embryo-sac with inverse polarity. Figs. 13, 14, 16, 18, 20, 22, 23, 24, 26, 27, ×366; Figs. 15, 17, 19, ×116.

16). The mother cell divides and forms a linear tetrad of megaspores. The chalazal megaspore functions and the other three degenerate, and are found in a degenerated state to cap over the functioning one (Figs. 17, 18). The functioning megaspore enlarges in size and becomes vacuolated.

EMBRYO-SAC

The nucleus of the embryo-sac mother cell divides and the two nuclei are displaced towards the poles with the appearance of a central vacuole (Fig. 20). The nuclei of the two-nucleate embryo-sac divide at their respective poles. The chalazal end of the four-nucleate embryo-sac buries itself deep in the chalaza (Figs. 22–23). It passes into an eight-nucleate 'Polygonum-type' of embryo-sac. Goodspeed (1947) reports an embryo-sac with more than eight-nuclei in *N. tabacum*. Twin embryo-sacs in an ovule have been recorded in *S. melongena* (Bhaduri, 1932) and *S. tuberosum* (Young, 1922).

The pear-shaped synergids which lie side by side elongate and slightly project into the micropyle (Fig. 26). The filiform apparatus was not observed and the beak of the synergid is also indistinguishable (Fig. 24). The egg usually becomes enlarged and the vacuole occupies a large area of the egg cell while its nucleus is accommodated in the thin cytoplasm at its base (Fig. 24). The egg may become elongated reaching very near the secondary nucleus (*cf.* Cooper, 1931; Walker, 1955). The synergids degenerate rather early.

In one case the egg apparatus had disintegrated while the antipodals were found in a healthy condition. Of the three antipodals, normally two are found to lie side by side while the third one is placed below them. The antipodals are semilunar in shape. They are filled with dense cytoplasm. The expansional activity of the embryo-sac is more pronounced at the chalazal end.

The polars fuse near the egg before fertilization (Fig. 26). The earlier fusion of the polars has also been reported by Cooper (1931) for *Lycopersicum esculentum* and by Guignard (1902) for *Datura lævis*. A case of inversion of the embryo-sac, with a characteristic egg apparatus at the chalazal end, has been noted (Fig. 27) (*cf.* Goodspeed, 1947). This embryo-sac has three antipodal-like cells at the micropylar end.

SUMMARY

In the anther, the archesporium is in the form of a plate in each lobe. The sub-epidermal wall layer differentiates as the endothecium and the innermost as secretory tapetum. There are two middle layers. The tapetal cells divide by normal mitosis. The sporogenous tissue is arc-shaped. There is no synchronization in the division of the mother cells of a loculus. The formation of the microspore tetrad by furrowing is of simultaneous type. The pollen grains are smooth-walled, triforate and spheroidal. They are shed at the two-celled stage.

The ovules are anatropous, unitegmic and tenuinucellate. The embryo-sac completely absorbs the nucellus and the inner integumentary layer differentiates as the 'Integumentary tapetum'. The placental tissue proliferates as a glandular obturator. The hypodermal archesporial cell directly functions as the megaspore mother cell and divides to form a linear row of four megaspores of which the chalazal functions. The development of the female gametophyte conforms to the monosporic eight-nucleate Polygonum type of embryo-sac. A mature embryo-sac with reverse polarity has also been observed. The expansional activity of the chalazal end of the embryo-sac is striking.

ACKNOWLEDGEMENT

I am thankful to Professor B. Tiagi, for guidance and to Principal V. V. John, for research facilities.

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STUDIES IN THE FAMILY EUPHORBIACEÆ

I. The Gametophytes of *Chrozophora rottleri* A. Juss.

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(Received for publication on December 13, 1955)

INTRODUCTION

CONSIDERING the inconsistency in the reproductive structures and the large number of species included in the family Euphorbiaceæ, the studies on the family made so far, are rather insufficient to ascertain its correct position in a natural system of classification. Moreover, there are contrasting reports which need further work and confirmation. As two different types of embryo-sac development have been reported for *Chrozophora rottleri* A. Juss., the present study was undertaken with the hope to add some more useful information. This work is the first of the series and is in accordance with the proposed scheme for further studies in this family.

Schnarf (1931) has reviewed the previous work on the family Euphorbiaceæ and eight types of embryo-sac recorded for this family have been tabulated by Maheshwari (1942). The Polygonum type of embryo-sac is of common occurrence in this family.

Recently Polygonum type of embryo-sac development has been reported in *Chrozophora obliqua* and *Chrozophora prostrata* var. *parvifolia* (Kapil, 1955; 1956). In *Chrozophora rottleri* (Srivastava and Agarwal,* 1953), a bisporic type of development has been found. The present investigation, however, reveals that the development in this species is of Polygonum type and confirms the recent report by Kapil (1956).

MATERIAL AND METHODS

Formalin-acetic-alcohol was used as fixative for fixing buds and flowers of different ages. The presence of dense stellate hairs on the ovary wall and on the calyx caused a great deal of difficulty in cutting serial microtome sections. Hence, as far as possible, the ovules and anthers of different ages were removed from the buds and processed in the usual manner. Sections of anthers and ovules were cut eight to twelve microns and ten to sixteen microns thick, respectively. The sections of ovules were stained in safranin—fast-green and in Heidenhain's iron hæmatoxylin and those of anthers in Delafield Hæmotoxylin and in Heidenhain's iron hæmotoxylin.

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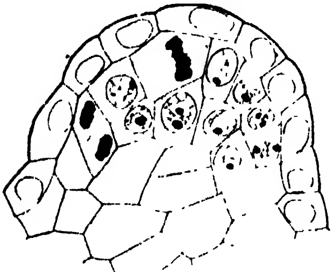
*.Quoted from Kapil, 1955.

Microsporogenesis and Male Gametophyte

The archesporium, as seen in cross-section, consists of three to five hypodermal cells. These divide periclinally to give rise to an inner primary sporogenous layer and an outer primary parietal layer (Fig. 1). The latter divides to form the hypodermal endothecium, two middle layers and the tapetum (Fig. 2). The sporogenous layer undergoes a few divisions to give rise to pollen mother cells.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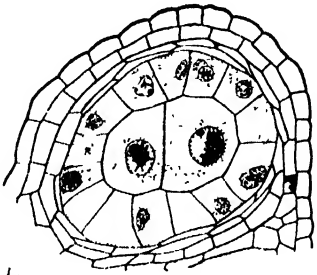
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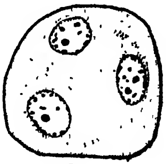
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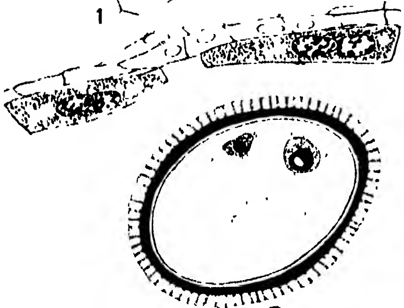
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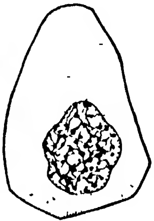
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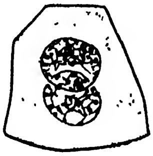
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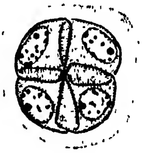
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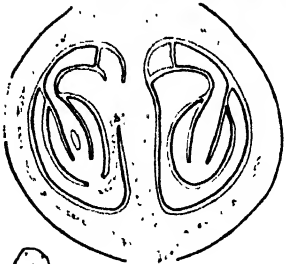
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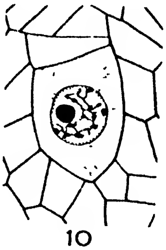
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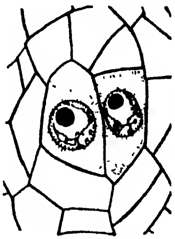
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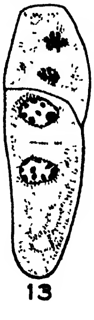
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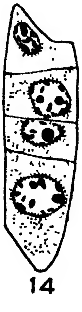
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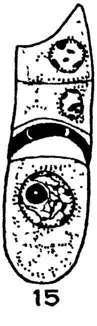
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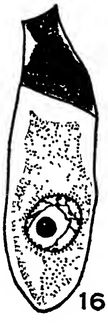
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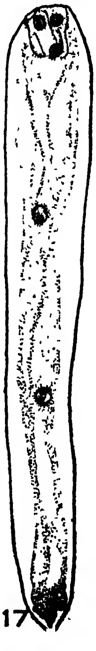
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FIGS. 1–17. Fig. 1. T.S. anther showing primary sporogenous and primary parietal layers, × 633. Fig. 2. T.S. anther showing microspore mother cells, tapetum and wall layers, × 433. Fig. 3. Tetrahedrally arranged microspore nuclei, × 633. Fig. 4. Microspore tetrad, ×633. Fig. 5. Decussate tetrad, × 633. Figs. 6–7. Binucleate and polyploid tapetal cells, × 633. Fig. 8. Mature bicelled pollen grain, tapetal cells persisting, × 633. Fig. 9. L.S. ovary showing two ovules, obturator and vascular supply, × 38. Fig. 10. Megaspore mother cell, × 833. Fig. 11. Two megaspore mother cells, × 833. Fig. 12. Dyad, × 833. Fig. 13. Same, dividing, × 833. Fig. 14. Linear tetrad, × 833. Fig. 15. Same, third megaspore from micropylar end degenerating, × 833. Fig. 16. Functioning megaspore, × 833. Fig. 17. Mature embryo-sac, × 266.

The cells of endothecium do not show any radial fibrous thickerings, so characteristic of the angiosperms (Fig. 8). The inner middle layer degenerates earlier by the end of the meiotic divisions in the pollen mother cells, while the remnants of the outer are present till the formation of the mature pollen grains. The uninucleate cells of the tapetal layer become binucleate at a time when the pollen mother cells are in early prophase. This layer becomes conspicuous due to enlargement and vacuolation of the cells (Fig. 2). At this stage it may detach from the rest of the wall layers and later on its cells separate from each other, but curiously enough, persist till the formation of the mature pollen grains (Fig. 8). The tapetal nuclei show divisions and fusions resulting in polyploid nuclei (Figs. 6, 7). Similar observations have been recorded for *Pedilanthus tithymaloides* and *Gelonium multiflorum* (Banerji, 1951). A multi-nucleate tapetum is reported in *Euphorbia esula* (Kapil, 1955).

The young pollen mother cell is surrounded by a distinct dense sheath of mucilage which develops in between the protoplast and the parent cell wall. It persists till the formation of microspore tetrads and their liberation (Figs. 3, 4). Division of microspore mother cells is simultaneous and cytokinesis takes place by furrowing (Fig. 3). Microspores are arranged tetrahedrally (Fig. 4). Decussate (Fig. 5) and isobilateral tetrads also occur.

The microspore develops an exine and intine and increases considerably in size. Vacuolation starts from the periphery, ultimately forming a large central vacuole and pushing thereby the nucleus towards the periphery where it divides mitotically to form a large vegetative and a small generative cell (Fig. 8). The mature bicelled pollen grain is octocolporate, reticulate and sphæroidal.

OVULE

The ovules are slightly hemianatropous, bitegmic and crassinucellate. Primordia for the inner integument appear when the megaspore mother cell is developing and is soon followed by the primordia for the outer integument. An early origin of the inner integument appears to be a common feature in this family and this has been reported by other workers also (Maheshwari, 1942; Banerji, 1951 and Srivastava, 1952). However, the outer integument overgrows the inner at the dyad stage of megasporogenesis. The inner integument is thicker and its apex is attenuated.

A true micropyle is not formed because of the conspicuously long and slender nucellar beak which is also found in other genera of this family. It projects far beyond the micropyle, curving and facing towards the placental obturator (Fig. 9), which is composed of long glandular cells. The presence of an obturator is a common feature for this family. The vascular supply to the ovule terminates at the chalaza (Fig. 9).

MEGASPOROGENESIS AND FEMALE GAMETOPHYTE

The hypodermal archesporium is found in very young ovules. The megaspore mother cell is pushed deep down in the nucellus by the repeated division of the parietal layers (Fig. 10). Divisions in nucellar epidermal cells (Kapil, 1956) were not observed in my material. The mother cell enlarges considerably and shows a large nucleus. Two mother cells lying side by side have also been observed (Fig. 11) and this feature is often recorded in this family. The megaspore mother cell undergoes heterotypic divisions to form a linear tetrad of megaspores (Figs. 12 to 14) of which the chalazal develops further (Fig. 16). A triad with an upper dyad cell as in *Chrozophora obliqua* and *Chrozophora prostrata* var. *parvifolia* (Kapil, 1955, 1956) was not observed in my material. The development of a linear tetrad of megaspores is clear and so I am unable to corroborate the findings of Srivastava and Agarwal (1953) who report a bisporic embryo-sac in this species. Degeneration of megaspores starting from the micropylar end is usual in the family. However, in *Chrozophora rottleri* the megaspore above the functional chalazal one, invariably degenerates first (Fig. 15) as in *Euphorbia hirta* (Kajale and Rao, 1942).

The functioning megaspore enlarges and small vacuoles appear on the polar sides of the nucleus (Fig. 16). By three more successive divisions it forms an eight-nucleate embryo-sac of the Polygonum type (Fig. 17). The embryo-sac elongates considerably. The beaked synergids overlap the egg which in turn lies in between them at a different level. The antipodal cells are variously arranged, usually two of them lie side by side while the third below them (Fig. 17). They degenerate prior to fertilization.

Fusion of polar nuclei takes place in the vicinity of egg.

SUMMARY

No fibrous thickenings are seen in the endothecium. The polyploid tapetum is of the secretory type. The mature bicelled pollen grain is octocolporate, reticulate and sphæroidal.

The ovule is crassinucellate, bitegmic and slightly hemianatropous and has a projecting nucellar beak facing the placental obturator. Development of the embryo-sac follows the Polygonum type and not the bisporic type.

ACKNOWLEDGEMENTS

I am thankful to Professor B. Tiagi, for guidance, to Principal V. V. John, for research facilities, and the Government of the State of Ajmer, for the award of a research scholarship. Thanks are also due to Shri M. B. Raizada of the Forest Research Institute, Dehra Dun, for the confirmation of the species.

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A CONTRIBUTION TO THE KNOWLEDGE OF FRESH-WATER DIATOMACEÆ OF SOUTH-WESTERN INDIA

I. Fresh-Water Diatoms of Dharwar

By H. P. Gandhi

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(Received for publication on October 2, 1955)

INTRODUCTION

There are only a few accounts dealing with fresh-water diatoms of India available and practically none so far covering the south-west region of the Peninsula. The following account is based on some collections in this region, at Dharwar.

TOPOGRAPHY AND THE CLIMATE OF DHARWAR

Dharwar, in the State of Bombay, is situated on the Poona-Bangalore line of the Southern Railway. The town proper lies at 15° 27′ latitude and 75° 6′ longitude on a plateau of medium height which varies between 2,400–2,544′ above the mean sea-level. It has a fairly cool climate and an average annual rainfall of 32″.

PLACES OF COLLECTION

The material for this investigation was collected from the garden reservoirs of the Karnatak College—Dharwar, by the author when he was attached to the said College during July–August 1949. He was particularly interested to know the nature of the floating frothy masses and encrustations in the reservoirs. An examination of the material revealed a mass of diatoms—particularly the Cymbellas embedded in gelatinous matrix and the tangled masses of some blue-green algæ. More material was then collected and preserved in 5–6% of commercial formalin. A few casual samples of algæ were also collected by the author from Kilgeri and Someswar tanks and preserved likewise during the same period. Due to unforeseen circumstances the collections, however, could not be examined then and there. The material was later studied at the Ismail Yusuf College, Jogeswari—Bombay, during 1949–51, and at the Rajaram College—Kolhapur, during 1951–55.

FEATURES OF THE MATERIAL

An interesting feature of the material from the garden reservoirs is the preponderance of *Cymbella cymbiformis* (Ag. ?) Kütz. and its varieties. They were found embedded in the gelatinous floating flakes and as encrustations in the reservoirs. Associated with these forms the following occur in good numbers: *Achnanthes microcephala* Kütz. v. *typica* A. Cl., *A. minutissima* (Kütz.) Grun. v. *genuina* A. Cl., *Stauronies legumen* Ehr., *Anomœoneis serians* (Bréb.) Cl. v. *modesta* A. Cl., *A. brachysira* (Bréb.) Grun. v. *genuina* A. Cl., *A. brachysira* (Bréb.) Grun. f. *subacuminata* A. Cl., *Navicula cryptocephala* Kütz. v. *subsalina* Hust., *Gomphonema parvulum* (Kütz.) V. H. v. *genuina* Mayer, *G. parvulum* v. *subellipticum* Cleve, *G. dharwarensis* sp. nov. and *Nitzschia amphibia* Grun. v. *genuina* Mayer. The other forms included in this account were present in lesser numbers. The noteworthy point regarding *Cymbella cymbiformis* and its varieties is that none of these were as large as the European specimens. It may perhaps be due to their warmer habitat in this country.

The material from Kilgeri tank resembled somewhat that of the garden reservoirs in the College; however, *Melosira granulata* (Ehr.) Ralfs. v. *typica* A. Cl., *Gomphonema subapicatum* Frit. and Rich and *Rhopalodia gibba* (Ehr.) O. Müll. v. *genuina* A. Cl., were present in numbers.

The Someswar tank material was rich in *Cymbella ventricosa* Kütz. v. *genuina* A. Cl., *Gomphonema subapicatum* Frit. and Rich, *G. montanum* Schum. v. *acuminatum* Mayer, *Rhopalodia gibba* (Ehr.) O. Müll. v. *genuina* A. Cl and *Nitzschia amphibia* Grun. v. *genuina* Mayer. The other forms occurred as stray forms.

In all 44 forms including a new species and a new variety, have been recorded from this area representing 18 genera.

The forms in this account are mainly arranged according to Hustedt (1930), the identification being carried out with the help of Cleve-Euler's monograph (1951–55) and other accounts.

BACILLARIOPHYTA (DIATOMEÆ)

A.	Order	**CENTRALES**
I.	Suborder	DISCINEÆ
1.	*Family*	*COSCINODISCACEÆ*
(*a*)	*Sub-family*	MELOSIROIDEÆ
	Genus	**Melosira** Agardh 1824

1. *Melosira granulata* (Ehr.) Ralfs. v. *typica* A. Cl.

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—I, p. 25, fig. 15 *a–b*. *M. granulata* (Ehr.) Ralfs—Van Heurck, *Treat. Diat.*, p. 444, pl. 19, fig. 621; Hustedt, *Bacil.*, p. 87, fig. 44; Tiffany and Britton, *Alg. Illinois*, p. 221, pl. 59, fig. 667.

Frustules cylindrical, united in short or long chains, 9–18 μ long, 6–12 μ in diameter, end cells with short and long spines and furrows. Cell surface with 8–10 rows of aerioles in 10 μ and 10–12 aerioles in 10 μ, aerioles arranged in straight and parallel rows on the end cells and spirally on the others.

(*b*) *Sub-family*	COSCINODISCOIDEÆ
Genus	**Cyclotella** Kutzing, F.T. 1834

2. *Cyclotella stelligera* Cl. and Grun.

Hustedt, *Bacil*, p. 100, fig. 65; Venkataraman, *S.I. Diat.*, p. 298, fig. 10; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—I, p. 43 fig. 52.

Frustules in chains, rectangular in the girdle view. Valves discoid, 10–15 μ in diameter with radiating striæ; middle portion with stellate structure around a central punctum, striæ 11–12 in 10 μ.

3. *Cyclotella meneghiniana* Kütz. v. *genuina* A. Cl.

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—I, p. 48, fig. 63 *a*. *C. Meneghiniana* Kütz.—Van Heurck, *Treat. Diat.*, p. 447, pl. 22, fig. 656; Hustedt, *Bacil.*, p. 100, fig. 67.

Frustules with undulated walls in the girdle view. Valves discoid, 11–29 μ in diameter with apparently smooth or radially punctate central field. Marginal striæ 7–9 in 10 μ, thick and radial.

4. *Cyclotella meneghiniana* Kütz. v. *genuina* A. Cl. f. *binotata* Grun.
(Fig. 1)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—I, p. 48, fig. 63 *c*. *C. meneghiniana* Kütz.—Van Heurck, *Treat. Diat.*, p. 447, pl. 22, fig. 656.

Frustules with undulated walls in the girdle view. Valves discoid, 15-25 μ in diameter with the radially punctate central field having two large distinct punctæ. Marginal striæ 8–9 in 10 μ, thick and radial.

B.	Order	**PENNALES**
I.	Sub-order	ARAPHIDINEÆ
1.	*Family*	*FRAGILARIACEÆ*
(*a*)	*Sub-family*	FRAGILARIOIDEÆ
	Genus	**Fragilaria** Lyngbye 1819

5. *Fragilaria rumpens* (Kütz.) Carlson v. *fragilarioides* (Grun.) A. Cl.

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—II, p. 42, fig. 352, *b*. *Synedra rumpens* Kütz. v. *fragilarioides* Grun.—Hustedt, *Bacil.*, p. 156, fig. 178; Gonzalves and Gandhi, *Diat. Bombay and Salsette*—I, p. 129, fig. 22.

Frustules in continuous chain. Valves linear-lanceolate with constricted slightly capitate ends, 38–52 μ long, 3–3·3 μ broad. Pseudoraphe narrow. Central area large. Striæ 10–12 in 10 μ, coarse and distinct.

Genus **Synedra** Ehrenberg 1830

6. *Synedra ulna* (Nitz.) Ehr. v. *amphirhynchus* (Ehr.) Grun.

Van Heurck, *Treat. Diat.*, p. 311, pl. 10, fig. 414; Hustedt, *Bacil.*, p. 154, fig. 167; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—II, p. 62, fig. 382 *g*.

Frustules elongated with widened truncate ends in the girdle view. Valves narrow, linear-lanceolate, bent in the middle with capitale ends, 175–255 μ long and 5–6 μ broad. Pseudoraphe very narrow. Striæ slender but distinct 9–10 in 10 μ.

7. *Synedra acus* Kütz. v. *genuina* Mayer

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—II, p. 64, fig. 385 *a–c*. *S. acus* (Kütz.) Grun.—Van Heurck, *Treat. Diat.*, p. 311, pl. 10, fig. 420; *S. acus* Kütz.—Hustedt, *Bacil.*, p. 155, fig. 170; Tiffany and Britton, *Alg. Illinois*, p. 237, pl. 63, fig. 720.

Valves weakly silicified, elongated, narrowly lanceolate, gradually tapering towards the poles, 77–133 μ long and 3·3–4 μ broad. Pseudoraphe very narrow. Central area large rectangular reaching the sides. Striæ fine those bordering the central area do not reach the centre, 13–14 in 10 μ.

II. Sub-order MONORAPHIDINEÆ
1. *Family* *ACHNANTHACEÆ*
(*a*) *Sub-family* COCCONEOIDEÆ
Genus **Cocconeis** Ehrenberg 1838

8. *Cocconeis placentula* Ehr. v. *euglypta* (Ehr.) Grun.

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 8, fig. 492 *e–f*. *C. placentula* Ehr. v. *euglypta* (Ehr.) Cl.—Hustedt, *Bacil.*, p. 190, fig. 261; Iyengar and Subrahmanyan, *Fossil Diat.*, p. 229, figs. 7–8.

Valves broadly elliptical, 18–24 μ long and 11–12 μ broad. Valves with raphe has small roundish central area. Striæ 20–23 in 10 μ, fine but distinctly punctate, radial and interrupted by two concentric hyaline zones near the margins. Rapheless valve with narrow pseudoraphe. Striæ 17–18 in 10 μ, radial, interrupted by several longitudinal undulated hyaline bands.

Genus **Achnanthes** Bory 1822
Sub-genus *Microneis*

9. *Achnanthes microcephala* Kütz. v. *typica* A. Cl.

(Figs. 2–3)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 40 fig. 568 *a–d*; *A. microcephala* Kütz.—Van Heurck, *Treat. Diat.*, p. 281, pl. 8, fig. 332. Hustedt, *Bacil.*, p. 198, fig. 273.

Frustules small, linear, bent in the girdle view. Valves narrow, linear-lanceolate with broadly rounded capitate ends, 15–20 μ long and 3-3·5 μ broad. Valve with raphe has narrow axial area and rounded central area. Striæ 26-32 in 10 μ, radial; rapheless valve with narrow pseudoraphe, small central area and slightly radial striæ 30–35 in 10 μ.

10. *Achnanthes minutissima* (Kütz.) Grun. v. *genuina* A. Cl.

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*,—III, p. 40 fig. 567 *a–f*. *A. minutissima* Kütz.- Hustedt, *Bacil.*, p. 198, fig. 274; Tiffany and Britton, *Alg. Illinois*, p. 242, pl. 64, fig. 727.

Frustules small, linear and bent in the girdle view. Valves narrow, linear-lanceolate with broadly rounded ends, 17–31 μ long and 3–3·7 μ broad. Central area somewhat wider on the raphe valve. Striæ fine and slightly radial, 28-30 in 10 μ.

III. Sub-order BIRAPHIDINEÆ
1. Family *NAVICULACEÆ*
(*a*) *Sub-family* NAVICULOIDEÆ
Genus **Mastogloia** Thwaites 1856

11. *Mastogloia smithii* Thwaites v. *lacustris* Grun.

(Figs. 4–5)

Van Heurck, *Treat. Diat.*, p. 154, pl. 2, fig. 61; Hustedt, *Bacil.*, p. 217, fig. 316.

Frustules rectangular in the girdle view with two longitudinal septa having several chambers in a row. Valves linear-elliptical with constricted somewhat broadly rostrate ends 27–37 μ long and 10–11 μ broad. Raphe thin and straight. Axial area narrow, linear; central area fairly wide quadrate to roundish. Interseptal chambers rectangular to quadrate, almost uniform 1·2–1·5 μ wide in a row near the margins. Striæ 16-18 in 10 μ, radial and distinctly punctate.

Cleve-Euler has treated this form synonymous with *M. lacustris* Grun. v. *antiqua* (Schum.) A. Cl. (Cleve-Euler, *Diat. von Schwed. u. Finn.*—III, p. 60, fig. 609 *d, g*) but in indices the same has been referred to *M. lacustris* v. *alpina* Brun. Under this condition the present author fails to refer his form to any one given by Cleve-Euler.

Genus **Diploneis** Ehrenberg 1840

12. *Diploneis subovalis* Cleve

Venkataraman G., *S.I. Diat.*, p. 322, fig. 74, pl. 17, figs. 3–4; Gonzalves and Gandhi, *Diat. Bombay and Salsette*—II, p. 254, fig. 87 *a*.

Valves broadly elliptical 31–35 μ long and 18–19 μ broad. Raphe thin enclosed between the capitate horns. Costæ radial distinctly capitate under a low focus alternate with double rows of distinct punctæ 9–9·5 in 10 μ and rows of punctæ 16–18 in 10 μ. Axial field with a row of punctæ in groups separated by a hyaline space from the inter-costal rows of punctæ.

Genus **Stauroneis** Ehrenberg 1843

13. *Stauroneis legumen* Ehr.

(Fig. 6)

Van Heurck, *Treat. Diat.*, p. 161, pl. 1, fig. 59; Hustedt, *Bacil.*, p. 260, fig. 419.

Valves linear with triudulate margins and constricted, broadly rostrate ends, 14–28 μ long and 4–6 μ broad. Polar septa short and distinct. Raphe thin and straight with distinct central pores. Axial area narrow; central area somewhat a large linear stauros. Striæ slightly radial, about 30 in 10 μ, very fine and indistinctly punctate.

Genus **Anomœoneis** Pfitzer 1871

14. *Anomœoneis serians* (Bréb.) Cl. v. *modesta* A. Cl.

(Figs. 7–8)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 197, fig. 918 *c–d.*

Valves rhombic-lanceolate to narrowly rhombic-lanceolate with acute ends, 22–32 μ long and 5–6 μ broad. Raphe thin and straight with closely placed central pores. Axial area narrow, linear; central area fairly large and quadrate. Striæ 27–30 in 10 μ, slightly radial, fine but distinctly punctate, crossed by 3–5 longitudinal, undulated hyaline bands 10–12 in 10 μ.

15. *Anomœoneis brachysira* (Bréb.) Grun. v. *genuina* A. Cl.

(Fig. 9)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 198, fig. 919 *a–b.* *A. serians* (Bréb.) Cl. v. *brachysira* (Bréb.) Hust. f. *thermalis* (Grun.) Hust.—Hustedt, *Bacil.*, p. 264, fig. 428.

Valves small, rhombic-lanceolate with feebly narrowed, produced, broadly rounded ends, 22–26 μ long and 6·6 μ broad. Raphe thin and straight with closely set central pores. Axial area narrow; central area moderate, roundish. Striæ 25–28 in 10 μ, radial fine but distinctly punctate, interrupted by a few longitudinal wavy hyaline bands.

16. *Anomœoneis brachysira* (Bréb.) Grun. f. *subacuminata* A. Cl.

(Fig. 10)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 198.

Valves rhombic-lanceolate with somewhat constricted, shortly produced ends, 23–33 μ long and 5–6 μ broad. In all other features like the type.

This form agrees well with the type described by Cleve-Euler, who has however not given a figure. Of several specimens which I have examined, I found their ends distinctly constricted and shortly produced as stated by Cleve-Euler.

Genus **Navicula** Bory 1822

Section—*Naviculæ orthostichæ* Cleve

17. *Navicula cuspidata* Kütz. v. *conspicua* Venkat.

Venkataraman, G., *S. I. Diat.*, p. 325, figs. 83, 88; Gonzalves and Gandhi, *Diat. of Bombay and Salsette*—III, p. 342, fig. 110.

Valves broadly lanceolate with narrowed produced rounded ends, 121–150 μ long and 32–35 μ broad. Raphe thin and straight with hook-like central pores. Axial area narrow, linear. Longitudinal striæ 9–12 in 10 μ, coarse and more widely set in the middle than at the margins; transverse striæ 14–16 in 10 μ, parallel and almost perpendicular to the middle line.

18. *Navicula pseudocuspidata* nov. nom. v. *rostrata* v. nov.

(Fig. 11)

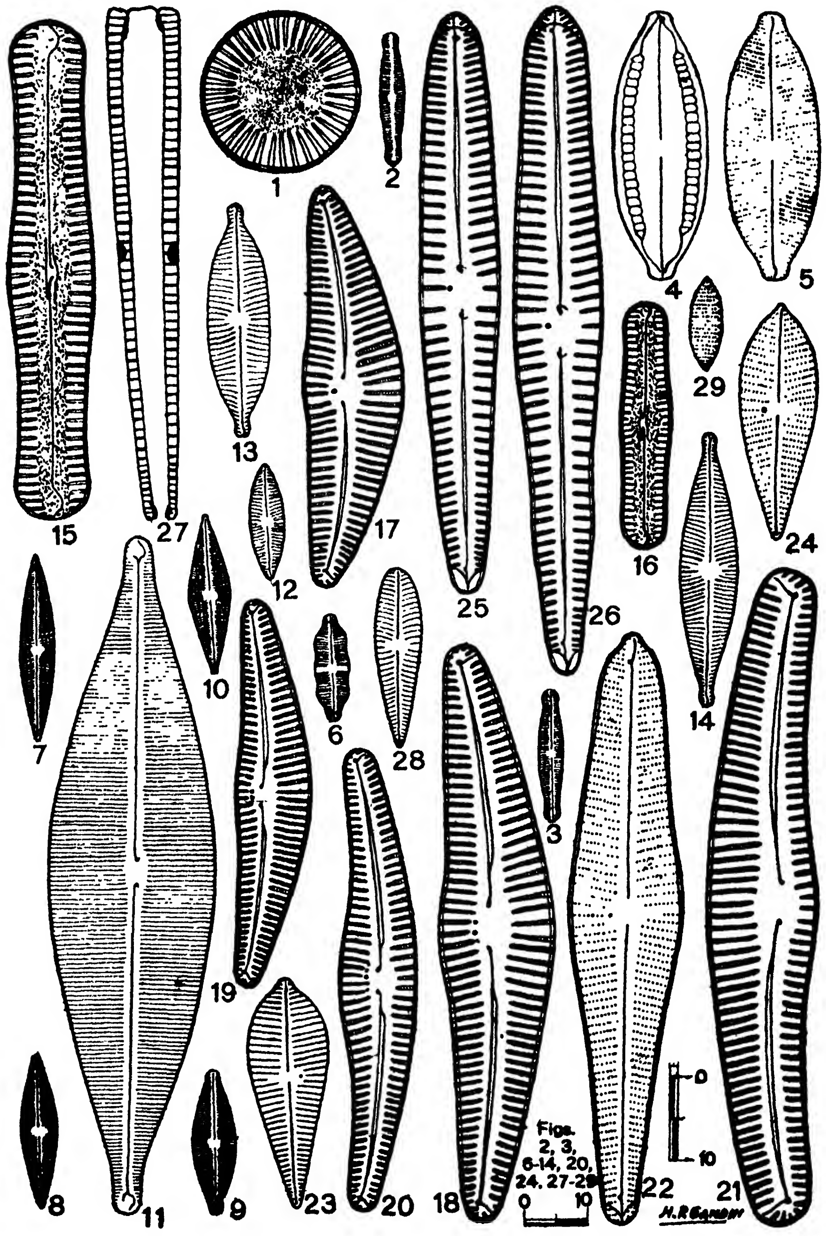
Valvæ rhombio-lanceolatæ vel late lanceolatæ, apicibus constrictis, producti atque rotundati. Raphe tenuis atque recta, poris centralibus hamosimilibus ornata. Area axialis angusta, linearis; area centralis aliquantum evoluta. Striæ longitudinales nullæ; striæ transversales parallelæ, indistincte punctatæ atque perpendiculares in lineam medium. Frustula 88–111 μ longa, 22–27 μ, lata, striæ transversæ 14–16 in 10 μ.

Habitat.—Atque dulcis. Lacu in horto.

Valves rhombic-lanceolate to broadly lanceolate with constricted produced rounded ends. Raphe thin and straight with hook-like central pores. Axial area narrow, linear; central area slightly developed. Longitudinal striæ absent; transverse striæ parallel, indistinctly punctate and perpendicular to the middle line. Frustules 88–111 μ long and 22–27 μ broad with transverse striæ 14–16 in 10 μ.

Habitat.—Fresh-water. Garden reservoirs.

This form agrees well with Krishnamurthy's *Navicula cuspidata* Kütz. f. *indica* Kri. (Krishnamurthy—*Diat. S. I.*, p. 367, fig. 30), in having no longitudinal striæ and in other respects, except that the ends in this form are prominently produced and rounded. The feature of longitudinal striæ so characteristic of *N. cuspidata* Kütz., being absent in these forms—I do not think it proper to retain them under the said species. I, therefore, propose for Krishnamurthy's form the status of a new species as *N. pseudocuspidata*, and create my form a new variety of it. The present form cannot be referred to *N. halophila* (Grun.) Cl. (Hustedt, *Bacil.*, p. 268, fig. 436) for the presence of hook-like central pores which is a feature of *N. cuspidata*.



Figs. 1-29. Fig. 1. *Cyclotella meneghiniana* Kütz. v. *genuina* A. Cl. f. *binotata* Grun. Figs. 2-3. *Achnanthes microcephala* Kütz. v. *typica* A. Cl. Figs. 4-5. *Mastogloia smithil* Thwaites v. *lacustris* Grun. Fig. 6. *Stauroneis legumen* Ehr. Figs. 7-8. *Anomœneis serians* (Bréb.) Cl. v. *modesta* A. Cl. Fig. 9. *Anomœoneis brachysira* (Bréb.) Grun. v. *genuina* A. Cl. Fig. 10. *Anomœoneis brachysira* (Bréb.) Grun. f. *subacuminata* A. Cl. Fig. 11. *Navicula pseudocuspidata* nov. nom. *rostrata* v. nov. Fig. 12. *Navicula cryptocephala* Kütz. v. *subsalina* Hust. Fig. 13. *Navicula viridula* Kütz. v. *capitata* Mayer. Fig. 14. *Navicula salinarum*.

Grun. v. *intermedia* (Grun.) Cl. Fig. 15. *Pinnularia acrosphœria* (Bréb.) W. Sm. f. *undulata* Cl. Fig. 16. *Pinnularia acrosphœria* (Bréb.) W. Sm. v. *minor* Cl. Fig. 17. *Cymbella cymbiformis* (Ag.?) Kütz. v. *unipuncta* A. Cl. Figs. 18-19. *Cymbella cymbiformis* (Ag.?) Kutz. v. *jimboi* (Pant.) A. Cl. Fig. 20. *Cymbella cymbiformis* (Ag.?) Kütz. v. *multipunctata* A. Cl. Fig. 21. *Cymbella cymbiformis* (Ag.?) Kütz. v. *nerei* (Pant.) A. Cl. Fig. 22. *Gomphonema sub-apicatum* Fritsch & Rich. Fig. 23. *Gomphonema augur* Ehr. v. *genuinum* Mayer. Fig. 24. *Gomphonema montanum* Schum. v. *acuminatum* Mayer. Figs. 25–26. *Gomphonema dharwarensis* sp. nov. Fig. 27. *Gomphonema dharwarensis* sp. nov.—girdle view. Fig. 28. *Gomphonema olivaceum* (Lyng.) Kütz. v. *balticum* Cl. Fig. 29. *Nitzschia amphibia* Grun. v. *acutiuscula* Grun.

Section—*Naviculœ lineolatœ* Cleve

19. *Navicula cryptocephala* Kütz. v. *subsalina* Hust.

(Fig. 12)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 154, fig. 813 *i*, *j*, *n*.

Valves small, lanceolate with acutely rounded ends, 17–26 μ long and 5 6 μ broad. Raphe thin and straight. Axial area narrow, linear; central area small, roundish. Striæ 14–16 in the middle and up to 18 in 10 μ at the ends, lineate, radial in the middle and convergent at the ends.

This form agrees well with the type described by Cleve-Euler but differs from *N. cryptocephala* v. *veneta* (Kütz.) Grun. (Hustedt, *Bacil.*, p. 295, fig. 497 *a*), in having more acute ends.

20. *Navicula viridula* Kütz. v. *capitata* Mayer

(Fig. 13)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 151, fig. 805 *f*, *g*.

Valves linear-elliptical with somewhat produced capitate rounded ends, 35–38 μ long and 9 μ broad. Raphe thin and straight. Axial area narrow, linear; central area moderately wide, quadrate. Striæ 9–13 in 10 μ, distinctly lineate, radial in the middle and convergent at the ends.

21. *Navicula salinarum* Grun. v. *intermedia* (Grun) Cl.

(Fig. 14)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 159, fig. 820 *b–c*.

Valves lanceolate with produced capitate ends, 38–41 μ long and 7–8 μ broad. Raphe thin and straight. Axial area narrow, linear; central area large. Striæ 14–16 in 10 μ, lineate, radial and curved in the middle and convergent at the ends, short and long striæ alternate in the middle.

Genus **Pinnularia** Ehrenberg 1843

Section—*Nodosæ* A. Cl.

22. *Pinnularia acrosphæria* (Bréb.) W. Sm. f. *undulata* Cl.

(Fig. 15)

Hustedt, *Bacil.*, p. 330; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 25, fig. 1022 *c*.

Valves linear, inflated in the middle with broadly rounded ends, 57–62 μ long and 10·5–11 μ broad. Raphe thin and straight with closely set and unilaterally bent central pores. Axial area very wide with irregularly disposed punctæ; central area not prominent. Striæ slightly radial in the middle 9–10 in 10 μ, and scarcely convergent at the ends.

23. *Pinnularia acrosphæria* (Bréb.) W. Sm. v. *minor* Cl.

(Fig. 16)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 25, fig. 1022 *d.*

Valves smaller than the type, 35–37 μ long and 8·8 μ broad with less dilated middle part and the ends. Striæ 12–13 in 10 μ, slightly radial in the middle or apparently parallel and scarcely convergent at the ends.

(*b*) *Sub-family* GOMPHOCYMBELLOIDEÆ

Genus **Amphora** Ehrenberg 1840

24. *Amphora veneta* (Kütz.) Hust.

Van Heurck, *Treat. Diat.*, p. 134, pl. 1, fig. 11; Hustedt, *Bacil.*, p. 345, fig. 631; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 96, fig. 682 *a–c*.

Frustules elliptical with rounded truncate ends in the girdle view, 10–12 μ broad. Valves convex on the dorsal and somewhat concave on the ventral side with curved obtuse ends, 17–22 μ long and 3–4·5 μ broad. Raphe thin and straight with central pores dorsally bent and terminal fissures ventrally directed. Axial area narrow. Striæ fine but distinctly punctate, 16–20 in 10 μ in the middle and 20–26 in 10 μ at the ends.

Genus **Cymbella** Agardh 1830

25. *Cymbella turgida* (Greg.) Cl.

Hustedt, *Bacil.*, p. 358, fig. 660; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p, 123, fig. 1176 *a–d*; *Encyonema turgidum* (Greg.) Grun.—Van Heurck, *Treat. Diat.*, p. 149, pl. 1, fig. 45.

Valves convex on the dorsal and almost straight or slightly concave on the ventral side with a median inflation, ends acutely rounded, 40–54 μ long and 12–13 μ broad. Striæ distinctly lineate 8–9 in 10 μ, radial in the middle and convergent at the ends only on the ventral side.

26. *Cymbella ventricosa* Kütz. v. *genuina* Mayer

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 124, fig. 1177 *a-c*. *C. ventricosa* Kütz.—Hustedt, *Bacil.*, p. 359, fig. 661; *Encyonema ventricosum* Kütz.—Van Heurck, *Treat. Diat.*, p. 150, pl. 1, fig. 49.

Valves strongly convex on the dorsal and straight or slightly convex on the ventral side with acutely rounded ends, 29–35 μ long and 9-9·5 μ broad. Raphe thin and straight. Axial area narrow. Striæ 10-12μ in the middle and 12-16 in 10μ at the ends, radial, coarse, lineate and slightly convergent at the ends.

27. *Cymbella cymbiformis* (Ag. ?) Kütz. v. *unipuncta* A. Cl.
(Fig. 17)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 160, fig. 1246 *a-b*. *C. cymbiformis* Ehr.—Van Heurck, *Treat. Diat.*, p. 147, pl. 1, fig. 38; *C. cymbiformis* (Ag. ?, Kütz.) V.H.·—Hustedt, *Bacil.*, p. 362, fig. 672.

Valves sickle-shaped, asymmetrical, dorsal side convex, ventral side almost straight or concave and inflated in the middle, ends broadly rounded, 46–65 μ long and 11–13 μ broad. Raphe arcuate and thick with ventrally bent central pores and dorsally directed terminal fissures. Axial area fairly wide; central area slightly enlarged with an isolated punctum on the ventral side at the end of the central striæ. Striæ 8–10 in 10 μ, radial, strong and lineate.

28. *Cymbella cymbiformis* (Ag. ?) Kütz. v. *jimboi* (Pant.) A. Cl.
(Figs. 18–19)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 160, fig. 1246 *g*.

Valves sickle-shaped more inflated in the middle on the ventral side than the type with broadly rounded ends, 55–75 μ long and 12–14 μ broad. Central area with 2-3 coarse punctæ on the ventral side. Striæ 9–10 in 10 μ, radial and lineate.

29. *Cymbella cymbiformis* (Ag. ?) Kütz. v. *multipunctata* A. Cl.
(Fig. 20)

Cleve-Euler, A. *Diat. von Schwed. u. Finn.*—IV, p. 161, fig. 1246 *h, i*.

Valves sickle-shaped with convex dorsal and concave ventral side inflated in the middle, ends broadly rounded and truncate, 70–80 μ long and 11–13 μ broad. Central area slightly widened with 3–5 coarse punctæ on the ventral side. Striæ 7–8 in 10 μ, distinctly lineate-punctate and radial.

30. *Cymbella cymbiformis* (Ag. ?) Kütz. v. *nerei* (Pant.) A. Cl.
(Fig. 21)

Cleve-Euler, A. *Diat. von Schwed. u. Finn.*—IV, p. 161, fig. 1246 *k–l*.

Valves narrowly sickle-shaped than the type with strongly inflated ventral side in the middle, ends gradually narrowed and broadly truncate rounded, 60–80 μ long and 11–13 μ broad. Striæ 8–9 in 10 μ radial and lineate.

Genus **Gomphonema** Agardh 1824

31. *Gomphonema subapicatum* Fritsch and Rich

(Fig. 22)

Fritsch, F. E. and Rich, F., *Diat. from Griqueland West.*, p. 108, fig. 6 *a–b*; Abdul-Majeed, M., *Bacil.*, p. 31, pl. 3, fig. 4.

Valves lanceolate-clavate, dilated in the middle, apex wedge-shaped, somewhat constricted and subapiculate, base narrowly rounded, 48–99 μ long and 12–15·6 μ broad. Raphe thin and straight. Axial area narrow, linear; central area unilateral, fairly large with an isolated stigma on the opposite side. Striæ 9–12 in 10 μ, radial, distinctly punctate and somewhat widely set in the middle.

32. *Gomphonema augur* Ehr. v. *genuinum* Mayer

(Fig. 23)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 176, fig. 1265 *a–b*. *G. augur* Ehr.—Van Heurck, *Treat. Diat.*, p. 271, pl. 7, fig. 301; Hustedt, *Bacil.*, p. 372, fig. 688.

Valves broadly ovate-clavate with apiculate rounded apex and strongly attenuated base, 26–32 μ long and 8·5 μ broad. Raphe thin and straight. Axial area narrow; central area unilateral, large with an isolated stigma on the opposite side. Striæ 12–16 in 10 μ, slightly radial, indistinctly punctate and closely set at the ends.

33. *Gomphonema parvulum* (Kütz.) V. H. v. *genuinum* Mayer.

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 177, fig. 1269 *a–c*. *G. parvulum* (Kütz.) Grun.—Van Heurck, *Treat. Diat.*, p. 272, pl. 7, fig. 306; Hustedt, *Bacil.*, p. 372, fig. 713 *a*.

Valves broadly lanceolate-clavate with constricted, shortly rostrate ends, 18–24 μ long and 6–6·5 μ broad. Raphe thin and straight. Axial area very narrow; central area small unilateral with an isolated stigma on the opposite side. Striæ 14–16 in 10 μ, radial and indistinctly punctate.

34. *Gomphonema parvulum* (Kütz.) V. H. v. *subellipticum* Cl.

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 178, fig. 1269 *h*. *G. parvulum* (Kütz.) Grun. v. *subelliptica* Cl.—Hustedt, *Bacil.*, p. 373, fig. 713 *b*.

Frustules small. Valves clavate-elliptical with scarcely constricted produced ends, 16–18 μ long and 6–6 μ broad. Striæ 13–15 in 10 μ, radial and indistinctly punctate.

35. *Gomphonema montanum* Schum. v. *acuminatum* Mayer

(Fig. 24)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 183, fig. 1276 *e–k*.

Valves broadly clavate-lanceolate with wedge-shaped, slightly constricted apiculate apex and graudally narrowed towards the acutely rounded base, 35 5 40 μ long and 12 μ broad. Raphe thin and straight. Axial area narrow, linear; central area unilateral with an isolated stigma on the opposite side. Striæ 10-11 in 10 μ, radial and distinctly punctate.

36. *Gomphonema dharwarensis* sp. nov.

(Figs. 25-27)

Frustula angusta-cuneati in aspectu zonali. Valvæ lineari-clavatæ, apex sæpsi atque late cuneatis; basi gradatim fastigatæ atque acuti-rotundati, margines aliquantum undulatis. Raphe crassa, unilateraliter inclinatis atque comma similibus in nodulus medio, fissuris terminalibus distincte. Area axialis lata; area centralis unilateraliter ornata puncto uno at latus. Stiæ fortes, tenuiter radiales, lineatæ atque proxime positæ in utroque apice. Frustula 66-75 μ longa, 8-9 μ lata, striæ 6-8 in medio atque 8-12 in 10 μ in utroque apice.

Habitat.- Aquæ dulcis. Lacu in horto.

Frustules narrowly wedge-shaped in the girdle view. Valves linear-clavate, apex septate and broadly cuneate, base gradually narrowed and acutely rounded, margins somewhat undulated. Raphe thick with unilaterally bent, comma-shaped ends in the central nodule, terminal fissures distinct. Axial area wide; central area unilateral with an isolated stigma on one side. Striæ strong, slightly radial, lineate and closely set at the ends. Frustules 66-75 μ long, 8-9 μ broad with 6 8 striæ in the middle and 8-12 in 10 μ at the ends.

Habitat.--Fresh-water. Garden reservoirs.

This form resembles *G. intricatum* Kütz. and its varieties (Hustedt, *Bacil.*, pp. 187-89, figs. 697-99; Cleve-Euler, *Diat. von Schwed. u. Finn.*-- IV, pp. 187 89, fig. 1283), in the outline, in number and arrangement of the striæ. However, it markedly differs from them in having cuneate septate apex and coarsely lineate striæ instead of clearly punctate ones. Moreover, the raphe ends in the central nodule are clearly comma-shaped and the central area comparatively smaller than in *G. intricatum* Kütz. It also differs from *G. dubravicense* Pant. (Cleve-Euler, *op. cit.*, p. 190, fig. 1826 *a-b*) in having no other punctæ in the mid-axial area than an isolated stigma and comma-shaped ends of the raphe in the central nodule. It also does not agree with any other forms with regards to lineate striæ and comma-shaped endings of raphe in the central nodule. It is, therefore, regarded as a new species.

37. *Gomphonema olivaceum* (Lyng.) Kütz. v. *balticum* Cl.

(Fig. 28)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 192, fig. 1291 *a-d. G. olivaceum* (Lyng.) Kütz.—Hustedt, *Bacil.*, p. 378, fig. 719 *a.*

Valves ovate-clavate with broadly rounded apex and attenuated base, 25-30 μ long and 5·5-6 μ broad. Raphe thin and straight.

Axial area narrow; central area large unilateral without an isolated stigma. Striæ 7-12 in 10 μ, radial and curved, indistinctly punctate and closely set at the ends.

2\. *Family* *EPITHEMIACEÆ*
(*a*) *Sub-family* EPITHEMIOIDEÆ
Genus **Epithemia** Brébisson 1838

38\. *Epithemia sorex* Kütz. v. *genuina* A. Cl.

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 41, fig. 1412 *a–b*. *E. sorex* Kütz.—Van Heurck, *Treat. Diat.*, p. 295, pl. 9, fig. 351; Hustedt, *Bacil.*, p. 388, fig. 736; Iyengar and Subrahmanyan, *Fossil Diat.*, p. 233, fig. 17.

Frustules epiphytic on aquatic plants, rectangular and somewhat curved in the girdle view. Valves strongly convex on the dorsal—and slightly concave on the ventral side with constricted, rounded capitate recurved ends, 31–37 μ long and 8·4–9·6 μ broad. Raphe in the raphe canal strongly arcuate with central pores almost reaching the dorsal side. Costæ 5–7 in 10 μ, strong, radial and alternating with 2–3 rows of aerioles, rows of aerioles 12–15 in 10 μ.

(*b*) *Sub-family* RHOPALODIOIDEÆ
Genus **Rhopalodia** O. Müll. 1895

39\. *Rhopalodia gibba* (Ehr.) O. Müll. v. *genuina* Grun.

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 44, fig. 1416 *a*, *e*. *R. gibba* (Ehr.) O. Müll.—Hustedt, *Bacil.*, p. 390, fig. 740; *Epithemia gibba* Kütz.—Van Heurck, *Treat. Diat.*, p. 296, pl. 9, fig. 352 *a*.

Frustules epiphytic on aquatic plants, broadly linear in the girdle view with notched inflation in the middle and broadly truncate ends, 20–25 μ broad. Valves gibbous and notched on the mid-dorsal side, ventral side straight or slightly depressed towards the acutely rounded curved ends, 8–10 μ broad and 80–90 μ long. Costæ 5–7 in 10 μ, strong, parallel in the middle and becoming strongly radial at the ends, alternating with 2–3 rows of aerioles, rows of aerioles 10–15 in 10 μ, fine but distinct.

40\. *Rhopalodia gibba* (Ehr.) O. Müll. v. *ventricosa* (Kütz.) Grun.

Hustedt, *Bacil.*, p. 391, fig. 741; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 44, fig. 1416 *c–d*; *R. ventricosa* (Kütz.) O. Müll.—Tiffany and Britton, *Alg. Illinois*, p. 282, pl. 75, fig. 885; *Epithemia gibba* Kütz. v. *ventricosa* Kütz.—Van Heurck, *Treat. Diat.*, p. 296, pl. 9, fig. 354.

Frustules smaller than the type and more gibbous in the middle with truncate broadly rounded ends in the girdle view, 30–38 μ long and 18–19 μ broad. Costæ strongly radial towards the ends, 6–7 in 10 μ, alternating with 2–3 rows of aerioles, rows of aerioles 10–14 in 10 μ.

3. *Family* *NITZSCHIACEÆ*
(*a*) *Sub-family* NITZSCHIOIDEÆ
Genus **Nitzschia** Hassall 1845

Section —**Lineares** (Grunow) Hustedt and others

41. *Nitzschia sublinearis* Hustedt

Hustedt, *Bacil.*, p. 411, fig. 786; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 80, fig. 1481.

Valves elongated, slightly backwardly bent with long wedge-shaped, constricted somewhat capitate ends, 65–88 μ long and 5–6 μ broad. Keel excentric without any notch in the middle, keel punctæ 8–12 in 10 μ, distinct. Striæ over 30 in 10 μ, very fine.

Section —**Lanceolatæ** Grunow

42. *Nitzschia amphibia* Grun. v. *genuina* Mayer

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 86, fig. 1496 *a–c*. *N. amphibia* Grun.—Van Heurck, *Treat. Diat.*, p. 403, pl. 17, fig. 563; Hustedt, *Bacil.*, p. 414, fig. 793.

Valves linear to linear-lanceolate with somewhat wedge-shaped constricted ends, 29–35 μ long and 4·4–5 μ broad. Keel excentric with large keel punctæ 7–8 in 10 μ. Striæ 16–18 in 10 μ, distinctly punctate.

43. *Nitzschia amphibia* Grun. v. *acutiuscula* Grun.
(Fig. 29)

Hustedt, *Bacil.*, p. 414,; Cleve-Euler, A., *Diat. von Schwed. u. Finn.* —V, p. 86, fig. 1496 *f–i*.

Valves lanceolate with scarcely constricted, acutely rounded ends, 14–22 μ long and 5–5·6 μ broad. Keel excentric with large keel punctæ 7–8 in 10 μ. Striæ 15–18 in 10 μ, distinctly punctate.

Section—**Obtusæ** Grun.

44. *Nitzschia obtusa* W. Sm. v. *scalpelliformis* Grun.

Van Heurck, *Treat. Diat.*, p. 397, pl. 16, fig. 538; Hustedt, *Bacil.*, p. 422, fig. 817 *b*; Venkataraman, *S. I. Diat.*, p. 355, figs. 142, 147; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 78, fig. 1476 *f, h*.

Frustules elongated and sigmoid in the girdle view, linear. Valves linear, slightly sigmoid with obliquely wedge-shaped ends, 87–100 μ long and 8–9 μ broad. Keel excentric with large rounded keel punctæ 6–8 in 10 μ, keel notched in the middle. Striæ very fine about 30 in 10 μ.

SUMMARY

For the first time the fresh-water Diatomaceæ of Dharwar has been investigated of which an illustrated account is given.

In the introduction topography of the place is given and mention has been made of features of the material from different places of collection.

In all 44 forms have been described and illustrations are given only of those which do not appear in the Indian literature. Of these forms, 18 are new records for India, one is a new species and one a new variety.

ACKNOWLEDGEMENT

The author expresses his grateful thanks to Prof. (Mrs.) E. A. Gonzalves, for affording the library facility and to Prof. S. A. Parandekar, for going through this manuscript. He is also grateful to Dr. V. A. Sangve, for supplying the topographical details of Dharwar.

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SOME SLIME-MOULDS FROM SOUTHERN INDIA—V

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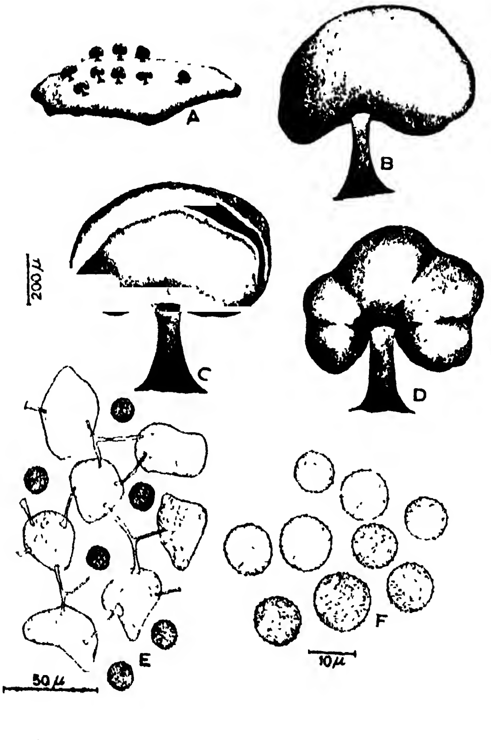
(Received for publication on February 22, 1956)

21. *Physarum compressum* Alb. and Schw., in *Consp. Fung.*, 1805, p. 97; Saccardo, *Syll. Fung.*, **7**: 1888, p. 337; Petch, *Ann. R. bot. Gdns.*, Peradeniya, **4**: 1909, pp. 333–34; Macbride, *The North American Slime-Moulds*, 1922, p. 80 ; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 49–50.

Plasmodium not observed. Sporangia typically scattered, measuring 0·75 1·5 mm. in total height, compressed, reniform, smooth or lobed, often umbilicate below, typically stipitate, rarely plasmodiocarpous or confluent sporangia were observed in some collections. Sporangial wall white or ashen-grey in colour, heavily impregnated with minute granules of lime, dehiscing along the apical edge by a

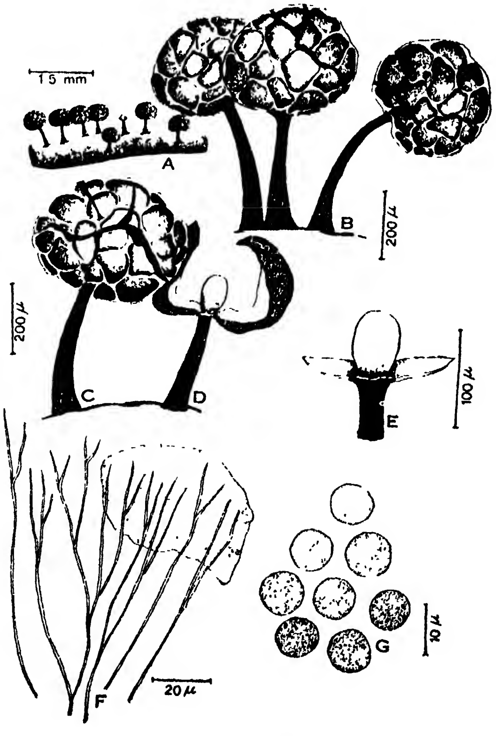


TEXT-FIG. 1. *Physarum compressum* Alb. and Schw. A, Sporangia on the bark of *Wrightia tinctoria*; B, A reniform compressed sporangium; C, Showing the apical cleft-like dehiscence of a reniform sporangium; D, A lobed sporangium; E, Capillitial threads and the lime knots; F, Spores.

cleft so that a dehisced sporangium has two widely gaping halves of the peridium. Stalk terete in cross-section, stout, erect, dark brown to almost black, enclosing refuse matter, with a well-developed hypothallus. Capillitium well developed, typically physaroid, forming a close reticulum consisting of hyaline threads anastomosing with round, subangular, white lime knots, highly variable in size. Spore mass deep fuscous brown, individually brownish purple in colour, distinctly echinulate, spherical to subglobose, measuring on average 11·4 μ, range 9·6–12·8 μ, mostly 12·0 μ.

On the bark of *Wrightia tinctoria* R. Br., Agri-Horticultural Gardens, Madras, 10–9–1954 (Herb. M.U.B.L. No. 1236); on the bark of *Morinda tinctoria* Roxb., University Campus, Marina, Madras, 14–9–1954 (Herb. M.U.B.L. No. 1237). All collections were made by V. Agnihothrudu.

22. *Diderma rugosum* (Rex.) Macbride, in *The North American Slime-Moulds*, 1899, p. 105; Petch, *Ann. R. bot. Gdns., Peradeniya*, **4** : 1909, p. 345 as *Chondrioderma rugosum* Rex.; as *Diderma rugosum* (Rex.) Macbride, *The North American Slime-Moulds*, 1922, p. 144; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, p. 99.

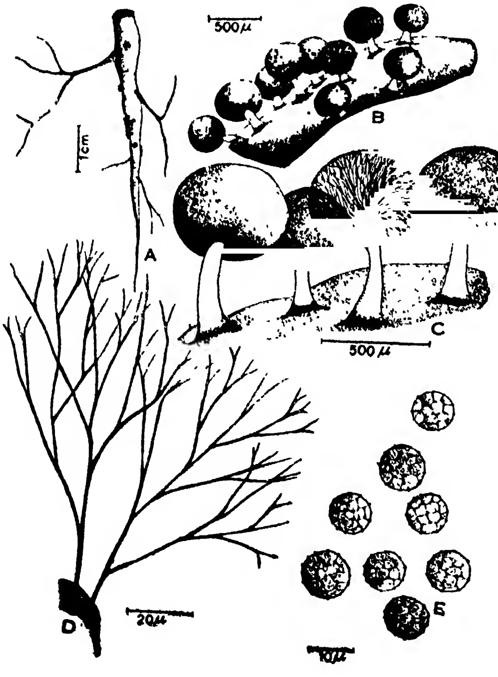


TEXT-FIG. 2. *Diderma rugosum* (Rex.) Macbride. A, Sporangia on a twig; B, Sporangia showing the polygonal areolæ and the method of dehiscence; C, Irregularly dehisced sporangium; D, Dehisced sporangium with the columella; E, Columella; F, Capillitium and a part of the peridium; G, spores.

Plasmodium not observed. Sporangia gregarious, scattered, measuring 0·6–1 mm. in total height, typically stipitate. Sporangium proper 0·4–0·7 mm. in diameter, globose, to subhemispherical, white or ashen-grey and pale brown at the base. Peridium distinctly rugose, divided into 20–30 polygonal shallow facets. These reticulate ridges or wrinkles pre-figure the line of dehiscence. In some instances the dehiscence of the sporangia was not along the ridges of the æreolæ. Sporangial wall single, thin, papery, densely impregnated with lime granules. Stalk terete, 0·2–0·8 mm. in height, subulate, furrowed, deep brown to black in colour, hypothallus none. After the spore dispersal the columella is seen distinctly with the remnants of the peridial wall. Columella clavate, reaching almost half the height of the sporangium, rough chalky to pale yellowish white in colour. Capillitium well developed, consisting of slender purplish threads sparingly furcate and anastomosing, the lower ends attached to the columella, the upper ends to the peridium. Spores deep brown in mass, pale purplish brown in transmitted light, spherical to subglobose, minutely warted, measuring on average 9·8 μ, range 8·0–11·2 μ mostly 10·4 μ in diameter.

Only one collection was made on decomposing leaves of *Cocos nucifera* L. and some unidentified decaying twigs, Agri-Horticultural Gardens, Madras, 10–10–1954, coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1238).

23. *Diachea subsessilis* Peck. in *Rep. N.Y. Mus. Nat. Hist.*, 1879, p. 31; Petch, *Ann. R. bot. Gdns., Peradeniya*, **4**: 1909, p. 347; Macbride, *The North American Slime-Moulds*, 1922, p. 187; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, p. 104.



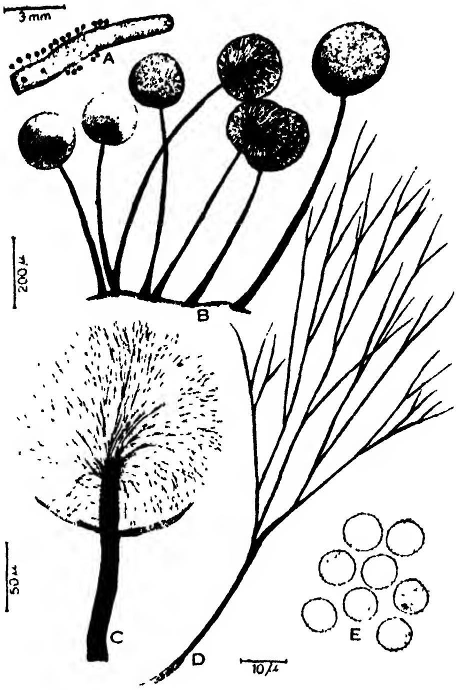
TEXT-FIG. 3. *Diachæa subsessilis* Peck. A, Sporangia on an incubated pigeon-pea root; B and C, Sporangia showing the columella and the radiating capillitium; D, Capillitial threads; E, Spores.

Plasmodium not observed. Sporangia gregarious, globose to subhemispherical, up to 0·6 mm. in diameter, dull iridescent, bluish green in colour, short stipitate. Peridial wall thin, membranous, evanescent, exposing the spore mass entangled in the capillitial threads. Stipe stout, cylindrical or conical when extremely reduced with an incipiently developed hypothallus, white to pale brown in colour, impregnated with lime granules, measuring 0·1–0·5 mm. Columella distinct, persistent, white, capillitium well developed radiating from the columella, consisting of profusely branched and anastomosing pale purplish brown threads, deeper in hue and stouter at the collumellar end and paler at the peridial extremity. Spore mass deep purple grey in colour, individually violaceo-fuscous, ornamented with closely reticulated delicate raised bands, measuring on average 8·8 μ, range 6·8–9·6 μ, mostly 9·2 μ in diameter. This myxomycete appeared only in one instance on incubated roots of pigeon-pea plants grown in the University Botany Field Research Laboratory, Madras, Coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1251).

24. *Lamproderma scintillans* (Berk. and Br.) Morgan in *J. Cinc. Soc. Nat. Hist.*, **16**: 1894, p. 131; as *Enerthenema muscorum* Lev., in *Ann. Sci. Nat. series*, **4**: **20**: 1863, p. 289; as *Lamproderma scintillans* (Berk. and Br.) Morgan, Macbride, in *The North American Slime-Moulds*, 1922, pp. 195–96; Schinz, *Rabenhorst's Kryptogamen Flora*, Abt., **10**: 1920, p. 261; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, 153–54; Brühl and Sen Gupta, *J. Dep. Sci. Calcutta Univ.*, **8**: 1927, p. 118; Lodhi, *Publ. Univ. Punjab*, 1934, p. 16.

Plasmodium not observed. Sporangia gregarious or scattered, globose, total height being 0·75–1·5 mm., sporangia proper 0·2–0·6 mm. in diameter, brilliantly metallic blue in colour. Peridium thin, delicate, fugacious, falling off in large flakes exposing the spore mass. Stipe long, rigid, setaceous, gradually tapering towards the sporangial end, deep brown to almost black in colour, arising from a small circular hypothallus, measuring up to 1 mm. in height. Columella distinct, appearing as a prolongation of the apex of the stipe, cylindrical, truncate, scarcely attaining half the height of the sporangium. Capillitium composed of rigid threads radiately arranged on the vertex of the columella, dichotomously branched and anastomosing, purple brown in colour, paler at the base, darker at the extremities. The threads appear at first sight simple but are really furcate and anastomose. The threads connecting the columella with the rather persistent base of the sporangial wall are slender and almost hyaline. Spores violaceous brown, distinctly warted, spherical, measuring on average 7·3 μ, range 6·0–8·0 μ, mostly 7·6 μ in diameter.

On dead twigs of *Pithecolobium dulce* Benth., Ayanavaram, Madras, 13-9-1954 (Herb. M.U.B.L. No. 1239); on decomposing twigs of



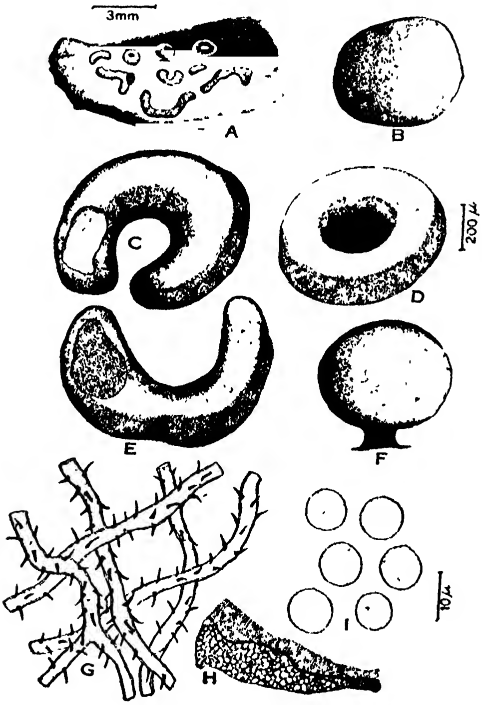
Text-Fig. 4. *Lamproderma scintillans* (Berk. and Br.) Morgan. A, Sporangia on a twig of *Pithecolobium dulce*; B, Sporangia showing the long stipe and the persistent capillitium; C, A dehisced sporangium showing the columella, the radiating capillitial threads, and the persistent base of the sporangial wall; D, Capillitial threads; E, Spores.

Feronia elephantum Corr., Perambur, Madras, 16–9–1954 (Herb. M.U.B.L. No. 1240); on dead twigs of *Tamarindus indicus* L., Soundarya Nursery, Madras, 18–9–1954 (Herb. M.U.B.L. No. 1241); on decomposing unidentified twigs, Queen Mary's College Campus, Marina, Madras, 26–9–1954 (Herb. M.U.B.L. No. 1242); on decaying leaves of *Bignonia unguis-cati* L., Agri-Horticultural Gardens, Madras, 20–10–1954 (Herb. M.U.B.L. No. 1243) All collections were made by V. Agnihothrudu.

25. *Perichæna chrysosperma* Lister in Mycetozoa, 1894, p. 196; Petch, *Ann. R. bot. Gdns., Peradeniya*, **4**: 1909, p. 368, as *Ophiotheca chrysosperma* Currey; Macbride, *The North American Slime-Moulds*, 1922, p. 241; as *Perichæna variabilis* var. *pedata* Lister in *J. Bot.*, **42**: 1904, p. 139; as *Perichæna corticalis* var. *affinis* Lister, in *Mycetozoa*, 1911, p. 251; as *P. chrysosperma* Lister in *A Monograph of the Mycetozoa*, 1925, pp. 243–44; Lodhi, *Publ. Univ. Punjab*, 1934, p. 25.

Plasmodium not observed. Sporangia subgregarious, sessile or stalked, simple or plasmodiocarpous. Individual sporangia measuring

0·4–1·0 mm. in diameter, spherical, globose or subhemispherical. Plasmodiocarps short, up to 4 mm. long, curved, horse-shoe-shaped or forming perfect rings, reddish brown to blackish brown in colour. Peridium dehiscing irregularly or falling apart in flakes exposing the spore mass. Peridium composed of two layers, an outer thicker and darker layer impregnated densely with brown granular matter and an inner translucent pale yellow submembranous layer which is rather faintly papillose. Stipe when present short, cylindrical, stout, deep brownish black enclosing refuse matter, measuring up to 0·4 mm. in height. Spore mass bright yellow in colour enclosed by profuse capillitial threads which measure up to 3·6 μ in diameter, constricted at irregular intervals and studded with prominent, slightly recurved spines measuring up to 3·0 μ in length. Spores typically citron yellow *en masse*, individually almost hyaline, minutely warted, measuring on average 9·4 μ, range 8·8–10·4 μ, mostly 9·6 μ in diameter.

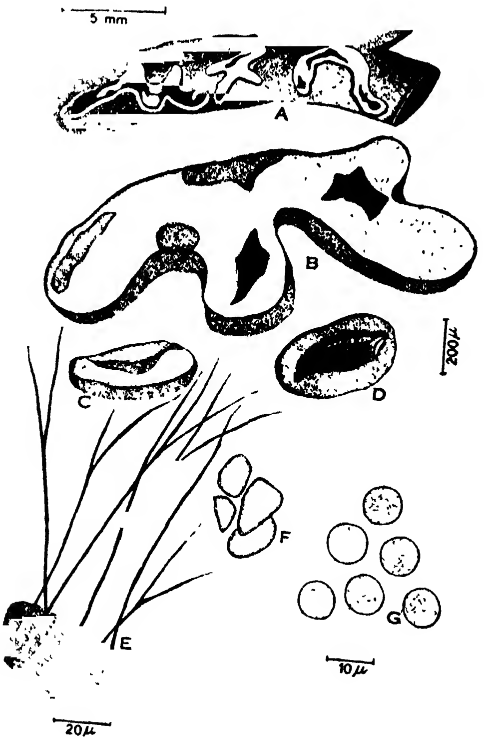


TEXT-FIG. 5. *Perichæna chrysosperma* Lister. A, Sporangia on the bark of *Wrightia tinctoria*; B, C, D and E, Sessile sporangia of different shapes; F, A stipitate sporangium; G, Capillitial threads with spines; H, Showing the double-layered nature of the peridium; I, Spores.

On bark of *Pithecolobium saman* Benth., Mylapore, Madras, 14–10–1954 (Herb. M.U.B.L. No. 1244); on bark of *Wrightia tinctoria* R. Br., Agri-Horticultural Gardens, Madras, 18–10–1954 (Herb. M.U.B.L. No. 1245); on bark of *Tamarindus indicus* L., Ayanavaram, Madras, 18–10–1954 (Herb. M.U.B.L. No. 1246). All collections were made by V. Agnihothrudu.

26. *Diderma effusum* (Schw.) Morgan, in *J. Cinc. Soc. Nat. Hist.*, **16**: 1894, p. 155; as *Chondrioderma reticulatum* Rost.; Lister, in *Mycetozoa*, 1894, p. 79; Petch, in *Ann. R. bot. Gdns.*, *Peradeniya*, **4**: 1909, p. 344; as *Diderma reticulatum* Morg., Macbride, *The North American Slime-Moulds*, 1899, p. 95; as *Diderma effusum* (Schw.) Morgan, Macbride, *The North American Slime-Moulds*, 1922, pp. 130–31; Lister, *A Monograph of the Mycetozoa*, 1925, pp. 85–86; Brühl and Sen Gupta, *J. Dep. Sci. Calcutta Univ.*, **8**: 1927, p. 114; Lodhi, *Publ. Univ. Punjab*, 1934, p. 11.

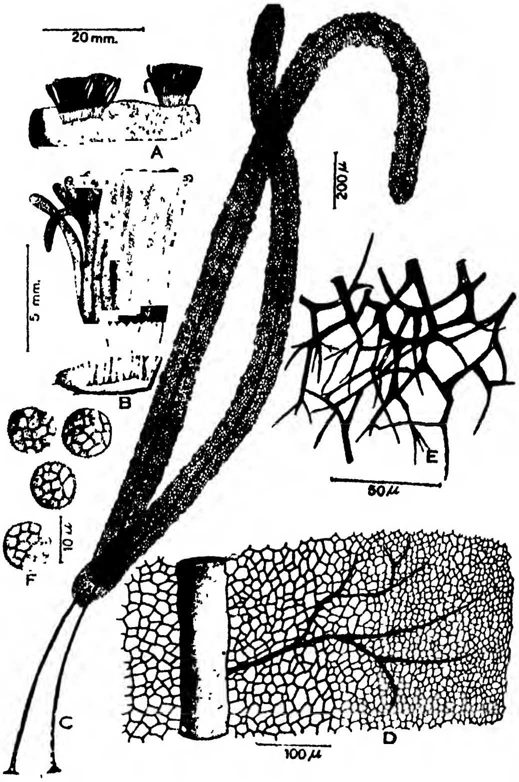
Plasmodium not observed. Fructifications plasmodiocarpous. Sporangia gregarious or crowded, creeping, applanate and generally effuse, milky white or pale dirty brown up to 2 cm. long and 2 mm. broad. Peridium double-layered, an outer fragile fugacious crust of calcareous granules which separates from an inner thin membranous colourless layer. Columella present, short, globose, pulvinate or depressed, dirty brown or pale pinkish enclosing large lime granules. Capillitium dense, consisting of short thin threads sparsely branched. Spores violet brown, almost smooth, measuring on average 8·3 μ, range 6·4–10·4 μ, mostly 8·9 μ.



TEXT-FIG. 6. *Diderma effusum* (Schw.) Morgan. A, Plasmodiocarps on decaying twigs of *Croton sparsiflorus*; B–D, Plasmodiocarps showing the double nature of the peridium; E, Capillitium attached to the peridium; F, Lime granules; G, Spores.

On decaying leaves of *Cocos nucifera* L., Agri-Horticultural Gardens, Madras, 13–7–1955 (Herb. M.U.B.L. No. 1536); on decomposing twigs of *Croton sparsiflorus* Morung, Mylapore, Madras, 18–8–1955 (Herb. M.U.B.L. No. 1537); on the mid-rib of an unidentified decaying leaf, University Botany Laboratory Campus, Madras, 18–10–1955 (Herb. M.U.B.L. No. 1538); on decaying leaves of *Terminalia paniculata* Roth., Guntur (Andhra State), 22–1–1956, (Herb. M.U.B.L. No. 1539). All collections were made by V. Agnihothrudu.

27. *Stemonites fusca* (Roth.) Rostafinski in *Sluzowce* (*Mycetozoa*) *Monografia*, Parys, 1875, p. 193; Macbride, *The North American Slime-Moulds*, 1922, p. 160; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 132–34.

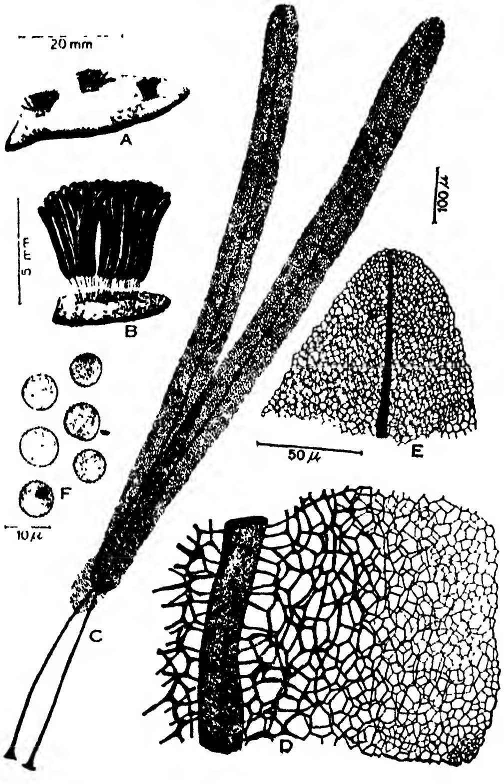


Text-Fig. 7. *Stemonites fusca* (Roth.) Rost. A and B, Sporangial aggregates; C and D, Sporangia with columella and capillitial reticulum; E, Capillitium; F, Spores.

Plasmodium not observed. Sporangia in large aggregations, measuring up to 2 cm. in height. Sporangia cylindrical obtuse, stipitate, deep purple. Stipe black, setaceous, shining, up to 5 mm. long with distinct brown membranous hypothallus which is common to all sporangia. Columella reaching to the apex of the sporangium. Capillitium consisting of dark brownish purple threads springing from all parts of the columella, profusely branched and anastomosing to form a lax reticulum proximal to the columella, the ultimate ramifications of the capillitium being slender, subhyaline, forming a close meshed surface net. Spores deep purple in mass, reddish violet in transmitted light, with continuous raised bands forming a reticulum, measuring on average 9·8 μ, range 8·4–11·8 μ mostly, 10·4 μ in diameter.

On stumps and twigs of *Casuarina equisetifolia* Forst., Professor T. S. Sadasivan's farm, Guindy, Madras, 8–9–1954, Coll. V. Agnihothrudu, Miss P. Shanta and S. Suryanarayanan (Herb. M.U.B.L. No. 1540); on decaying wood, Ayanavaram, Madras, 7–8–1955, Coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1541).

28. *Stemonites herbatica* Peck in *Rep. N.Y. Museum*, **26**: 1874, p. 75; Macbride, *The North American Slime-Moulds*, 1922, p. 171; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, p. 137.

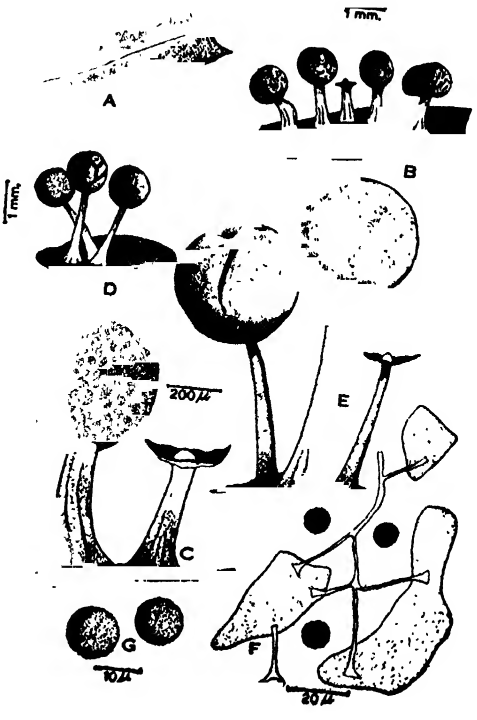


TEXT-FIG. 3. *Stemonites herbatica* Peck. A and B, A group of sporangia on decaying leaf-sheath of *Musa paradisiaca* L.; C, D and E, Showing columella and capillitial reticulum; F, Spores.

Plasmodium not observed. Sporangia clustered in scattered aggregates, cylindric, obtuse, brownish red or dilute ferruginous up to 10 mm. high, stipitate, Stipe deep fuscous or black, 1–3 mm. long arising from a membranous but a distinct hypothallus. Columella distinct, reaching almost the tip of the sporangium. Capillitium consisting of dark brown threads forming a lax net work with wide expanded nodes uniting at the surface into a dense mesh of delicate colourless strands. Spore mass ferruginous, spores globose, minutely spinulose, measuring on average 6·8 μ, range 5·0–8·4 μ, mostly 8·0 μ in diameter.

On the leaf sheath of *Musa paradisiaca* L., Chingleput, 18–7–1955, Coll. Miss K. Bhuvaneswari (Herb. M.U.B.L. No. 1542).

29. ***Physarum melleum*** (Berk. and Br.) Massee in *A Monograph of the Myxogastres*, London, 1892, p. 278; as ***Didymium melleum*** Berk. and Br. in *J. Linn. Soc.*, **14**: 1873, p. 83; as ***Physarum melleum*** (Berk. and Br.) Massee, Macbride, *The North American Slime-Moulds*, 1922, pp. 65–66.



TEXT-FIG. 9. *Physarum melleum* (Berk. and Br.) Massee. A–C, Sporangia on decaying cocoanut leaves. D and E, Sporangia from collection Herb. M.U.B.L. No. 1545; F, Capillitium; G, Spores.

Plasmodium not observed. Sporangia scattered, measuring up to 1 mm. in height, globose or subglobose, slightly flattened below in some, yellow or honey-coloured measuring up to 600 μ in diameter. Stipe stout, short and wrinkled or long and smooth measuring up to 800 μ long, white or slightly brownish with an incipient hypothallus. Sporangial wall, thin membranous, smooth or wrinkled, yellowish with deposits of lime granules which are minute and citron yellow in colour. The peridium falls off in flakes exposing the spore mass. Peridium persistent at the base. Columella short, small but distinct, conical or subspherical. Capillitium abundant, consisting of dense reticulum of irregularly branched hyaline threads, often expanded in the axils with pale yellow to sulphur yellow angular lime knots of various sizes and shapes. Spores violet, deep brown to almost black in mass, spherical or subglobose, almost smooth, measuring on average 8·5 μ, range 6·4–11·2 μ, mostly 9·6 μ in diameter.

This species was collected from three localities, in all instances on decaying leaves of *Cocos nucifera* L., Agri-Horticultural Gardens, Madras, 14–9–1955 (Herb. M.U.B.L. No. 1543); Tindivanam (Madras State), 18–10–1955, Coll. V. Agnihothrudu, Miss P. Shanta and S. Suryanarayanan (Herb. M.U.B.L. No. 1544); Guntur (Andhra State), 22–1–1956 (Coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1545).

30. *Arcyria denudata* (Linn.) Wettstein in *Verusch. Zool.-Bot. Ges.*, Wien, 1855, p. 585; as *Arcyria punica* Lister, *Mycetozoa*, 1884, p. 188; as *Arcyria denudata* (Linn.) Wett., Macbride in *The North American Slime-Moulds*, 1922, pp. 253–54; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 235–36; Brühl and Sen Gupta, *J. Dep. Sci. Calcutta Univ.*, **8**: 1927, p. 121.

TEXT-FIG. 10. *Arcyria denudata* (Linn.) Wett. A and B, Undehisced and dehisced sporangia; C, Undehisced sporangia with evanescent peridium; D, Sporangia with capillitial reticulum; E, Calyculus; F, Capillitium; G, A fragment of sporangial wall; H, Spores.

Plasmodium not observed. Sporangia gregarious, measuring up to 4 mm. in height, stipitate, ovoid to subcylindrical, broader at the base tapering at the apex, brownish red in colour, measuring 0·5–2·2 mm. in height and 0·5–1·2 mm. broad, first red or crimson later becoming reddish brown or dirty brown in colour. Stalk terete, up to 1 mm. long and 0·2 mm. thick, furrowed, pale red, or deep reddish brown, filled with spore-like cells, with a well developed hypothallus. Calyculus well formed, membranous, plaited, smooth, wide, shallow. Capillitium centrally attached, consisting of dense reticulate threads brick red when fresh, fading with exposure. Capillitial threads terete up to 6·4 μ in diameter, ornamented with prominent cogs, half rings in lax spirals. Spores bright red in mass, pale red in transmitted light, globose to subglobose, smooth, measuring on average 7·3 μ, range 5·6–8·8 μ mostly 8·0 μ in diameter. On decaying stumps of *Cocos nucifera* L., Mylapore, Madras, 18–8–1955, Coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1546); on stumps of *Phœnix* sp. Professor T. S. Sadasivan's farm, Guindy, Madras, 19–10–1955, Coll. V. Agnihothrudu, Miss P. Shanta and S. Suryanarayanan (Herb. M.U.B.L. No. 1547); on *Borassus flabellifer* L., Guntur (Andhra State), 22–1–1956 (Herb. M.U.B.L. No. 1548).

ACKNOWLEDGEMENTS

I am indebted to Professor Dr. T. S. Sadasivan and Dr. C. V. Subramanian, for their helpful suggestions in the preparation of this paper. I thank Mr. S. Suryanarayanan, for critically reading the manuscript and the Government of India, for the award of a senior scholarship during the tenure of which this work was done.

STUDIES IN THE MELIACEÆ

I. Development of the Embryo in *Azadirachta indica* A. Juss.

By G. K. Garudamma

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(Received for publication on March 13, 1956)

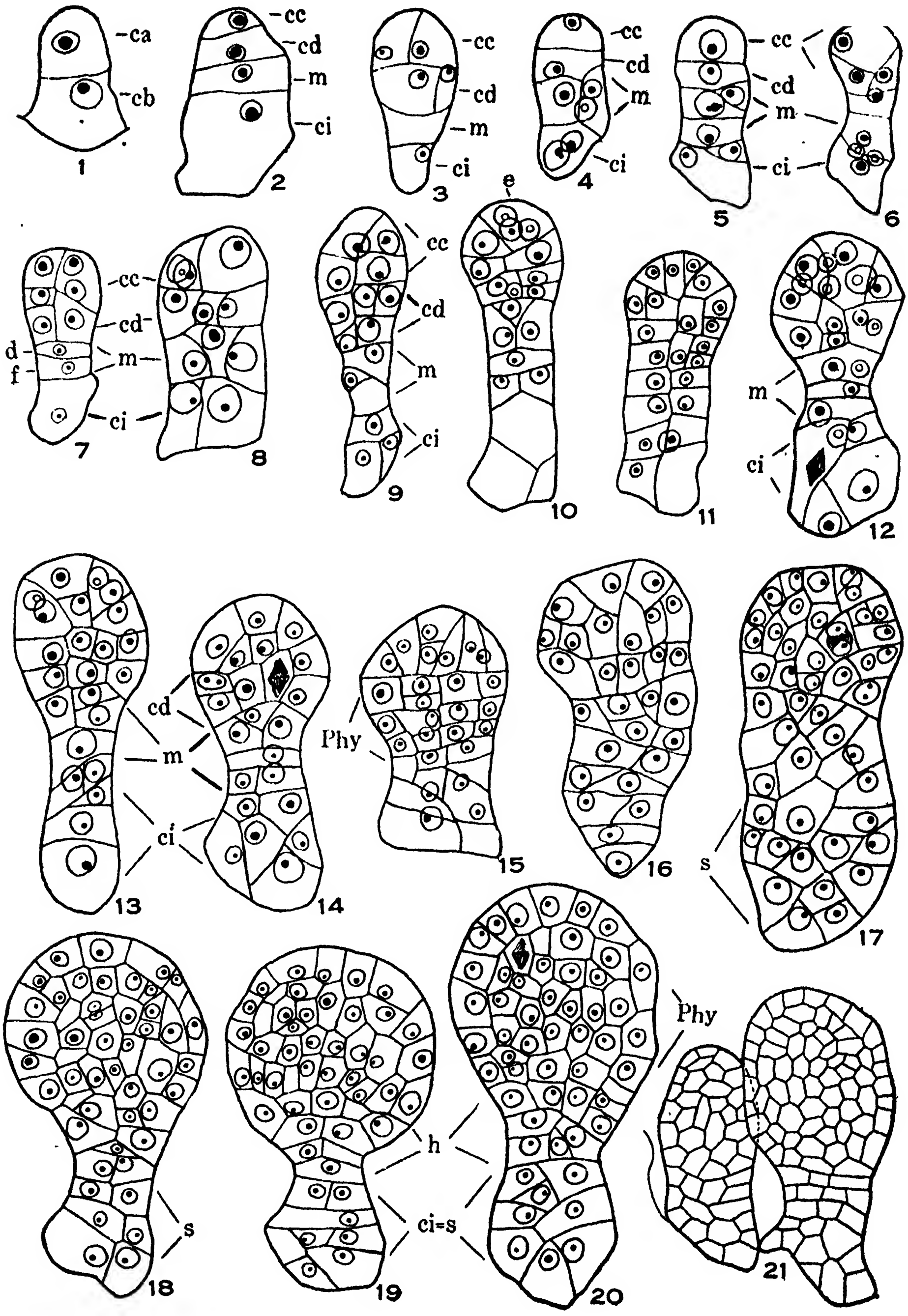
There has been, so far, no detailed account of the embryogeny of any member of the Meliaceæ. Johansen (1950) has stated that the information available on the Meliaceæ is insufficient to permit any conclusions. Wiger (1935) who investigated a number of species of the Meliaceæ figured a few embryos of *Dysoxylum alliaceum* and *Melia azaderach.* These are many celled embryos and in regard to earlier stages, he writes that he did not observe the development following the two-celled condition. The present study was, therefore, undertaken with a view to understand the embryogeny of some representatives of this important tropical family. A detailed account of the development of the embryo in *Azadirachta indica* is given in this paper.

Material and Methods

Azadirachta indica is a well-known tree of the tropics which is cultivated extensively as a shade plant and whose leaves are used in indigenous medicine. The plants bear flowers in great profusion during the months, February to July. The material for study was collected from plants growing in a private garden in Bangalore and fixed in formalin-acetic-alcohol. Preparations for microscopic examination were made according to customary schedule.

Observations

The fertilized egg divides by a transverse wall resulting in the two superposed cells, the apical and the basal cells (*ca* and *cb* in Fig. 1). A linear tetrad of the C_2 category is formed following transverse division in each of the cells, *ca* and *cb* (Fig. 2). The terminal cell, *cc* undergoes an oblique division and a similar oblique to vertical division takes place in the cell, *cd* (Fig. 3). The two cells, *m* and *ci* derived from the basal cell (Figs. 2, 3) may, however, divide earlier (Figs. 4, 5). An epiphysis initial appears to be cut off in the terminal cell following another oblique division (Fig. 6). In the following stages there is neither synchronisation nor regularity of divisions in the derivatives of the apical and basal cells with the result the embryo assumes various shapes. In some cases it has been observed that there is greater activity in the basal region of the embryo and the suspensor in such cases is massive and consists of several cells (Fig. 17). In other cases, however, the suspensor is elongated and presents only a few cells. An examination of a large number of preparations has enabled the following



TEXT-FIGS. 1–20. Stages in development of embryo, ×450.

TEXT-FIG. 21. Occurrence of two embryos in developing seed, ×225.

ca and *cb*, apical and basal cells of two-celled embryo; *m* and *ci*, daughter cells of *cb*;] *d* and *f*, daughter cells of *m*; *e*, epiphysis; *phy*, hypocotyledonary part; *h*, hypophyseal part; *s*, suspensor.

account to be given for the subsequent development of the embryo (Figs. 7 to 20).

The cell, *m*, may divide transversely giving the two superposed cells, *d* and *f* (Fig. 7). Several embryos were, however, found to show a vertical to oblique division in this cell (Figs. 4, 8). The subsequent shape assumed by the embryo appears to depend partly on the plane of first division of the cell, *m*. In the course of further development, the hypocotyledonary and hypophyseal parts of the embryo are differentiated. While it is not always possible to know the exact limits and also the origin of these two parts, it is evident, at least in some embryos, that the basal cell, *cb*, also contributes to the hypocotyledonary part (Figs. 15, 16). A part of the hypocotyledonary region is thus derived from the basal cell and the remaining portion from the apical cell. *Azadirachta* thus appears to belong to the third megarchetype in the first period in the system of embryogenic classification proposed by Souèges (1939). The hypophyseal part is derived from the inferior derivatives of the cell, *m*, (Figs. 19, 20) and this part eventually organizes the root cortex and the root cap. The suspensor which, as has already been mentioned, consists of varying number of cells is derived from the cell, *ci*. It may, however, be mentioned at this stage that the limit between the hypophyseal part and the suspensor is not always clear, particularly, in those cases where a massive basal region is present.

It is evident from the above description that *Azadirachta indica* definitely belongs to the first period in the system of embryogenic classification of Souèges by virtue of the fact that both the apical and basal cells of the two-celled embryo contribute to the embryo proper. The first tetrad of the C_2 category and an oblique division in the terminal cell *cc*, necessarily brings this in the fifth group and as the hypocotyledonary region is derived from both the apical and basal cells, *Azadirachta indica* can be considered as belonging to the third megarchetype.

Only one instance of polyembryony was met with. Two embryos were found in one of the preparations and as the embryos were in an advanced stage of development (Fig. 21) their exact origin could not be determined.

SUMMARY

A detailed study of the development of the embryo in *Azadirachta indica* reveals that this species is ranged in the first period of the embryogenic system of classification. The embryo proper is derived from both the apical and basal cells of the two-celled embryo. There is considerable irregularity in the sequence and extent of cell divisions at the basal end which results in a suspensor of varying dimensions.

ACKNOWLEDGEMENTS

This work was done during the tenure of a Junior Research Training Scholarship awarded by the Government of India. I wish to express my sincere thanks to Prof. K. N. Narayan, for kind encouragement

and to Dr. M. A. Rau, for many helpful suggestions in the preparation of this paper.

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ON THE GENUS *AMPHICHÆTA* McALPINE

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(Received for publication on March 16, 1956)

THE genus *Amphichæta* was described in 1904 by McAlpine. His diagnosis of the genus (McAlpine, 1904, p. 118) is as follows:—

> "Acervuli beneath the epidermis, often erumpent, disc- or cushion-shaped, black. Sporules elongated, with two or more transverse septa, at least partially coloured, and with one seta at each end; basidia hyaline, filiform."

Two species were described by him under this genus, *viz.*, *A. daviesiæ* on *Daviesia latifolia* R. Br. and *A. kennedyæ* on *Hardenbergia monophylla* Benth. and *Kennedya prostrata* R. Br. In establishing his new genus McAlpine compared his genus with *Cryptostictis* and stated that "in *Cryptostictis* Fckl. the spores are similar to those of *Amphichæta*, but they are enclosed in a perithecium" (McAlpine, 1904, p. 118). McAlpine's statement reflects the then current concept of *Cryptostictis*, as accepted by Saccardo (1884, p. 443), by Lindau (1900, p. 374) and by Allescher (1903, p. 251), who included this genus in the Sphæropsidales-Sphærioideæ. Later on, however, Hoehnel (1923, p. 342) classified *Cryptostictis* in the Melanconiales and this has been followed by Clements and Shear (1931) and by Ainsworth and Bisby (1954). Indeed, both Saccardo (1884) and Allescher (1903), whilst placing this genus in the Sphæropsidales, took care to mention in their generic descriptions of this genus that the fructifications are not typical (of the Sphæropsidales). When Hoehnel (1923) assigned *Cryptostictis* to the Melanconiales, he did away with the only difference between *Cryptostictis* and *Amphichæta* on which McAlpine erected his genus. One would, therefore, have normally expected *Amphichæta* being reduced to synonymy with *Cryptostictis* which was described much earlier. However, this was not done; on the other hand, Hoehnel accepted both the genera. In his key to the Melanconiales (Hoehnel, 1923, p. 342) *Cryptostictis* was distinguished from *Amphichæta* thus: *Cryptostictis* was stated to have conidia with only one basal appendage but no apical one, whereas *Amphichæta* was stated to have conidia with one basal as well as one apical appendage. Hoehnel's key relating to these two genera has been followed by Clements and Shear (1931) also.

Cryptostictis Fuckel was established in 1869 and the type species is *C. hysterioides* (Fuckel) Fuckel (≡ *Hendersonia hysterioides* Fuckel) (Saccardo, 1884). In erecting *Amphichæta*, McAlpine did not specify the type species of his genus; but since, of the two species he described, *A. daviesiæ* appeared immediately after the generic diagnosis followed by *A. kennedyæ*, the former may be considered the type species. We have been able to examine type material of both *Cryptostictis hysteri-*

oides (Fungi rhenani 1838, on *Vitis vinifera*, ca. Budenheim: Herbier Fuckel, 1894) and of *Amphichæta daviesiæ* (on stems of *Daviesia latifolia*, Ringwood, Victoria, 23–10–1903). Our study indicates that both these species are congeneric with each other since they are similar in the structure of the acervuli and the nature of the conidiophores and conidia. In both the species the conidia are phæophragmospores, and each conidium has one apical and one basal appendage, and the middle cells of the conidium are dark, the apical and the basal cells being hyaline. It is thus clear that Hoehnel was correct in classifying *Cryptostictis* in the Melanconiales; but he erred in considering the spores of *Cryptostictis* as having only one basal appendage, but no apical one. We, therefore, propose that *Amphichæta* McAlpine be relegated to synonymy with *Cryptostictis* Fuckel, in accordance with the rules of priority.

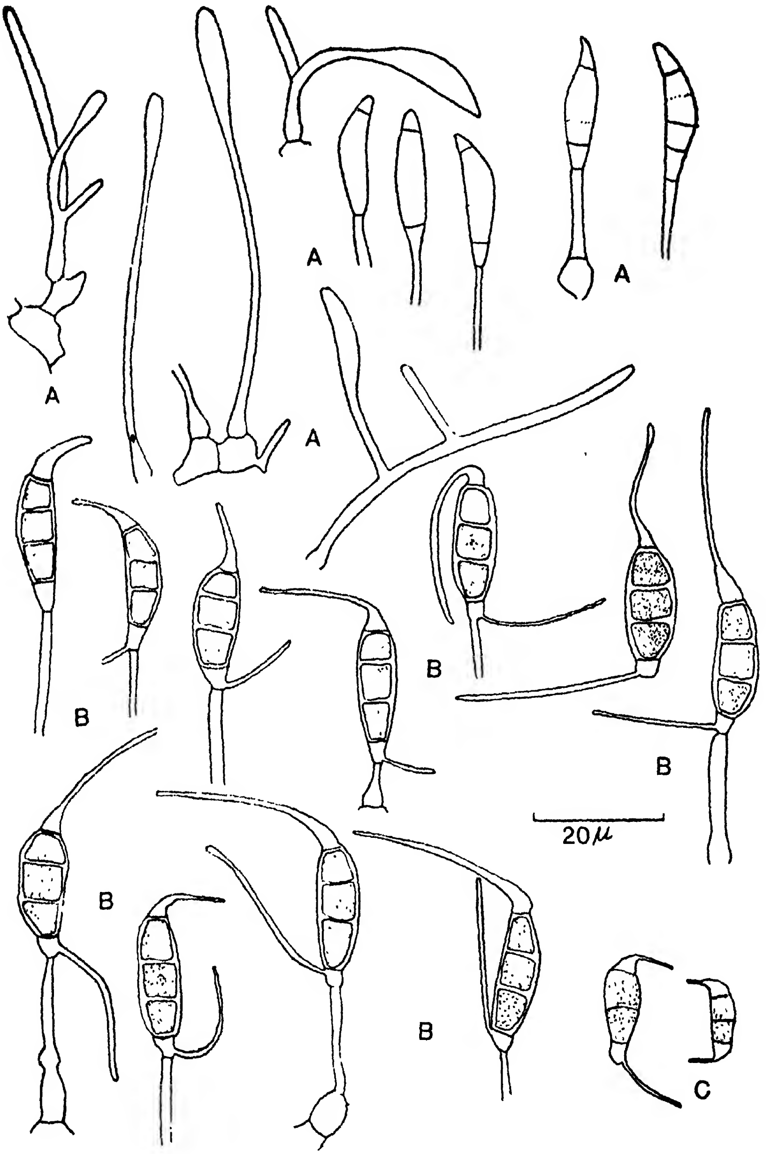
Accordingly, the two species of *Amphichæta* described by McAlpine (1904) are being transferred to *Cryptostictis*. The descriptions of the two species which are given below are based on a study of type specimens and they are largely in agreement with McAlpine's descriptions.

Cryptostictis daviesiae (McAlpine) Subramanian and Ramakrishnan comb. nov.

Basonym: *Amphichæta daviesiæ* McAlpine, 1904, in *Proc. Linn. Soc. N.S.W.*, **29**: 118; Saccardo, 1906, *Sylloge Fungorum*, **18**: 487.

The fungus forms black, scattered, separate or confluent, somewhat circular acervuli subepidermally on stems; they become erumpent later on. They are up to 1 mm. in diameter. A section through an acervulus shows a basal stromatic layer of 2–3 tiers of irregular, brownish, somewhat pseudoparenchymatous cells. Numerous conidiophores arise from the surface of the stroma. The conidiophores are hyaline, simple or branched, thin and long, non-septate, erect, straight or bent, up to 84 μ long and 1·6–2·4 μ wide. Each conidiophore or conidiophore branch bears at the tip one conidium. The mature conidium is somewhat fusiform, dorsiventral, 4-septate, 24–31 μ long and 8 μ broad. The three middle cells of the conidium are dark brown in colour and thick-walled; the apical and basal cells are hyaline. The apical cell is drawn out into a filiform, hyaline, simple, straight, curved or bent appendage 20–32 μ long. The basal cell is truncate at the locus of attachment to the conidiophore and is provided with one filiform, hyaline, simple, straight, curved or bent appendage 16–30 μ long and springing obliquely from near its junction with the conidiophore.

The type material of this species is exceptionally good and it has, therefore, been possible to study the development of the conidia in this species. The conidium arises as a short, hyaline, clavate swelling of the tip of the conidiophore. As this swelling enlarges it assumes the characteristic dorsiventral shape. The first septum to be formed appears to be the one immediately below the apex, followed by the



Text-Fig. 1. A and B. *Cryptostictis daviesiæ* from type specimen Herb. M.U.B.L. No. 1560; A, Conidiophores and development of conidia; B, Mature conidia; C, *Cryptostictis hysterioides* conidia from type specimen Herb. M.U.B.L. No. 1514.

septum cutting off the basal cell of the conidium. Following or preceding this the conidium may be cut off by a septum from the conidiophore. The two middle septa of the conidium are then formed. Meanwhile, the central cells of the conidium gradually become darker and finally assume the characteristic colour of the mature spores. The apical cell then gradually gets drawn out into the characteristic caudate appendage. A little later, the basal cell also develops its appendage similarly.

Type specimen: on *Daviesia latifolia* R. Br. (Leguminosæ), Ringwood, Victoria, Australia 23-10-1903, coll. C. French Jr., Herb. M.U.B.L. No. 1569 ex Herb. Department of Agriculture, Burnley Gardens, Victoria, Australia.

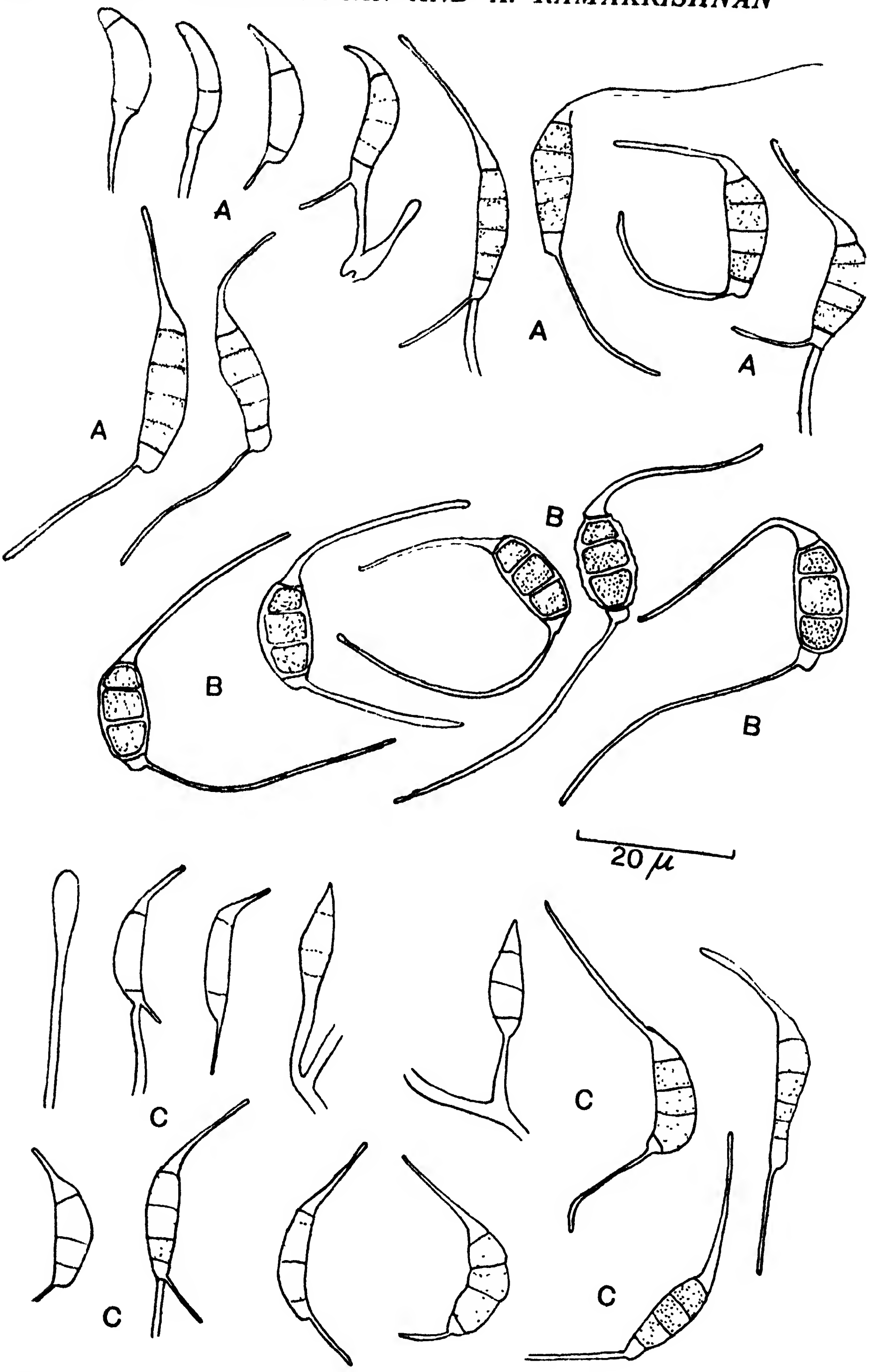
Cryptostictis kennedyae (McAlpine) Subramanian and Ramakrishnan comb. nov.

Basonym: *Amphichæta kennedyæ* McAlpine, 1904, in *Proc. Linn. Soc. N.S.W.*, **29**: 119; Saccardo, 1906, *Sylloge Fungorum*, **18**: 486.

The fungus forms small, black, erumpent, scattered acervuli on the leaves. The conidiophores are filiform, hyaline, much shorter than those of *C. daviesiæ*, and 10–16 μ long. Each conidiophore bears one conidium acrogenously. The conidium is fusiform, slightly dorsiventral, 5-septate, 24–28·2×6·4–8 μ, and with the middle four cells brown in colour. The apical and the basal cells are hyaline. The apical cell is drawn out into a caudate, filiform, simple, slightly curved, hyaline appendage 31–40 μ (6–17 μ according to McAlpine) long. The basal cell is truncate at the locus of attachment to the conidiophore and has one filiform, simple, hyaline, straight or curved appendage 24–35 μ (9–22 μ according to McAlpine) long and springing obliquely from near the junction with the conidiophore.

Type specimen: In dry portions of leaves of *Kennedya prostrata* R. Br. (Leguminosæ), Cheltenham, Victoria, Australia, 27–9–1903, coll. C. French Jr., Herb. M.U.B.L. No. 1571 ex Herb. Department of Agriculture, Burnley Gardens, Victoria, Australia.

Another collection was also assigned to this species by McAlpine (1904, p. 119), *viz.*, on leaves of *Hardenbergia monophylla* (recorded as *Kennedya monophylla* in herbarium specimen), Ringwood, Victoria. The material available of this species is very meagre. We have, nevertheless, examined this specimen. We find that it is not conspecific with *Cryptostictis kennedyæ* since the conidia are 4-septate and are shorter and thicker than those of *C. kennedyæ*. Only conidia could be seen from the meagre material available and the conidia are fusoid, dorsiventral, 4-septate, 19–27 μ long and 8–9·6 μ broad. The middle cells are dark brown in colour and thick-walled; the apical and the basal cells are hyaline. The apical cell is drawn out into a caudate, filiform, simple, curved or bent appendage 19–34 μ long. The basal



TEXT-FIG. 2. A, *Cryptostictis kennedyæ* from type specimen Herb. M.U.B.L. No. 1571; development of conidia and mature conidia; B, *Cryptostictis macalpineæ* from type specimen Herb. M.U.B.L. No. 1570; mature conidia; C, *Cryptostictis grevilleæ* from type specimen Herb. M.U.B.L. No. 1535, development of conidia and mature conidia.

cell is truncate at the locus of attachment to the conidiophore and has an appendage arising obliquely from near the junction with the conidiophore. It is filiform, simple, hyaline and 24–46·4 μ long.

This fungus is sufficiently different from *Cryptostictis daviesiæ* and *C. kennedyæ* to be considered a separate species. Its conidia are shorter and stouter and have longer basal appendages than those of *C. daviesiæ* and *C. kennedyæ*. We, therefore, propose a new species for it, named after D. McAlpine.

Cryptostictis macalpineae Subramanian and Ramakrishnan
sp. nov.

Acervulis minutis, nigris, erumpentibus, sparsis. Conidiis fusiformibus, leniter curvulis, 4-septatis, cellulis medianis coloratis, extimis hyalinis, 19–27×8-9·6 μ; setula apicali 19–34 μ longa, basilari obliqua, 24–46·4 μ longa. Hab. in areis siccis foliorum *Hardenbergiæ monophyllæ* (Leguminosæ), Ringwood, Vict., Australiæ, 12–9–1903, leg. C. French Jr., Herb. M.U.B.L. No. 1570 ex Herb. Department of Agriculture, Burnley Gardens, Victoria.

Since McAlpine described his genus, several species of *Amphichæta* have been described. Of these, we have been able to obtain part of the type material of *Amphichæta grevilleæ* Loos which was described by Loos (1950) as causing a disease of *Grevillea robusta* seedlings in Ceylon. This is a good *Amphichæta* and it is, therefore, congeneric with the type species of *Cryptostictis*. Accordingly, we propose the following new combination:—

Cryptostictis grevilleae (Loos) Subramanian and Ramakrishnan
comb. nov.

Basonym: *Amphichæta grevilleæ* Loos., 1950, in *Trans. Brit. mycol. Soc.*, **33**: 41–42.

The fungus forms acervuli on diseased leaves. The acervuli are black, scattered, erumpent and amphigenous. The conidiophores are filiform, hyaline, simple or branched, and 12–15×1·3 μ. Each conidiophore or branch bears one conidium accrogenously. The mature conidia are fusiform, dorsiventral, predominantly 4-septate, and 17·6–24×4·8–8 μ. The central cells of the conidia are pale brown in colour; the apical and the basal cells are hyaline. The apical cell is drawn out into a filiform, hyaline, simple, usually straight appendage 16–18 μ long. The basal cell is truncate at the locus of attachment to the conidiophore and is provided with one filiform, hyaline, simple, usually straight appendage 11–18 μ long and springing obliquely from near the junction with the conidiophore.

Type specimen: on leaves of *Grevillea robusta* A. Cunn., Kandapolla, Ceylon, Herb. M.U.B.L. No. 1535 ex Herb. Tea Research Institute of Ceylon No. 437.

SUMMARY

A study of the type material of the type species of *Cryptostictis* Fuckel [*C. hysterioides* (Fuckel) Fuckel, 1869] and of *Amphichæta* McAlpine (*A. daviesiæ* McAlpine, 1904) has shown that both the species are congeneric. *Amphichæta* McAlpine is, therefore, reduced to synonymy with *Cryptostictis* Fuckel. *Amphichæta daviesiæ* McAlpine, *A. kennedyæ* McAlpine and *A. grevilleæ* Loos are transferred to *Cryptostictis*, following a study of type material of these three species. One collection on *Hardenbergia monophylla* from Australia assigned by McAlpine to *Amphichæta kennedyæ* was found to be distinct from that and other species, and a new species, *Cryptostictis macalpineæ* is proposed to take it.

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STUDIES ON THE CYTOLOGY AND PHYLOGENY OF THE PTERIDOPHYTES

I. Observations on the Marattiaceæ

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(Received for publication on January 14, 1956)

INTRODUCTION

An investigation on the cytology of the South Indian Pteridophytes was started in 1952, in the Botany Department of the Travancore University. The considerations which prompted this venture are threefold: (1) the south-west region of peninsular India is very rich in Pteridophytes and this group has not received sufficient attention from Botanists; (2) it was found easy to grow in the Botanical Garden of the University several Pteridophytes which were believed to thrive only in much higher altitudes, thus facilitating easy availability of material for study; and (3) the realisation that cytological studies in the living representatives of this ancient group of plants might throw valuable light on taxonomy and phylogeny.

During the course of the last three years over a hundred species of Pteridophytes have been studied cytologically and it is proposed to publish the results in convenient instalments dealing with major groups. This paper deals with the cytology of the South Indian Marattiaceæ.

Represented by seven genera of living ferns and with a fossil record dating back to the Palæozoic period, the Marattiaceæ is a well-defined family of relatively primitive ferns. All the seven genera are tropical in distribution. *Angiopteris* and *Marattia* are the only two genera that are indigenous to South India. *Angiopteris evecta* (Forst.) Hoffm. was collected from several localities in the Western Ghats, like Ponmudi (1,500–3,000 feet elevation), Munnar area (3,000 feet), Thekkady (2,500 feet), Parambikulam (2,000 feet), etc. *Marattia* is represented by only one species, *M. fraxinea* Smith. and was obtained from Kodaikanal hills (at an elevation of 7,000 feet). Both genera are confined to higher elevations, in humid, shady areas, and when brought to the plains thrive well under green house conditions.

METHODS

The cytological difficulties inherent in most members of the tropical ferns, like the small size and thick wall of the spore mother cells (Manton, 1954) together with the diffuseness of outline of the meiotic chromosomes, though shared by both the genera are most marked in *Angiopteris*, which makes it a difficult cytological material. *Marattia* on the other hand is relatively easy to handle. The fixative used was Carnoy's fluid with a modified proportion of absolute alcohol, glacial acetic acid and chloroform (Ninan, 1955). Sporangia were fixed for not less than 24 hours and acetocarmine smear technique was used throughout. Root tips were fixed in Carnoy's fluid for at least 24 hours after keeping the fresh roots in a refrigerator at close to 0° C. for 24 hours. Photographs were taken from permanent preparations. Explanatory diagrams were drawn on enlarged photographic prints and reduced to the desired size in reproduction.

CYTOLOGICAL OBSERVATIONS

Angiopteris.—Meiosis in spore mother cells was studied in *Angiopteris evecta* from two localities, both from Ponmudi area in Western Ghats. Appreciable difference was observed in the size and position of sporangia in the two materials. In both cases, there were clearly 80 bivalents at the first meiotic division (Text-Fig. 1 and Plate IX, Fig. 1). Root-tip counts clearly showed the presence of 160 chromosomes (Text-Fig. 3 and Plate X, Fig. 3). The chromosomes (both meiotic and mitotic) show a slightly fuzzy outline and this feature was observed in certain other genera of the Eusporangiate ferns also. Manton (1954) has recorded $n = 40$ in *A. hypoleuca* de Vriese. from a plant growing at Kew and $n = 80$ in *A. evecta* (Forst.) Hoffm. from two Ceylon specimens, clearly showing the existence of polyploidy in this genus. The present observation shows that in chromosome number Travancore material is similar to those studied by Manton from Ceylon. In a recent paper Mehra and Singh (1955) have reported $n = 40$ in *Angiopteris evecta* from Darjeeling, Himalayas.

Marattia.—Only one plant of *M. fraxinea* collected from Kodaikanal was studied. This gave very clear preparations showing 78 bivalents at meiosis (Fig. 2 and Pl. IX, Fig. 2). In all preparations made during two seasons, and also in materials fixed originally in the wild condition, it was found that one of the bivalents was distinctly smaller than the other 77 which were nearly of the same size. Except for this small bivalent, the size of the chromosome is comparable to the chromosomes of *Angiopteris*. To confirm the number definitely, root-tip smears were examined. Several clear preparations were obtained showing 156 chromosomes at metaphase, of which 2 were markedly smaller than the rest (Text-Fig. 4 and Pl. X, Fig. 4). This removes any doubt as to the nature of the small chromosome seen at meiosis—it is clearly a bivalent.

PHYLOGENETIC CONSIDERATIONS

The family Marattiaceæ is of great interest in so far as it shows in living genera features which recall in a striking manner those found in extinct forms. Features of the sorus in certain fossils assigned to this

FIG. 1

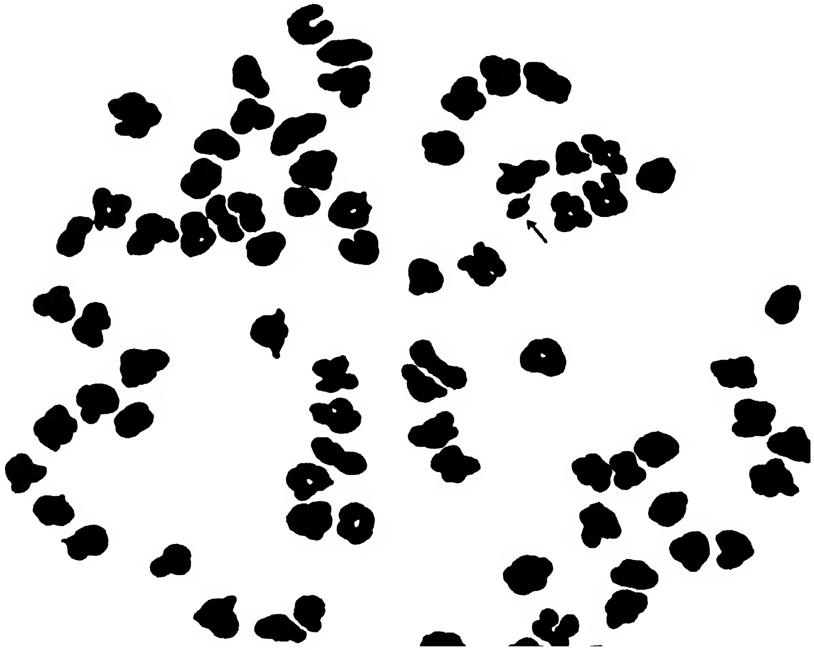


FIG. 2

TEXT-FIGS. 1-2. Fig. 1. Explanatory diagram showing meiosis in *Angiopteris evecta*. 80 bivalents are clearly seen, ×2,000. Fig. 2. Explanatory diagram of meiosis in *Marattia fraxinea*. The number of bivalents is 78, of which the one indicated by the arrow is appreciably smaller than the rest, ×2,000.

FIG. 3

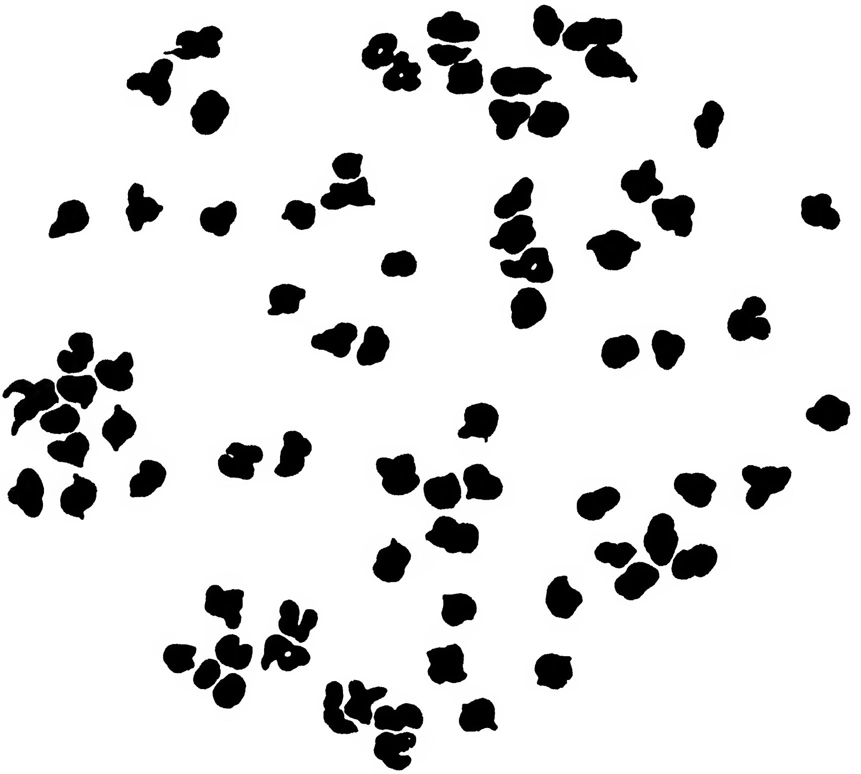
FIG. 4

TEXT-FIGS. 3–4. Fig. 3. Explanatory diagram of mitosis in *Angiopteris evecta.* The somatic chromosome number is 160, ×1,800. Fig. 4. Explanatory diagram of mitosis in *Marattia fraxinea.* Out of the 156 chromosomes, two are markedly smaller, ×1,800.

family are exactly similar to those in some of the living genera. As Bower (1926) has remarked "nothing in Palæobotany is more striking than a detailed comparison of the Palæozoic sori of *Ptychocarpus* or of *Scolecopteris* with those of the living *Christensenia* and *Marattia*". The living genera show many archaic features and have not much in common with the other families of ferns; "they appear as survivals to the present day of a Palæozoic and Mesozoic Stock."

Bower (1926) from a careful comparative study of the different genera of the Marattiaceæ has subdivided the family into three phyletic groups: (1) Sporangia separate (*Angiopteris*, *Macroglossum*, *Archangiopteris* and the fossil form *Danæopsis*); (2) Sporangia united into Synangia (*Ptychocarpus* a fossil, *Marattia*, *Protomarattia* and *Danæa*); and (3) Sori subdivided (*Christensenia*). Of the seven living genera materials of only two were available for the present study. The presence of chromosome numbers $n = 40$ and $n = 80$ in *Angiopteris* sps. (Manton, 1954 and the present observations) clearly shows that in this family also polyploidy has played a role in evolution of species. Though there is no evidence of the existence of a number lower than 40, observations on a large number of genera of Pteridophytes led Manton (1953) to suggest that this number may have arisen from a number as low as 10. The presence in *Marattia* of a chromosome number different from *Angiopteris* is of great interest especially in view of the fact that this number ($n = 78$) is an exact multiple of 13, which is found in other primitive Pteridophytes. Manton (1950, 1954) has recorded $n = 13$ in *Hymenophyllum*, $n = 26$ in *Matonia* and $n = 39$ in *Dicranopteris*. (*Gleichenia* sens. lat.). Observations on materials of *Dicranopteris* collected in Travancore also show the chromosome number to be a multiple of 13 ($n = 78$) (Text-Fig. 5). The presence in *Psilotum nudum* L. of a polyploid series with numbers in multiples of 26 (Ninan, 1956) together with the above observations clearly suggest that the chromosome number 13 must have been widely prevalent in the past in primitive groups.

It seems reasonable to assume that the Marattiaceæ must have originated from ancestors with 13 as the basic chromosome number, and the situation in *Angiopteris* is a condition derived from this. On morphological considerations the two genera *Angiopteris* and *Marattia* fall into two distinct groups, the latter clearly being a direct survival of the ancient types. While the chief difference between the two genera is in sporangial character, it may be noted that there is considerable similarity between the two genera in external features, and the one is easily mistaken for the other if sporangia are absent. Therefore we need not suppose that the two genera have originated from different ancestral types. The greater probability appears to be that both had a common origin in some ancestral type with 13 as the basic chromosome number, and in *Angiopteris* duplication of one chromosome has given rise to $n = 40$, and from this the forms with $n = 80$ might have arisen, while in *Marattia* the number is retained as an exact multiple of 13. It would be very desirable to find the cytological situation in the other five genera of this family. The difficulty in procuring material has so far prevented this being done.



TEXT-FIG. 5. Diagram showing meiosis in *Dicranopteris linearis*. 78 bivalents are clearly seen, × 2,000.

Regarding the relationship of the Marattiaceæ with other families of ferns, Bower (1926) has suggested analogy in the structure of the sorus to the Gleicheniaceæ and Matoniaceæ. The suggestion of this relationship is amply supported by cytological evidence in that *Matonia*, *Gleichenia* and *Marattia* are traceable back to a base number as low as 13.

SUMMARY

The cytology of *Angiopteris evecta* and *Marattia fraxinea* from South India is described. The chromosome number in *Marattia* ($n = 78$) is different from that in *Angiopteris* ($n = 80$). Certain phylogenetic aspects are discussed in relation to chromosome numbers in the Marattiaceæ, Gleicheniaceæ and Matoniaceæ. Evidence is pre-

FIG. 1

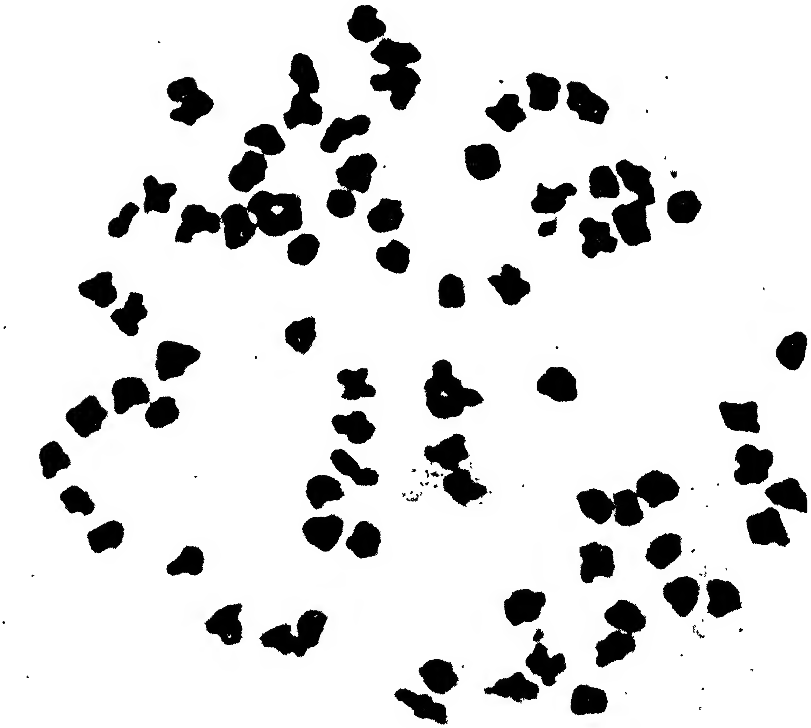


FIG. 2

C. A. Ninan

sented to show that 13 is probably a common basic chromosome number in the ancient vascular Pteridophytes. *Marattia fraxinea* shows an exact multiple of this number, while *Angiopteris evecta* has a slightly higher number derived from this.

ACKNOWLEDGEMENT

The author is indebted to Prof. A. Abraham under whose supervision this work was carried out, for valuable guidance. The award of a senior research scholarship by the Ministry of Education, Government of India, is also gratefully acknowledged.

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EXPLANATION OF PLATES

PLATE IX

FIGS. 1-2. Fig. 1. Microphotograph of chromosomes of *Angiopteris evecta* showing meiosis in a spore mother cell. The chromosome number is clearly $n = 80$. Note the fuzzy outline of the chromosomes, ×2,000. Fig. 2. Meiosis in a spore mother cell of *Marattia fraxinea* showing 78 bivalents, of which one is extremely small, ×2,000.

PLATE X

FIGS. 3-4. Fig. 3. Root-tip squash of *Angiopteris evecta* showing 160 chromosomes. Note the peculiar texture of the chromosomes, ×1,800. Fig. 4. Somatic mitosis from a root-tip squash preparation of *Marattia fraxinea*. 156 chromosomes are clearly seen, ×1,800.

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The Journal of the Indian Botanical Society

Vol. XXXV 1956 No. 3

FERNS OF PARASNATH, BIHAR

BY A. S. MEHTA

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(Received for publication on April 30, 1956)

THE Parasnath Hill forms a prominent feature in the landscape of South Hazaribagh. The topography, geology and climate of, and route to Parasnath Hill have been described in detail by Srivastava (1955). But to make this article complete in itself some of the points mentioned therein are repeated here.

There are two routes to the Parasnath Hill from the Parasnath railway station (locally also known as Isri). One may catch the Grand Trunk Road which will take him in a south-east direction to Nimiaghat at the southern base of the hill and a zig-zag path from here leads to the top of the hill. For the other route, again the Grand Trunk Road but in opposite direction, that is in the north-west direction, has to be covered for a short distance from where one has to proceed along the Giridih Road until he reaches another road, a branch thereof, which will take him to Madhuban at the northern base of the hill. From here a hilly track leads to the top.

The height of Parasnath Hill is 4,480 feet and its annual rainfall is about 60 inches. Relative humidity is also pretty high. That is why the hill shows a dense forest growth thus providing plenty of shade for the shade-loving plants. This at once makes it clear that the conditions of the hill are very conducive to fern growth.

The ferns of this locality have not received so much attention as the angiospermic flora, though they have been described by Beddome (1892) and Haines (1921–25). But these are more of a general nature and have become out of date with great progress in our knowledge of ferns. Even Mooney's (1950) *Supplement to the Botany of Bihar and Orissa* does not take us very far. So in this article an attempt has been made to give an up-to-date account of the ferns of the locality. Mehta (1956) has already reported three ferns from this area and these are new to Bihar.

The genera described here have been placed in the families on the basis of Copeland's (1947) classification.

Class— **FILICINEÆ**

Order **OPHIOGLOSSALES**

Family OPHIOGLOSSACEÆ

1. *Ophioglossum vulgatum* L.—Very common between 3,000 to 4,000 feet on the Madhuban side, but not on the Nimiaghat side. Haines (1921-25) has described two species of *Ophioglossum* from Bihar, *O. reticulatum* L. from Parasnath and *O. nudicaule* L. from Manbhum. Both of these, however, have been accepted by D'Almeida (1922) to be *O. vulgatum*. Some of the specimens show bifurcated spike. Very widely distributed in India.

Order **FILICALES**

Family SCHIZAEACEÆ

2. *Lygodium flexuosum* Sw.—Ascending to the top of the hill. Also in other parts of India. South India up to 4,000 feet on both sides of the Madras Presidency; North India up to 5,000 feet.

udpeal

3. *Pteris quadriaurita* Retz. sens. lat.—This fern has not been described by Haines from Bihar and Orissa. But Mooney (1950) in his *Supplement to the Botany of Bihar and Orissa* describes it from Kapilas Hill (2,000 feet) in Dhenkanal, Orissa. So this will be a new record not only for Parasnath but also for the State of Bihar constituted as it is.

The material was collected by Prem Sharan, a student of mine, near a stream at about 2,000 feet and was handed over to me.

According to Mooney its distribution is throughout India from the plains up to 8,000 feet.

Now a short description of the specimen—Terrestrial; fronds uniform, pinnate with a terminal pinna; pinnæ alternate and pinnatifid, ending into a linear entire tail, glabrous; veinlets forked from their base and free except in the sori; costules prominent, the lowest vein from each costule usually meeting the lowest from the next costule and forming a low arch and giving several veinlets towards the sinus; sori continuous along the margin but avoiding the apices of the ultimate segments and usually the sinuses between them, borne on a marginal connecting vein, protected by the scarious reflexed margin, without other (true) indusium; annulus longitudinal, interrupted and composed of about 17 thickened cells.

4. *Aleuritopteris farinosa* (Forsk.) Fee.—Ascending to the top of the hill. Also in all districts of Chota Nagpur. The genus is segregated from *Cheilanthus* by Fee from which it differs in the form of the frond, in densely white ceraceous covering on the lower surface and in having few sporangia.

5. *Adiantum philippense* L.—Throughout Chota Nagpur. *A. lunulatum* Burm. is its synonym and has been described as such by Haines. Very common throughout Northern India in moist places.

Family PARKERIACEÆ

6. *Ceratopteris thalictroides* (L.) Brongn.—Collected from a ditch near the southern base of the hill towards Nimiaghat; very common in Purnea; common in Chota Nagpur. Only the pinnately divided aerial fertile fronds with numerous narrower segments were collected. Aquatic or sub-aquatic annuals. Widely distributed in the tropics. According to Mahabale (1948) it occurs as annuals or perennials in India and Ceylon in an amphibious state; but is also seen in floating condition in deep waters in Bengal, Assam and other parts of India. He collected it on the banks of the Sabarmati River at Ahmedabad, Western India.

Family DAVALLIACEÆ

7. *Araiostegia pulchra* (Don.) Copel.—Collected at about 4,000 feet, epiphyte. The genus has been included in *Leucostegia* by Beddome and Christensen (Copeland, 1947). And *Leucostegia* has been described under *Humata* by Haines. According to Copeland *Leucostegia* differs from *Araiostegia* in texture, colour, dissection of the frond and in very large sori.

8. *Leucostegia immersa* (Wall.) Presl.—Collected at about 4,000 feet, epiphyte. Its morphology has been described in detail by Kachroo (1955). It occurs in Assam at Shillong, Cherrapunji (Khasi Hills) and Imphal (North-East Frontier of India).

Family ASPIDIACEÆ

9. *Dryopteris cochleata* (Don.) C. Chr.—Ascending to the top of the hill and also in other areas of Bihar. Described by Haines as *Lastrea cochleata* Bedd. in which the fronds are dimorphic. This character is not mentioned by Copeland. I have the fertile as well as the sterile fronds.

10. *Tectaria macrodonta* (Fee) C. Chr.—This fern is also a new record for Bihar. It occurs between 2,000 to 3,000 feet. Its description from the specimen runs as follows:—

Terrestrial; fronds uniform, pinnatifid at the apex and pinnate below. (I have only the apical portion of the frond and further description is based on this portion alone.) Segments further pinnatifid more than halfway to the rachis, ultimate segments bluntish at the apex with crenate margin, surface glabrous on both sides; venation Sagenioid or Pleocnemioid; sori uniform, round, terminal on the veinlet and indusiate, sori generally in two rows one on each side of the main vein of the ultimate segments, but occasionally irregular; indusium round-reniform, affixed under sorus and opening around the margin; annulus longitudinal, interrupted and composed of 13 to 14 thickened cells.

11. *Cyclosorus multilineatus* (Wall.) C. Chr. & Tard.—Collected at about 3,000 feet. Described by Haines as *Nephrodium moulmeinense* Bedd. Also occurs in some other parts of Bihar.

12. *Athyrium macrocarpum* (Bl.) Bedd.—Reported for the first time from Bihar by Mehta (1956).

13. *A. drepanopterum* (Kze.) A.Br.—This species has also been reported from Bihar for the first time by Mehta (1956).

Family POLYPODIACEÆ

14. *Drynaria propinqua* (Wall. ex Mett.) J. Sm.—Like the previous two species this is also a new record for Bihar (Mehta, 1956).

SUMMARY

In this short paper the author has described fourteen fern specimens which he collected (except *Pteris quadriaurita*) from Parasnath Hill from time to time. This description includes five fern specimens which have not been reported earlier from Bihar. Out of these five, three were reported by me in a separate communication.

The author is thankful to Principal M. Q. Doja for many courtesies and also to Prof. R. P. Roy for the facilities which he very kindly provided. Thanks are also due to the Director, Royal Botanic Gardens, Kew, for arranging the identifications of some of the fern specimens.

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SOME NEW RECORD OF PLANTS FROM THE PARASNATH HILL

By S. K. Mukerjee

Indian Botanic Garden, Calcutta

(Received for publication on May 29, 1956)

The Parasnath Hill in Chota Nagpur, which rises abruptly from the plains to an elevation of 4,480 feet above the sea-level, is the highest mountain in Bihar and is a prolongation of the north-eastern edge of the Deccan Plateau into the Gangetic plain. In a country of park-like appearance, this hill is densely forest clad from the base and the vegetation is of a mixed deciduous type, the common trees being *Shorea robusta*, *Terminalia chebula*, *Terminalia arjuna*, *Dalbergia latifolia*, *Schleichera oleosa*, *Sterculia urens*, *Lagerstrœmia parviflora*, *Randia dumetorum*, *Emblica officinalis* and *Albizzia procera*. Near the top of the hill the forest is more open with scattered stunted trees, a few shrubs and herbs and different species of tall and low grasses. A few Sub-Himalayan plants like *Berberis*, *Clematis*, *Thalictrum*, *Cardamine*, *Bulbophyllum*, *Habenaria*, *Begonia*, *Aeginetia*, *Disporum*, *Panax*, etc., occur in Parasnath in association with those of the drier southern regions. The availability of such sub-temperate or temperature species indicate that the hill has served as a stepping-stone for the passage of species from the high lands of the Indian peninsula to the Himalayas and in some cases in the reverse direction.

The Parasnath Hill attracted the attention of botanists since 1848, when it was visited by the late J. D. Hooker. An account of his visit to this locality is available in his famous *Himalayan Journal* and also elsewhere. The specimens collected by him are now preserved in different herbaria in India and Europe. After Hooker, the place was botanised by many, *e.g.*, Thompson, Anderson, Edgeworth, Clarke, Prain, Haines and others. A recent account of this area has been published by Srivastava who has given a list of *Phanerogams* collected by him, including a number of plants which happen to be new records.

In September 1955, the writer paid a short visit to this area and collected specimens for the Calcutta Herbarium. A total of about 650 specimens of 136 species of plants were collected in 2 days. This collection being small is far from complete. Yet on comparing with the recent list published by Srivastava, it was found that at least 7 species collected by the writer from the Parasnath Hill have not been recorded even by Srivastava. This is certainly interesting as Srivastava's paper was published only a few months ago. These include 2 species of ferns, which group, however, has been left out by Srivastava from his survey. These new records are listed below and the specimens referred to here have been lodged at the Calcutta Herbarium.

1. **Bidens bipinnata** Linn. (*Compositæ*)

   Near the top of the hill, about 4,000 feet. Haines has not included this in his *Botany of Bihar and Orissa* although there are several old collections from Chota Nagpur and more than one from Parasnath itself. A common pantropic weed which may have reached this area in recent years. *Mukerjee* No. 3900.

2. **Euphorbia microphylla** Heyne (*Euphorbiaceæ*)

   Open ground in front of Dak-bungalow at 4,200 feet elevation. Previously collected by J. D. Hooker on banks of streams in Bihar and also from Bettiah by Hieronymus. *Mukerjee* No. 3891.

3. **Habenaria stenopetala** Lindl. (*Orchidaceæ*)

   Found on the northern slope of the hill at an elevation of 2,000 feet. Only one specimen was found. It had been collected only once from this province by C. B. Clarke from Singbhum. *Mukerjee* No. 3971.

4. **Setaria intermedia** R. & S. (*Gramineæ*)

   Collected from near the Dak-bungalow at 4,000 feet on the hill. Recorded from many other places in Bihar-Orissa and its occurrence in Parasnath was not unexpected. *Mukerjee* No. 3930.

5. **Themeda villosa** Dur. & Jack. (*Gramineæ*)

   Found near the top of the hill above 4,000 feet. Recently H. F. Mooney found it in Bamra, Orissa. It was not known west of Assam till then. *Mukerjee* No. 3934.

6. **Tectaria macrodonta** (Fee) C. Chr. (*Aspidiaceæ*) *Syn. Aspidium cicutarium var. coadunata* Haines.

   Bot. Bihar and Orissa, **6**: 1192, 1924.

   On northern slope of Parasnath Hill, at 2,500 feet elevation. Reported to be common in Singhbum. *Mukerjee* No. 3992.

7. **Pleopeltis linearis Bedd.** (*Polypodiaceæ*)

   Found on northern slope of Parasnath Hill at an elevation of 2,500 ft. Previously reported only from Netarhat. *Mukerjee*, No. 3996.

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STUDIES ON THE CYTOLOGY AND PHYLOGENY OF THE PTERIDOPHYTES

III. Observations on *Osmunda regalis L.*

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Osmunda regalis, the only South Indian representative of the family Osmundaceæ, has very limited distribution in South India, and is confined to higher elevations. It is found in Munnar (4,500 feet), Deviculam (5,000 feet), Ponmudi (3,500 feet) and Kodaikanal Hills (7,000 feet). They grow on the sides of fast flowing streams or fresh-water lakes. When brought to the plains they do not thrive too well even under green-house conditions, though they may survive for a few years, occasionally producing fresh leaves and sporangia.

Osmunda is an easy cytological material and excellent preparations could be obtained by simple acetocarmine squash technique. The materials used in this study were collected from all the above localities. Sporangia were fixed from plants growing in the wild conditions and root tip counts were made from plants grown in the green-house. The cytological and photographic techniques followed were similar to those described earlier (Ninan, 1955, 1956 *b*).

Chromosome studies of materials collected from Ponmudi showed 22 bivalents in spore mother cells (Pl. XI, Fig. 1) and 44 chromosomes in root tip cells (Pl. XI, Fig. 2). The Munnar and Kodaikanal materials also showed 22 bivalents each during meiosis. Earlier observations made in this laboratory has shown the Deviculam material also to possess the same number of chromosomes.

Comparing the above observations with previous reports of chromosome numbers in this genus, the first thing that strikes us is the remarkable uniformity in chromosome number in all the species studied from different geographical regions. Manton (1950) reported the haploid number of $n = 22$ in garden materials of *Osmunda cinnamomea*, *O. claytoniana*, *O. palustris* and *O. gracilis* and in wild materials of *O. regalis* from the British Isles. Britton (1953) observed the same number in American materials of *O. regalis* and *O. cinnamomea*. Observation on Malayan and Ceylon materials of *O. javanica* (Manton, 1950, 1954) also showed the same number. All investigated species of this genus are thus found to be diploids with $n = 22$. In the possession of a haploid number as low as 22 and in the lack of natural polyploidy, *Osmunda* is remarkably different from most of the other genera of ancient Pteridophytes. Palæontological evidence shows that the Osmundaceous stock is traceable back in geological horizons to the Upper Permian; and in spite of the long period available for evolution to

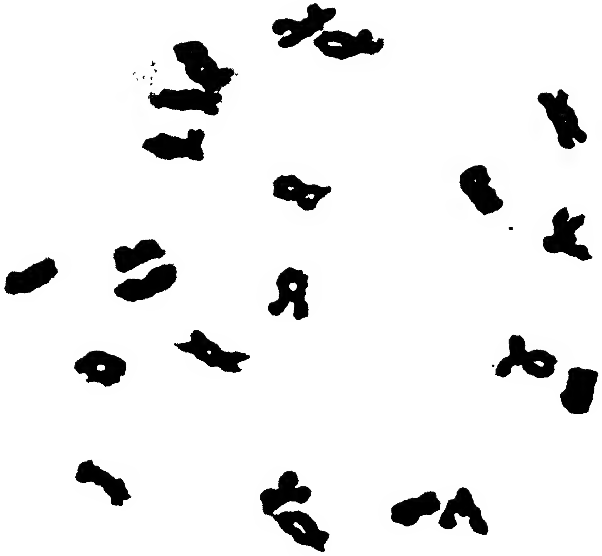

FIG. 1

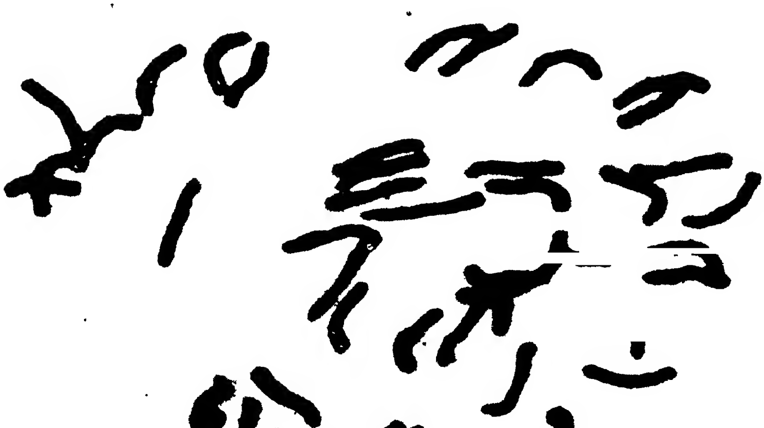

FIG. 2

proceed, the same primitive morphological features combined with a presumably conservative cytological situation are still retained in this genus. In this sense *Osmunda* may be considered genuinely primitive.

Text-Fig. 1. Explanatory diagram to Plate XI, Fig. 1 showing 44 chromosomes, ×1,500.

The other two genera of the Osmundaceæ, namely, *Todea* and *Leptopteris* also possess the haploid number of $n = 22$ (Manton, 1950). It can reasonably be assumed that the number $n = 22$ might have been derived from the basic number 11. Bower (1928) has suggested the probability that *Ceratopteris* and allied genera (primitive Gymnogrammoids) "represent derivative lines which originated in relation to such antique types as the Osmundaceæ and particularly *Todea*". Evidence discussed elsewhere (Ninan, 1956 *d*) shows clearly that *Ceratopteris* is related to the Osmundaceous stock in the possession of a chromosome number which is a multiple of 11.

The Osmundaceæ is held to be a synthetic type between the Eusporangiate and Leptosporangiate ferns (Bower, 1926). The two Eusporangiate families Ophioglossaceæ and Marattiaceæ are shown to have evolved from ancestral types with 15 and 13 respectively as the basic chromosome numbers (Ninan, 1956 *a*, *b*). The ancient Leptosporangiate genera like *Gleichenia* and *Matonia* also possess a basic number of 13 (Manton, 1953 and Ninan, 1956). Other principal haploid numbers like 29, 30, 36, 37, 40 and 41, characteristic of advanced Leptosporangiate families of ferns also show no apparent relation to the number 11, which might be regarded as fundamental to the beginnings of the Osmundaceæ. It seems, therefore, clear enough, that the Osmundaceæ started as a separate line even from very early times and that they are distinct in descent from the Eusporangiate and Leptosporangiate groups.

As Eames (1936) has remarked—"the Osmundaceæ do not connect the Eusporangiates and Leptosporangiates phyletically, though it appears transitional between the Eusporangiate and the Leptosporangiate groups."

In the possession of fundamentally low chromosome numbers and in the lack of a polyploid series, the genus *Osmunda* affords comparison to the ancient genus *Selaginella*. The latter is exceptional in the Pteridophytes in the possession of a haploid number as low as 9, the lowest chromosome number reported in a Pteridophyte (Manton, 1950 and Ninan, 1956 *c*). However, *Selaginella* has succeeded in evolving several hundreds of species with differing habitat preferences. This means that apart from polyploidy, other factors, probably gene mutations, may have been operative in bringing about effective speciation in *Selaginella*. In *Osmunda*, however, all evolutionary activities are apparently at a standstill. Artificially produced polyploids in *O. regalis* (Manton, 1950) have also shown lack of survival value. The Osmundaceæ are to be regarded as representing end lines of an ancient stock which has lost all evolutionary potential.

SUMMARY

The cytology of *Osmunda regalis* from four localities in India is described. There is remarkable uniformity in chromosome number ($n = 22$, $2n = 44$) in all the investigated species of *Osmunda* from widely separated areas. The cytological evidence supports the view expressed by Eames that Osmundaceæ does not constitute a connecting link between Eusporangiate and Leptosporangiate ferns. The Osmundaceæ stands apart from the other Pteridophyte families and is in all probability the end line of an ancient stock.

The author is indebted to Prof. A. Abraham, for valuable guidance and encouragement. His thanks are also due to the Ministry of Education, Government of India, for the award of a Senior Research Scholarship.

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EXPLANATION OF PLATE XI

FIG. 1. Diakinesis in a spore mother cell of *Osmunda regalis* L. 22 bivalents are clearly seen, ×1,500.

FIG. 2. Somatic mitosis from a root tip squash in *O. regalis* L. $2n = 44$, ×1,500.

STUDIES ON THE CYTOLOGY AND PHYLOGENY OF THE PTERIDOPHYTES

IV. Systematic Position of *Ceratopteris thalictroides* (L.) Brongn.

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Ceratopteris is an aquatic annual consisting of 2-4 species widely distributed in the tropics. *Ceratopteris thalictroides* (L.) Brongn. is the only species that is indigenous to South India. It is found throughout the low lands as a weed in rice fields and by the sides of streams in shallow water.

Ceratopteris is a genus of very doubtful affinities and hence the assigning of a proper systematic position for this genus has for long been a difficult problem to Pteridologists. Different authors have treated it in quite different ways in their classifications. It is accepted by all that a valid phylogenetic system can be evolved only by the exercise of all available criteria for comparison (Bower, 1923 and Wagner, 1952). Due to lack of information on certain important aspects like cytology and gametophyte phase it has not been possible to come to any definite conclusion regarding the systematic position of certain problematic genera.

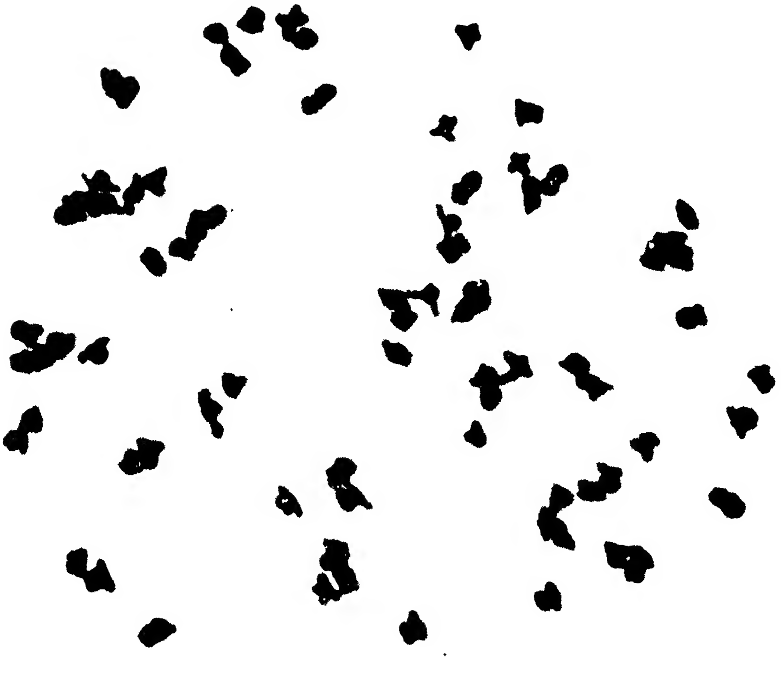
In *Ceratopteris*, though we have information on the gametophyte (Kny, 1875 and Mahabale, 1948) details of the cytology are not yet clearly known. The present paper attempts to fill this gap.

Materials for investigation were obtained from Veli near Trivandrum City. The cytological and photographic techniques followed were similar to those described earlier (Ninan, 1955, 1956 *a*).

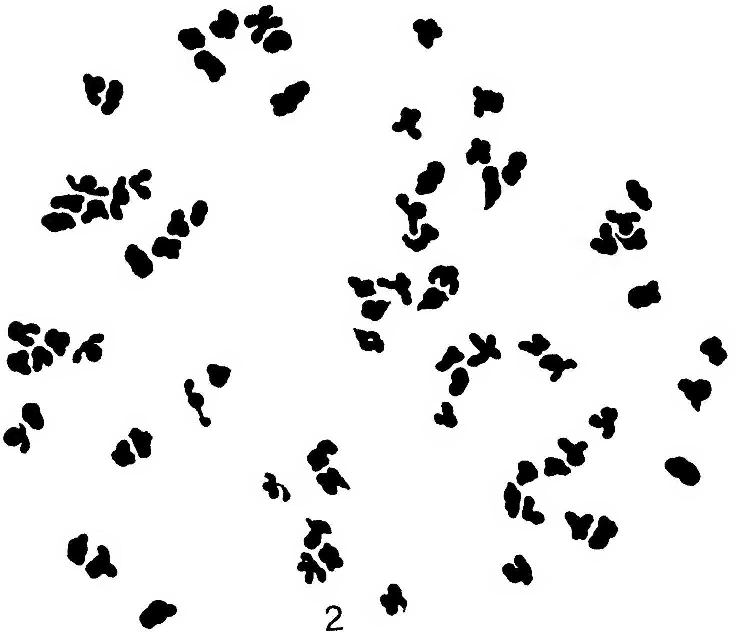
Preparations of somatic mitosis made from root tips showed 154 chromosomes at metaphase (Pl. XII, Fig. 1 and Text-Fig. 1). Meiotic counts clearly showed 77 bivalents (Pl. XII, Fig. 2 and Text-Fig. 2). Manton (1954) has reported the presence of 76-78 bivalents in Malayan materials of *Ceratopteris thalictroides*. The present study has shown very clearly that the haploid chromosome number for this genus is exactly 77.

The somatic chromosomes are fairly large in size in spite of the high chromosome number and they are all nearly of the same length. Most of them have median or sub-median constrictions and two show satellites. Some of the meiotic chromosomes show "antenna-like" shapes reminding one of the chromosomes of *Lycopodium inundatum* described by Manton (1950). Both meiotic and mitotic chromosomes take very good stain and excellent preparations could be obtained even with 12–24 hours of fixation.

FIG. 1



1



2

TEXT-FIGS. 1–2. Fig. 1. Explanatory diagram to Plate XII, Fig. 1 showing 154 chromosomes in root tip squash, ×1,200. Fig. 2. Explanatory diagram to Plate XII, Fig. 2, showing 77 bivalents at I metaphase of meiosis in spore mother cell, ×1,500.

DISCUSSION

The family Parkeriaceæ (Ceratopteridaceæ) was established by Hooker in 1825 to accommodate the genus *Ceratopteris*. Diels (1900), Ching (1940) and Copeland (1947) maintain this as a separate family. Christensen (1938) includes the genus in Polypodiaceæ (sub-family Gymnogrammoideæ, tribe Ceratopterideæ), while Holttum (1947) relegates it to Adiantaceæ. Bower (1928) associates it with the Gymnogrammoid group of genera, with many of which it shares features like the arrangement of sporangia along the veins and large short-stalked sporangia with irregular annulus. He believes that the primitive Gymnogrammoideæ (including the genera *Llavea*, *Onychium*, *Jamesonia*, *Cryptogramme* and *Ceratopteris*) have originated from types with superficial sporangia like *Todea* or *Plagiogyria* and that these five genera are probably related to one another. Holttum (1947) lends support to Bower's view and regards it as more plausible than any other. He (1954) states "*Ceratopteris* is undoubtedly a specialised genus and not closely related to the other Gymnogrammoid ferns which are mainly xerophytic, but most probably it comes of the same stock". Christensen (1938) while supporting Bower's view in the main, is sceptical about the interrelationships of the various genera of Bower's primitive Gymnogrammoideæ. He regards the Gymnogrammoids as a group of uncertain mutual relationship probably representing different lines of evolution. Copeland (1947) considers that the genus *Ceratopteris* is derived from indusiate ancestors. He comments: "I let the genus stand as a family because the degeneration of the sporangial structure has taken it beyond easy inclusion in any family description of *Pteridaceæ*; but do not doubt that it is derived from that family as here construed." On the contrary, Bower (1928) is of opinion that "the primitive Gymnogrammoids stand phyletically on their own feet distinct in descent from the Pteroid ferns".

Out of the 5 genera of Bower's primitive Gymnogrammoideæ, the cytology of *Ceratopteris* and *Cryptogramme* are now known. The latter has a chromosome number of $n = 30$ a number so characteristic of most of the Gymnogrammoid, Pteroid, Adiantoid and Cheilanthoid ferns (Manton, 1950, 1954 and Ninan, unpublished observations). *Cryptogramme* therefore aligns itself very closely with the Gymnogrammoids. But *Ceratopteris* with a haploid chromosome number of $n = 77$ can in no way be related to *Cryptogramme*, which in the light of other evidences, is considered (Bower, 1928 and Christensen, 1938) to be a close relative of *Ceratopteris*. Though the cytological situation in *Llavea*, *Onychium* and *Jamesonia* are not yet known, the disparity in chromosome numbers evidenced by *Ceratopteris* and *Cryptogramme* is itself clear indication that the primitive Gymnogrammoids of Bower represent more than one evolutionary line. The Gymnogrammoid state as shown by these genera might be the result of parallel evolution and it cannot be construed as indicating closer relationship.

Cytological evidence also shows clearly that Holttum's inclusion of *Ceratopteris* in his Adiantaceæ (1947) is the result of an inadequate appreciation of the affinities of the genus. Recent observations have shown that all the genera of Holttum's Adiantaceæ like *Monogramma*, *Vittaria*, *Antrophyum*, *Syngramma*, *Doryopteris*. *Hemionitis*, *Adiantum*, *Coniogramme*, *Pityrogramma* and *Cheilanthes* (except *Tænitis*, the cytology of which is not known) are characterised by the presence of numbers like 29 or 30 or their multiples (Manton, 1954 and Ninan, unpublished observations). The presence in *Ceratopteris* of a haploid chromosome number of $n = 77$ at once suggests discord in an otherwise cytologically homogeneous group. There is thus sufficient reason for separating *Ceratopteris* from Holttum's Adiantaceæ.

Copeland's contention that *Ceratopteris* is derived from indusiate ancestors, most probably from the Pteroid ferns is also not in agreement with evidence from cytology. The close affinity of *Ceratopteris* with the *Cheilanthes* group of ferns (Copeland, 1947 and Stokey, 1951) is equally unconfirmed. However Bower's suggestion of an origin of *Ceratopteris* from Osmundaceous ancestors gains support in that all the living genera of the Osmundaceæ and *Ceratopteris* are traceable back to 11 chromosomed ancestors (Ninan, 1956 *b*).

Coming to purely cytological considerations, the nature of the somatic chromosomes in *Ceratopteris* also supports an ancestry from some primitive group. The chromosomes closely resemble those of some of the ancient genera of Pteridophytes like *Psilotum* and *Angiopteris*, in the large size of the chromosomes in spite of high numbers. The other genera included by Holttum in Adiantaceæ and which have been investigated in this laboratory all show much smaller somatic chromosomes even where the number is appreciably smaller (Ninan and Mathew, unpublished observations). This clearly shows that on cytological grounds *Ceratopteris* stands in a position distinct from these genera.

Evidences already discussed provide sufficient warranty for the separation of *Ceratopteris* from the taxonomic groupings of Bower and Holttum. Bower's view that the genus probably represents a distinct line of evolution from some primitive stock in close relation to the Osmundaceæ seems more palusible in the light of evidence from cytology. Copeland's assignment of family status to the genus appears to be the best taxonomic arrangement. In the peculiar blending of advanced and primitive characters *Ceratopteris* seems to be a specialised genus which occupies an isolated position.

SUMMARY

The cytology of *Ceratopteris thalictroides* is described. It has a chromosome number of $n = 77$ and $2n = 154$. The chromosomes are large in size in spite of the high number, and in this respect recall the condition in *Psilotum* and *Angiopteris*.

The systematic position of *Ceratopteris* is discussed in the light of cytological data of supposedly related genera and it is shown that Copeland's treatment of the genus as the only representative of the family, Parkeriaceæ, appears to be the most satisfactory.

ACKNOWLEDGEMENT

The author wishes to express his indebtedness to Prof. A. Abraham for valuable guidance and encouragement. His thanks are also due to the Ministry of Education, Government of India, for the award of a Senior Research Scholarship.

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EXPLANATION OF PLATE XII

FIG. 1. *Ceratopteris thalictroides* (L.) Brongn. Root tip squash showing a somatic number of $2n = 154$, × 1,200.

FIG. 2. Meiosis in *Ceratopteris thalictroides*, 77 bivalents are clearly seen, × 1,500.

FOSSIL SILICOFLAGELLATES FROM COLEBROOK AND NANCOORI ISLANDS

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INTRODUCTION

THE Silicoflagellates constitute a very small group having only a few genera. These are known from the Cretaceous to the present day (Fritsch, 1935, p. 558) and their distribution through the geological period is of considerable significance and is often reckoned as evidence in deciding the geological age of any particular deposit.

The silicoflagellates have been recorded from various parts of the world. From India Ehrenberg (1851, 1854) has recorded a few forms from the Nancoori fossil deposits in the Nicobars. Recently Jacob and Shrivastava (1952) have recorded a *Dictyocha* (D. sp.) from fossil deposits in the Colebrook Island in the Ritchie's Archipelago of the Andamans.

The Director. Geological Survey of India, kindly sent the authors some material from the Colebrook Island fossil deposits. A study of this material revealed a few interesting forms. The writers had also an opportunity of studying the original diatom slides prepared from the Nancoori deposits, collected by Grunow and distributed by Cleve and Möller (1878, Slide Nos. 162, 163). The writers found in these two slides, in addition to the diatoms, a number of silicoflagellates also. The silicoflagellates from the Nancoori Deposits are also included in this paper.

DESCRIPTION OF THE SPECIES

Mesocena Ehrbg.

M. polymorpha Lemm., var. *triangula* (Ehrbg.) Lemm.

(Text-Fig. 7)

Gemeinhardt, *Silicoflagellatæ*, 29, fig. 12 *c*, 1930.

Basal ring somewhat triangular with convex sides; angles with three short spines, 3·5–5 μ long, distance between neighbouring spines 42–47 μ; surface rough, ornamented with small protuberances (Plate XIII, Fig. 1).

Nancoori deposit.

Only a single specimen of this species has been observed in Cleve and Möller's Slide No. 163.

M. polymorpha Lemm., var. *quadrangula* (Ehrbg.) Lemm.

(Text-Figs. 1, 3, 5)

Gemeinhardt, *Silicoflagellatæ*, 29, fig. 13, 1930.

Basal ring roughly quadrangular with slightly convex sides, 51–66 μ diameter; surface rough, ornamented with small protuberances; sides 39–42·5 μ long; spines 3–6 μ long (Plate XIII, Fig. 2).

Nancoori deposit.

In one specimen a long narrow inward projection is seen from one of the sides. Of interest is the form in Fig. 5, which simulates var. *triangula* but has a fourth very small spine.

Dictyocha Ehrbg.

D. tricantha Ehrbg., f. *minor* Schulz.

(Text-Fig. 2)

Gemeinhardt, *Silicoflagellatæ*, 40, fig. 29 *a*, 1930.

Basal ring triangular, sides convex slightly depressed in the middle, one side 19–20 μ long; the angles produced into spines; spines up to 8 μ long; chambers three, subequal in size (Plate XIII, Fig. 3).

This species occurred only sparsely in the Colebrook material.

D. fibula Ehrbg.

Gemeinhardt, *Silicoflagellatæ*, 47, 1930.

Basal ring quadrangular, rhombic, oval or almost orbicular; angles produced into four spines in two opposite pairs; spines up to 10 μ long; on the basal ring usually four small inwardly projecting spines present; surface smooth or rough; four basal rods or arms meeting in pairs and connected by a transverse bar; basal ring with four chambers, of which two are usually smaller than the opposite pair.

D. fibula Ehrbg. and *D. fibula* f. *aspera* Lemm. have been earlier recorded from Nancoori. These forms have not been seen in the present investigation.

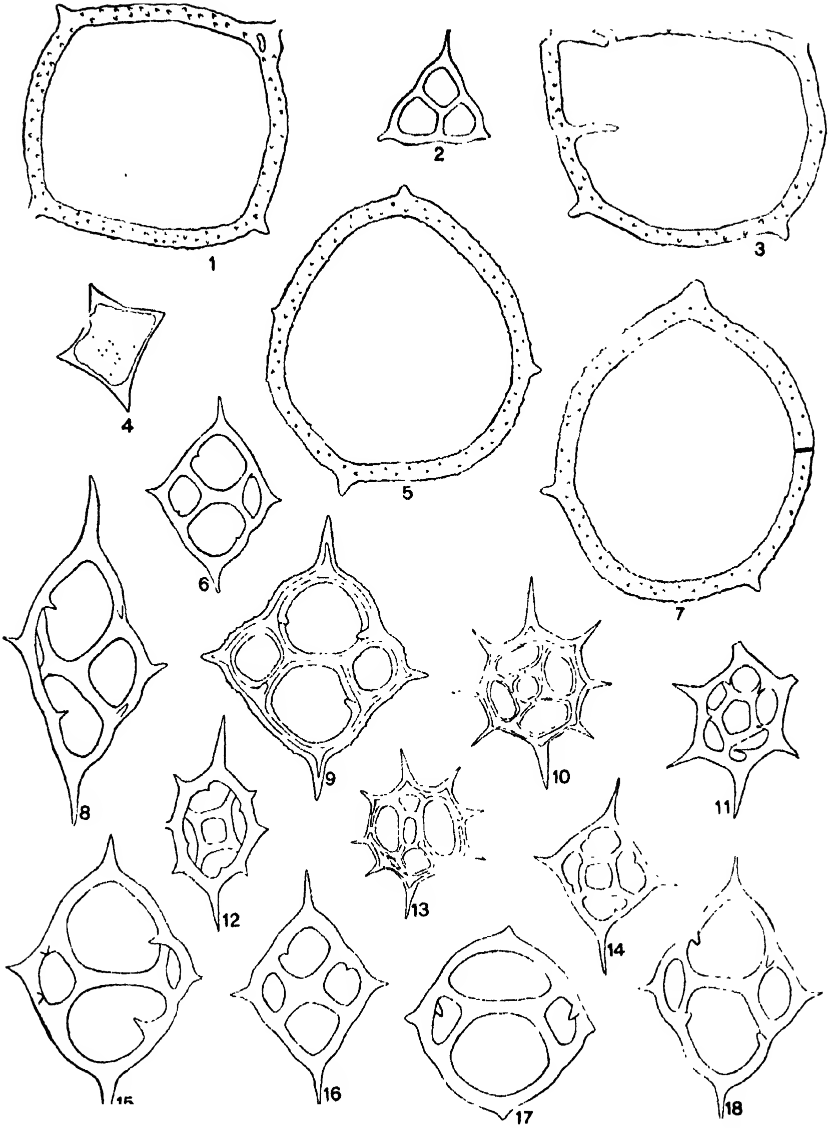
D. fibula Ehrbg., f. *rhombica* Schulz.

(Text-Figs. 6, 8, 9, 15–18)

Gemeinhardt, *Silicoflagellatæ*, 50, fig. 40, 1930.

Basal ring rhombic, 27–39 μ long and 20–35 μ broad; angles produced into four spines in two opposite pairs, spines 3–10 μ long; on the basal ring four small spines; surface smooth or rough; the four rods of the basal ring meeting in pairs and united by a transverse rod in the direction of the shorter axis; basal ring with four chambers, of which two are smaller than the opposite pair (Plate XIII, Figs. 5, 6).

Nancoori and Colebrook deposits.



TEXT-FIGS. 1–18. Figs. 1, 3, 5. *Mesocena polymorpha* Lemm. var. *quadrangula.* (Ehrbg.) Lemm., from Nancoori (× 300). Fig. 2. *Dictyocha tricantha* (Ehrbg.) f. *minor* Schulz., from Colebrook Island (× 300). Fig. 4. *Dictyocha siderea* Schulz. var. *quadrata* Schulz., from Nancoori Island (× 300). Figs. 6, 8, 9, 15–18. *Dictyocha fibula* Ehrbg. f. *rhombica* Schulz., showing variations, Figs. 9 and 18 from Nancoori, and the rest from Colebrook Island (Figs. 8, 15, 17. × 430; Figs. 6, 9, 16, 18: × 300). Fig. 7. *Mesocena polymorpha* Lemm. var. *triangula* (Ehrbg.) Lemm., from Nancoori Island (× 300). Figs. 10, 12, 13. *Distephanus crux* (Ehrbg.) Haeckel var. *octacanthus* var. nov., from Nancoori Island (Fig. 12 shows 4 small spires on the inside of the basal ring), (× 300). Fig. 11. *Distephanus speculum* (Ehrbg.) Haeckel, from Nancoori Island (× 300). Fig. 14. *Distephanus crux* (Ehrbg.) Haeckel, from Nancoori Island (× 300).

This form is very variable. Of interest is the form represented in Text-Fig. 17, which is very nearly round. It resembles very much forma *rotundata* Schulz., but differs in having four spines instead of two. Of similar interest is the form in Text-Fig. 16 (*cf.* Gemeinhardt, 24, fig. 8 *a*).

D. siderea Schulz. var. *quadrata* Schulz.

(Text-Fig. 4)

Gemeinhardt. *Silicoflagellatæ*, 56, fig. 48. 1930.

Basal ring four-sided, size 13×17 μ; spines four, short, 3–5 μ long; the central plate covered with numerous minute irregularly arranged granules (Plate XIII, Fig. 4).

Nancoori deposit.

A single specimen of this was found inC leve and Möller's Slide No. 163. This specimen differs from the type in having a smaller basal ring and shorter spines.

Distephanus Haeckel

D. crux (Ehrbg.) Haeckel

(Text-Fig. 14)

Gemeinhardt, *Silicoflagellatæ*, 58, fig. 49. 1930.

Basal ring rhombic to elliptical, diameter 18–24 μ; end-spines 5–10 μ long; four small inwardly projecting spines; apical ring quadrangular; basal ring and apical ring connected by four silicate rods, forming four subequal basal chambers; surface smooth (Plate XIII, Fig. 7).

Nancoori deposit.

D. crux (Ehrbg.) Haeckel var. *octacanthus* var. nov.

(Text-Figs. 10, 12, 13)

Annulus basalis octogonus, 19–26×15·5–20·5 μ, octo spinis radiantibus ornatus, quarum duo longiores sunt cæteris; longiores spinæ 8·5–10 μ longæ, breviores vero 3·5–5 μ longæ; annulus basalis 4-locularis; annulus apicalis quadratus; facies levis.

Typus lectus in Nancoori, et positus in Herb. Crypt. Mus. Hist. Nat., Paris (Cleve and Möller sub-numero 163).

Basal ring octagonal, somewhat longer in the direction of the longer spines, size 19–26×15·5–20·5 μ, with eight radial spines, two opposite ones longer than the other six; the longer spines 8·5–10 μ long, and the shorter spines 3·5–5 μ long; basal ring with four chambers; apical ring quadrate; surface smooth (Plate XIII, Figs. 8, 9).

Nancoori deposit: type in Cleve and Möller, Slide No. 163 in Herb. Crypt. Mus. Hist. Nat., Paris.

This variety by its characteristic eight spines is easily distinguished from the other known varieties of *Distephanus crux*.

D. speculum (Ehrbg.) Haeckel

(Text-Fig. 11)

Gemeinhardt *Silicoflagellatæ*, 61, 1930.

Basal ring nearly round, six-sided, 19–24 μ long and 17–19 μ broad; produced into six spines of which two are longer (8·5–15 μ) and four shorter (5–8·5 μ); equal number of small spines inwardly projecting from the sides; basal ring with 5–7 chambers.

Nancoori deposit.

The present form is somewhat different from the type. The number of chambers in the basal ring has been observed to vary from 5–7, though there are only six long spines as in the type. The apical ring has a single chamber as in the type.

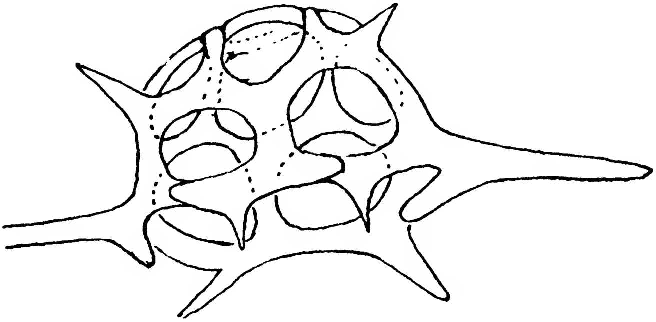
Cannopilus Haeckel

C. hemisphæricus (Ehrbg.) Haeckel

(Text-Fig. 19)

Gemeinhardt, *Silicoflagellatae*, 76, fig. 63, 1930.

Basal ring hexagonal, about 23·8 μ broad; capsule hemispherical, with spines at the angles, the erect spines longer, 17 μ long, the others short, up to 7·0 μ long; apical ring many chambered, with short spines.



TEXT-FIG. 19. *Cannopilus hemisphæricus* (Ehrbg.) Haeckel from Nancoori Island (×1360).

Nancoori.

A single distinct specimen of this species was found in Cleve and Möller's Slide No. 162. The form agrees very closely with the type, but is somewhat smaller in size. This species has so far not been reported from Nancoori.

DISCUSSION

Three species and one form have been previously known from the Nancoori deposits, *viz*.. *Mesocena polymorpha* var. *quadrangula*, *Dictyocha fibula*, *D. fibula* f. *aspera* and *Distephanus speculum*. The present study has revealed three more species and one new variety from the same area. *Dictyocha* sp. (= *D. fibula*) was the only species known from the Colebrook Island. One more interesting species, *D. tricantha* was found in the Colebrook deposit in the present investigation.

Nancoori deposits have been known to belong to the Miocene period. Some discussion has been going on regarding the age of the Colebrook Island deposits. According to Oldham (1885), Gee (1926) and Jacob and Shrivastava (1952) it belongs to the Miocene. S. R. N. Rao (1942) suggests a late Oligocene or an early Miocene age. Boileau (1950 *ex*. Jacob and Shrivastava, 1952; see also table in Jacob, 1954, p. 399), however, refers these to the pre-upper (or lower) Oligocene.

The above conclusions on the age of the Colebrook deposit are mostly based on evidence from the Radiolarian and Foraminiferous fossils. However, in recent studies great stress is laid on evidence from the distribution of Silicoflagellates though not to the exclusion of evidence from the Radiolarians, Diatoms. etc. In fact, Hanna (1927–28) says, "...... the Silicoflagellata as a group furnish most trustworthy horizon-markers." Silicoflagellates have been known only since the Cretaceous. Forms such as *Dictyocha tricantha* have been generally regarded as more primitive (Fritsch, 1935, p. 558). Haeckel (1887), however, suggests that *Mesocena* is the more primitive. Hanna (1927/28, p. 260) has very correctly pointed out that *Mesocena* is found only later than *Dictyocha*, which alone is found in the Cretaceous.

The genus *Mesocena* is definitely known to occur in the Miocene deposits of Nancoori. These have not been found in the Colebrook deposit in spite of careful search. Again in the Colebrook deposit is found *Dictyocha tricantha* which has not been observed in the Nancoori material. How the absence of the one and the presence of the other helps in finally deciding the age of the deposit is not known. But these, at any rate, suggest that the two deposits are not of simultaneous origin, and that the Colebrook deposit is probably earlier in origin than the Nancoori. This conclusion supports S. R. N. Rao's view that the Colebrook deposits may be of early Miocene or Oligocene age.

In this connection it may be mentioned that there is considerable similarity between the diatom floras of Colebrook and Nancoori deposits. Of interest is the occurrence of the very rare diatom *Coscinodiscus paleaceus* which was first described from Nancoori (Grunow, in *Van Heurck*, 1880–85). Frequency in the occurrence of this species is greater than in the Nancoori slides. This diatom has since been reported from the Naparima beds of Trinidad (Rattray, 1889). From these beds, a single Silicoflagellate, *viz*.. *Distyocha fibula*, has been described. No other Silicoflagellates appear to have been reported from Naparima beds.

Surprisingly enough, the same stratigraphical problem as regards the Colebrook deposits exists in the Naparima deposits also. Boileau (see Jacob, 1954) thinks that no real Miocene beds are present in the Andamans and suggests an Oligocene age, while others suggest a Miocene age. Similar view has been expressed in the case of Naparima too by Dall (see Reed, 1921. p. 183). According to him the Naparima formation belongs to the Upper-Oligocene and he denies the presence of any true Miocene beds in Trinidad. Recently. however, Waring (see Reed, 1946, p. 270) suggested a Lower Middle Miocene derivation.

It would be difficult to make any affirmative conclusion regarding the age of the Colebrook Island deposit. The writers can only repeat the suggestion that they made earlier in the discussion that these beds are of an earlier origin than the Miocene Nancoori.

SUMMARY

An account is given of fossil silicoflagellates from deposits in Nancoori and Colebrook Islands. In all are described eight forms from Nancoori and two from Colebrook Island. One new variety *Distephanus crux* var. *octacanthus* is described from the Nancooris.

It is suggested that the Colebrook Island may belong to an earlier age than the Miocene Nancoori.

ACKNOWLEDGMENTS

Dr. P. Bourrelly of Lab. Crypt. Mus. Hist. Nat., Paris, very kindly sent Cleve and Möller's slides of Nancoori deposit. Rev. Fr. H. Santapau very kindly rendered into Latin the diagnosis for *Distephanus crux* (Ehrbg.) Haeckel var. *octacanthus*. Prof. W. D. West has very kindly lent us some of the literature. To these gentlemen the authors express their grateful thanks. The authors wish to gratefully acknowledge the help rendered by the Director, Geological Survey of India, by way of material and literature.

The authors are grateful to the Ministry of Education, Government of India, and the authorities of the University of Saugar who very kindly granted special funds for literature, etc.

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EXPLANATION OF PLATE

PLATE XIII

FIG. 1. *Mesocena polymorpha* Lemm. var. *triangula* (Ehrbg.) Lemm., from Nancoori Island (× 520).

FIG. 2. *Mesocena polymorpha* Lemm. var. *quadrangula* (Ehrbg.) Lemm., from Nancoori Island (× 520).

FIG. 3. *Dictyocha tricantha* Ehrbg. f. *minor* Schulz., from Colebrook Island (× 1,060).

FIG. 4. *Dictyocha siderea* Schulz. var. *quadrata* Schulz., from Nancoori Island (× 650).

FIGS. 5, 6. *Dictyocha fibula* Ehrbg. f. *rhombica* Schulz., Fig. 5 from Colebrook and Fig. 6 from Nancoori Islands (× 650).

FIG. 7. *Distephanus crux* (Ehrbg.) Haeckel from Nancoori Island (× 1,060).

FIGS. 8 & 9. *Distephanus crux* (Ehrbg.) Haeckel var. *octacanthus* var. nov. from Nancoori Island (× 650).

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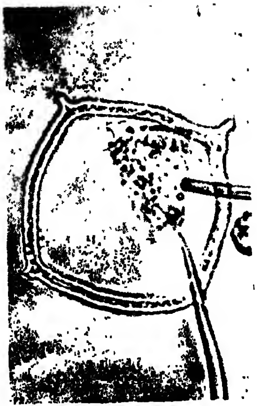

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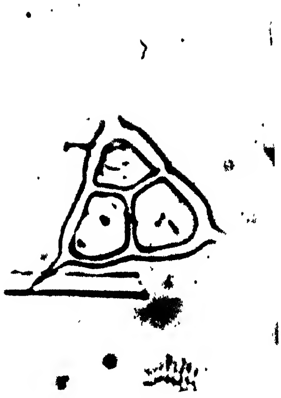

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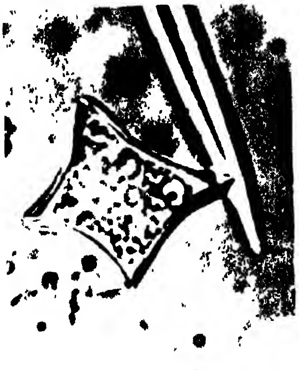

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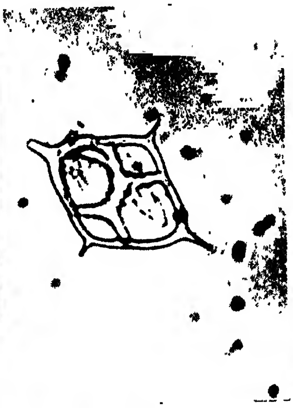

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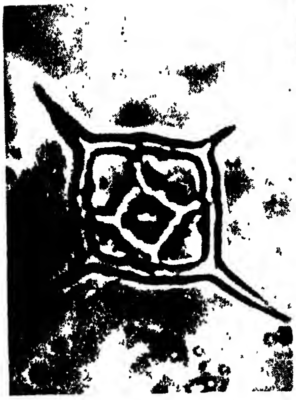

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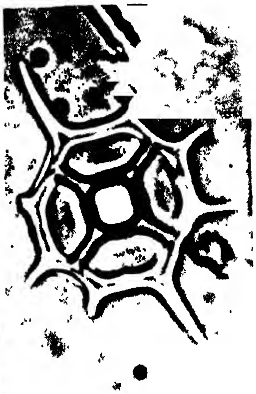

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T. V Desikachary & C L Maheshwari

ANNUAL FORAY OF THE INDIAN BOTANICAL SOCIETY TO BUND BARETA, AGRA, ON JANUARY 7, 1956

By H. Santapau, S.J., F.N.I.

(Received for publication on May 15, 1956)

The annual excursion of the Indian Botanical Society was held this year in the neighbourhood of Agra; the spot selected was Bund Bareta, about 45 miles from Agra. A good number of members joined the excursion, among them professors and research students of Agra. Banaras and Bombay Universities; the outing was a great success from every point of view.

On leaving the railway station, the party traversed a stretch of sandy fields, which during the more favourable part of the year seem to be under cultivation. Some distance from the station there is a small hill of great interest; the plains at the foot of the hill are barren waste lands, where intensely xerophytic plants seem to dominate the field; we noticed large clumps of *Zizyphus*, dense clumps of *Sericostoma pauciflorum*, bushes of *Capparis decidua* and *Leptadenia pyrotechnica*; in the middle of these spiny plants some smaller, slender plants found refuge and protection against grazing animals.

In the open fields a few notable plants were found: *Arnebia hispidissima*, *Polycarpæa corymbosa*, etc. These plants showed stout, straight roots, out of all proportion to the overall size of the plant.

The hill is rather rocky and dry; under the shelter of rocks a few fresh plants managed to find refuge, among them some of the commoner ferns of the area (*Actinopteris*, etc.). The trees on the side of the hill facing the station are small, rather stunted and woody. We noticed *Anogeissus pendula*, *Gymnosporia spinosa*, *Acacia arabica*, etc., the first of these being the more common. On the very top of the hill *Anogeissus* assumes a rather striking cushion form; the tree grows more or less flat on the ground, about 30–50 cm. high, branches spreading horizontally and rather dense, so that each tree forms a solid cushion on which it is possible to stand quite comfortably.

For the rest the components of the drier parts of the country about Bund Bareta showed a striking similarity to the plants seen, *e.g.*, on the south-western parts of Saurashtra.

The slopes of the hill facing the large water reservoir are even drier than the northern ones. Climbing down the slopes became rather difficult on account of the steep nature of the slope and of the many loose stones covering the ground. There are fewer trees on this side of the hill, but at the base there is a group of *Wrightia* that deserve attention; the trees at first appeared like some intermediate form between *W. tinctoria* and *W. tomentosa*, but are definitely not *W. tomentosa*.

In the neighbourhood of the water reservoir, we found a number of the commoner weeds of cultivated fields (*Anagallis*, *Veronica*, *Ageratum*, etc.). The large deep pools below the reservoir showed some interesting water plants, mainly water ferns, and dense masses of *Typha*, but these plants could not be collected on account of the depth of the pools.

In the following list, plants are given in alphabetical order, the names of the families being left out for the sake of brevity; after the name of each plant, reference is made to Duthie's " Flora of the Upper Gangetic Plain" in brackets. Where nomenclatural changes have been introduced, the correct name is given first, then the name of Duthie's Flora; on purpose the synonymy of plants has been left out. Interested readers may be referred to several works by the author, among them: " Flora of Khandala " in *Rec. bot. Surv. India* **16** (1); " Plants of Saurashtra—A Preliminary List ", Rajkot, 1953; and several other minor papers. The numbers given after some of the plants refer to the collections made by my assistant, N. A. Irani, B.Sc., and preserved in Blatter Herbarium, Bombay.

1. *Acacia arabica* Willd. (Duthie **1**: 314).

Occasional on hill slopes; many trees at the further end of the large reservoir; some large trees in cultivated fields along the road.

2. *Acacia leucophlæa* Willd. (**1**: 315).

Saw one tree with plenty of fruit, near road at foot of hill.

3. *Acacia senegal* Willd. (**1**: 317).

Rare; seen on the slopes of the hill.

4. *Achyranthes aspera* Linn. (**3**: 18).

Occasional in fruit and leaf, on plains and hill slopes.

5. *Actinopteris* spec.

Sterile fronds only, in sheltered spots on upper parts of hill, rather common.

6. *Adhatoda vasica* Nees.

Justicia adhatoda Linn. (**2**: 207).

Common and abundant, small clumps on the hill; in flower and fruit; only about 50–75 cm. high. (I. 1642).

7. *Ageratum conyzoides* Linn. (**1**: 443).

In moist cultivated fields below reservoir; flowers uniformly light blue only.

8. *Albizzia lebbeck* Benth. (**1**: 320).

Planted along roads, with plenty of fruits; large trees.

9. *Anagallis arvensis* var. *cærulea* Gren. & Godr.
Anagallis arvensis Duthie. non Linn. nisi pro parte. (**2**: 6).
In cultivated fields below reservoir, locally rather abundant, flowers bright blue. (I. 1639).

10. *Andrographis echioides* Nees. (**2**: 197).
On higher slopes, locally in small clumps, in fruit; 10-20 cm. high only.

11. *Andrographis paniculata* Nees. (**2**: 196).
On the upper parts of the hill slopes; rather similar in general appearance to *Peristrophe*, from which the type of corolla at once distinguishes it.

12. *Anisochilus carnosus* Wall. (**2**: 240).
Several dry plants with clear remains of inflorescence, but leafless, on upper part of hill (I. 1645).

13. *Annona squamosa* Linn. (**1**: 23).
Small trees, cultivated below reservoir.

14. *Anogeissus pendula* Edgew. (**1**: 339).
About the commonest tree on the slopes of the hill, in fruit; forming cushions on the very highest part of hill. (**1**: 1649).

15. *Argemone mexicana* Linn. (**1**: 36).
Common and rather abundant along the road from the village to the hill, often in flower. This plant seems to be larger and greener than in Bombay.

16. *Aristolochia indica* Linn. (**3**: 44).
Large climber in fruit and leaf; collected seeds for planting. (I. 1648).

17. *Arnebia hispidissima* DC. (**2**: 97).
Flowers yellow; leaves forming rosette on ground; tap root stout and long. In open sandy fields (I. 1657).

18. *Azadirachta indica* Juss.
Melia azadirachta Linn. (**1**: 150).
Only seen in leaf; planted along roads, much damaged from constant cutting of branches.

19. *Barleria prionitis* Linn. (**2**: 200).
Small plants; remains of flowers; small clumps about the middle of the hill.

20. *Bidens* spec.
Collected several dry plants in fruit, leafless, 30-45 cm. high; about the middle of the slopes it is locally abundant.

21. *Blainvillea latifolia* (L. f.) DC.
B. rhomboidea Cass. (**1**: 469).
Dry plants in fruit, abundant in plains, among clumps of spiny plants.

22. *Blepharis maderaspatensis* Roth.
B. bœrhaviæfolia Pers. (**2**: 183).
On the slopes of hill, fairly common, in flower.

23. *Blepharis molluginifolia* Pers. (**2**: 183).
At the foot of the hill and on the lower slopes.

24. *Blumea* spec.
In leaf only; strongly scented and rather hairy. Common on plains, scarce on hill.

25. *Borreria hispida* (L.) Schum.
Spermacoce hispida Linn. (**1**: 429).
A few prostrate plants, mostly dry, some in fruit; plains.

26. *Borreria stricta* (L. f.) Schum.
Spermacoce stricta Linn. f. (**1**: 429).
Common and abundant on hill slopes, dry plants; but the fruit and leaves are typically those of *Borreria stricta* and not of *Anotis* spec.

27. *Calotropis procera* R. Br. (**2**: 48).
About 1·5 m. high, in flower; common on plains, rare on hill.

28. *Capparis decidua* (Forsk.) Pax.
C. aphylla Roth. (**1**: 53).
On plains, in waste lands, in clumps up to 1·5 m. high, about 1 m. diam.; leafless. Many interesting unarmed plants seem to find shelter from grazing animals under this plant.

29. *Capparis zeylanica* Linn.
C. horrida Linn. f. (**1**: 53).
Subscandent shrubs in leaf only, on hill; rare.

30. *Cardiospermum halicacabum* Linn. (**1**: 178).
A few plants in fruiting condition on plains and hill; rare.

31. *Carica papaya* Linn. (**1**: 383).
Flowers and fruits; cultivated in garden below reservoir.

32. *Cassia absus* Linn. (**1**: 294).
Very small plants in flower; rare; near base of hill.

33. *Cenchrus setigerus* Vahl.

C. biflorus of the Fl. Brit. Ind., non Roxb.

Upper slopes and top of hill, not common. One of the few grasses seen to-day.

34. *Chenopodium album* Linn. (**3**: 22).

Fairly common on plains, rare on hill. (I. 1658).

35. *Cissampelos pareira* Linn. (**1**: 30).

Large clump at the foot of hill near road, in leaf only.

36. *Clerodendrum phlomidis* Linn. f. (**2**: 225).

Large shrubs, about 3 m. high. masses of flowers; on hedge at foot of hill.

37. *Clitoria ternatea* Linn. (**1**: 230).

Dry plants in leaf and fruit, rare; on plains and lower slopes. The fruits seem rather small for this species.

38. *Cocculus hirsutus* (Linn.) Diels.

C. villosus DC. (**1**: 28).

From the middle of the hill upwards, common; some large plants in fruit (black). (I. 1641).

39. *Corchorus æstuans* Linn.

C. acutangulus Lamk. (**1**: 121).

Dry plants, plenty of fruits; below reservoir, 1 m. high.

40. *Cordia dichotoma* Forst. f.

C. myxa auct., non Linn. (**2**: 82).

Saw several trees, about 8 m. tall, along road near reservoir.

41. *Cordia rothii* R. & S.? (**2**: 85).

Small tree, near top of hill, in leaf only.

42. *Coriandrum sativum* Linn. (**1**: 397).

In cultivated fields, cultivated or escaped; in flower.

43. *Coronopus didymus* (Linn.) Sm.

Senebiera didyma Pers. or *S. pinnatifida* DC.

Common in moist ground, prostrate or suberect, slender herb. (I. 1635). Not mentioned by Duthie.

44. *Dalbergia sissoo* Roxb. (**1**: 264).

About the largest trees in the plains; generally cultivated and often in fruit.

45. *Datura innoxia* Mill.

D. metel auct., non Linn. (**2**: 131).

Shrubby, about 1 m. tall, flowers pure white; along the road near cultivated fields of village.

46. *Daucus carota* Linn. (**1**: 398).

Near the railway line; flowers pinkish; cultivated and escaped.

47. *Dichrostachys cinerea* Wt. & Arn. (**1**: 310).

Small shrubs, only 0·75–3 m. high; on plains near base of hill and on lower slopes.

48. *Dicoma tomentosa* Cass. (**1**: 487).

On the very top and upper slopes, fairly common; small plants only 5–10 cm. high, in fruit and leaf. Rare.

49. *Digera muricata* (Linn.) Mart.

D. arvensis Forsk. (**3**: 8).

Flowers and fruits, rare; saw some plants on bund of cultivated field near village.

50. *Echinops echinatus* Roxb. (**1**: 480).

Along the plains or on the lower slopes of the hill; rather scarce, in fruit.

51. *Elytraria acaulis* (Linn. f.) Lindau.

Tubiflora acaulis in Kuntze (**2**: 180).

The generic name *Elytraria* has been conserved under No. 7908 against the older one, *Tubiflora* (see *Internat. Code Bot. Nomencl.*, 1952, p. 134). A rare plant; seen in bud and leaf under shrubby plants on top of hill; spikes up to 12 cm. long.

52. *Euphorbia hirta* Linn. (**3**: 80).

Common on top of hill, not so common on the slopes, very rare on the plains.

53. *Euphorbia neriifolia* Linn. (**3**: 76).

In leaf; not common; lower part of hill.

54. *Euphorbia thymifolia* Linn. (**3**: 81).

On ground below reservoir, along paths, etc. Abundant, locally in flower and fruit.

55. *Evolvulus alsinoides* Linn. (**2**: 104).

In flower; erect herbs on slopes, in sheltered spots; on rocks on the top of the hill it is prostrate. Fairly common.

56. *Ficus religiosa* Linn. (**3**: 150).

Along the roads at the base of the hill near the reservoir.

57. *Fumaria indica* Pugsl.

F. parviflora Lamk. (**1**: 37).

A weed of cultivated fields; in fields of *Brassica nigra* near station. (I. 1634).

58. *Glossocardia bosvallea* (L. f.) DC.

G. linearifolia Cass. (**1**: 471).

On the upper slopes of hill, in very dry spots. (I. 1647).

59. *Grewia orbiculata* Rottl. (**1**: 115).

Saw several trees on the upper slopes of the hill, in leaf only; identification uncertain.

60. *Grewia damine* Gaertn.

G. salvifolia auct. non Linn. (**1**: 116).

Several trees on slopes, but identification uncertain.

61. *Guazuma tomentosa* H.B.K.

Not in Duthie's Flora: this tree was noted by Prof. R. Misra.

62. *Gymnosporia spinosa* (Forsk.) Fiori.

Celastrus senegalensis Lamk.? (**1**: 159).

I am not satisfied that Lamark's plant is identical with the Indian spiny shrub, hence the name of Lamark has not been adopted. Shrubby, 0·75–4 m. tall, armed with plenty of spines; plenty of fruits on some plants. Common just at the foot of the hill (I. 1650).

63. *Helicteres isora* Linn. (**1**: 102).

On hill slopes, common; some plants in fruit; small shrub.

64. *Heliotropium eichwaldi* Steud. (**2**: 92).

Erect, small herb, with white flowers; typical teeth between the corolla lobes present. Rare. In sandy soil on plains.

65. *Heliotropium indicum* Linn. (**2**: 90).

In flower and leaf, on moist soil near the reservoir.

66. *Hibiscus micranthus* Linn. f. (**1**: 89).

On plains, among spiny shrubs, fairly common, 1–2 m. high; mostly in fruit; flors. fleshy pink, 5–6 mm. diam.

67. *Holoptelea integrifolia* Planch. (**3**: 119).

Planted along roads, large trees, near road leading to reservoir.

68. *Indigofera cordifolia* Heyne (**1**: 250).

Saw several plants in fruit on the higher parts of the hill.

69. *Indigofera trita* Linn. f. (**1**: 252).

On slopes near top of hill, a few plants only.

70. *Ipomœa cairica* (Linn.) Sw.

I. palmata Forsk.

On garden hedge below reservoir, cultivated and running wild; plenty of flowers. Not in Duthie's Flora.

71. *Ipomœa pes-tigridis* Linn. (**2**: 116).

Abundant, but dry, on clumps of *Leptadenia*, etc.; fruits and bracts typical and common.

72. *Ipomœa sindica* Stapf. (**2**: 113).

On plains and lower slopes of hill, rare. Flower and fruit.

73. *Justicia simplex* Don. (**2**: 210).

In open fields, on the plains; flowers rather light in colour; small prostrate plants with erect inflorescence.

74. *Kickxia ramosissima* Janchen.

Linaria ramosissima Wall. (**2**: 140).

Occasional on hill, in flowers and leaves.

75. *Lantana camara* L. var. *aculeata* Mold.

L. camara auct., non Linn. nisi partim. (**2**: 216).

Along hedges in the plains; also near the reservoir; flowers of the paler type; some plants with masses of fruits. Rare on hill. The true *L. camara* Linn. has no spines on stems, etc.

76. *Lantana indica* Roxb. (**2**: 216).

Undershrub with white flowers and unarmed; saw one plant at the foot of the hill.

77. *Lactuca runcinata* DC.? (**1**: 490).

Small plants in leaf only, in open sandy fields at the base of hill.

78. *Lepidagathis trinervis* Wall. (**2**: 204).

On the plains it is a rare plant; on the hill slopes rather common in flower and leaf (I. 1654).

79. *Leptadenia pyrotechnica* (Forsk.) Decne.

L. spartium Wt. (**2**: 63).

Along the plains near the base of the hill this plant is common and abundant. forming large and dense clumps; plenty of flowers and some fruit (I. 1607, 1629).

80. *Lindenbergia indica* (Linn.) O. Kuntze.

L. urticæfolia Lehm. (**2**: 160).

In shaded spots, small plants in flower and leaf. Rare.

81. *Malvastrum tricuspidatum* Gray. (**1**: 79).

Very similar to *Sida*, but flowers larger, yellow; on moist ground below reservoir.

82. *Mangifera indica* Linn. (**1**: 189).

Several large trees near reservoir. obviously cultivated.

83. *Melilotus indica* All. (**1**: 208).

In moist ground below reservoir, flowers yellowish; rare.

84. *Melothria maderaspatana* Cogn. (**1**: 379).

Noticed several plants climbing on spiny clumps on plains; fruits fresh, seeds only 2–3, but typical.

85. *Momordica charantia* Linn. (**1**: 369).

One fresh plant in flower and leaf, on plains; not seen on hill.

86. *Musa paradisiaca* Linn. (**3**: 238).

Cultivated in garden below reservoir.

87. *Nyctanthes arbor-tristis* Linn. (**2**: 24).

In fruit, in garden, near reservoir.

88. *Ocimum americanum* Linn.

O. canum Sims. (**2**: 234).

Abundant on plains near cultivated fields, rare on hill; flowers white, leaves strongly scented. (I. 1656).

89. *Oxalis corniculata* Linn. (**1**: 130).

In moist ground near reservoir. Common herb, rarely in flower.

90. *Pedalium murex* Linn.

Said to be abundant at foot of hill, but I did not see it myself. Not in Duthie's Flora.

91. *Pedilanthus tithymaloides* Poit. (**3**: 116).

Cultivated in garden near reservoir; leaves only.

92. *Pergularia dæmia* (Forsk.) Blatt. & McC.

Dæmia extensa R. Br. (**2**: 52).

In fruit, on plains; rare. (I. 1608).

93. *Peristrophe bicalyculata* Nees. (**2**: 210).

In plains and on lower slopes of hill, in flower and fruit; occasionally mixed with *Andrographis paniculata*, from which it is clearly distinguished by the structure of the corolla.

94. *Polycarpæa corymbosa* Lamk. (**1**: 68).

On plains, in sandy fields; rare.

95. *Polygala erioptera* DC. (**1**: 62).

Flowers purple; fruits present with leaves. Saw in all four specimens, one on plains, others on hill slopes (I. 1644).

96. *Polygonum plebeium* R. Br. (**3**: 31).

Whole plant deep red; plenty of white hairs at the nodes; common on higher parts of hill.

97. *Polygonum barbatum* Linn. (**3**: 36).

Axillary ochrea with large hairs on upper edge; flowers white or nearly so. Common near water below reservoir.

98. *Pupalia lappacea* Juss. (**3**: 19).

Fairly common on plains, dry; on hill slopes, fresh plants.

99. *Ricinus communis* Linn. (**3**: 113).

Cultivated or escape; only seen near cultivated fields.

100. *Rosa* spec.

Cultivated below reservoir; flowers highly scented.

101. *Saccharum spontaneum* Linn.

On plains, along dry ditches, in large clumps. Dry plants.

102. *Salmalia malabarica* Schott. & Endl. ?

Bombax malabaricum DC. (**1**: 98) ?

Among the largest trees along road near reservoir; plenty of leaves, no sign even of buds. Identification probable only.

103. *Salvadora persica* Linn. (**2**: 28).

Noted by Prof. R. Misra; I did not see the tree.

104. *Sericostoma pauciflorum* Stocks.

Not in Duthie's Flora; yet the plant seems to be indigenous to judge from its abundance. Very abundant on plains at the base of hill, forming dense low cushions, often in almost pure. stands (I. 1652).

105. *Sesamum indicum* Linn. (**2**: 175).

Dry plants with remains of fruit, on upper slopes of hill, 50–70 cm. high, unbranched; rare.

106. *Sida grewioides* G.P. & R. (**1**: 81).

Common in flower and fruit; leaves small. Plains near base of hill. (I. 1653).

107. *Solanum nigrum* Linn. (**2**: 124).

Large plants, deep green leaves, white flowers, green fruits; fairly abundant in cultivated field below reservoir.

108. *Sonchus oleraceus* Linn. (**1**: 492).

Below reservoir in moist spots, in flowers; stout plants. (I. 1638).

109. *Spergula arvensis* Linn. (**1**: 67).

In cultivated fields below reservoir. (I. 1637).

110. *Striga euphrasioides* Benth. (**2**: 157).

One plant in flower, several in fruit among grasses on plains and lower slopes.

111. *Tagetes erecta* Linn.? (**1**: 495).

Cultivated in garden near reservoir, in flower.

112. *Tephrosia purpurea* Pers. (**1**: 245).

On top of hill, and on slopes of South side, common and fairly abundant in fruit and leaf.

113. *Tephrosia villosa* Pers. (**1**: 245).

On the lower slopes on South side of hill, clumps of this plant in fruit.

114. *Trianthema decandra* Linn.

T. pentandra auct., non Linn. (**1**: 386).

On bunds of cultivated fields at base of hill; masses of fruits in leaf axils. Rare. (I. 1655).

115. *Tridax procumbens* Linn. (**1**: 475).

In flower and fruit, from the middle to the top of hill, fairly common and abundant.

116. *Trigonella* spec.

Noted by Miss D. Panthaki, B.Sc., in moist ground near reservoir.

117. *Triumfetta bartramia* Linn.?
T. rhomboidea Jacq. (**1**: 118)?
Occasional on plains and hill slopes: 25-60 cm. tall; the size and shape of fruits suggest *bartramia*, though the hairiness at the base of the fruit spines seems somewhat abnormal.

118. *Typha* spec. *elephantina* Roxb.? (**3**: 293).
Large masses in pond below reservoir in flower and fruit.

119. *Urginea indica* Kunth. (**3**: 264).
Bulb collected on hill; only one bulb seen.

120. *Vernonia cinerea* Less. (**1**: 441).
On plains and hill, fairly common; in flower and fruit.

121. *Veronica agrestis* Linn. (**2**: 154).
In moist ground below reservoir. rare; flowers white.

122. *Vicoa indica* (Linn.) DC.
V. auriculata Cass. (**1**: 464).
Flowers yellow; small plant, among *Zizyphus* clumps on plains; occasional on hill.

123. *Wedelia* spec. *wallichii* Less.? (**1**: 470).
Small herb, with yellow flowers: among *Capparis* and other spiny clumps on plains.

124. *Wrightia tinctoria* var. *rothii* Hook.
W. tinctoria R. Br., pro parte. (**2**: 38).
Trees 3-4 m. high, along the road and lower slopes on the further side of the hill. This tree shows a strange mixture of characters of *tinctoria* and *tomentosa*; the fruits are slender. double. as in *tinctoria*; the leaves are strongly pubescent and not acuminate, as in *tomentosa*. Identification certain. (I. 1627).

125. *Xanthium strumarium* Linn. (**1**: 467).
Long dense rows of this plant along the roads in the plains: not seen on hill. Noticed several small donkeys loaded with the fruits abundantly covering their hides.

126. *Zizyphus rotundifolia* Lamk. (**1**: 164).
On plains very common and abundant in almost pure stands, 30–90 cm. high. in dense clumps; occasionally in fruit. This plant is very rare on hill.

127. *Lochnera rosea* (Linn.) Reichenb.
Vinca rosea Linn.
Cultivated in garden below reservoir; flowers only purple, did not see the white-flowered variety.

STUDIES ON INDIAN *PORIA*

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Introduction

In the course of studies of wood-rotting fungi in the Herbarium of the Mycology Branch, Forest Research Institute, five species of *Poria* were encountered which have been found to be new records in this country. All the fungi have been collected from the temperate regions of the Himalayas in the divisions of Bashahr (Himachal Pradesh), Chakrata (Uttar Pradesh), Kulu and Seraj (Punjab) between altitudes of 6,000–10,000 feet. Like other Hymenomycetous flora of India, particularly from temperate and sub-tropical regions which are similar to that of temperate regions of Europe and America. these species of *Poria* are also of common occurrence in the U.S.A.

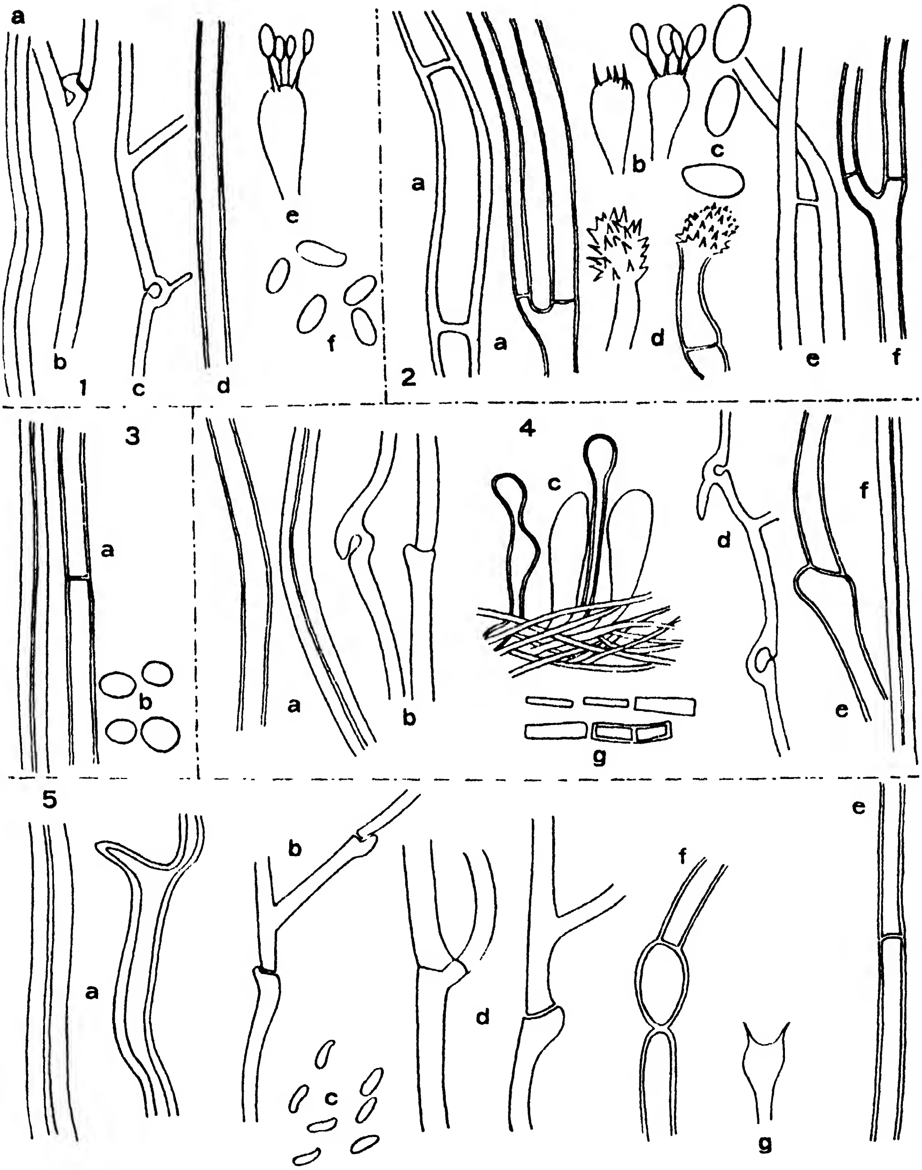
Complete morphological descriptions of these five species and cultural characters of four of them are given. The specimens examined under each fungus are listed along with the host, locality, date of collection and herbarium number (indicated in bold type). The cultures examined are from the National Type Culture Collection of wood-rotting fungi maintained in this laboratory.

Poria callosa (Fr.) Ckc. (Pl. XIV, Figs. 1-2)

Sporophore.—Annual, broadly effused, sometimes slightly raised at the margin, coriaceous to corky; margin white. narrow, sterile; subiculum white, less than 1 mm. thick, hyphæ of 2 types: (i) hyaline, thick-walled, aseptate, unbranched (Text-Fig. 1 *a*), abundant, 2·6–3·6 μ broad, (ii) hyaline, thin-walled. branched, septate with clamp connections (Text-Fig. 1 *b*), comparatively rare, 2·5 μ broad; tramal hyphæ similar to hyphæ in the subiculum; pore surface white to 'light buff' becoming 'light ochraceous buff' in older specimens, pore tubes 2–3 mm. long, pores round (Plate XIV, Fig. 2), 3-4 per mm., edges entire; spores hyaline, smooth. cylindric-ellipsoid, 7-9×2-3 μ (Lowe, 1946).

On dead *Picea morinda*, Mundali, Chakrata Division (Uttar Pradesh), June, 1951, **5525**; on logs of *Abies pindrow*, Banjar Range, Seraj Division (Punjab), November 1952, **6097** (*a*), **6099**.

Poria callosa is considered to be the resupinate form of *Trametes serialis* Fr. (Baxter, 1931; Cartwright and Findlay, 1946; Lowe, 1946), which also occurs in the Himalayas and both the species agree in their cultural characters. Interfertility tests were made between monospore cultures of *P. callosa* and *T. serialis* resulting in the formation of clamp-connections which confirm that they belong to the same species. Both *P. callosa* and *T. serialis* are widespread in the temperate Himalayas, and also of common occurrence in America and Europe.



TEXT-FIGS. 1–5. Fig. 1. *Poria callosa.* (*a*) thick-walled hypha from subiculum, (*b*) thin-walled hypha from the subiculum, (*c*) hypha from advancing zone of culture, (*d*) thick-walled hypha in culture, (*e*) basidium in culture, (*f*) basidiospores in culture, ×938. Fig. 2. *Poria corticola.* (*a*) thick-walled hyphæ from subiculum, (*b*) basidia, (*c*) basidiospores, (*d*) capitate cystidia, (*e*) thin-walled hypha and (*f*) thick-walled hypha in culture, ×938. Fig. 3. *Poria nigrescens.* (*a*) thick-walled hyphæ from the subiculum, (*b*) basidiospores, ×938. Fig. 4. *Poria versipora.* (*a*) thick-walled hyphæ from subiculum, (*b*) thin-walled hyphæ from subiculum, (*c*) terminally inflated hyphæ in the hymenium, (*d*) thin-walled hyphæ from advancing zone of culture, (*e*) hypha from aerial mycelium, (*f*) thick-walled hypha in culture, (*g*) oidia, ×938. Fig. 5. *Poria xantha.* (*a*) thick-walled hyphæ from subiculum, (*b*) thin-walled hyphæ from subiculum, (*c*) basidiospores, (*d*) thin-walled hyphæ in culture, (*e*) thick-walled hypha in culture, (*f*) chlamydospore, (*g*) basidium in culture, ×938.

Rot.—The fungus causes a brown cuboidal rot on conifers (Plate XIV, Fig. 1 *b*).

Cultural characters

Growth characters.—Growth slow, optimum between 23–25° C. (1·7 cm.), inhibiting at about 33–35° C. Advancing zone hyaline, appressed, abruptly changing to white. Mat white, appressed, felty, becoming pitted and corrugated to form an irregularly pored surface (2-4 weeks) practically extending over the whole of the mat. On gallic and tannic acid agars,* no diffusion zones, growth† 0·7 cm. each. On gentian violet agar growth good, media not discoloured.

Hyphal characters (Advancing zone).—Hyphæ hyaline, branched, septate with clamp-connections (Text-Fig. 1 *c*), 1·4–4·3 μ broad. Aerial mycelium: (i) hyphæ as in advancing zone; (ii) hyaline, thick-walled, unbranched, aseptate (Text-Fig. 1 *d*), 1·4–2·9 μ broad; (iii) Fruit-body: hyphæ as above, basidia clavate (Text-Fig. 1 *e*), 4·3–5·7 μ broad with 4 sterigmata bearing 4 basidiospores; basidiospores hyaline, thin-walled, smooth, fusiform-elliptical or ellipsoid-cylindric (Text-Fig. 1 *f*), 4·2–6·3 × 1·7–2·4 μ. Submerged mycelium: hyphæ as in advancing zone.

Cultures examined. 207 (*a*)/K; 68–T; 194/K.

Poria corticola (Fr.) Cke. (Plate XIV, Fig. 3)

Sporophore.—Annual, completely resupinate, inseparable, soft-leathery when dry; subiculum very thin, inconspicuous, white, hyphæ of the subiculum hyaline to 'light buff' under the microscope, thick-walled, branched with abundant septa, clamp connections absent (Text-Fig. 2 *a*), 2·6–5·7 μ broad; tramal hyphæ similar to those in the subiculum; pore surface 'pale ochraceous buff', 'light ochraceous buff', or a shade darker, dull, tubes up to 2 mm. long, pores round to angular or irregular (Plate XIV, Fig. 3), averaging 2-4 per mm., edges thin, fimbriate sometimes lacerate; basidia clavate (Text-Fig. 2 *b*), 5·0–6·5 μ broad; basidiospores hyaline, smooth, ellipsoid (Text-Fig. 2 *c*), 6·1–7 × 3·6–4 μ; cystidia conspicuous, abundant, capitate, elongate (Text-Fig. 2 *d*), diameter of the head up to 9·3 μ, also present in the sub-hymenium.

On a log of *Abies pindrow*. Banjar Range, Seraj Division (Punjab), November, 1952, **6097**.

The fungus is reported to be common in the U.S.A. on broad-leaved hosts like species of *Acer*, *Fagus*, *Populus*, etc. (Baxter, 1935; Lowe, 1946; Overholts, 1923), though the fungus is also recorded on *Thuja plicata* (Overholts, 1929) and fir (Rea, 1922).

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* The tests laid down by Bavendam (1928), Preston and McLennan (1948) were followed for distinguishing lignin and cellulose destroying fungi in culture. Colours described within commas are from Ridgway (1912).

† Growth in all cases represents radial growth in 7 days at 25° C. unless otherwise stated.

Rot.—The fungus causes a white fibrous rot.

Cultural characters

Growth characters.—Growth moderately rapid, optimum between 20-22° C. (2 cm.), inhibiting at about 36-38° C. Advancing zone white, growth unequal around the inoculum, aerial mycelium extending up to limit of growth. Mat white, cottony-woolly, later becoming prostrate and felty except near the periphery where it is thick woolly and rolls over the walls of the Petri dish, faintly zonate. Reverse bleached. On gallic acid agar, diffusion zones weak, growth none; on tannic acid agar diffusion zones moderately strong, growth 0·7 cm. On gentian violet agar growth weak, media not discoloured.

Hyphal characters (Advancing zone).—Hyphæ hyaline, thin-walled, branched with simple septa (Text-Fig. 2 *e*), 1·5-4·3 μ broad. Aerial mycelium: hyphæ as in advancing zone, also slightly thick-walled (Text-Fig. 2 *f*), 2·9-4·3 μ broad. Submerged mycelium: hyphæ as in aerial mycelium, up to 5·8 μ broad.

Culture examined. 207/K.

Poria nigrescens Bres. (Plate XIV, Fig. 4)

Sporophore.—Annual, completely resupinate, hard, brittle on drying, separable; margin thin to thick becoming involute on drying, matted; subiculum up to 1 mm. thick. 'light ochraceous buff'. hyphæ of the subiculum hyaline ('light buff' under the microscope), thick-walled with narrow lumen, apparently unbranched, septate (Text-Fig. 3 *a*) but septa very rare and difficult to demonstrate, 2·0-5·4 μ broad, thinner few; tramal hyphæ same as subiculum hyphæ; pore surface 'pale olive buff', 'tilleul-buff', 'pale pinkish buff' with patches of 'avellaneous' turning darker at the margin, tubes 'light ochraceous salmon', up to 4 mm. long. pores round to angular. 5-8 per mm.; basidiospores hyaline, smooth. thin-walled, sub-globose (Text-Fig. 3 *b*), 3·5-5·6 × 2·8-4·3 μ.

On a log of *Quercus incana*. Mundali, Chakrata Division (Uttar Pradesh), September, 1949, **5369**.

The specimen on which the above description is based is an annual plant. *P. nigrescens* is, however, perennial (Baxter, 1931; Lowe, 1946; Overholts, 1922), the annual form of which is *Poria undata* (Pers.) Bres. (Lowe, 1946). Cunningham (1947) and Murrill (1921) also consider *P. nigrescens* and *P. undata* as synonyms. It is preferred to name our specimen as *P. nigrescens* since it was described earlier by Bresadola in 1897. Further, the specimen has been compared with an American specimen of the species, identified by D. V. Baxter (No. 5600) and is identical with it in all characters, though the American specimen is somewhat thicker.

The fungus is reported to be quite common on wood of deciduous or rarely of coniferous trees in the U.S.A. right up to Alaska (Lowe, 1946) and has also been reported from England and Europe (Murrill, 1921).

Rot.—The fungus is associated with a white rot.

Poria versipora (Pers.) Rom. (Plate XIV, Figs. 5 and 6)

Sporophore.—Annual. broadly effused. corky, brittle when dry; margin white to 'pale ochraceous buff', narrow to wide—non-porous in the latter case; subiculum 'pale ochraceous buff' to 'pinkish buff' less than 1 mm. thick, hyphæ of two types: (i) hyaline, thick-walled, apparently aseptate, unbranched or rarely branched (Text-Fig. 4 *a*), 3·0–4·3 μ broad, (ii) hyaline, thin-walled, sparsely branched, septate with clamp connections (Text-Fig. 4 *b*), up to 2·7 μ broad; trama continuous with the subiculum, tramal hyphæ same as subiculum hyphæ; pore surface 'pale ochraceous buff', 'light ochraceous buff', 'pinkish buff', 'cinnamon buff', pore tubes up to 1·5 mm. long, pores round, oblong or angular, lamellate on sloping surface (Plate XIV, Fig. 6), 4–6 per mm., edges entire or lacerate, pore surface irpiciform in certain areas; basidia clavate, 3–4 μ broad (Baxter. 1939; Lowe, 1946), basidiospores hyaline. smooth, oblong-ellipsoid to ellipsoid, 4–5 (– 7) × 2·5–3·5 (– 4) μ (Baxter. 1939; Cunningham. 1947; Lowe, 1946), small cystidia-like structures infrequently present in the hymenium; thick-walled terminally-inflated hyphæ projecting slightly beyond the hymenium (Text-Fig. 4 *c*).

On a log of *Celtis australis*, Kasol, Parbatti Range, Kulu Division (Punjab), October, 1952, M. **797**, **6021**.

Though no basidia and basidiospores have been observed in the specimens examined, other characters like the habit, colour of the pore surface, subiculum and subicular hyphæ, presence of cystidia-like structures, and terminally inflated hyphæ in the hymenium, the rot produced by the fungus, etc., agree with *Poria versipora*.

Rot.—The fungus causes a white rot of hardwood species.

Cultural characters

Growth characters.—Growth moderately rapid, optimum between 20–22° C. (2·5 cm.), inhibiting at about 32–33° C. Advancing zone white, raised, even, aerial mycelium extending to limit of growth. Mat white, raised woolly with somewhat farinaceous appearance, particularly around the inoculum, later becoming loosely appressed, sub-felty. Reverse partially bleached. On gallic and tannic acid agars diffusion zones weak, growth nil and 2·2 cm. respectively. On gentian violet agar growth good, medium discoloured.

Hyphal characters.—Advancing zone: hyphæ hyaline, thin-walled, branched, septate with clamp connections (Text-Fig. 4 *d*), 1·2–4·4 μ broad. Aerial mycelium: (i) hyphæ hyaline, thin-walled or slightly thick-walled with clamp connections (Text-Fig. 4 *e*) as in advancing zone; (ii) hyphæ hyaline, thick-walled, unbranched, aseptate (Text-Fig. 4 *f*), 2·5–3·1 μ broad; (iii) oidia scanty, 1–2-celled (Text-Fig. 4 *g*), 7·3–11·6 × 1·5–2·2 μ. Submerged mycelium: hyphæ same as in advancing zone.

Culture examined. 27/K.

Poria xantha (Fr.) Cke. (Plate XIV, Figs. 7 and 8)

Sporophore.—Annual, broadly effused, not readily separable, brittle when dry; margin white to 'pale pinkish buff', sterile or pores extending up to the edge, pubescent, thin to thick; subiculum white, thin, less than 1 mm. thick, hyphæ of the subiculum of two types: (i) hyaline to 'light buff', thick-walled, aseptate, rarely branched (Text-Fig. 5 *a*), 2·9 5·6 μ broad, (ii) hyaline, thin-walled, branched, septate with clamp connections (Text-Fig. 5 *b*), 1·2–2·3 μ broad, the two types compactly interwoven; tramal hyphæ similar to hyphæ of the subiculum; pore surface 'cream colour', 'ivory yellow', 'straw yellow', often exhibiting cracks, pore surface chalky, pore tubes up to 4 mm. long, pores round (Plate XIV, Fig. 8), averaging 5–6 per mm.; basidia clavate or cylinderaceous, 4·2 μ broad: basidiospores hyaline, smooth, cylinderaceous, slightly allantoid (not strongly curved) (Text-Fig. 5 *c*), 3·6–4·3 × 1·1–1·4 μ.

On a charred log of *Pinus excelsa*, Toshnal, Kulu Division (Punjab), October, 1940, **3211**, **3212**, Pulga, Kulu Division (Punjab). October, 1952, **6064**, Toshnal, Kulu Division (Punjab), October, 1952, **6028**, M. **802**; on logs of *Pinus excelsa*, Narkanda, Lower Bashahr Division (Himachal Pradesh), June, 1946, **4406**, **4423**, Bandal, Banjar Range, Seraj Division (Punjab), November 1952, **6016**, Jibbi, Banjar Range, Seraj Division (Punjab), November, 1952, **6115**, Pulga. Kulu Division (Punjab), October, 1952, **6022**; on log of *Quercus semecarpifolia*, Soja, Banjar Range, Seraj Division (Punjab), November 1952, **6204**, M. **808**.

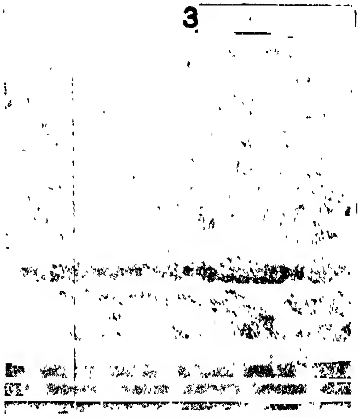
The fungus is world-wide in distribution and has been reported from America, England, Europe and New Zealand. In the former two countries it is common as house rot on building timber and also causes decay in wooden boats (Boyce, 1948; Cunningham, 1947). The fungus is quite common in the coniferous forests of the temperate Himalyas where it has been frequently encountered. It has often been found growing on charred logs and stumps.

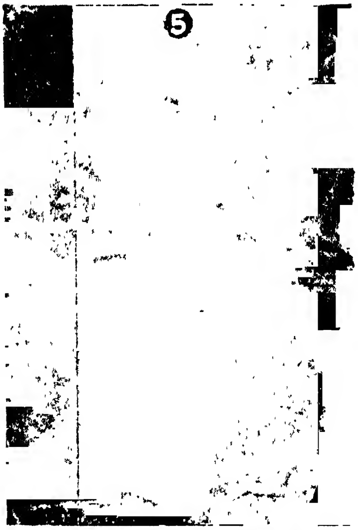
Rot.—The fungus causes a brown cuboidal rot. usually of conifers and less commonly of hardwood species (Plate XIV, Fig. 7 *b*).

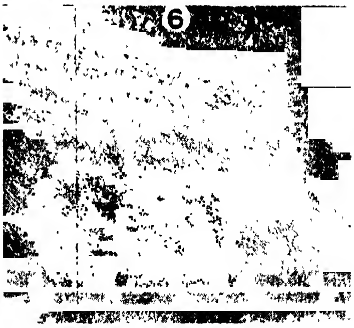
Cultural characters

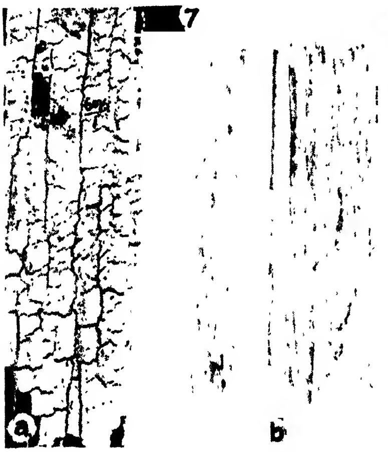
Growth characters.—Growth moderately rapid, optimum between 30–31° C. (2·9 cm.), inhibiting at 40° C. Advancing zone hyaline, completely appressed, even. Mat hyaline, appressed. Aerial mycelium lacking or limited to a thin film, surface becoming minutely poroid away from the inoculum after two weeks. Reverse unchanged. On gallic and tannic acid agars. no diffusion zones, growth 0·5 and 0·1 cm. respectively. On gentian violet agar growth good, medium not discoloured.

Hyphal characters.—Advancing zone: hyphæ hyaline, thin-walled, branched, septate with clamp connections, 1·6–5·8 μ broad. Aerial mycelium: (i) hyphæ hyaline, thin-walled to slightly thick-walled, branched, septate with clamp connections (branches also arising from









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the clamps) (Text-Fig. 5 *d*), 1·6–5·8 μ broad, (ii) hyaline, thick-walled, non-staining segments of hyphæ, clamp connections comparatively less (Text-Fig. 5 *e*); (iii) chlamydospores present though rare, usually intercalary, rarely terminal, walls slightly thickened (Text-Fig. 5 *f*), 11·4–15·8×5·7–7·0 μ; (iv) Fruit body composed of thin-walled hyaline, hyphæ with clamp connections, interwoven with non-staining fibre hyphæ, basidia 3·7 μ broad (Text-Fig. 5 *g*), bearing 4 spores; basidiospores hyaline, smooth, cylinderaceous, slightly allantoid, 3·6–4·3 (– 5·3)×1·1–1·4 μ.

Cultures examined. 62/K; 86/K; 149/K; 177/K; 197/K.

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EXPLANATION OF PLATE

PLATE XIV

FIG. 1 (*a*) *Poria callosa.*—Sporophore growing on wood of *Abies pindrow*, ×0·21.
(*b*) Brown cuboidal rot caused by *P. callosa*, ×0·21.

FIG. 2. *Poria callosa.*—A view of the pore surface, ×1·0.

FIG. 3. *Poria corticola.*—A view of the pore surface, ×1·0.

FIG. 4. *Poria nigrescens.*—A sporophore, ×0·47.

FIG. 5. *Poria versipora.*—Sporophore growing on log of *Celtis australis*, ×0·30.

FIG. 6. *Poria versipora.*—A view of the pore surface, ×1·0.

FIG. 7 (*a*) *Poria xantha.*—Sporophore growing on a log of *Pinus excelsa*, ×0·33.
(*b*) Brown cuboidal rot caused by *P. xantha*, ×0·33.

FIG. 8. *Poria xantha.*—A view of the pore surface, ×1·0.

FOSSIL WOODS OF EUPHORBIACEAE FROM THE TERTIARY ROCKS OF SOUTH ARCOT DISTRICT, MADRAS

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INTRODUCTION

THE present paper deals with three new genera of fossil woods of Euphorbiaceæ collected from the Tertiary rocks of Mortandra, five miles North-West of Pondicherry in the South Arcot District. A brief description of two of these woods has already been published in the form of a short note (Ramanujam, 1954 *a*). The fossiliferous locality has so far yielded a tolerably rich collection of interesting petrified woods of angiosperms. From the same locality the writer has previously reported the occurrence of fossil woods resembling the modern genera *Mangifera*, *Shorea* and *Albizzia* (Ramanujam 1953), and described in detail the wood anatomy of two leguminous woods comparable with the modern genera *Acacia* and *Cæsalpinia*, and three species of Dipterocarpaceæ resembling the extant species of *Dipterocarpus* and *Shorea* (Ramanujam, 1954 *b*, 1955). Again very recently two new species of fossil woods of *Terminalia* have been described from the same locality (Ramanujam, 1956).

As far as is known to the writer no fossil woods of Euphorbiaceæ have been described hitherto from the Indian horizons. Even from outside India the reports of fossil woods of Euphorbiaceæ are few and far between. They are known to occur, however, in the Cretaceous of Arizona (Bailey, 1924), Tertiary of Columbia (Felix, 1887), East Africa (Bancroft, 1932), Kiushu and Tobata, Japan (Ogura, 1933, Watari, 1943), Algeria (Boureau, 1951), and Eocene of Eden Valley, Wyoming (Kruse, 1954).

The preservation of all the fossils is sufficiently good to make possible the study of the significant details of their anatomical structures, and consequently their affinities with the modern timbers. Several transverse, tangential and radial sections were made of each wood. The sections usually tend to become extremely transparent when mounted in Canada balsam, consequently they had to be examined under glycerine in reflected light. Comparisons were made as far as possible with the modern timbers.

Putranjivoxylon nov. gen.

Putranjivoxylon puratanam nov. sp.

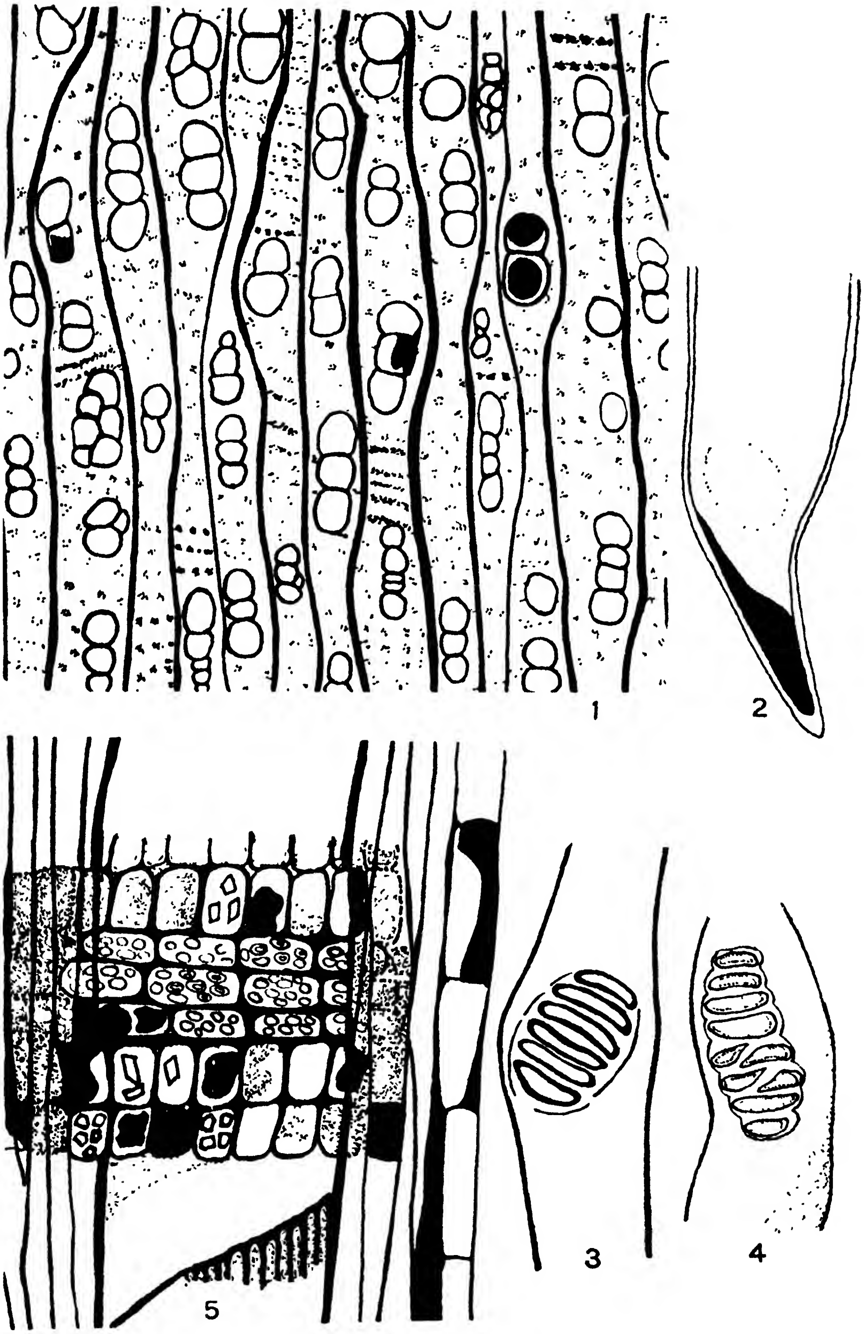
The material consists of a small block of highly silicified wood which has a variegated colour ranging from white to yellow with brick-red patches here and there. The preservation of the fossil is very satisfactory.

The fossil does not show any growth rings either to the naked eye or under the microscope. The vessels are moderately thick-walled, mostly small, sometimes medium and are not visible to the naked eye; but with a hand-lens they can be seen as light-coloured dots against the general background of the wood. The vessels are evenly distributed without showing any distinct pattern. They are frequently with contiguous rays on one or both sides. The vessel-segments are short, truncate or abruptly or frequently attenuately tailed on one or both ends (Text-Fig. 2). The vessels usually occur in radial multiples of 2–5 (Plate XV, Fig. 2). Solitary vessels are as a rule quite few and oval to rounded in outlines; those in the radial multiples are flattened often extremely so at the places of contact. The vessels are either empty or plugged with a brown-coloured deposit which either completely occludes the vessel cavities or occurs only in the form of a parietal layer. The fossil does not show any tylosic ingrowths. The perforations are simple or often scalariform (Text-Figs. 3, 4; Plate XV, Figs. 3, 4). The scalariform perforations are formed usually of 4–8 considerably thick scalariform bars, and are either vertical or oblique. The scalariform bars are either entire or broken. The simple perforations are horizontal or slightly inclined. The intervessel pitting is abundant; the pits, however, are very small, bordered and alternate. They are usually circular with oval to elliptical apertures. The vessel-ray pits are simple or bordered, large, rounded or slightly elongated tangentially and many per cell (Text-Fig. 5).

The fibres are libriform and well preserved. They are squarish to polygonal and distributed in radial seriations when seen in transverse sections, frequently interrupted by the cells of the apotracheal parenchyma. They are long and typically aseptate. Pitting of the fibres can be seen here and there in tangential sections. The pits, however, are very small, simple, and oval to rounded in outline (Text-Fig. 6); they generally tend to be arranged in a linear manner.

The parenchyma despite being fairly abundant cannot be seen easily with the naked eye or a hand-lens on the polished transverse surface of the fossil. Under the microscope the parenchyma is found to be well preserved. It is wholly apotracheal and occurs principally in the form of numerous scattered cells or small groups of cells (Text-Fig. 1; Pl. XV, Figs. 1, 2). Frequently the parenchyma cells are arranged in very short, uniseriate rows, which tend to form an extremely fine, more or less irregular reticulum with the wood rays. These rows of parenchyma are, usually rather widely spaced, but at times several of them may be found close together radially. The parenchyma cells are either empty or filled with an yellowish-brown gummy deposit. They are rounded or angular in transverse section. Pits to the parenchyma seen in tangential sections are simple, small, round to oval and 4–10 per cell.

The xylem rays are numerous and somewhat closely arranged. Their outlines are quite distinct to the unaided eye. With a hand-lens



TEXT-FIGS. 1-5. *Putranjivoxylon puratanam* nov. gen., nov. sp. Fig. 1. Semi-diagrammatic cross-section to show the distribution of the parenchyma (stippled) and the vessels, ×70. Fig. 2. A part of the vessel-segment to show the tailed nature, ×210. Figs. 3-4. Scalariform perforation plates, ×210. Fig. 5. Radial section showing the vessel-ray pitting, ×300.

they are visible on the transverse surface of the fossil as fine lines, often deflected by the vessels. The form and the nature of the rays as seen in tangential and radial sections provide valuable information regarding the affinity of the fossil. The rays as a rule are narrow, being only 1–3 cells wide and are 10–60 cells high (Pl. XV, Figs. 5, 6). Most of the rays are markedly heterogeneous.

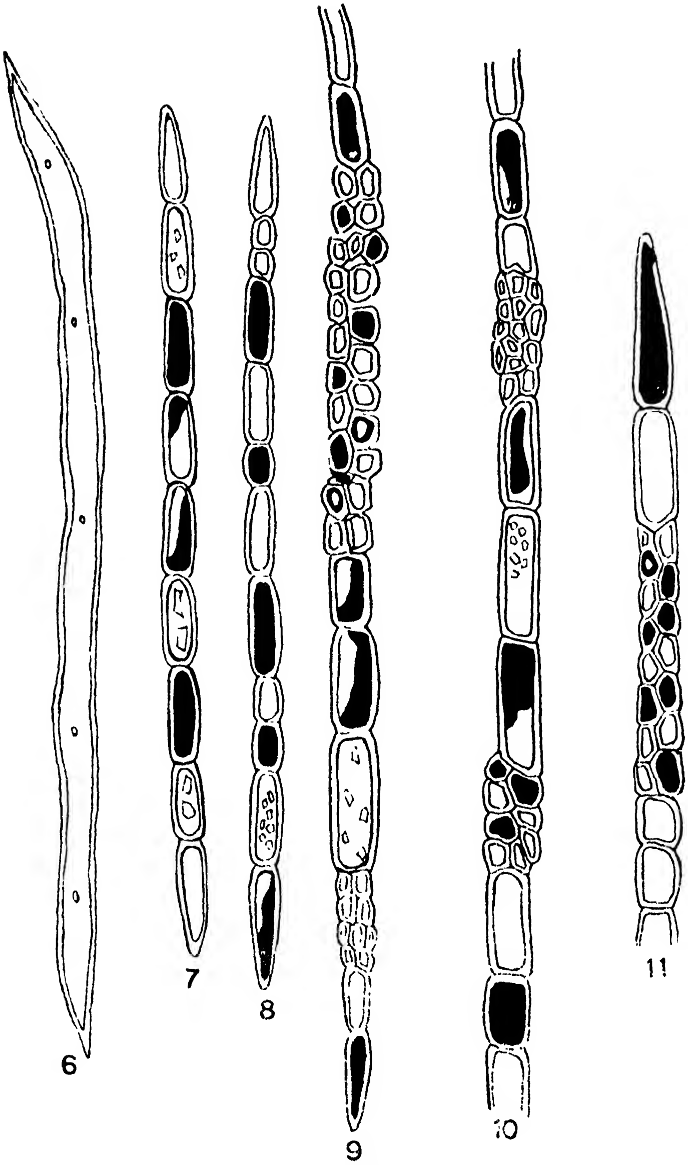
The multiseriate parts are limited to relatively small portions of each ray. These multiseriate portions are made up entirely of small procumbent cells, and alternate with the uniseriate parts formed of vertical cells. The rays can be distinguished into four distinct types: (1) uniseriate rays with vertical cells only (Text-Fig. 7; Pl. XV, Fig. 5); (2) uniseriate rays with alternate vertical and procumbent cells (Text-Fig. 8); (3) rays with alternating multiseriate small procumbent cells and uniseriate vertical cells (Text-Figs. 9, 10); and (4) rays with multiseriate small procumbent cells in the middle and uniseriate vertical cells (2–8 rows) at the margins (Text-Fig. 11). The markedly heterogeneous nature of the rays can be seen clearly in radial sections also (Pl. XV, Fig. 7). The ray cells in general are considerably thick-walled and crystalliferous; sometimes the ray cells are plugged with a dark brown substance of unknown nature which masks the crystals. Pits to the tangential walls of the rays are not observed.

Comparison with the living species.—The diagnostic features of this fossil wood that help in finding out its affinities are: (1) vessels small, arranged in radial multiples of 2–5, (2) perforations simple or often scalariform, (3) parenchyma, diffuse, in the form of numerous scattered cells or cell groups, also frequently in very short uniseriate rows, (4) rays markedly heterogeneous, considerably high, 1–3 seriate, with the multiseriate portions usually limited to relatively small portions of each ray; ray cells crystalliferous. A comparison with the modern woods has shown that the fossil approaches some genera of families like Cunoniaceæ, Sterculiaceæ, Sapotaceæ, Ebenaceæ, and Euphorbiaceæ more or less closely.

In Cunoniaceæ species of *Geissois* (Dadswell and Eckersley, 1938) present many similarities with our fossil in the general wood structure. Significant differences are there, however, in some minute details. Thus in the species of *Geissois* scalariform perforations are sporadic, fibres possess bordered pits with slit-like apertures, and the xylem rays are 1–4 seriate with the vertical cells present only on the margins.

In Sterculiaceæ species of *Pterospermum* show some strong similarities to our fossil in the general anatomy of the wood, but differ in possessing exclusively simple perforations, and storied nature of parenchyma (Chattaway, 1937).

In the family Sapotaceæ the genus, *Madhuca latifolia* (syn. *Bassia latifolia*) shows several similarities to our fossil. In both, the vessels are small and arranged in radial groups of 2–5, the parenchyma is diffuse or in short uniseriate rows, and the rays are 1–3 seriate, and markedly heterogeneous. But, there are also several differences.



TEXT-FIGS. 6–11. *Putranjivoxylon puratanam* nov. gen., nov. sp. Fig. 6. A libriform fibre showing the pitting, × 300. Fig. 7. Uniseriate ray with entirely vertical cells, × 210. Fig. 8. Uniseriate ray with vertical cells and procumbent cells, × 210. Figs. 9–10. Multiseriate rays with alternating patches of procumbent and vertical cells, × 210. Fig. 11. A biseriate rays with marginal vertical cells, × 210.

Thus in *Madhuca latifolia* the radial groups of the vessels are frequently disposed in oblique rows, vasicentric tracheids are common, scalariform perforations are conspicuous by their absence, and lastly the rays do not show alternating patches of procumbent and vertical cells, a characteristic feature of our fossil.

In the family Ebenaceæ the woods of some species of *Diospyros*, *viz.*, *Diospyros melanoxylon*, *D. ebenum*, and *D. montana* show resemblance to the South Indian fossil in the size, shape and arrangement of the vessels and in the distribution of the parenchyma. But in other features there are marked differences. Thus in the above species of *Diospyros* growth rings are fairly distinct, the perforations are exclusively simple, and the fibres possess distinct bordered pits, and the rays although narrow and heterogeneous do not contain intermittent multiseriate patches of procumbent cells.

Euphorbiaceæ is a markedly heterogeneous family. It is divided into two major sections based on wood anatomy (Janssonius, 1929; Soleredor, 1908; Metcalfe and Chalk, 1950), (1) Phyllanthoideæ and (2) Crotonoideæ. The Phyllanthoideæ is again divided into two groups, *Aporosa* and *Glochidion*. The *Aporosa* type is characterised by the following characters: Vessels often with scalariform perforation plates, intervessel pitting small to minute, pits to ray cells elongated and large. Parenchyma abundant, diffuse, strands of 8 16 cells. Rays of 2 sizes, considerably broad, several millimetres high, markedly heterogeneous, often with more than 10 marginal rows of upright cells. Fibres long, with very thick walls and simple pits.

The *Glochidion* type shows: vessels with simple perforations, intervessel pitting minute to large, pits to ray cells elongated and large or round and small. Parenchyma absent or as rare cells about the vessels. Rays sometimes of 2 distinct sizes, up to 3-11 cells wide; heterogeneous, sometimes markedly so. Fibres medium to long, septate, with simple pits.

The *Crotonoideæ* section is characterized by the following features: Vessels with simple perforations, intervessel pitting typically medium to large, pits to ray cells either large and elongated or similar to the intervessel pitting. Parenchyma abundant, apotracheal, varying from scattered cells to continuous tangential bands, sometimes with a little paratracheal addition. Rays exclusively uniseriate, or 2–3 cells wide, markedly heterogeneous. Fibres short to medium, commonly aseptate with simple pits (Metcalfe and Chalk, 1950, Vol. 2, pp. 1208-09).

The combination of the anatomical features exhibited by the South Indian fossil wood indicates in no uncertain manner a definite relation with the wood of the *Aporosa* type of the family Euphorbiaceæ. A comparison of the South Indian fossil with the various members of the *Aporosa* type has revealed that it resembles closely two genera, *Putranjiva* and *Drypetes*. (According to Metcalfe and Chalk, 1950, the genera *Putranjiva* and *Drypetes* can be very easily fitted into *Aporosa* group than elsewhere.) Both *Putranjiva* and *Drypetes*, resemble each other more or less closely in their wood anatomy. *Drypetes* is represented by about six species in India. *Putranjiva* is represented in India by two species, *Putranjiva roxburghii*, and *Putranjiva zeylanica*, the first of which is very common both wild and in cultivation. The author has compared the fossil wood with both these species of *Putranjiva* and also with the species of *Drypetes*, *viz.*, *D. longifolia*, etc.. It is with the wood type of

Putranjiva that the South Indian fossil agrees most closely. The resemblance occurs in all the major anatomical features. In the genus *Drypetes* scalariform perforations are generally rare, the parenchyma is more definitely banded and the vessels are more commonly solitary. *Drypetes longifolia* differs from the fossil in possessing only simple perforations, mostly solitary vessels, and in ray cells which are only occasionally crystalliferous.

Comparison with the fossil species.—Only a few fossil woods of the family Euphorbiaceæ are known. They are. *Euphorbioxylon speciosum* (Felix, 1887) from Columbia, *Paraphyllanthoxylon arizonense* (Bailey, 1924) from Arizona, *Dryoxylon drypeteoides* (Bancroft, 1932) from East Africa, *Phyllanthinium pseudo-hobashiraishi* (Ogura, 1933, Watari, 1943) from Kiushu and Tobata, Japan, *Euphorbioxylon lafrancii* (Boureau, 1951) from Algeria, and *Haveoxylon microporosum* (Kruse, 1954) from the Eocene of Eden Valley, Wyoming. All these except *Paraphyllanthoxylon arizonense* are of Tertiary age. *P. arizonense* was described from the Cretaceous of Arizona.

All these species differ more or less markedly from the South Indian wood. Thus *Euphorbioxylon speciosum* differs from the present specimen in the possession of vasicentric parenchyma, relatively short rays which are only weakly heterogeneous, and in lacking scalariform perforations. *Paraphyllanthoxylon arizonense* is characterized by much broader rays (1-7 seriate), exclusively simple perforations, and the absence of wood parenchyma.

Of the fossil woods of Euphorbiaceæ hitherto described only one species, *Dryoxylon drypeteoides* (Bancroft, 1932) from the Tertiary of East Africa, shows some close resemblance to our fossil. This wood is, however, very imperfectly preserved and Bancroft could give the description of only its transverse sections. Consequently our fossil cannot be compared with the East African species in all its details. The parenchyma in *Dryoxylon drypeteoides* is like that in our fossil, *i.e.*, occurring in uniseriate rows or scattered cells. But in Bancroft's species the parenchyma bands are more definite and numerous, and more closely set. In *Dryoxylon drypeteoides* radial multiples of more than 2 or 3 vessels are only occasionally seen. As the longitudinal sections of *Dryoxylon drypeteoides* were not described, we know nothing regarding the nature of the perforations and the structural details of the rays of that wood.

Our fossil also differs from Ogura's *Phyllanthinium pseudo-hobashiraishi* in more than one respect. Thus, in the latter species the fibres are fusiform, xylem parenchyma is scanty, the rays are shorter and the perforations are exclusively simple.

Euphorbioxylon lefrancii (Boureau, 1951) which according to its author resembles closely the genus *Anthostema* of the section *Crotonoideæ*, is easily distinguishable from the South Indian fossil in possessing only simple perforations, very scanty parenchyma and mostly uniseriate rays.

Haveoxylon microporosum (Kruse, 1954) differs from our species in possessing exclusively simple perforations, abundantly tylosed vessels, and irregular multiseriate bands of metatracheal parenchyma. Moreover, rays in *Haveoxylon microporosum* are only 1-2 seriate with uniseriate and biseriate patches regularly alternating with each other.

For detailed comparisons. reference may be made to the table at the end.

Name of the fossil and diagnosis.—A comparison of the fossil with the living species has shown that its nearest affinity is with the timbers of Euphorbiaceæ. Felix (1887) after discussing the affinities of his fossil wood, from the Tertiary of Columbia, named it as *Euphorbioxylon speciosum*. The name *Euphorbioxylon* if adopted would naturally include all the fossil woods showing similarities with any member of the Euphorbiaceæ. But it is an established fact that Euphorbiaceæ is not a homogeneous family so far as its wood anatomy is considered (Solercdor, 1908; Record and Mell, 1924; Jansonnius, 1929; Metcalfe and Chalk, 1950). Bailey (1924) says: "To attempt to include all putative Euphorbiaceous woods in a single form genus, *e.g.*, *Euphorbioxylon*, would be unfortunate. The Euphorbiaceæ structurally are an extremely heterogeneous group. So many different stages in the specialization of the vascular tissues are represented that there appear to be no diagnostic characters which are constant in the family as a whole." Felix compared his *Euphorbioxylon* with the woods of *Jatropha* and *Euphorbia* and therefore his diagnosis of the genus *Euphorbioxylon* includes the characters of these genera which fall on the basis of their wood anatomy, in the section *Crotonoideæ*. It is, therefore, evident that the genus *Euphorbioxylon* cannot be employed in a wide sense to include the woods of Euphorbiaceæ as a whole. In fact, it would be extremely difficult to define the limits of *Euphorbioxylon* if all the structural variations of the family Euphorbiaceæ were to be incorporated in it. Since our specimen shows a very strong resemblance with the modern genus *Putranjiva* it is being described here under a new generic name *Putranjivoxylon*. It is specifically named as *Putranjivoxylon puratanam*, the word *puratanam* being derived from the Sanskrit root *puratan*, meaning ancient.

In the present-day flora of India species of *Putranjiva* (especially *Putranjiva roxburghii*) have a wide distribution being found in South India, Deccan peninsula, Western Ghats, Orissa, and Uttar Pradesh (Hooker, 1885; Gamble, 1922).

Putranjivoxylon nov. gen.

A diffuse porous wood.

Growth rings absent.

Vessels mostly small, sometimes medium, hardly visible to the naked eye; mostly in radial multiples of 2-5, solitary vessels few; thick-walled, oval to round; tyloses absent; vessel-segments short, truncate, or abruptly or attenuately tailed; perforations simple, often scalariform, horizontal or oblique; intervessel pits small, alternate, circular with oval to elliptical apertures, vessel-ray pits large, simple, or bordered, rounded or elongated tangentially and many per cell.

Fibres long, libriform square to polygonal in cross-section, arranged regularly in undisturbed radial seriations; aseptate; pits very small, simple, oval.

Parenchyma fairly abundant; wholly apotracheal, either in the form of numerous closely scattered cells or cell groups, or as very short uniseriate lines of 3–5 cells; parenchyma cells rounded or angular in cross-section, empty; pits simple, small round to oval, 4–10 per cell.

Rays numerous, closely spaced; evenly distributed; markedly heterogeneous with 2–8 marginal rows of vertical cells, 1–3 seriate, 10-60 cells high; uniseriate rays made up either entirely of vertical cells or alternating vertical and procumbent cells; in multiseriate rays multiseriate portions short, formed wholly of procumbent cells, such multiseriate parts alternating with portions formed of vertical cells in a single row; ray cells thick-walled, abundantly crystalliferous.

Putranjivoxylon puratanam nov. sp.

Vessels 75–120 μ in diameter; evenly distributed 25 per sq. mm.; in radial multiples of 2–5, thick-walled and without tyloses, vessel-segments 150–550 μ long, perforations simple or often scalariform, with 4-8 thick perforation bars.

Fibres 150-2,500 μ long, 15 μ in diameter, aseptate.

Parenchyma fairly abundant, diffuse or in very short uniseriate lines of 3-5 cells, parenchyma cells 30 35 μ in diameter, pits simple, oval to round, 4–10 per cell.

Rays 10–15 per mm., 1-3 cells or 12–40 μ wide, 10–60 cells or 250-1,500 μ high, markedly heterogeneous with 2 8 marginal rows of vertical cells.

Holotype No. 5078 of the Museum of Birbal Sahni Institute of Palæobotany.

Bridelioxylon nov. gen.

Bridelioxylon cuddalorense nov. sp.

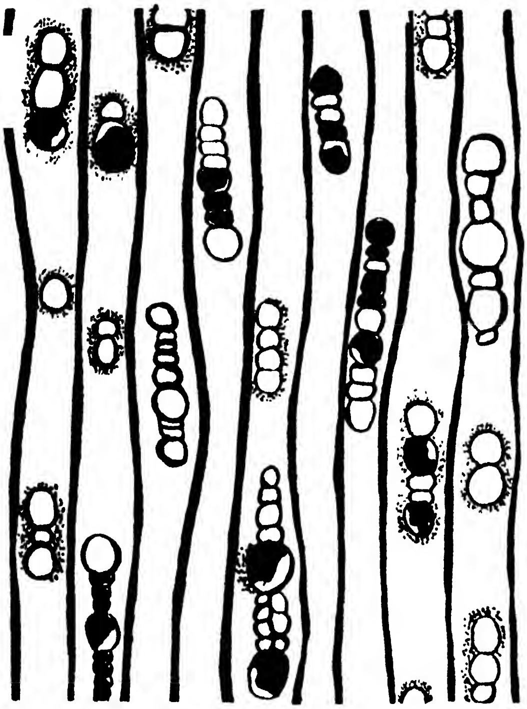
The species is represented by two specimens. The figured one measures 6 cm. in length and 10 cm. in diameter. It is an almost complete longitudinal half of the original stem and shows a part of the pith also (Pl. XVI, Fig. 8). The pith, however, does not show good preservation, it is formed of loosely packed parenchyma cells, filled here and there with some dark contents.

The preservation of the secondary xylem is very good. The finely polished transverse surface of the fossil shows growth marks quite distinctly to the naked eye (Pl. XVI, Fig. 8), under the microscope the contrast between the spring wood and late wood is marked. The spring wood is much more developed than the late wood which forms only a narrow zone (Pl. XVI, Fig. 9). The vessels are medium-sized to small and just visible to the naked eye. Their distribution is primarily diffuse and exhibit no marked variation in size within the growth ring. The vessels are mostly in radial groups of 2–5. Both pore chains and pore multiples are commonly observed. Solitary vessels also occur commonly. The vessels in a group are generally unequal in size, and are mostly flattened at the places of contact. They are thick-walled and very commonly filled with a dark-coloured deposit. Tyloses are not seen. The vessel-segments are rather short, truncate or abruptly or attenuately tailed on one or both ends (Text-Fig. 13). The perforations are exclusively simple, and horizontal. Intervessel pitting is abundant. The pits are moderately large, alternate and distinctly vestured (Pl. XVI, Figs. 11, 12); the pit membrane, as seen in surface view, presents a punctate or dotted appearance. The intervessel pits are as a rule contiguous and so become hexagonal in outline. The vessel-ray pitting is simple; the pits are small to medium, rounded and many per cell (Text-Fig. 14). The vessel-parenchyma pits are not observed.

The fibres constitute the best preserved tissue of the wood and show all the details excellently. They are very thick-walled, and medium in length, They are laterally stretched and with very narrow lumina in the late wood, while in the spring wood they are equidiametric and more open. The fibres are always arranged in uniform radial seriations. They are usually empty, but sometimes filled with black deposit. They are libriform and typically septate. The septa are considerably thick. Pits to the fibres are small, simple and rounded to elliptical and placed linearly (Text-Fig. 15).

The parenchyma is not visible either to the naked eye or under a hand-lens. It is, however, present in limited amount. The parenchyma is mostly paratracheal and in 1-2 layered vasicentric sheaths (Text-Fig. 12; Pl. XVI, Figs. 9, 10). Single parenchyma cells (apotracheal type) are also met with scattered among the fibres. The cells of the parenchyma contiguous to the vessels are as a rule flattened to confirm to the vessel wall, while the rest are round to oval. They are thin-walled, and mostly filled with a dark-coloured deposit. Pits to the parenchyma cells are not observed.

The outlines of the xylem rays are visible to the naked eye, both on the transverse as well as longitudinal surfaces of the fossil. They are more or less fusiform or spindle-shaped and closely packed, forming a conspicuous feature in the tangential sections. The rays are 1–4 cells wide and 12–35 cells in height. The majority of them are triseriate, but uniseriate rays are not infrequent. The rays are heterogeneous and contain 1-2 marginal rows of vertical cells (Text-Fig. 15, Pl. XVI, Fig. 13). As compared with *Putranjivoxylon puratanam*, the rays here are not so markedly heterogeneous. The marginal vertical cells are quite conspicuous in both tangential and radial sections (Pl. XVI, Fig. 14). In tangential sections they form the pointed ends of the rays; the procumbent cells which fill the rest of the ray are polygonal



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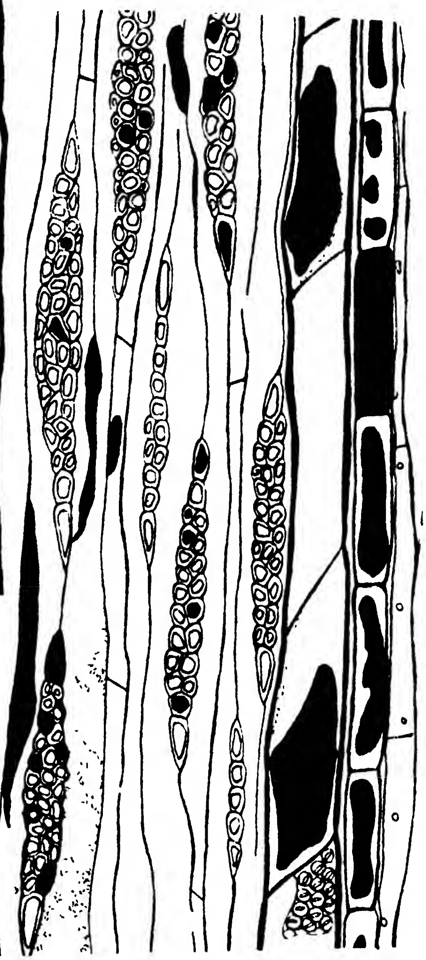

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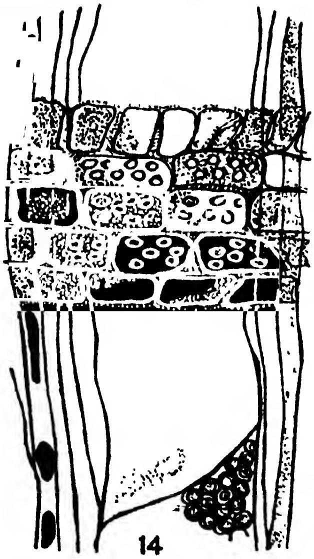

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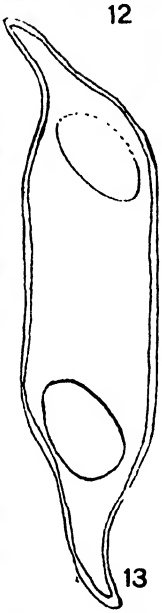

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Text-Figs. 12-15. *Bridelioxylon cuddalorense* nov. gen., nov. sp. Fig. 12. Semi-diagrammatic cross-section showing the distribution of the parenchyma (stippled) and the vessels, × 70. Fig. 13. A vessel-segment showing the tailed ends, and simple perforations, × 210. Fig. 14. Radial section showing the vessel-ray pitting, × 300. Fig. 15. Tangential section showing the general nature of the xylem rays, parenchyma and pitting on the fibres, × 150.

or rounded in outline. End-to-end ray fusions are of frequent occurrence. The ray cells are thick-walled, and filled with a dark content. The tangential walls of the rays show a few, simple, oval pits.

Comparison with the living species.—The important features of the fossil wood under investigation, that are of some diagnostic value, are the occurrence of vestured pitting, scanty paratracheal parenchyma and the details of the xylem rays. The evidence to date is to the effect that vestured pits are extremely consistent in their distribution, and for this reason their presence or absence appears to be of decided diagnostic importance in the identification of angiosperm woods. According to Bailey (1924) nearly 25 families are characterised by the possession of vestured pits, the important ones of which are Combretaceæ, Euphorbiaceæ (only two genera), Leguminosæ, Melastomaceæ, Myrtaceæ, Lythraceæ, Sonneratiaceæ, Vochysiaceæ, etc. When significant details of all the tissues of the wood are taken into consideration along with the nature of intervessel pitting it is found that the South Indian fossil specimen belongs to the family Euphorbiaceæ. Among Euphorbiaceæ it is particularly with the wood of *Glochidion* type that a strong resemblance is indicated. The wood of *Glochidion* type as has been mentioned previously shows simple perforations, broad heterogeneous rays, typically septate fibres; the xylem here is either absent or occurs sparingly. From a comparison with the genera like *Phyllanthus*, *Antidesma*, *Glochidion*, *Bridelia* and *Cleistanthus* it is seen that the fossil is nearer to the last two genera.

Both *Bridelia* and *Cleistanthus* resemble our fossil in the nature and arrangement of the vessels (especially in the vestured nature of the intervessel pitting), the fibres and the parenchyma. *Cleistanthus*, however, differs from the fossil in its minute intervessel pits and much longer rays which are not fusiform. The uniseriate rays in this genus are more numerous when compared to the fossil wood; *Bridelia*, on the other hand, agrees with the fossil very closely in all its characters.

Comparison with the fossil species.—The present specimen differs markedly from *Putranjioxylon puratanam*, in possessing exclusively simple perforations, vestured intervessel pits, very limited, vasicentric parenchyma, and relatively short, more or less spindle-shaped xylem rays which are much less heterogeneous.

Among fossil woods of Euphorbiaceæ described from outside India the only comparable ones are *Euphorbioxylon speciosum* (Felix, 1887), and *Phyllanthinium Pseudo-hobashiraishi* (Ogura, 1933; Watari, 1943).

Euphorbioxylon speciosum from Columbia is similar to our fossil in possessing limited amount of parenchyma in the form of vasicentric sheaths, and in its rays which are 1–3 seriate and heterogeneous with 1–2 marginal rows of vertical cells. But the Columbian species differs markedly in not possessing growth rings, in its generally solitary vessels, the absence of vestured intervessel pits, and lastly in the aseptate nature of its fibres.

Phyllanthinium pseudo-hobashiraishi from Japan is considerably similar to our specimen in the size, shape and distribution of the vessels, in the nature of the parenchyma and the xylem rays. But it differs in not possessing vestured pits; moreover the vessels in the Japanese species are profusely tylosed, fibres are long and fusiform, parenchyma is crystalliferous and the growth rings are faint.

For detailed comparisons reference may be made to the table at the end.

Name of the fossil and diagnosis.—Owing to its marked resemblance with the modern genus *Bridelia* of the family Euphorbiaceæ a new generic name *Bridelioxylon* has been proposed to the present fossil. It is specifically named as *Bridelioxylon cuddalorense* after the Cuddalore series.

Among the modern flora of India species of *Bridelia* are widely distributed throughout India, being found in Punjab, Uttar Pradesh, Bihar, Orissa, Central India and South India (Gamble, 1922; Pearson and Brown, 1932).

Bridelioxylon nov. gen.

A diffuse porous wood.

Growth rings distinct.

Vessels small to medium, fairly visible to the naked eye as dots; solitary or in numerous radial groups of 2-5 or more vessels; thick-walled, circular or flattened; tyloses not seen; vessels, commonly filled with a dark deposit; vessel-segments, medium, truncate or abruptly or attenuately tailed on one or both ends; perforations simple, horizontal; intervessel pits moderately large, alternate, vestured and usually hexagonal; vessel-ray pits small to medium, simple, rounded, many per cell.

Fibres libriform, medium in length, arranged regularly in radial seriations; late wood fibres very thick-walled, laterally stretched, with narrow lumina, spring wood fibres equidiametric with wide lumina; septate, septa thick. Pits simple, small and rounded, placed linearly.

Parenchyma limited, not visible to the naked eye; mostly paratracheal in 1-2 layered vasicentric sheaths; often also diffuse; cells round to oval, commonly filled with dark contents.

Rays' outlines fairly visible to the naked eye; numerous, closely packed, evenly distributed; 1-4 seriate 12-35 cells high, fusiform or spindle-shaped; heterogeneous, but not markedly so, there being only 1-2 marginal rows of vertical cells; end-to-end ray fusions frequent; cells thick-walled, commonly filled with a dark deposit; pits on tangential walls simple and oval.

Bridelioxylon cuddalorense nov. sp.

Vessels 90–140 μ in diam.; evenly distributed. 20 per sq. mm., solitary or in groups of 2–5, thick-walled, perforations simple, horizontal; vessel-segments 175–600 μ, truncate or tailed abruptly or alternately.

Fibres 1400–1550 μ long, 12 μ in diam. Libriform, walls of late wood fibres 8–10 μ thick, of spring wood fibres 2-5 μ thick; septate, septa thick; pits simple, small, rounded.

Parenchyma limited, in 1–2-layered vasicentric sheaths, often also diffuse. Cells 18–25 μ in diam.

Rays 7–12 per mm. 1–4 cells or 10–70 μ wide, majority 3 seriate, 12–35 cells or 340–500 μ high, majority 12–19 cells high. Heterogeneous with 1–2 marginal rows of vertical cells.

Holotype No. 5028 of the Museum of Birbal Sahni Institute of Palæobotany.

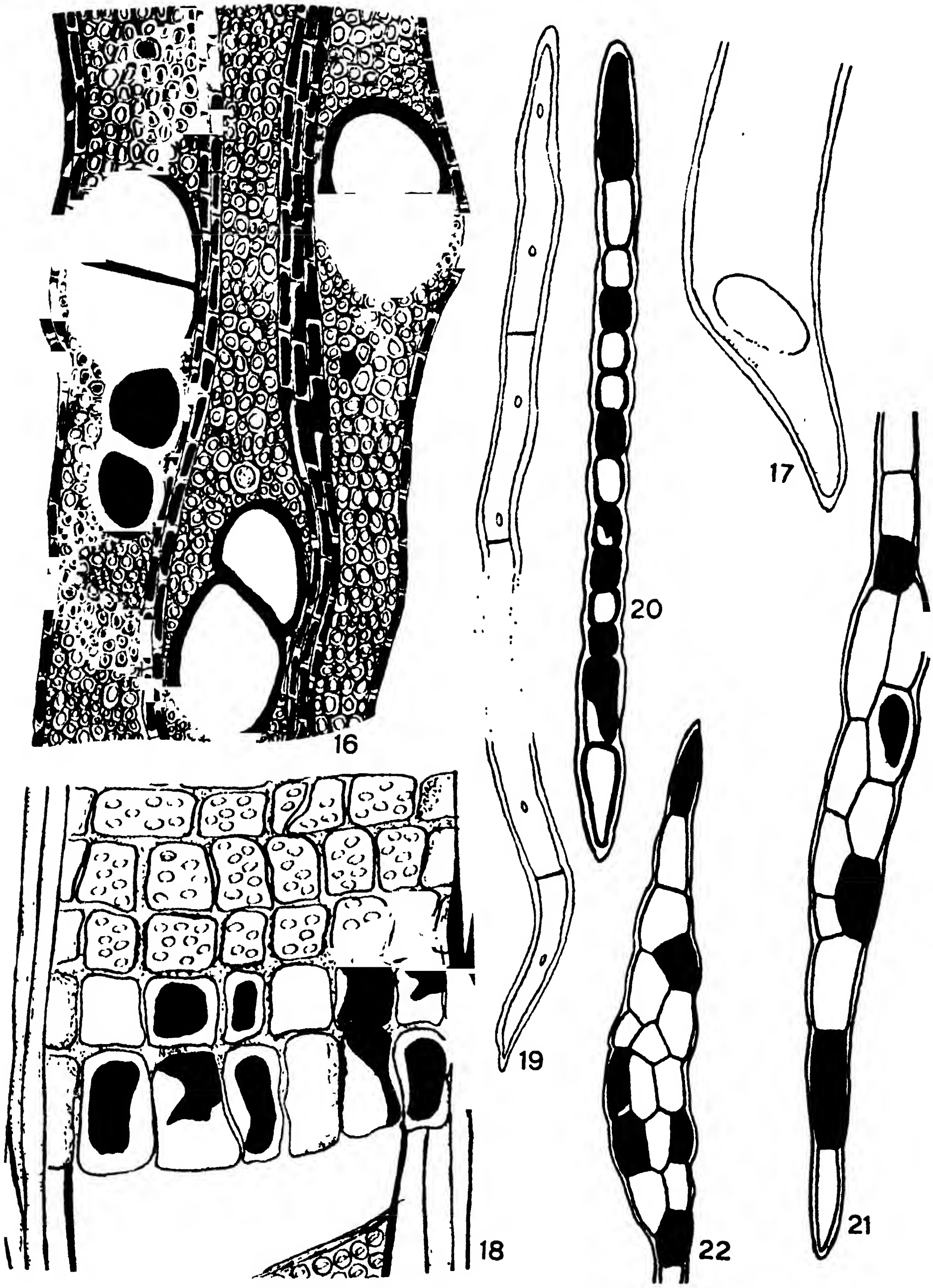
Glochidioxylon nov. gen.

Glochidioxylon tertiarum nov. sp.

The species is represented by two small, highly silicified, decorticated stem pieces.

The central part of the stem shows the pith. The pith is angular and made up of rounded parenchyma cells, often filled with a dark-coloured deposit (Pl. XVII, Fig. 15). The primary xylem is clearly preserved; it shows numerous, minute vessels arranged radially. The pitting of the primary xylem elements is either of annular or reticulate type. The phloem tissue, however, is not preserved.

The fossil exhibits faint growth rings to the naked eye but under the microscope no distinction can be made out between the spring wood and the late wood. The vessels are very indistinctly visible to the naked eye. They are small to medium and arranged in numerous radial multiples of 2–4, or sometimes more (Pl. XVII, Fig. 17). The distribution of the vessels is primarily diffuse. The vessels are oval or rounded when solitary, when in radial multiples they are usually flattened at the places of contact showing a chain formation and constricted in the fused portion, but sometimes the vessels in the radial groups do not show any flattening and then are oval or elliptical in cross-sections. They are thick-walled, and are either empty or filled up with some solid dark deposit. Tylosic ingrowths are not observed. The vessel-segments are of medium size, truncate or attenuately tailed on one or both the ends (Text-Fig. 17). The perforations are exclusively simple, and horizontal or sometimes steeply inclined. Intervessel pitting is very conspicuous. The pits are fairly large, distinctly bordered, alternate and circular, the orifice of the pits is more or less lenticular or slit-like and orientated horizontally or often obliquely (Pl. XVII, Fig. 18). The



Text-Figs. 16–22. *Glochidioxylon tertiarum* nov. gen., nov. sp. Fig. 16. Cross-section showing the distribution of the fibres, parenchyma (slightly bigger cells) and the vessels, × 210. Fig. 17. A part of the vessel-segment showing the tailed nature and simple perforation, ×210. Fig. 18. Radial section showing the vessel-ray pitting, × 300. Fig. 19. A libriform fibre showing the pitting, × 300. Fig. 20. Uniseriate ray with marginal vertical cells, ×210. Figs. 21–22. Multiseriate rays with marginal vertical cells, ×210.

vessel-ray pits are abundantly preserved; they are simple to very narrowly bordered, of medium size, oval to rounded or tangentially elongated and 2–8 per cell, distributed irregularly (Text-Fig. 18).

The fibres constitute the fundamental element of the wood in cross-section since the parenchyma is very meagrely represented. They are libriform and invariably aligned in regular, undisturbed radial seriations. They are rounded or polygonal when seen in transverse sections (Text-Fig. 16), and are considerably thick-walled. The fibres are long and septate; the septa in most cases are fairly thick. The interfibre pits are simple, rounded or longitudinally stretched; they are only a few per each fibre and rather widely spaced in a linear manner. The fibre pitting is seen distinctly both in the tangential and radial sections (Text-Fig. 19).

The wood parenchyma is very scanty; only a few scattered cells are observable here and there among the fibres (Text-Fig. 16). As the form and often the size of these scattered parenchyma cells is nearly the same as the fibres, to distinguish the former from the latter in cross-sections presents a rather difficult task. In longitudinal sections, however, the parenchyma is always clearly distinguishable by its horizontal walls. The parenchyma cells are rounded or polygonal in transverse sections; pitting to these cells is not seen.

The outlines of the xylem rays are fairly visible to the naked eye both on transverse as well as longitudinal surfaces of the fossil. They represent the most conspicuous of the tissues in the tangential sections. The rays are uniformly and closely distributed and numerous. They are 1–4 seriate (Pl. XVII, Figs. 19, 20). They are distinguishable into two types, the uniseriates and multiseriates. The uniseriate rays are comparatively fewer while the multiseriate ones are the most abundant. The rays in general are of considerable heights; in most cases they are 20-75 cells high. Here and there rays as high as 105 cells are also met with. The rays, as a rule, are always markedly heterogeneous and exhibit a good variety in the proportion and arrangement of the vertical cells to the procumbent cells. The uniseriate rays are made up either entirely of vertical cells (Text-Fig. 20), or procumbent cells, or have vertical cells at the margins and procumbent cells in the middle; the last type is rather sporadic. The multiseriate rays have marginal rows (1–6) of vertical cells at each end and procumbent cells of various sizes and forms in the middle (Text-Figs. 21, 22; Pl. XVII, Figs. 19, 20); or as is seen in some rare cases the margins may possess both vertical and procumbent cells intermingled with each other. The ray cells are thick-walled and plugged with a dark coloured deposit. Pits to the tangential walls of these cells are often observable, but their structural details are not clear.

The fossil shows some knots in the tangential sections. Each knot consists of more than one branch base. In one case as many as six branch bases can be seen clubbed together. The pith of the branch base is more or less angular and purely parenchymatous; the cells are mostly filled up with a dark substance. The primary xylem is very compact, consisting of numerous, very small vessels arranged uniformly in radial chains (Pl. XVII, Fig. 17). The pith is circumscribed by a parenchymatous tissue in which the majority of the cells contain the same dark substance. The whole branch base, in turn, is encircled by the xylem rays of the parent stem, cut at various angles and different levels presenting a rather characteristic look in the tangential sections.

Comparison with the living species.—The fossil wood under investigation is characterized by the following characters: vessels small to medium, in numerous radial multiples of 2–4. Intervessel pits large, circular, distinctly bordered and alternate. Perforations simple, horizontal or sometimes steeply inclined. Fibres libriform, septate, long, with few simple pits placed in a linear manner. Parenchyma very scanty, being represented by a few irregularly scattered cells. Rays 1–4 cells wide, of two types, markedly heterogeneous and of considerable heights. Among the structural features of this fossil there is none which if considered alone is striking enough to help in its identification. The only method of determining its affinities is the laborious one of searching for similar combinations of anatomical characters in extant dicotyledons. This combination of characters is met with in varying extents in the members of the families like Bixaceæ, Celastraceæ, Connaraceæ, Pittosporaceæ, Flacourtiaceæ, Lauraceæ, Burseraceæ and Euphorbiaceæ, especially the last five families, with which the fossil has been compared in detail.

The woods of Pittosporaceæ agree with the fossil to a considerable extent in some features, but the xylem rays in this family are entirely homogeneous as against the markedly heterogeneous rays of our fossil. In Flacourtiaceæ genera like *Doyalis* and *Taraktogens* approach our fossil in general features, but they differ strongly in possessing scalariform perforations and much broader rays (Gilg, 1908; Metcalfe and Chalk, 1950).

In Lauraceæ genera like *Phœbe*, *Litsea*, *Tetradenia* (Dadswell and Eckersley, 1940) present to a considerable extent many similarities to our fossil, but all of them differ fundamentally in possessing fairly abundant xylem parenchyma.

In Burseraceæ genera like *Garuga* and *Bursera* agree with our fossil to a great extent in general features of the anatomy, but differ in possessing horizontal gum ducts, non-libriform fibres; the parenchyma in these genera although scanty, is represented by paratracheal type in contradistinction to the diffuse type present in the fossil wood (Pearson and Brown, 1932).

In the family Euphorbiaceæ it is with the wood type of the *Glochidion* group of the Phyllanthoideæ section that the fossil wood from South India resembles to a great extent. The *Glochidion* group as has already been mentioned is characterized by simple perforations, typically septate, libriform fibres, markedly heterogeneous rays, and very scanty parenchyma. *Glochidion*, *Bischofia*, *Antidesma* (Foxworthy, 1907; Kanehira, 1924 *a*, 1924 *b*, 1926; Pearson and Brown, 1932), seem to be very similar to our fossil, particularly the former two genera; but none of them are quite the same as the fossil in each and every respect. Consequently it has not been possible for hazarding the statement that the fossil from South India resembles any one of these aforementioned genera exclusively. It can be said that the present fossil is an Euphorbiaceous wood resembling the wood type of *Glochidion* group, excluding the genera *Bridelia* and *Cleistanthus* which possess vestured intervessel pits, of the Phyllanthoideæ section.

Comparison with the fossil species.—The genera *Putranjivoxylon* and *Bridelioxylon* described from the same locality differ markedly from the present specimen.

Thus, *Putranjivoxylon puratanam* differs from the fossil under study in possessing often scalariform perforations and a fairly abundant apotracheal parenchyma; the nature of the rays in this genus is also quite different from that of the present specimen.

Bridelioxylon cuddalorense differs from the present wood in possessing distinctly vestured intervessel pits, 1-2 cells thick vasicentric parenchyma and relatively short fusiform or spindle-shaped xylem rays.

Paraphyllanthoxylon arizonense (Bailey. 1924), described from the Cretaceous of Arizona, shows several common features with our fossil, but possesses much broader rays and abundantly tylosed vessels.

Phyllanthinium pseudo-hobashiraishi (Ogura, 1933; Watari, 1943), described from the Tertiary of Japan while resembling our fossil in several characters, differs from it in possessing very abundantly tylosed vessels, much shorter and weakly heterogeneous rays, and the presence of crystalliferous elements in the parenchyma.

For detailed comparisons with all the species of fossil Euphorbiaceous woods a reference may be made to the adjoining table.

Name of the fossil and diagnosis.--From the above description it can be gathered that the fossil under investigation belongs to the family Euphorbiaceæ, showing its resemblances in particular with the wood type of the *Glochidion* group of the section Phyllanthoideæ. Bailey (1924) describing a fossil wood from the Cretaceous of Arizona, which according to him shows resemblances with *Phyllanthus* and other structurally similar representatives of Phyllanthoideæ, instituted a new name *Paraphyllanthoxylon* for the fossil woods showing apparent similarities to the section Phyllanthoideæ. Ogura (1933) created a new generic name *Phyllanthinium* for his fossil wood resembling according to him, genera like *Antidesma*, *Glochidion*, *Bischofia* and *Bridelia*. Our fossil too, it is obvious, resembles these general which by virtue of their anatomical characters fall under the wood type of *Glochidion* group. Since the section Phyllanthoideæ could be split up into two groups, *Glochidion* and *Aporosa* based on the wood anatomy, each group characterized by its own set of anatomical characters, it might be better, and probably more natural, if the fossil woods showing affinities to these groups be named after these groups, unless they exhibit unmistakable resemblances with some particular genus, instead of grouping such woods under a single rather broad genus *Phyllanthinium* or *Paraphyllanthoxylon*. The name *Paraphyllanthoxylon* may, however, be retained for the woods coming from the Cretaceous horizon.

Thus the new generic name *Glochidioxvlon* that has been proposed for the fossil, does not indicate in particular the resemblances of the fossil with the extant genus *Glochidion*, but indicates, on the other hand, strong similarities to the wood type of the *Glochidion* group of the Phyllanthoideæ section. The fossil is specifically named as *Glochidioxylon tertiarum*.

Glochidioxylon nov. gen.

A diffuse porous wood.

Growth rings faint to the naked eye, but disappear under the microscope.

Vessels small to medium, indistinct to the naked eye; arranged in numerous radial multiples of 2-4 or more, occasionally also solitary; thick-walled, oval or rounded when solitary and usually flattened when in radial groups; tyloses not observed; vessel-segments medium, truncate or attenuately tailed on one or both sides; perforations simple, horizontal or sometimes steeply inclined; intervessel pits fairly large, distinctly bordered, circular and alternate orifice lenticular or slit-like, placed horizontally or obliquely; vessel-ray pits of medium size, simple or narrowly bordered, oval to rounded, often tangentially stretched and 2-8 per cell.

Fibres medium to long; libriform; arranged uniformly in undisturbed radial seriations; rounded or polygonal in cross-sections; septate, septa thick; pits to the fibres few, simple, rounded or slightly elongated longitudinally, arranged in a linear manner.

Parenchyma very scanty, consists of a few irregularly scattered cells among the fibres. Cells rounded or polygonal.

Rays numerous, evenly distributed; outlines fairly visible to the naked eye; 1-4 seriate, 20–75 cells high, often as high as 105 cells; markedly heterogeneous with 1–6 marginal rows of vertical cells; rays exhibit considerable variety in the proportion and distribution of vertical cells to the procumbent cells; cells commonly filled up with a dark deposit.

Glochidioxylon tertiarum nov. sp.

Growth rings not distinct under the microscope.

Vessels 75–130 μ in diam., evenly distributed, 20–25 per sq. mm.; mostly in radial multiples of 2–4, thick-walled; tyloses not observed; vessel-segments 500–750 μ, truncate or attenuately tailed; intervessel pits alternate, distinctly bordered, circular; orifice lenticular or slit-like placed horizontally or obliquely.

Fibres libriform, 1600–2500 μ in length, 15–22 μ in diam., septate, septa of considerable thickness.

Parenchyma very scanty, diffuse; cells 15–25 μ in diam.

Rays 5–12 per mm.; 1–4 cells broad, majority 2–3 seriate or 25 40 μ broad, 20–75 cells or 550–2200 μ high, ray cells commonly filled up with a dark substance.

Holotype: No. 5030 of the Museum of Birbal Sahni Institute of Palæobotany.

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SUMMARY

Three new genera of the fossil woods of Euphorbiaceæ have been described in detail for the first time from Indian horizons. They are named as *Putranjivoxylon puratanam*, *Bridelioxylon cuddalorense* and *Glochidioxylon tertiarum*, by virtue of their striking resemblances to the modern genera *Putranjiva*, *Bridelia* and the wood-type of the *Glochidion* group of the Phyllanthoideæ section. All these woods have been collected from the Tertiary rocks of Mortandra in South Arcot District, 5 miles North-West of Pondicherry.

Table showing the salient features

Species	Growth rings	Vessels	Intervessel pitting
Euphorbioxylon speciosum Felix, 1887	..	Diffuse, mostly solitary, oval to rounded, perforations simple	Pits large, rounded or hexagonal bordered
Paraphyllanthoxylon arizonense Bailey, 1924	Feebly differentiated	Large, diffuse, 8–14 per sq. mm., solitary or in radial groups of 2–4, tyloses abundant, perforations simple	Pits crowded, hexagonal
Dryoxylon drypeteoides Bancroft, 1932	Very fine to the naked eye, but disappear under the microscope	Small, diffuse, solitary or in radial rows of 3 or more, other details not clear	Pits small forming a close network, details not preserved
Phyllanthinium pseudohobashiraishi Ogura, 1933, Watari, 1943	Present, but not prominent	Medium, diffuse, solitary or in radial groups of 2–4, tyloses abundant, perforations simple	Abundant, bordered, oval or angular
Euphorbioxylon Lefranci Boreau, 1951	Very faint	Medium, diffuse, 6 per sq. mm., mostly solitary, sometimes in radial groups of 2, vessel-segments tailed, perforations simple	..
Hancoxylon microporosum Kruse, 1954	Very indistinct, possibly absent	Medium, extremely variable in size, diffuse, 30–100 per sq. mm. Solitary and in radial multiples of 2–9, tyloses abundant, perforations simple	Alternate, fine, details not preserved
Putranjivoxylon puratanum Ramanujam	Absent	Small to sometimes medium, diffuse, 25 per sq. mm. mostly in radial multiples of 2–5 solitary vessels few, tyloses absent, vessel-segments short, truncate or abruptly or attenuately tailed, perforations simple or often scalariform	Abundant, pits small, alternate, bordered, circular with oval to elliptical apertures
Bridelioxylon cuddalorense Ramanujam	Distinct	Small to medium, diffuse, 20 per sq. mm., solitary or in radial groups of 2–5, tyloses absent, commonly filled with a dark deposit, vessel-segments medium, truncate or abruptly or attenuately tailed, perforations simple	Pits moderately large, alternate, distinctly vestured, usually hexagonal
Glochidioxylon tertiarum Ramanujam	Faint to the naked eye, but disappear under the microscope	Small to medium, diffuse, mostly in radial multiples of 2–4, 20–25 per sq. mm., tyloses absent, vessel-segments medium, truncate or attenuately tailed, perforations simple	Pits fairly large, distinctly bordered, alternate, circular, orifice lenticular, placed horizontally or obliquely

of fossil woods of Euphorbiaceæ

Fibres	Parenchyma	Rays	Locality and age
Libriform	Scanty, paratracheal	1–5 seriate, heterogeneous	Columbia, Tertiary
Thick-walled, septate, pits slit-like, simple or very narrowly bordered	Paratracheal, scanty, thin-walled, large-celled	1–7 seriate, 3–80 cells high, markedly heterogeneous	Arizona, Cretaceous
Thick-walled, details not preserved	Apotracheal in numerous closely set uniseriate tangential lines of varying regularity	1–4 seriate, slightly heterogeneous	East Africa, Miocene (?)
Libriform, septate, or aseptate, variable in size, irregular in arrangement, pits small, simple (?)	Very scanty, vasicentric, crystalliferous	1–4 cells wide, fusiform, slightly heterogeneous, 13–38 cells high, rays often fuse vertically end to end	Japan,Tertiary
Libriform, disposed in radial rows aseptate (?), pits simple	Very scanty, paratracheal	Uniseriate, heterogeneous, 9–20 cells high, ray cells filled with a black deposit	Algeria, Tertiary
Thick-walled, length not determined, aseptate (?)	Fairly abundant, paratracheal and apotracheal, the former scanty, the latter represented by multiseriate tangential bands	1–2 seriate, strikingly heterogeneous with alternation from 1-celled to 2-celled condition, 10–40 cells high.	Wyoming, Eocene
Libriform long, arranged regularly in radial seriations, aseptate, pits very small, simple, oval	Fairly abundant, apotracheal (1) in the form of numerous closely scattered cells or (2) as very short uniseriate lines, pits simple, round to oval 4-10 per cell	Evenly distributed. 1–3 seriate, 10–60 cells high, markedly heterogeneous, short multiseriate parts with procumbent cells alternating with portions formed of vertical cells in a single row, ray cells crystalline	South India, Tertiary
Libriform. medium arranged regularly in radial rows, septate, septa thick, pits simple, small, and rounded	Limited, mostly paratracheal, in 1–2 layered vasicentric sheaths, often also diffuse	Evenly distributed, 1–4 seriate, 12–35 cells high, heterogeneous with 1–2 marginal rows of vertical cells	South India, Tertiary
Libriform, medium to long, arranged in regular radial chains, septate, septa thick, pits simple, few rounded, arranged in a linear manner	Very scanty, as irregularly scattered cells among the fibres	Uniformly distributed, 1–4 seriate, 20–75 cells high, markedly heterogeneous with 1–6 marginal rows of vertical cells	South India, Tertiary

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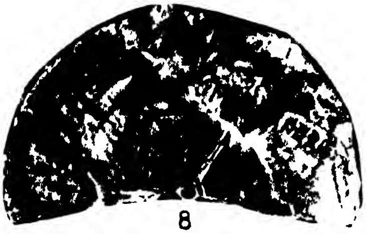
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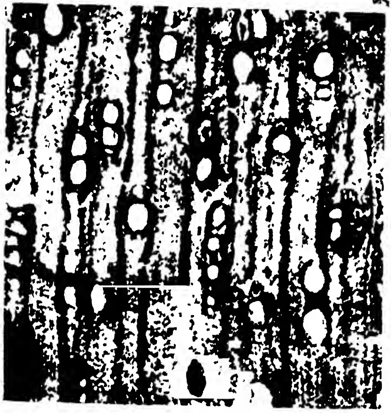
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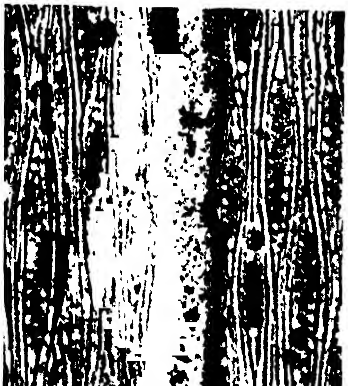
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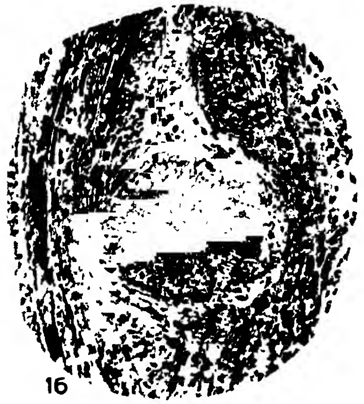
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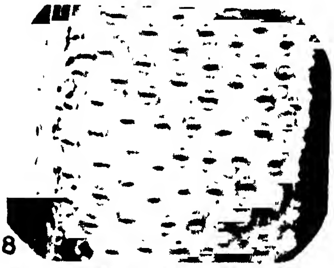
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EXPLANATION OF THE PLATES

PLATE XV

FIGS. 1 7. *Putranjivoxylon puratanam* nov. gen., nov. sp.

FIG. 1. Cross-section showing the distribution of the parenchyma and the vessels, × 95.

FIG. 2. Cross-section showing the radial multiples of vessels, and the diffuse paiencyhma cells, ×95.

FIG. 3. Vertical scalariform perforation plate, ×150.

FIG. 4. Oblique scalariform perforation plate, ×150.

FIG. 5. Tangenital section showing the uniseriate and multiseriate xylem rays. Note the crystals in the ray cells, ×95.

FIG. 6. Tangential section showing the multiseriate rays, ×95.

FIG. 7. Radial section showing the crystals in the ray cells, ×150.

PLATE XVI

FIGS. 8-14. *Bridelioxylon cuddalorense* nov. gen., nov. sp.

FIG. 8. Polished transverse surface of the fossil showing the growth rings, and the general structure, × ½ nat. size.

FIG. 9. Cross-section showing the late wood and spring wood fibres and the radial groups of vessels. Note the dark thin sheath of vasicentric parenchyma around the vessels, × 35.

FIG. 10. Cross-section slightly enlarged to show the vasicentric parenchyma and the nature and distribution of the fibres, ×95.

FIGS. 11, 12. Intervessel pitting to show the vestured nature of the pits, ×500.

FIG. 13. Tangential section showing the xylem rays and the septate fibres, ×95.

FIG. 14. Radial section, ×35.

PLATE XVII

FIGS. 15-20. *Glochidioxylon tertiarum* nov. gen., nov. sp.

FIG. 15. Central part of the wood to show the angular pith and the primary xylem, ×95.

FIG. 16. Tangential section showing a branch base, ×95.

FIG. 17. Cross-section showing the radial chains of vessels and the general nature and distribution of the fibres, ×95.

FIG. 18. Intervessel pits, ×500.

FIG. 19. Tangential section showing the multiseriate heterogeneous rays, ×95.

FIG. 20. Tangential section showing both the types of rays, the uniseriates entirely with vertical cells and the multiseriates with marginal vertical cells, ×95,

ON THE RECENT INTRODUCTIONS IN THE FLORA OF PURNEA (BIHAR)

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A FLORISTIC survey of the Purnea District by the author spread over a period of about 7 years (1948-55) and in various seasons of the year, yielded the list of plants given in Appendix I. In all 644 species are noted, of which more than half are not mentioned in Haines' Botany (1921-25) from Purnea (Appendix II) though Haines had made a thorough personal study of the flora of the district in the late twenties of the present century. It is interesting to note that within the short period of about 30 years, since the publication of Haines' book, over 300 plants have been introduced in the district, 274 of them reported from districts of Bihar other than Purnea, and 36 new to the State.

The present paper is an attempt to study the causes that made introductions of plants from other states possible, the agencies that brought these about, and the sources from which these plants could have come.

AN ANALYSIS OF THE NEW INTRODUCTIONS

Leaving aside the plants found near human habitations (where the list is not complete and where all introductions have possibly been by the agency of man), the proportion of the newly introduced plants to the total is as under.

Zone	Total No. of plants in the zone	Number of new introductions	Percentage of new over total
Aquatic and Amphibious	124	16	12·9
Low Grass-lands ..	124	9	7·24
High Grass-lands ..	122	2	1·6
Scrub Jungles ..	94	1	1·06
Monsoon Forests ..	165	5	3·0

The highest percentage of introductions are in the Aquatic and Amphibious zone and in the Low Grass-lands, slightly lower in the Monsoon Forests and very low in the Scrub Jungles and in the High Grass-lands.

Appendix I also shows that almost all the new introductions are herbs, shrubs and trees being rare.

ADAPTATIONS FOR DISPERSAL

Adaptations among the newly introduced plants for dispersal and the agencies by which they could be transported were studied (based mainly on Ridley, 1930).

1. Seed, fruit, or whole plant edible: dispersed mainly by birds:

Myriophyllum indicum Willd., *Ceratophyllum demersum* Linn., *Alisma reniforme* Don., *Lagarosiphon alternifolia* (Roxb.) Druce, *Spirodela polyrrhiza* (Linn.) Schleid., *Cyperus polystachyos* Rottb., *Brachiaria setigera* (Retz.) Hubbard, *Pseudoraphis aspera* (Koen.) Pilger, *Heliotropium subulatum* Hochst., *Plectronia parviflora* Bedd., *Vitis lanata* Roxb., *Solanum pubescens* Willd., *Eriocaulon intermedium* Koern., *Lolium perenne* Linn.

2. Seed, fruit, whole plant, or bits buoyant; dispersed mainly by adhering to the body of aquatic birds:

Myriophyllum indicum Willd., *Ceratophyllum demersum* Linn., *Alisma reniforme* Don., *Aponogeton crispum* Thunb., *Lagarosiphon alternifolia* (Roxb.) Druce, *Spirodela polyrrhiza* (Linn.) Schleid., *Cyperus polystachyos* Rottb., *Diplacrum caricinum* R. Br., *Eriocaulon intermedium* Koern., *Staurogyne glauca* O. Ktz., *Nesæa lanceolata* Koehne, *Ludwigia parviflora* Roxb., *Sphenoclea zeylanica* Gaertn., *Cyperus kyllinga* Endl., *Cyperus cephalotes* Vahl., *Alternanthera echinata* Sm., *Eichhornia crassipes* Solms., *Aegenetia pedunculata* (Roxb.) Wall., *Veronica anagallis* Linn.

3. Seed, fruit or whole plant buoyant; carried by rivers to long distances and drift with flood waters:

All plants of list 1 (except *Vitis lanata* Roxb., *Plectronia parviflora* Bedd. and *Solanum pubescens* Willd.).

All plants of list 2 and also *Neptunia oleracea* Lour., *Evolvulus nummularius* Linn., *Asystasia macrocarpa* Nees., *Aponogeton crispum* Thunb., *Peperomia pellucida* (Linn.) H. B. & K., *Pilea peploides* Hook. & Arn.

4. Fruit or seed light and feathery or winged; disperesd by winds and cyclones:

Urtica parviflora Roxb., *Pilea peploides* H. B. & K., *Lolium perenne* Linn., *Derris scandens* (Roxb.) Benth., *Dioscorea oppositifolia* Linn.

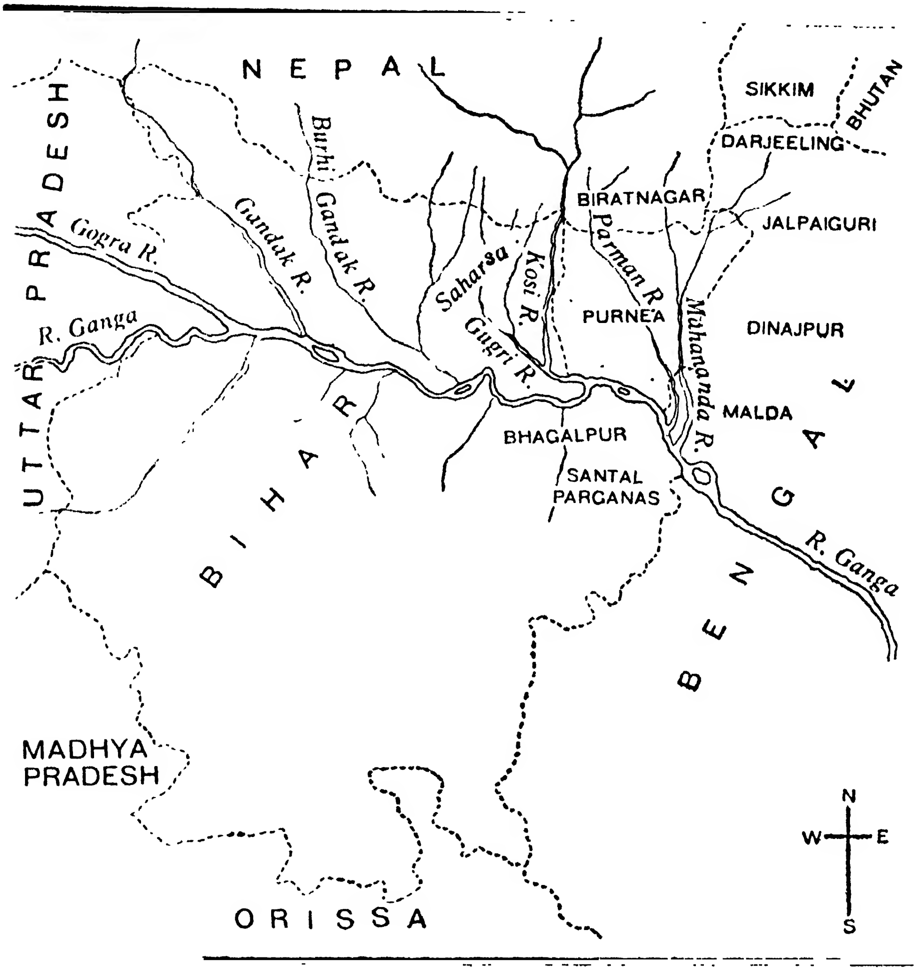
The physical features, rivers, climate, winds and birds of Purnea were studied to get an idea as to how the new introductions could have taken place.

PHYSICAL FEATURES

(Based mainly on the *District Gazetteer*, 1911, and Srivastava, 1955 *a*)

The district (*see* map) lies in the extreme north-east of the province. It has on its north the Biratnagar District of Nepal and the Darjeeling

District of Bengal. On its east, it has the Jalpaiguri, Dinajpur and Malda Districts of Bengal. On its south it has the river Ganga which separates it from the Bhagalpur and Santal Pargana Districts. On its east lies the Saharsa District.



Purnea District and its Neighbourhood

Purnea District, like the rest of North Bihar, is a low plain (elevation 125 ft. above sea-level) lying between the Himalayas in the north and the high lime-stone built left bank of the Ganga on its south. The soil is a sandy alluvium.

The rivers are: Kosi in the west, Mahananda in the east and the Panar (Parman, Parwana) running a south-east course and dividing the district into two halves. The Kosi is formed by the confluence of 7 streams in the east of Nepal. The Mahananda arises below the

Mahaldiram Hills in the Darjeeling District and flowing southwards forms the boundary between Purnea and Jalpaiguri Districts for a distance of 8 miles. Its tributaries come from Jalpaiguri District, Dinajpur District and Nepal. The Panar and its tributaries come from lower Nepal and Nepal Terai. The Kosi has been the chief river of the district in the past. Due to excessive deforestation in its upper reaches and in those of its tributaries in Nepal, and the consequent loss of top vegetation, the Kosi comes in floods with extreme suddenness. Its tributary Arun is cutting gorges in the Himalayas, therefore the Kosi brings an unlimited amount of rocks, boulders, sand and coarse silt, all of which get deposited in the bed of the river as it flows through the plains of Bihar. This accumulation naturally elevates the bed of the river and forces it to change its course. This happens every few years. A new channel is formed and the old one is left behind. When the river changes course, vast areas of arable land get covered with a layer of sand. It is therefore that the north-west part of Purnea shows only old channels of Kosi and sand-covered uplands alternating with each other. The north-east part of Purnea also shows a sandy soil, perhaps the sand was deposited by the Kosi ages back.

Due to defective drainage in the southern part of the district, the Kosi, its old channels, and the other rivers and rivulets, every year overflow their banks and inundate the country for hundreds of miles. The swamps and marshes and all the low lands get filled up with water. As the water recedes from over the slightly elevated lands, it leaves behind it a layer of fine sand and coarse silt.

CLIMATE

(Based mainly on the *District Gazetteer*, 1911, the *Climatological Atlas*, 1943, the data received from the Director of Meteorological Observatories, Poona, and the author's own observations)

The climate is of the monsoon type with a dry cool winter from middle of October to middle of February, and a dry hot summer from middle of February to early June. In the hot wet season from about the 1st of June to middle of October, Purnea Town gets about 60 inches of rainfall, Kishangunj gets 79·6 inches and Kaliagunj gets about 82 inches. But the rainfall is irregular and uneven, it falls in torrents rather than in evenly spread showers, so that over most of the excessively grazed land and in the cultivated fields, it has no chance to be absorbed in the soil but rushes down carrying the precious top soil.

Winds blow in Purnea from every direction in one part of the year or the other. The surface winds blow from north-east in November-December, and from east in May–September; the westerly winds in February–April are very strong and dry and are blowing away the top soil especially in the tree-less plains of Araria. The upper winds move from south-east in July–September, from north-east in March and from north-west in January–February and October–December.

BIRDS

(Based mainly on the *District Gazetteer*, 1911, Whistler, 1935 and Salim Ali, 1946)

Purnea District with its large number of marshes and slow-flowing streams abounds in fish and aquatic plants. For feeding on them, lots of birds visit Purnea. Damoiselle Crane, European Swallow, pale Harrier, Sand-Piper, Common Teal, several geese and ducks, the Grey, Yellow and Common Wagtail and others visit Purnea in the winter. These come from north and central Asia and from the Himalayas where the winter conditions are very severe. The Wood-snipe and Yellow Wagtail migrate further south but visit Purnea on their return journey in March. The Large Wagtail, Black-headed Oriole, Pea-fowl, Jungle-fowl, Whistling Teal, Bengal Floriken, Likh Floriken, Common Sand-grouse, Rain-quail, Button Quail, Rock Pigeon, Cuckoo, Hawk-cuckoo, Ibis, Curlew, Rail, Black Partridge, Green Pigeon, Comb Duck and others come from the sub-Himalayan tracts and the neighbouring states of Bengal, Assam, Uttar Pradesh and Orissa during and after the rainy season. The Plaintive Cuckoo and many others come in March from the Deccan Peninsula and further south.

CONDITIONS THAT FAVOUR INTRODUCTIONS

The introduction of such a large number of plants in Purnea District within such a short space of time has possibly been due to the creation in several ways of virgin soils and open areas, places that offer facilities of lodgement to the new arrivals.

The to-and-fro movement of the Kosi River covers large areas of land with sand and coarse silt. During floods, the three rivers, particularly the Kosi, inundate large areas in South Purnea and in the Purnea Town and, on receding, leave it covered with a layer of silt. In the portions kept open by cultivation, there is no question of any competition of the new arrivals with the original vegetation. Even the uncultivated parts, being covered with new layers of silt, offer place for landing. The dry beds of the wide and shallow Kosi River and the newly formed islands, offer good places for lodgement to the new species. All the three rivers, during floods, cause erosion on one bank and deposition on the other. Thus both banks are kept as open areas. Excessive grazing in the grass-lands, particularly, the scraping away of doob-grass by man, and excessive cutting in the scrub-jungles and forests exposes the soil. The torrential rains wash away the soil and form ravines and gulleys on which some of the new arrivals can settle. The erosion by wind, as in Araria area, exposes the lower layers of soil; these also form open areas for the new plants.

POSSIBLE SOURCES

The possible sources of these newly introduced plants in Purnea District have been the following:

1. Nepal Terai, Darjeeling Terai or Sikkim Terai for:

Ludwigia prostrata Roxb., *Aegenetia pedunculata* (Roxb.) Wall., *Asystasia macrocarpa* Nees., *Alisma reniforme*, Don, *Peperomia pellucida* (Linn.) H. B. & K. (*vide* Haines, 1921–25).

Staurogyne glauca O. Ktz., *Diplacrum caricinum* R. Br., *Pilea peploides* Hook. & Arn. (*vide* Hooker f., 1872-97).

2. The lower Himalayas or Nepal for:

Vitis lanata Roxb., *Veronica anagallis* Linn. (*vide* Hooker f., 1872–97). *Urtica parviflora* Roxb., *Derris scandens* (Roxb.) Benth. (*vide* Burkill, 1910).

3. Assam, Sikkim, or Abor for:

Ceratophyllum demersum Linn., *Urtica parviflora* Roxb. (*vide* Burkill, 1924), *Urtica parviflora* Roxb. (*vide* Smith & Cave, 1911 and Smith, 1913), *Eriocaulon intermedium* Koern., *Dioscorea oppositifolia* Linn., (*vide* Hooker f., 1872–97), *Staurogyne glauca* O. Ktz. (*vide* Kanjilal, Kanjilal and Das, 1934), *Pseudoraphis aspera* (Koen.) Pilger., *Lolium perenne* Linn. (*vide* Bor, 1940).

4. North Bengal for:

Cyperus cephalotes Vahl., *Veronica anagallis* Linn., *Aegenetia pedunculata* (Roxb.) Wall., *Derris scandens* (Roxb.) Benth., *Neptunia oleracea* Lour., *Myriophyllum indicum* Willd., *Sphenoclea zeylanica* Gaertn., *Ceratophyllum demersum* Linn., *Lagarosiphon alternifolia* (Roxb.) Druce, *Alisma reniforme* Don, *Aponogeton crispum* Thunb., *Diplacrum caricinum* R. Br. (*vide* Prain, 1905).

5. Bengal in general for:

Eichhornia crassipes Solms. (*vide* Biswas and Calder, 1937), *Vitis lanata* Roxb., *Evolvulus nummularius* Linn., *Cyperus kyllinga* Endl., *Pseudoraphis aspera* (Koen.) Pilger, *Brachiaria setigera* (Retz.) Hubbard, *Spirodela polyrrhiza* (Linn.) Schleid., *Dioscorea oppositifolia* Linn. (*vide* Prain, 1903).

6. Uttar Pradesh or its Terai for:

Derris scandens (Roxb.) Benth. (*vide* Kanjilal, 1933), *Lagarosiphon alternifolia* (Roxb.) Druce, *Sphenoclea zeylanica* Gaertn., *Neptunia oleracea* Lour., *Veronica anagallis* Linn., *Aponogeton crispum* Thunb., *Cyperus kyllinga* Endl. (*vide* Duthie, 1903–29), *Alternanthera echinata* Sm. (*vide* Raizada, 1950, and Srivastava, 1955 *b*).

7. The Madhya Pradesh for:

Aponogeton crispum Thunb. (*vide* Haines, 1921—25).

8. Orissa for:

Cyperus polystachyos Rottb., *Cyperus cephalotes* Vahl. (*vide* Haines, 1921–25).

9. The Deccan, Madras Presidency or the Eastern Ghats for:

Lagarosiphon alternifolia (Roxb.) Druce, *Spirodela polyrrhiza* (Linn.) Schleid., *Pseudoraphis aspera* (Koen.) Pilger, *Ludwigia prostrata* Roxb., *Aponogeton crispum* Thunb., *Cyperus cephalotes* Vahl., *Cyperus kyllinga* Endl., *Diplacrum caricinum* R. Br., *Lolium perenne* Linn. (*vide* Gamble, 1918–35), *Lagarosiphon alternifolia* (Roxb.) Druce, *Vitis lanata* Roxb. (*vide* Haines, 1921–25), *Cyperus polystachyos* Rottb., *Brachiaria setigera* (Retz.) Hubbard, *Solanum pubescens* Willd., *Nesæa lanceolata* Koehne, *Plectronia parviflora* Bedd., *Eriocaulon intermedium* Koern, *Heliotropium subulatum* Hochst. (*vide* Hooker f., 1872-97).

SUMMARY

The virgin soils and open areas of the Purnea District that are being formed in various ways have invited plants from outside to settle on them. The larger number of these have been brought by water, birds and wind from the adjoining states. A few have been brought by birds even from distant lands. In this way 36 plants have been introduced in the Purnea District within the last 30 years or so. The progressive desiccation of the district has made the hardier plants from the western districts to come and settle down here.

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APPENDIX I

A complete list of plants collected so far from the Purnea District, arranged in ecological zones. An arrow mark after the name indicates that the plant occurs in the next higher zone also. An asterisk before the name indicates that the plant is being recorded for the first time from Purnea, and a dagger before the name means that it is a new record for Bihar.

I. Aquatic and Amphibious Plants

**Nymphæa pubescens* Willd.
**Nymphæa esculenta* Roxb.
Euryale ferox Salisb.
Pentapetes phœnicea L.
**Melochia corchorifolia* L.
**Corchorus capsularis* L.
Corchorus olitorius L.
**Aeschynomene indica* L.
Aeschynomene aspera L.
†*Neptunia oleracea* Lour.
†*Myriophyllum indicum* Willd.
**Rotala rotundifolia* Koehne.
**Rotala indica* (Willd.) Koehne.
**Rotala leptopetala* Koehne.
**Ammannia pygmæa* Kurz.
**Ammannia baccifera* L.
†*Nesæa lanceolata* Koehne.
Jussiæa repens L.
**Jussiæa suffruticosa* L.—
Jussiæa erecta L.—
**Ludwigia parviflora* Roxb.—
†*Ludwigia prostrata* Roxb.—
Trapa bispinosa Roxb.
Oenanthe benghalensis Benth.
Adenostemma lavenia (Linn.) O. Ktz.
**Cæsulia axillaris* Roxb.
**Enhydra fluctuans* Lour.
†*Sphenoclea zeylanica* Gaertn.
**Limnanthemum indicum* (Linn.) Griseb.
**Limnanthemum cristatum* (Roxb.) Griseb.
Hydrolea zeylanica (Linn.) Vahl.
**Ipomœa aquatica* Forsk.
**Bacopa monnieri* (Linn.) Pennell.
Limnophila conferta Benth.
**Limnophila indica* (Linn.) Druce.
Limnophila heterophylla Benth.
Limnophila diffusa Benth.
Limnophila sessiliflora (Vahl.) Blume.
†*Veronica anagallis* L.
Utricularia stellaris Linn. f.
**Utricularia flexuousa* Vahl.
Hygrophila polysperma (Roxb.) T. Anders.—
**Asteracantha longifolia* (Linn.) Nees.—
Lippia geminata H. B. & K.—
Achyranthes aquatica R. Br.
Alternanthera sessilis (Linn.) R. Br.
**Polygonum orientale* L.
**Polygonum limbatum* Meissn. ?
Polygonum glabrum Willd.
Polygonum lanigerum R. Br.
Polygonum minus Huds.
Polygonum barbatum L.
Polygonum stagnium Ham.
Polygonum rottleri Roth.
Polygonum hydropiper L.
Polygonum prætermissum Hook. f.
†*Ceratophyllum demersum* L.
Alisma plantago L.
†*Alisma reniformis* Don.
Sagittaria sagittifolia L.
Sagittaria guayanensis H. B. & K.
**Butomopsis lanceolata* Kunth.
**Aponogeton natans* (Linn.) Engler.
†*Aponogeton crispum* Thunb.
**Potamogeton crispus* L.
**Potamogeton pectinatus* L.
Naias Kurziana Rendle.
**Naias graminea* Del.
**Hydrilla verticillata* (Linn. f.) Presl.
†*Lagarosiphon alternifolius* (Roxb.) Druce
**Vallisnaria spiralis* Linn.
Ottelia alismoides (Linn.) Pers.
**Pistia stratioides* L.
†*Spirodela polyrrhiza* Schleid.
**Spirodela oligorrhiza* Hegelm.
Wolffia arrhiza Wimm.
†*Cyperus cephalotes* Vahl.
Cyperus platystylis R. Br.
**Cyperus tenuispica* Steud.
**Cyperus distans* Linn.f.
**Cyperus exaltatus* Retz. var. *amæna*
†*Cyperus polystachyos* Rottb.
**Cyperus stramineus* Clarke.
**Cyperus latespicatus* Boeck.
**Cyperus sanguinolentus* Vahl.
**Cyperus pumilus* Linn.
Cyperus cyperoides (Linn.) O. Ktz.
Cyperus compactus Retz.
**Eleocharis capitata* R. Br.
Eleocharis atropurpurea Kunth.
**Eleocharis palustris* R. Br.
**Eleocharis chætaria* Roem. & Schult.
**Fimbristylis miliacea* Vahl.—
**Fimbristylis quinqueangularis* Kunth.
**Fimbristylis thomsoni* Boeck.

Fimbristylis schœnoides Vahl.
*_Fimbristylis bis-umbellata_ (Forsk.) Baheni.
*_Fimbristylis podocarpa_ Nees.
*_Fimbristylis diphylla_ (Retz.) Vahl. var. _pluri-aristata_ Clarke.
*_Fimbristylis annua_ Roem. & Schult.
Fimbristylis tetragona R. Br.
Fimbristylis dispacea Benth.
*_Fimbristylis squarrosa_ Vahl.
Bulbostylis barbata Kunth.—
*_Bulbostylis capillaris_ Kunth.
*_Scirpus squarrosus_ Linn.
*_Scirpus articulatus_ Linn.
*_Scirpus grossus_ Linn. f.
*_Scirpus supinus_ L.
Phragmites maxima Chiovenda.
Oryza sativa L.
Leersia hexandra Swartz.
*_Hygroryza aristata_ (Roxb.) Nees.
*_Sacciolepis myosuroides_ (R. Br.) A. Camus.
Sacciolepis interrupta (Willd.) Stapf.
Panicum repens Linn.
*_Panicum paludosum_ Roxb.
†_Pseudoraphis aspera_ (Koen.) Pilger.
Paspalum scrobiculatum Linn.—
*_Paspalidium punctatum_ (Burm.) A. Camus.—
*_Ischæmum rugosum_ Salisb.—
Vetiveria zizanioides (Linn.) Stapf.—
Hemarthria compressa (Linn. f.) R. Br.
*_Coix lachryma-jobi_ L.
Coix gigantea Roxb.
†_Eriocaulon intermedium_ Koern.
*_Eriocaulon cinerum_ R. Br.
*_Eriocaulon soleyanum_ Royle.
Eriocaulon quinqueangulare Linn.
*_Cyanotis axillaris_ Roem. & Schult.—
Juncus prismatocarpus R. Br.
*_Monochoria hastata_ Solms.
*_Monochoria vaginalis_ Presl.
†_Eichhornia crassipes_ Solms.
*_Ceratopteris thalictroides_ Brong.
Salvia cucullata Roxb.

2. Plants of the Low Grass-Lands

Stellaria wallichiana Haines.
Polycarpon indicum (Retz.) Merrill.
Phyllanthus urinaria L.
*_Phyllanthus simplex_ Retz.—
*_Phyllanthus niruri_ L.
Phyllanthus debilis Ham.
Smithia sensitiva Ait.
Potentilla supina L.
Drosera burmannii Vahl.
*_Centella asiatica_ (Linn.) Urban.
*_Hydrocotyl sibthorpoides_ Lamk.
Dentella repens (Linn.) Forst.
Oldenlandia scandens K. Schum.
Oldenlandia diffusa Roxb.
Oldenlandia gracilis DC.
*_Oldenlandia paniculata_ L.
*_Gnaphalium luteo-album_ L.
*_Gnaphalium indicum_ L.
*_Gnaphalium pulvinatum_ Delile.
*_Chrysanthellum indicum_ DC.
Cotula hemispherica Wall.
Centipeda minima (Linn.) A. Br. & Aschers.
*_Launea nudicaulis_ Hook. f.
*_Launea asplenifolia_ DC.
Stylidium kunthii Wall.
*_Lobelia alsinoides_ Lamk.
Lobelia terminalis Clarke.
Lobelia affinis Wall.
Wahlenbergia gracilis Schrad.
Androsace saxifragæfolia Bunge.
*_Anagallis arvensis_ L.
*_Anagallis pumila_ Swartz.
*_Exacum pedunculatum_ L.
Exacum tetragonum Roxb.
Swertia angustifolia Buch-Ham. var. _pulchella_ Burkill.
*_Canscora diffusa_ R. Br.
*_Canscora decurrens_ Dalz.
Hoppea dichotoma Willd.
Merremia vitifolia (Burm. f.) Hallier.
Mazus japonicus (Thunb.) O. Ktz.
*_Bacopa hamiltoniana_ (Benth.) Wetts.
Adenosma capitatum (Benth.) Hance.
Lindernia hirta (Cham. & Sch.) Pennell.
Lindernia crustacea (Linn.) F. Muell.
Lindernia cordifolia (Colsm.) Merrill.
Lindernia verbenæfolia (Colsm.) Pennell.
*_Lindernia ciliata_ (Colsm.) Pennell.
*_Lindernia anagallis_ (Burm.) Pennell.
*_Lindernia pyxidaria_ All.
Lindernia parviflora (Roxb.) Haines.
Centranthera nepalensis D. Don.
Centranthera hemifusa Wall.
Striga asiatica (Linn.) O. Ktz.
Aegenetia indica Linn.
†_Aegenetia pedunculata_ (Roxb.) Wall.
*_Staurogyne glutinosa_ O. Ktz.
†_Staurogyne glauca_ O. Ktz.
Cardenanthera triflora Buch.-Ham.
*_Justicia quinqueangularis_ Koen.
Justicia peploides T. Anders.
*_Justicia diffusa_ Willd.
*_Justicia simplex_ Don.
*_Phyla nodiflora_ (Linn.) Green.
Dysophila cruciata Benth.
Dysophila verticillata Benth.
Dysophila crassicaulis Benth.
Salvia plebeia R. Br.
*_Meriandra benghalensis_ Benth.
*_Nepeta hindostana_ (Roth.) Haines.
Celosia argentea Linn.
*_Digera muricata_ (Linn.) Mart.
†_Alternanthera echinata_ Sm.

*_Rivina lævis_ L.
Polygonum chinensis L.
Rumex nigricans Hook. f.
*_Cannabis sativa_ L.
†_Urtica parviflora_ Roxb.
Pilea scripta Wedd.
†_Pilea peploides_ Hook. & Arn.
*_Pouzolzia zeylanica_ (Linn.) Benn.
*_Pouzolzia pentandra_ Benn.
*_Cyperus iria_ L.
Cyperus cuspidatus H. B. & K.
*_Cyperus difformis_ L.
Cyperus niveus Retz.—
Cyperus amabilis Vahl.—
*_Cyperus nutans_ Vahl.
*_Cyperus rotundus_ Linn.
*_Cyperus triceps_ (Rottb.) Endl.
†_Cyperus kyllinga_ Endl.
†_Diplacrum caricinum_ R. Br.
*_Fuirena glomerata_ Lamk.
*_Eragrostis japonica_ Trin.—
Eragrostis unioloides (Retz.) Nees.
*_Eragrostis gangetica_ (Roxb.) Steud.
*_Eragrostis cilianensis_ (All.) Link.
*_Eragrostis pilosa_ (Linn.) Beauv.
Eragrostiella bifaria Bor.—
Elytrophorus spicatus (Willd.) A. Camus.
Cynodon dactylon (Linn.) Pers.
Eleusine indica (Linn.) Gaertn.
*_Dactyloctenium ægyptium_ (Linn.) Beauv.
*_Sporobolus tremulus_ Kunth.
*_Echinochloa crus-galli_ (Linn.) Beauv.
*_Oplismenus burmanni_ (Retz.) Beauv.
†_Brachiaria setigera_ (Retz.) Hubbard.
Eriochloa procera (Retz.) Hubbard.
*_Saccharum spontaneum_ Linn.
*_Eriantha benghalensis_ (Retz.) Hubbard.
Apocopsis paleaceous (Trin.) Host.
†_Lolium perenne_ L.
Apluda mutica L. var. _eumutica_ (Linn.) Pilger.
*_Commelina nudiflora_ L.
*_Commelina salicifolia_ Roxb.
*_Commelina benghalensis_ L.
Murdannia spiratum (Linn.) Bruckner.
Murdannia nudiflorum (Linn.) Bruckner.
Murdannia vaginatum (R. Br.) Bruckner.
Floscopa scandens Lour.

3. PLANTS OF THE HIGH GRASS-LANDS

*_Cleome viscosa_ Linn.
*_Gynandropsis gynandra_ (Linn.) Briq.
*_Sida veronicæfolia_ Lamk.
*_Sida glutinosa_ Cav.
*_Sida cordifolia_ Linn.
Sida spinosa Linn.
Hibiscus pungens Roxb.
*_Hibiscus panduræformis_ Burm.
*_Abelmoschus manihot_ (Linn.) Medik.
*_Triumfetta annua_ Linn.
*_Triumfetta pentandra_ A. Rich.
Triumfetta rhomboidea Jacq.
*_Corchorus trilocularis_ L.
*_Corchorus fascicularis_ Lamk.
*_Corchorus æstuans_ Linn.
*_Euphorbia granulata_ Forsk.
Euphorbia parviflora Linn.
Euphorbia thymifolia L.
*_Crotalaria acicularis_ Buch-Ham.
*_Crotalaria prostrata_ Roxb. var. _lævis_ Haines.
*_Crotalaria tetragona_ Roxb.
*_Medicago lupulina_ L.
*_Medicago denticulata_ Willd.
*_Indigofera linifolia_ Retz.
*_Indigofera sumatrana_ L.
*_Indigofera hirsuta_ Linn.
*_Uraria picta_ (Jacq.) Desv.
*_Uraria pulchra_ Haines.
*_Uraria lagopodioides_ Merr.
*_Uraria alopecuroides_ Wight.
*_Alysicarpus bupleurifolius_ (Linn.) DC.
*_Alysicarpus rugosus_ (Willd.) DC.
*_Alysicarpus monilifer_ DC.
*_Alysicarpus hamosus_ Edgew.
*_Desmodium triflorum_ (Linn.) DC.
Desmodium triangularis (Retz.) Santapau
Desmodium triquetrum (Linn.) DC.
Desmodium motorium Merr.
Desmodium gyroides (Roxb.) DC.
*_Phaseolus trilobatus_ Ait.
*_Phaseolus aconitifolius_ Jacq.
*_Cassia occidentalis_ Linn.
Cassia leschaultiana DC.
*_Mimosa pudica_ Linn.
*_Melothria zehneroides_ Haines.—
Trachyspermum roxburghii (DC.) Sprague.
*_Oldenlandia pumilla_ DC.
*_Oldenlandia corymbosa_ Linn.
*_Oldenlandia dichotoma_ Koen.
*_Borreria stricta_ (Linn. f.) Schum.
*_Borreria hispida_ (Linn.) Schum.
*_Elephantopus scaber_ L.
*_Erigeron asteroides_ Roxb.
Blumea atropurpurea Haines.
Blumea lacera DC.
Blumea virens DC.
Bidens biternata (Lour.) Merr. & Sherff.
*_Cirsium avense_ (Linn.) Scop.
Artemisia caruifolia Buch-Ham.
Sausurea affinis Spr.
*_Youngia japonica_ (Linn.) DC.
Lactuca polycephala DC.
Sonchus arvensis L. var. _glaber_ Haines.
*_Lochnera pusilla_ Schum.
*_Heliotropium indicum_ L.
Heliotropium strigosum Willd.
†_Heliotropium subulatum_ Hochst.
*_Heliotropium ovalifolium_ Forsk.

*_Evolvulus alsinoides_ Linn.
†_Evolvulus nummularius_ Linn.
Ipomœa cæspitosa Haines.
Merremia chryseoides Hallier. f.
*_Scoparia dulcis_ L.
Striga euphrasioides Benth.
Dipteracanthus prostratus (Poir.) Nees.
*_Peristrophe bicalyculata_ (Retz.) Nees.
*_Dicliptera roxburghiana_ Nees.
Clerodendron viscosum Vent.
*_Ocimum americanum_ L.
*_Ocimum basilicum_ L.
*_Hyptis suaveolens_ (Linn.) Poit.—
*_Pogostemon plectranthoides_ Desf.
Plectranthus ternifolius Don.
*_Leonurus sibericus_ L.
Leucas lavandulæfolia Rees.
*_Leucas cephalotes_ Spreng.
Pupalia atropurpurea Moq.
*_Aerva lanata_ (Linn.) Juss.
*_Aerva sanguinolenta_ (Linn.) Bl.
*_Achyranthes aspera_ Linn.
Chenopodium album L.
*_Chenopodium murale_ L.
*_Chenopodium ambrosoides_ L.
*_Eragrostis plumosa_ Link.
*_Eragrostis coarctaca_ Stapf.
*_Chloris incompleta_ Roth.
Chloris barbata Sw.
*_Sporobolus diander_ Beauv.
*_Aristida adscenscionis_ L.
Arundinella benghalensis Druce.
*_Digitaria ascendans_ (H.B. K.) Henrard.
Perotis indica (Linn.) O. Ktz.
*_Oplismenus compositus_ (Linn.) Beauv.
Isachne miliacea Roth.
Isachne dispar Trin.
*_Isachne albens_ Trin.
Setaria italica (Linn.) Beauv.
*_Panicum humile_ Nees. ex. Steud.
Echinochloa colona (Linn.) Link.
Panicum trypheron Schult.
Paspalidium flavidum (Retz.) A. Camus.
Erianthus arundinaceus (Retz.) Jeswait.
Narenga porphyrocoma (Hance.) Bor.
Saccharum fastigiatum Steud.
*_Imperata cylindrica_ (Linn.) Beauv.
Eulalia cummingii (Nees.) A. Camus.
*_Eulalia binata_ (Retz.) Hubbard.
*_Bothriochloa pertusa_ (Willd.) A. Camus.
*_Chrysopogon aciculatus_ (Retz.) Trin.
*_Dichanthium caricosum_ (Linn.) A.Camus.
*_Dichanthium annulatum_ (Forsk.) Stapf.
Schizachyrium brevifolium (Sw.) Nees.
Cymbopogon flexuous (Nees.) Wats.
*_Themeda quadrivalvis_ (Linn.) O. Ktz.
Themeda strigosa (Buch-Ham.) A. Camus.
Themeda arundinacea Ridley.
*_Ophiuros megaphyllus_ Stapf.
*_Apluda mutica_ L. var. _aristata_ (L.) Pilger.
*_Hackelochloa granularis_ (Linn. f.) O. Ktz.
Murdannia scapiflorum (Wight) Bruckner.
*_Habenaria constricta_ Hook f.
Adenostylis strateumatica (Linn.) Ames.
Zeuxine membranacea Lindl.

4. Plants of the Scrub-Jungles

*_Annona squamosa_ L.—
Flacourtia sepiaria Roxb.
*_Flacourtia indica_ Merr.
*_Flacourtia jangomas_ (Lour.) Raeusch.
*_Salmalia malabarica_ (DC.) Schott. & Endl.
Grewia sepiaria Roxb.
*_Jatropha curcas_ Linn.
*_Jatropha gossypifolia_ Linn.
Bridelia stipularis (Linn.) Blume.
Bridelia tomentosa (Linn.) Blume.
*_Kirganellia reticulata_ (Poir.) Baill.—
*_Melanthesa turbinata_ (Koen.) Wight.—
Glochidion multiloculare Muell-Arg.
Aporosa dioica (Roxb.) Muell-Arg.
Antidesma ghæsembilla Gaertn.
*_Antidesma diandrum_ (Roxb.) Roth.
Euphorbia acaulis Roxb.
*_Glycosmis pentaphylla_ (Retz.) Correa.—
*_Murraya kœnigii_ (Linn.) Spreng.
Aegle marmelos (Correa) Tanaka.
Toona ciliata (Roem.)
*_Zizyphus mauritiana_ Lamk. var. _fruticosa_ (Haines) Srivastava.
Zizyphus œnoplia Mill.
Zizyphus rugosa Lamk.
Cayratia trifolia (Linn.) Gagnep.
Abrus lævigatus F. Mey.
Abrus precatorius Linn.
Canavalia virosa (Roxb.) W. & A.
Butea monosperma (Linn.) O. Ktz.
*_Mucuna nigricans_ (Lour.) Steud.
Erythrina variegata L. var. _orientalis_ Merrill.
Dalbergia sissoo Roxb.
*_Cæsalpinia spicata_ Dalz.
*_Cæsalpinia crista_ L.
Mimosa himalayana Gamble.
*_Acacia arabica_ (Lamk.) Willd.
Acacia canescens Grahm.
Acacia concinna (Willd.) DC.
*_Acacia catechu_ Willd.
Melothria maderaspatensis (Linn.) Cogn.
Bryonia amplexicaule Lamk.
*_Momordica charantia_ L.
*_Momordica dioica_ Roxb. ex Willd.
Luffa echinata Roxb.
Luffa graveolens Roxb.
Opuntia monacantha Haw.

*_Opuntia dillenii_ (Ker-Grawl.) Haw.
*_Alangium salvifolium_ (Linn. f.) Wang.
Alangium chinensis (Lour.) Merr.
Morinda angustifolia Roxb.
*_Randia brandisii_ Gamble.
Randia fasciculata DC.
*_Pavetta indica_ L.
Coffea benghalensis Roxb.
†_Plectronia parviflora_ Bedd.
Vangueria spinosa Roxb.—
*_Vangueria pubescens_ Kurz.
Pæderia fœtida L.
Diospyros montana Roxb.
Symplocos racemosa Roxb.
Ichnocarpus frutescens R. Br.
*_Hemidesmus indicus_ (Linn.) R. Br.
Cryptolepis buchanani Roem. & Schult.—
Streptocaulon sylvestre Wight.
*_Pergularia dæmia_ (Forsk.) Blatter & McCann.
Oxystelma esculentum (Linn. f.) R. Br.
Calotropis acia Buch.-Ham.
Cynanchum callialatum Buch.-Ham.
Gymnema sylvestre (Retz.) R. Br.
*_Telosma pallida_ (Roxb.) Craib.
*_Ipomæa muricata_ (Linn.) Jacq.
*_Ipomæa pes-tigris_ L. var. _capitellata_ Clarke.
*_Ipomæa obscura_ (Linn.) Ker-Grawl.
*_Merrenia emarginata_ (Burm. f.) Hallier.
Calystegia hederacea Wall.
Solanum verbascifolium L.—
*_Solanum indicum_ L.
Solanum torvum Swartz.—
*_Martynia annua_ Linn.
*_Lantana camara_ L. var. _aculeata_ L.
*_Premna flavescens_ Buch.-Ham.
Colebrookea oppositifolia Sm.
Deeringia amaranthoides (Lamk.) Merr.
Bœhmeria platyphylla Don.
Bœhmeria scabrella (Roxb.) Gaud.
Streblus asper Lour.
*_Ficus retusa_ L.
Ficus heterophylla Linn. f.
*_Phœnix sylvestris_ (Linn.) Roxb.
*_Borassus flabellifer_ L.
Dioscorea puber Blume.
Dioscorea hispida Dennst.
Dioscorea bulbifera L.
Alpinia allughas Rosc.—
Lygodium flexuosum Sw.
Lygodium japonicum Sw.
Lygodium microphylla Sw.
Pteris longifolia L.
Other ferns.

5. Plants of the Monsoon Forests

Naravelia zeylanica DC.
Dillenia indica L.
Dillenia pentagyna Roxb.
Michelia champaca L.
Annona reticulata L.
Saccopetalum longiflorum Hook. f. & Arn.
*_Cissampelos pareira_ Linn.
Stephania hernandifolia (Willd.) Walp.
*_Tinospora cordifolia_ (Willd.) Miers.
*_Tiliacora acuminata_ (Lamk.) Miers.
*_Cocculus hirsutus_ (Linn.) Diels.
Casearia tomentosa Roxb.
Mesua ferrea L.
*_Hibiscus lobatus_ O. Ktz.
*_Pterospermum acerifolium_ Willd.
Pterospermum suberifolium Lamk.
Grewia sapida Roxb.
Eleocarpus sphæricus (Gaertn.) Schum.
Eleocarpus serratus L.
Croton oblongifolius Roxb.
*_Trewia polycarpa_ Benth.
Mallotus repandus Muell-Arg.
Baliospermum montanum Muell-Arg.
Sapium sebiferum Roxb.
*_Tragia involucrata_ L.
Putranjiva roxburghii Wall.
*_Murraya paniculata_ (Linn.) Jack.
Aphanamixis polystachya (Wall.) Parker.
Natsium herpeticum Buch.-Ham.
Cissus adnata Roxb.
Cissus repanda Vahl.
†_Vitis lanata_ Roxb.
Ampelocissus latifolia (Roxb.) Planch.
Ampelocissus tomentosa Planch.
Tetrastigma bracteolata Planch.
Tetrastigma thomsoniana Planch.
Leea crispa Linn.
Leea macrophylla Roxb. ex. Hormen.
Lannea coromandeliana (Houst.) Merrill.
*_Desmodium pulchellum_ (Linn.) Benth.
*_Desmodium laxiflorum_ DC.
*_Desmodium gangeticum_ (Linn.) DC. var. _maculatum_ Baker.
Puereria phaseoloides Benth.
*_Mucuna prurita_ Hook. f.
*_Derris cuneifolia_ Benth.
†_Derris scandens_ (Roxb.) Benth.
Mezoneuron cucullatum (Roxb.) W. & A.
Entada phaseoloides (Linn.) Merr.
*_Acacia farnesiana_ (Linn.) Willd.
Albizzia lucida (Roxb.) Benth.
Albizzia lebbek (Linn.) Benth.
Rosa involucrate Roxb.
*_Terminalia bellerica_ (Gaertn.) Roxb.
Syzygium operculatum Gamble.
Syzygium jambos (Linn.) Alston.
Barringtonia acutangula Gaertn.
Osbeckia rostrata Don. var. _pulchella_ Benth.
Osbeckia nepalensis Hook. f.
Trichosanthes bracteata (Lamk.) Wight.
*_Trichosanthes dioica_ Roxb.

Coccinia cordifolia Cogn.
Trevesia palmata Vis.
Hymenodicyton excelsum (Roxb.) Wall.
Hyptianthera stricta W. & A.
Ardisia solenacea Roxb.
*_Madhuka indica_ Gmel.
*_Madhuka butyracea_ (Roxb.) McBride.
Malinkara hexandra (Roxb.) Dubard.
Jasminum pubescens (Retz.) Willd.
Ervatamia divaricata (Linn.) Burm.
Alstonia scholaris R. Br.
Buddleia neemda Buch.-Ham.
Ehretia acuminata R. Br.
Ehretia lævis Roxb.
Argyreria roxburghii Choisy.
*_Porana paniculata_ Roxb.
Calonyction aculeatum (Linn.) Houst.
*_Merremia umbellata_ (L.) Hallier. f. var. _cochleata_ (Haines) Srivastava.
Ipomœa digitata Linn.
Solanum ferox L.
†_Solanum pubescens_ Willd.
*_Datura stramonium_ L.
Stereospermum suaveolens DC.
Strobilanthes scaber Nees.
*_Erianthemum nervosum_ R. Br.
Barleria strigosa Willd.
†_Asystasia macrocarpa_ Nees.
Adhatoda vasica Nees.
Callicarpa tomentosa (Linn.) Murr.
Callicarpa macrophylla Vahl.
*_Tectona grandis_ Linn. f.
*_Vitex negundo_ L.
Premna scandens Roxb.
*_Premna barbata_ Wall.
Premna latifolia Roxb. var. _latifolia_ proper.
..........var. _mucronata_ Clarke.
.... var. _gamblei_ Haines.
*_Premna benghalensis_ Clarke.
*_Gmelina arborea_ Roxb.
Clerodendron serratum (Linn.) Moon.
Clerodendron indicum O. Ktz.
*_Caryopteris wallichiana_ Schauer.
Anisomeles indica (Linn.) O. Ktz.
Ajuga macrosperma Wall.
Piper betel L.
Piper longum L.
†_Peperomia pellucida_ (Linn.) H. B. & K.
*_Litsæa glutinosa_ (Lour.) C. B. Rose.
Litsæa salicifolia Roxb. var. _laurifolia_ Hook. f.
*_Dendrophthœ falcata_ (Linn. f.) Etting.
*_Loranthus globosus_ Roxb.
Distemon indicum Wedd.
*_Morus indica_ L.
Cudrania javanica Trecul.
*_Ficus cunia_ Ham.
Ficus religiosa L.
*_Ficus benghalensis_ L.
Ficus lacor Buch.-Ham.
Salix tetrasperma Roxb.
Pothos cathcartii Schott.
*_Amorphophallus campanulatus_ Bl.
*_Sauromatum guttatum_ (Wall.) Schott.
*_Typhonium trilobatum_ Schott.
Remusatia vivipara (Roxb.) Schott.
Colocasia esculenta (Linn.) Schott. var. _illustris_ (Engler) Srivastava
.... var _stolonifera_ (Haines) Srivastava.
.... var. _rupicola_ (Haines) Srivastava.
Alocasia indica Schott.
*_Alocasia fornicata_ Schott.
Calamus viminalis Willd.
Calamus tenuis Roxb.
Calamus garuga Buch.-Ham.
Pogonatherum paniceum (Lamk.) Hack.
*_Smilax prolifera_ Roxb.
Dracena angustifolia Roxb.
Crinum asiaticum L.
*_Curculigo orchioides_ Gaertn.
†_Dioscorea oppositifolia_ L.
Dioscorea glabra Roxb.
*_Dioscorea belophylla_ Voight.
Dioscorea wallichii Hook. f.
Dioscorea alata L.
*_Dioscorea pentaphylla_ L.
Burmannia cœlestis Don.
*_Curcuma zeodaria_ Rosc.
*_Hedychium coronarium_ Koenig.
*_Hedychium stenopetalum_ Lodd.
Amomum dealbatum Roxb.
*_Zingiber casumnar_ Roxb.
Costus speciosus (Koen.) Smith.
Alpinia allughas Rosc.
*_Alpinia galanga_ Sw.
*_Alpinia malaccensis_ Rosc.
*_Vanda parviflora_ Lindl.
*_Vanda tessellata_ Hook.
Nephrodium molle Desv.
Diplazium esculentum Sw.
Selaginella spp.
Ophioglossum spp.

6. Plants near Human Habitations

(Ruins, dust-heaps, along roads, and in cultivated fields)

*_Argemone mexicana_ L.
Withania somnifera Dunal.
Lindenbergia indica (L.) O. Ktz.
Ocimum sanctum L.
Rumex vesicarius L.
Celtis tetrandra Roxb.
†_Croton bonplandianum_ Baill.
†_Gomphrena celosioides_ Mart.
Ficus spp.
Pandanus fœtidus Roxb.
*_Pandanus tectorius_ Sol.
†_Lolium temulentum_ L.
Pteris longifolia L.

APPENDIX II

An ecological analysis of the Purnea flora

Ecological Category	Number of plants reported in Haines' book from Purnea	Number of plants reported in Haines' book from districts other than Purnea	Number of plants new to the State
Aquatic and Amphibious plants	53	54	16
Plants of the Low Grass-lands	59	55	9
Plants of the High Grass-lands	50	70	2
Plants of the Scrub-Jungles	55	37	1
Plants of the Monsoon Forests	102	56	5
Plants found near Human Habitations	9	2	3
	328	274	36

THE CLAVARIACEAE OF THE MUSSOORIE HILLS—IV

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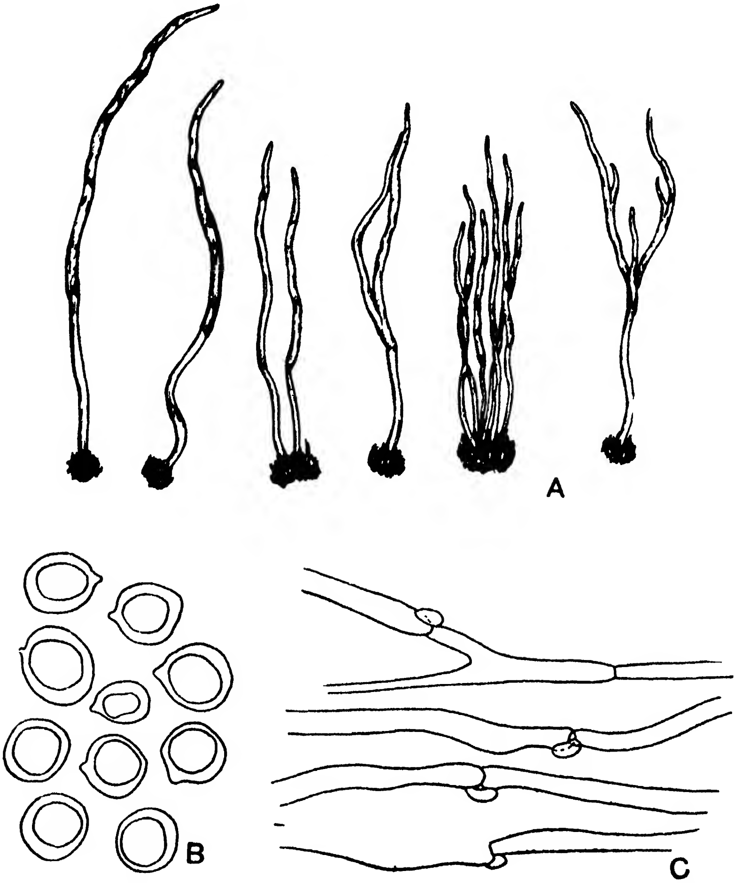
This paper is intended to record more Clavariaceæ from the Mussoorie Hills (5,000–7,000 ft. altitude in the North-Western Himalayas), as a part of the study of the Fungal Flora of that region undertaken by the senior author and his students (Thind and Anand, 1956; Corner, Thind and Anand, 1956; and Thind and Anand, 1956). All the seven Clavarias described in this paper belong to the Clavaria series. Six of these are new records for India whereas *Clavulina cristata* (Fr.) Schroet. var. *brunneola* var. nov. is described here as a new variety. All the specimens are deposited in the Herbarium of the Panjab University.

The classification as proposed by Corner, 1950, in his Monograph of Clavaria and allied genera, has been followed in the present series.

Clavaria Series

22. *Clavulina amethystinoides* (Pk.) Corner

Fructifications gregarious, solitary, mostly singly, sometimes in cæspitose clusters of 2–4 or more clubs, erect, small to medium-sized, slender, radial, trunk present, mostly simple but there is marked tendency towards slight or sparse branching, fleshy, smooth, glabrous, violet, 5–8 cm. tall, individual clubs up to 4 mm. broad. Trunk sharply differentiated by its brown colour, cylindrical, sometimes flattened and twisted, solid, 1–2 cm. long and up to 2·5 mm. broad. Clubs mostly simple, sometimes sparsely branched up to a maximum of four times. The clubs may look almost unbranched except for one or two short antler branches, at other times a club may divide only once into two branches (usually unequal) which may soon fuse together for the most part or only towards the top, thus giving a marked grooved appearance. In some cases a club may be divided into 2–4 equal branches having a common stalk below. Thus the sparse branching is of irregular type or irregularly dichotomous. Apices are pointed or blunt. Taste and smell inparticular. *Hymenium* spread all over except the trunk, stratose, 40–53 μ broad. *Basidia* clavate, 7–10·5 μ broad. Sterigmata 2, 3·5–12 μ long. *Basidiospores* subhyaline, globose, subglobose, or sometimes pyriform, papillate, uniguttate, guttule large, occupying more than half of the spore cavity, 9–12·3 × 8·8–10·5 μ. *Hyphæ* monomitic, hyaline, branched, parallel, thin-walled, inflated, septate, septa at short intervals, thus hyphæ with short, broad, inflated cells, branches of hyphæ narrow and not inflated, clamped, clamps abundant, ends of hyphal cells often gliding over one another, sub-hymenial hyphæ 5–8 μ broad, context hyphæ 5–12 μ broad, hyphal cells up to 176 μ long (Text-Fig. 1, A–C).



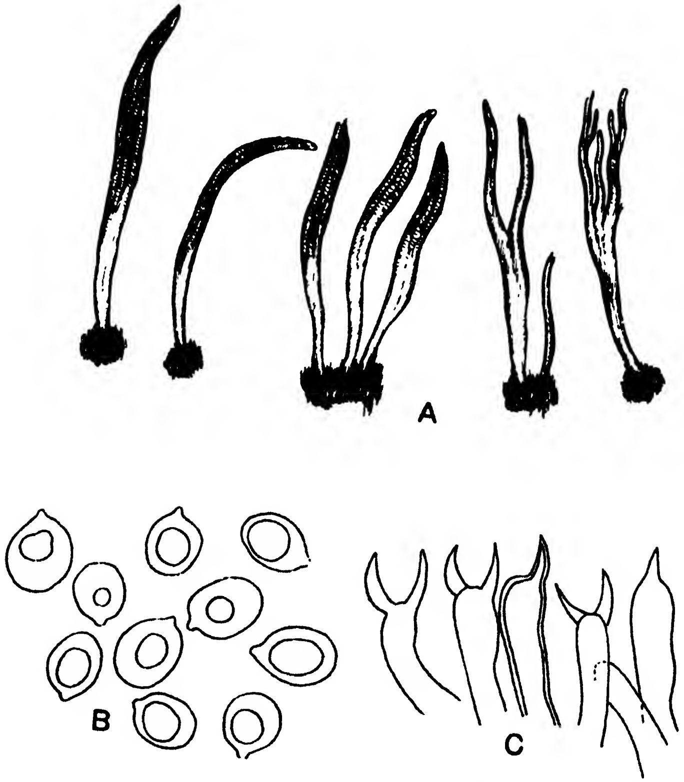
TEXT-FIG. 1. *Clavulina amethystinoides* (Pk.) Corner, A. Fructifications, ×1. B. Basidiospores, ×880. C. Hypnæ with clamps, ×380.

Collected on soil amid mosses, Dhobi Khud, Mussoorie, August 8, 1953, 53.

This collection undoubtedly belongs to *Clavulina amethystinoides* (Pk.) Corner and is marked by simple, or sparsely branched, violet-coloured fructifications. However, its spores are larger than usual, being 9–12·3 × 8·8–10·5 μ against 7–10 × 6–8 μ as reported for *C. amethystinoides* (Corner, 1950). This larger spore size, together with the violet colour (of the fruit bodies), fits *Clavulina amethystina* (Fr.) Donk, but the latter has always profusely branched fruit bodies.

23. *Clavulina cristata* (Fr.) Schroet.

Fructifications solitary, gregarious, cæspitose, erect, medium-sized, radial to flattened, trunk usually present, simple to sparsely branched, fleshy, smooth, glabrous, white or cream coloured, up to 6·8 cm. tall, cæspitose clusters up to 1·5 cm. broad, individual clubs up to 0·8 cm. broad. Trunk indistinct, lighter coloured or concolorous, narrower than the clubs above, usually about one-third of the total length of the fructifications, or absent. Fructifications simple, or very sparsely branched, usually only once, solid, narrow below and broader above, longitudinally grooved, flattened, and wrinkled when old, often spathulate or cerebriform, branches often remain antler-like. Apices subacute to rounded. Flesh concolorous or lighter. Taste and smell inparticular. Rhizomorphic mycelial strands abundantly given out from the bases of the fructifications. *Hymenium* spread all over except near the base, thickening, 38–105 μ thick. *Basidia* subclavate to cylindrical, 4·2–7 μ broad. Sterigmata 1–2, mostly 2, incurved, 3·5–7 μ long. *Basidiospores* paler yellowish brown, globose to subglobose, papillate, smooth, uniguttate, guttule large and filling one-half to two-third of the spore cavity, 7·6–10·9 × 7–10·5 μ. *Hyphæ* monomitic, hyaline, branched, thin-walled, inflated, narrow hyphæ uninflated, septate, septa at short intervals, clamped, clamps abundant and present at all septa, H-connections present but rare, 2·8–11·6 μ broad, hyphal cells 38–102 μ long, or even more (Text-Fig. 2, A–C).



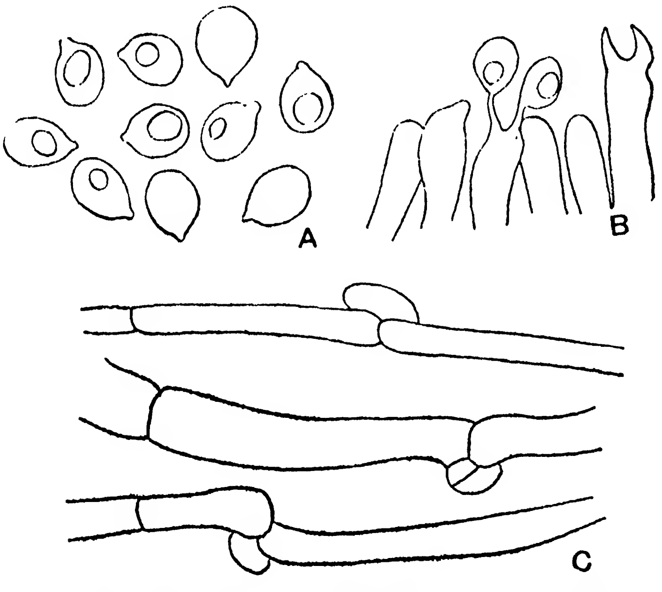
TEXT-FIG. 2. *Clavulina cristata* (Fr.) Schoroet. A. Fructification, ×1. B. Basidiospores, ×880. C. Basidia, ×880.

Collected on soil amid mosses and under Oak forest, Jabbar Khud, Mussoorie, August 17, 1953, 54.

This collection apparently is a simple to sparsely branched form of *Clavulina cristata* (Fr.) Schroet.

24. *Clavulina cristata* (Fr.) Schroet. var. *curta* Jungh.

Fructifications solitary, cæspitose, gregarious, erect, small-sized, radial, trunk invariably present, branched, rarely simple, fleshy, smooth, glabrous, white, 1-4 cm. tall, 0·2-2·3 cm. broad. Trunk white, radial, 4-8 mm. long, up to 4 mm. wide. Branching sparse to profuse, often crowded, irregular, polychotomous below giving rise to several trunk-like primary branches which divide further dichotomously, upper branches usually flattened, sometimes fused with one another, short and stubby. Ultimate branchlets cristate, short, some mere protuberances. Apices blunt and concolorous. Flesh white. Taste and smell inparticular. *Hymenium* spread all over except the trunk, 35-60 μ thick. *Basidia* clavate, 4·6-7 μ broad. Sterigmata 2, short, usually incurved like pair of a tong, 4·2-7 μ long. *Basidiospores* hyaline or subhyaline, globose, subglobose, or broadly ellipsoid, papillate, smooth, uniguttate, guttule large and filling one-half, or more, of the spore cavity, 8-10·5 × 7-7·7 μ. *Hyphæ* monomitic, hyaline, branched, thin-walled, inflated, septate, septa at short intervals, clamped, clamps present at all septa, 3·5-9·8 μ broad, hyphal cells 7-10·6 μ long. (Pl. XVIII, Fig. 1; Text-Fig. 3, A-C).



TEXT-FIG. 3. *Clavulina cristata* (Fr.) Schroet. var. *curta* Jungh. A. Basidiospores, ×880. B. Basidia, ×880. C. Clamped hyphæ, ×380.

Collected on soil, under Oak forest, Woodstock College, Mussoorie, September 19, 1953, 55.

Var. *curta* Jungh. represents merely a small state of *Clavulina cristata* (Fr.) Schroet. connecting it with var. *lappa* Karst.

25. *Clavulina cristata* (Fr.) Schroet. var. *brunneola* var. nov.

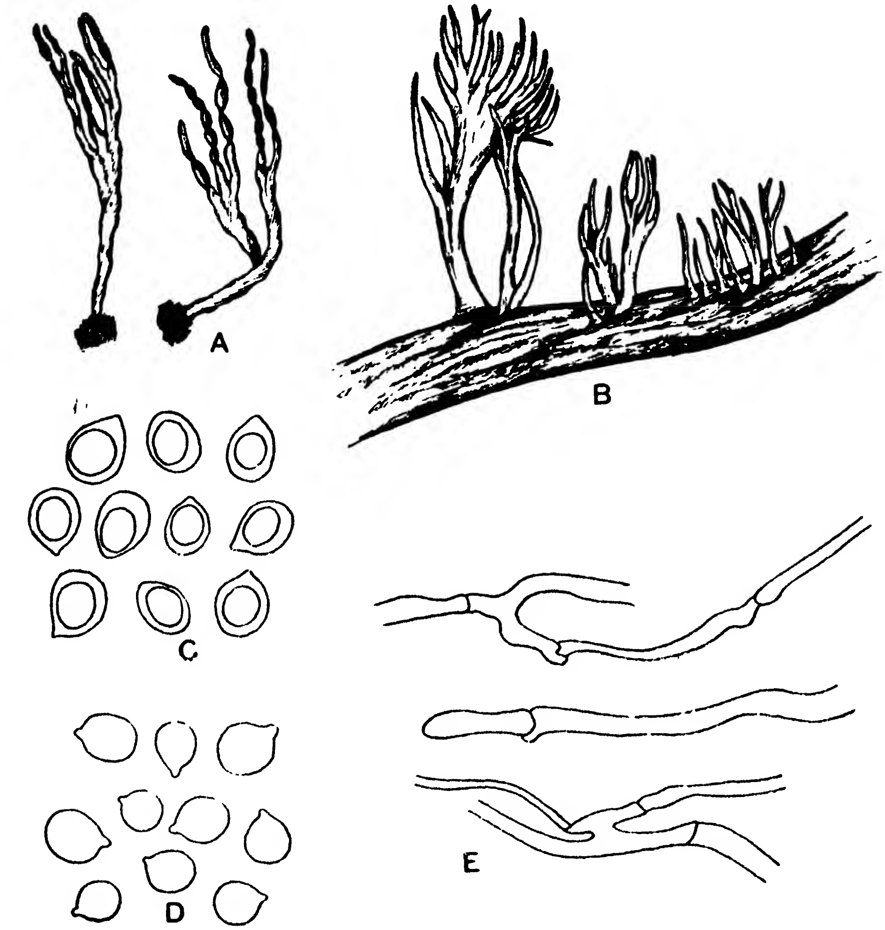
Usque 6·2 × 2·2 cm., solitaria vel cæspitosa vel gregaria, brunneola, laxe ramosa: basidiis secondo septatis: sporis 7–10·5 × 6–8 μ, 1-guttatis: hyphis inflatis, fibulatis: ad terram, Chakrata Toll, Mussoorie, India, September 2, 1953, 56; ad folia emortua, ramulos emortuos et corticum emortuum, Chakrata Toll, Mussoorie, India, September 7, 1953, 57.

Up to 6·2 × 2·2 cm., solitary, or cæspitose and gregarious, brownish, dust-coloured or milk-toffee-coloured, branches lax: basidia secondarily septate after spore discharge: spores 1-guttate, 7–10·5 × 6–8 μ: hyphæ inflated, clamped: on soil, Chakrata Toll, Mussoorie, India, September 2, 1953, 56; on dead leaves, dead twigs and dead bark, Chakrata Toll, Mussoorie, India, September 7, 1953, 57.

Fructifications terrestrial or lignicolous, solitary, or cæspitose and gregarious, erect, small to medium-sized, radial, trunk present, branched, fleshy, smooth, glabrous, brownish, dust-coloured or milk toffee-coloured, up to 6·2 cm. tall and up to 2·2 cm. broad. Trunk up to 1 cm. long and up to 2 mm. broad, cylindrical, concolorous. Branching lax, polychotomous to dichotomous, or irregular, branches unequal, in alternating planes, usually flattened at the point of origin and often twisted due to irregular and spiral flattening, sometimes fused with one another, some branches very small and antler-like. Primary branches up to 2 mm. wide, ultimate branchlets very minute to 2·2 cm. long and usually cristate, apices acute and concolorous. Flesh paler concolorous. Taste and smell inparticular. *Hymenium* spread all over except the trunk, thickening, up to 88 μ broad. *Basidia* clavate, secondarily septate after spore discharge, 5–7 μ broad. Sterigmata usually 2, sometimes 1, incurved, 3·5–7 μ long. *Basidiospores* hyaline to subhyaline, globose, subglobose, or oval to obovate, papillate, papilla eccentric, uniguttate, guttule large and almost completely filling the spore cavity, 6–10·5 × 5·2–7·8 μ. *Hyphæ* monomitic, hyaline, branched, thin-walled, inflated, septate, septa at short intervals, clamped, clamps present at almost all septa, H-connections present, 3·5–14 μ wide, hyphal cells 24–116 μ long (Text-Fig. 4, A–E).

Collected on soil along the eroded slopes of hills, Chakrata Toll, Mussoorie, September 2, 1953, 56. On dead leaves, dead twigs, and dead bark of trees, Chakrata Toll, Mussoorie, September 9, 1953, 57.

These two collections, n. 56 and n. 57, undoubtedly belong to *Clavulina cristata* (Fr.) Schroet. However, their fruit bodies are regularly brownish or milk-toffee-coloured which colour is not reported for *C. cristata* or any if its varieties. Hence these two collections are made a new colour variety—*brunneola* on the basis of their brownish colour. Their spores, especially those of n. 57, are slightly smaller than in *C. cristata* (*C. cristata*, 7–11 × 6·5–10 μ; n. 56, 7·7–10·5 × 7 μ; n. 57, 6–8·6 × 5·2–7·8 μ).

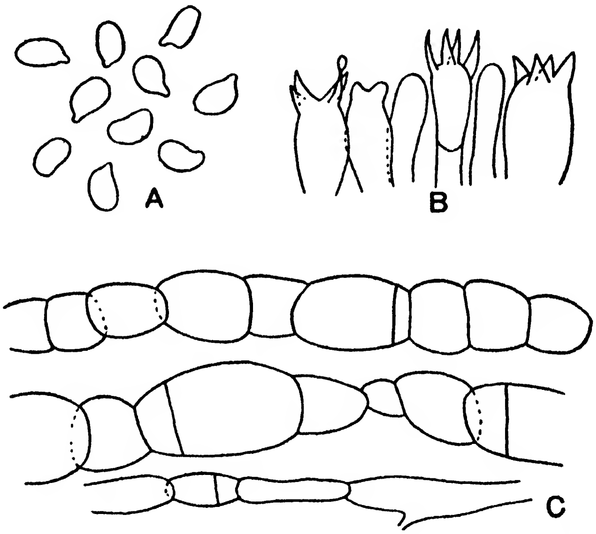


Text-Fig. 4. *Clavulina cristata* (Fr.) Schroet. var. *brunneola* var. nov., A. Fructifications of *n.* 56 with twisted branches, ×1. B. Fructifications of n. 57, ×1. C. Basidiospores of n. 56, ×880. D. Basidiospores of n. 57, ×880. E. Hyphæ with clamps and H-connection from n. 57, ×380.

Var. *brunneola* var. nov. as proposed here is easily differentiated from var. *curta* Jungh. and var. *lappa* Karst. (of *C. cristata*) both of which are pure white. It is also easily differentiated from *C. cristata* (n. 54) which is white or cream-coloured as reported in this paper.

26. *Clavaria fumosa* Fr.

Fructifications solitary, densely cæspitose, erect, large-sized, radial, without a trunk, simple, fleshy, brittle, smooth, glabrous, light milk-toffee-coloured, base whitish, up to 12·5 cm. tall and up to 10·5 cm. broad. A large number of clubs arise from a common base. Each club is long, clyindrical, tapering at the top and is unbranched. Individual clubs are up to 3 mm. broad. Some clubs possess a longitudinal groove and are ligulate and hollow. Apices are concolorous and blunt. Flesh pale concolorous, does not change on bruising. Taste and smell inparticular. *Hymenium* spread all over except the whitish base, compound, up to 56 μ broad. *Basidia* clavate, 5·6–8 μ broad. Sterigmata 3–4, small, stout, slightly incurved, 1·8–4·2 μ long. *Basidiospores* usually broadly ellipsoid, some slightly allantoid, papillate, hyaline, smooth, aguttate, filled with granular contents, 7–8 × 2·8–6·3 μ. *Hyphæ* monomitic, hyaline, thin-walled, inflated, some hyphæ very narrow and uninflated, clamps absent, septate, septa at short intervals, also secondarily septate, 5–17 μ wide, hyphal cells small, 4–68 μ long, mostly 8–13 μ long. Hyphæ are short-celled and closely apposed so as to give the appearance of a pseudoparenchyma. The individual hyphal nature is, however, easily revealed by separating them with dissecting needles because the hyphæ are very easily separated from one another (Pl. XVIII, Fig. 2; Text-Fig. 5, A–C).



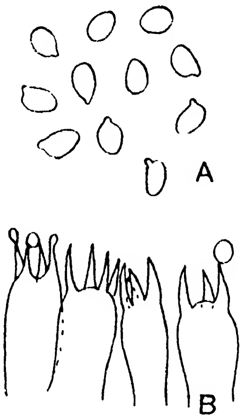
TEXT-FIG. 5. *Clavaria fumosa* Fr. A. Basidiospores, ×880. B. Basidia, ×880. C. Inflated hyphæ with secondary septa, ×380.

Collected on soil under Oak forest, The Park, Mussoorie, August 31, 1953, 58.

The species is easily recognized by simple, densely cæspitose, light-coloured and large-sized fruit bodies (—12·5 cm.) lacking a trunk, aguttate spores filled with granular contents and small-celled inflated hyphæ with secondary septa but without clamps.

27. *Clavaria vermicularis* Fr. var. *gracilis* Bourd. et Galz.

Fructifications solitary, gregarious, cæspitose, erect, medium-sized, radial, trunk present, mostly simple, sometimes sparsely branched, fleshy-brittle, smooth, glabrous, milk white, up to 7·5 cm. tall, individual clubs up to 2 mm. broad, cæspitose clusters up to 1 cm. broad or slightly more. Trunk white, transluscent or glassy, cylindrical, distinct by its transluscent appearance, about one-fourth of the total length of the clubs. Clubs mostly simple and cylindrical, sometimes slightly branched, flattened and grooved, branching dichotomous, usually only once, or 1-3 times near the top. Apices acute or subacute and concolorous. Flesh concolorous. Taste and smell inparticular. *Hymenium* spread all over except the trunk, up to 60 μ thick. *Basidia* clavate, 3·5–4·6 μ broad. Sterigmata 4, sometimes 2, straight or slightly incurved, 3·5–7 μ long. *Basidiospores* broadly ellipsoid or ovoid, papillate, hyaline, smooth, aguttate, occasionally one guttule filling half of the spore cavity observed, 3·5–4·2 × 3·5 μ. *Hyphæ* monomitic, hyaline, branched, thin-walled, parallel, mostly inflated, a few narrow hyphæ uninflated, septate, septa at short intervals, at longer intervals in narrow hyphæ, clamps absent, secondary septa absent, 2–12 μ broad, narrow ones 1·7–3·5 μ broad while inflated ones 5·2–12 μ broad, hyphal cells 25–63 μ long (Pl. XVIII, Fig. 3; Text-Fig. 6, A–B).



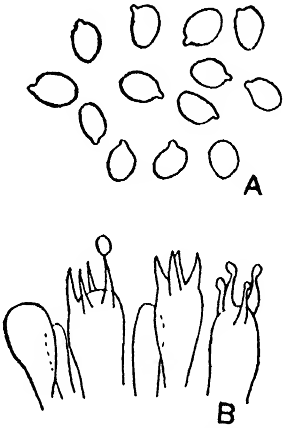
TEXT-FIG. 6. *Clavaria vermicularis* Fr. var. *gracilis* Bourd. et Galz. A. Basidiospores, × 880. B. Basidia, × 880.

Collected on soil under Oak forest, Mussoorie, August, 1953, 59.

The var. *gracilis* Bourd. et Galz. is determined by solitary, gregarious, cæspitose (usually less cæspitose) fruit bodies with a distinct and characteristically transluscent or transparent to glassy trunk and broadly ellipsoid to ovoid small spores (3·5–4·2 × 3·5 μ).

28. *Clavaria vermicularis* Fr. f. *fasciata* Bourd. et Galz.

Fructifications gregarious, cæspitose, erect, slender, medium-sized, radial, trunk present, sparsely branched, rarely simple, firm-fleshy, smooth, glabrous, milk-white, up to 5 cm. tall, cæspitose clusters up to 1·5 cm. broad, individual clubs up to 4 mm. broad. Trunk indistinct, narrower than the club above, lighter coloured, cylindrical, about one-fourth of the total length of the clubs. Clubs cylindrical, grooved, sometimes fused together, simple but mostly branching only once near the top into unequal dichotomous branches, antler-like protuberances given out rarely, apices concolorous and blunt. Flesh concolorous. Taste and smell inparticular. *Hymenium* spread all over except the trunk, up to 52 μ broad. *Basidia* clavate, 5·3–7·7 μ broad. Sterigmata 4, rarely 2, 3·5–5·3 μ long. *Basidiospores* pale yellowish, obovate, rarely globose or subglobose, papillate, smooth, aguttate, 5·3–5·6 × 3·2–3·9 μ. *Hyphæ* monomitic, hyaline, parallel, thin-walled, branched, mostly inflated, some hyphæ narrow and uninflated, septate, septa mostly at short intervals, at longer intervals in narrow hyphæ, clamps absent, secondary septa absent, 3·5–21 μ broad, hyphal cells 18–133 μ long or even longer (Pl. XVIII, Fig. 4, Text-Fig. 7, A–B).



TEXT-FIG. 7. *Clavaria vermicularis* Fr. f. *fasciata* Bourd. et Galz. A. Basidiospores, ×880. B. Basidia, ×880.

Collected on soil under Oak forest, Chakrata Toll, Mussoorie, August, 16 1953, 60.

F. fasciata Bourd. et Galz. of *Clavaria vermicularis* Fr. is easily differentiated from the var. *gracilis* Bourd. et Galz. by its regularly cæspitose fructifications with indistinct trunk.

ACKNOWLEDGEMENTS

The writers are deeply indebted to Mr. E. J. H. Corner, F.R.S., of the Botany School, Cambridge, England, for valuable criticism and help in the identification of some of the Clavarias and Prof. P. N. Mehra, Head of the Panjab University Botany Department, for providing facilities and encouragement. They are also thankful to Mr. B. Khanna for making illustrations of some of the fruit bodies.

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EXPLANATION OF PLATE

FIG. 1. *Clavulina cristata* (Fr.) Schroet var. *curta* Jungh.

FIG. 2. *Clavaria fumosa* Fr.

FIG. 3. *Clavaria vermicularis* Fr. var. *gracilis* Bourd. et Galz.

FIG. 4. *Clavaria vermicularis* Fr. f. *fasciata* Bourd. et Galz.

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K. S. Thind & G. P. S. Anand

STUDIES IN PTERIDACEÆ

II. *Hemionites* Linn.

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(Received for publication on January 4, 1956)

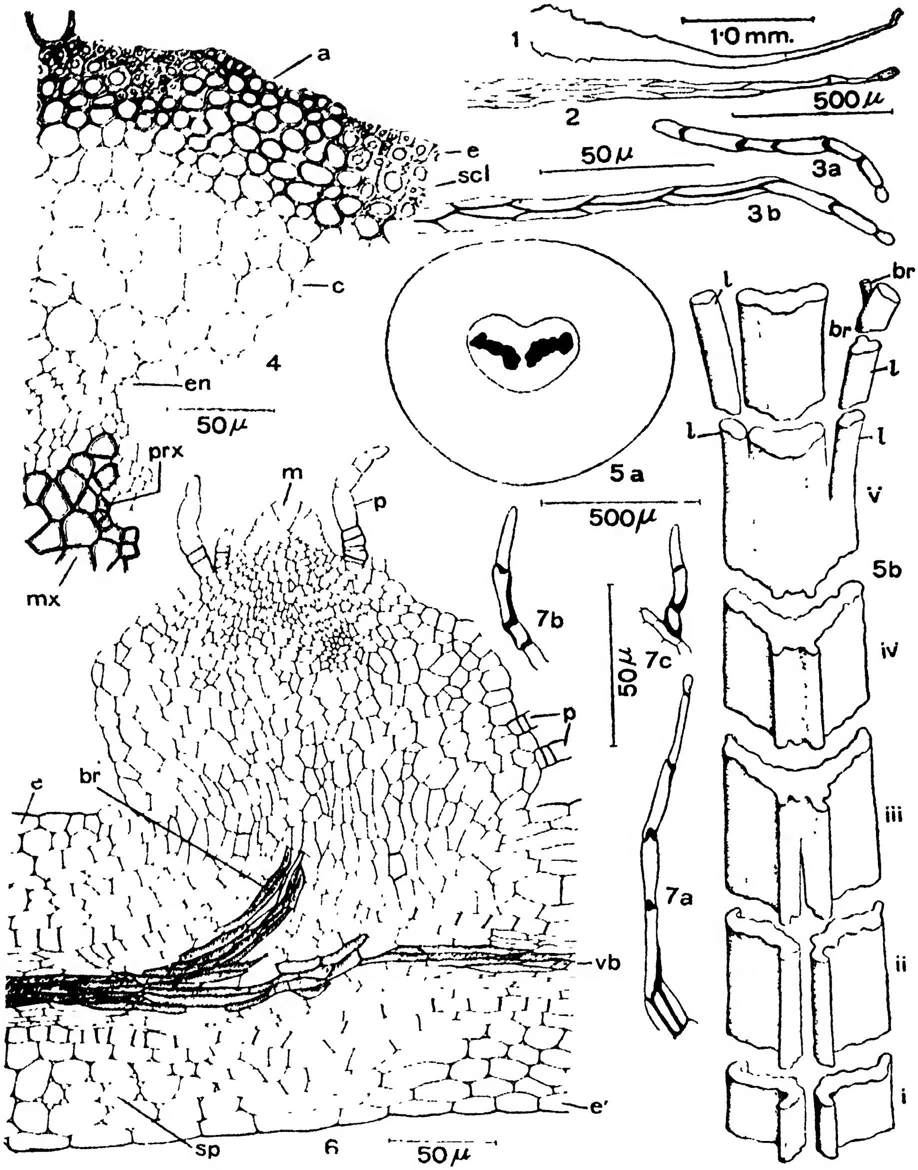
INTRODUCTION

Hemionites Linn. is a small genus of ca. 8 sps., mainly of tropical America, *H. arifolia* being the only Oriental representative. The present study is based on the latter species. A small terrestrial fern of moderately dry localities occurring on the Malabar Coast of South India and plains of North-Eastern India (East Bengal, Assam and Burma), *H. arifolia* grows generally on exposed earth cuttings (loamy or gravelly soil) forming small rosettes of short-stalked, ovate-cordate, sterile leaves (and a few erect, long-stalked, cordate-hastate, fertile leaves during fertile seasons).

Methods of study followed are the same as reported earlier (Kachroo and Nayar, 1953; Nayar, 1954). Young sporophytes and all stages in development of gametophytes are studied entirely from sand cultures raised in earthernware pots supplied with Knop's solution from below and kept in shaded regions of the garden. Sporophyte morphology is based mainly on plants transplanted from natural surroundings to the gardens in Assam and later at the National Botanic Gardens, Lucknow. Morphology of exine is studied from acetolysed spores.

OBSERVATIONS

The rhizome is short, hard, obconical, erect, and covered by persistent leaf-bases, light-brown paleæ and long wiry roots. The palea is slightly clathrate, with a broad base and gradually tapering to an acuminate apex terminating in a glandular cell (Fig. 1) which is thin-walled, with thick brown contents and oblong in shape (Fig. 2). Multicellular uniseriate hairs with glandular tips occur intermixed with appendages intermediate between paleæ and hairs. The larger paleæ are ca. 4·0 × 0·5 mm., and generally have smooth margins except towards the base where sparse dentations are not uncommon. The fully grown regions of the rhizome are dictyostelic (with one to three leaf traces in a t.s.). All stages of transition from the protostelic to the dictyostelic condition are discernible in the earlier formed regions of the rhizome. The leaf trace is a single band curved with the concavity facing inwards. While passing through the cortex of the rhizome it becomes broadly V-shaped in t.s. The stele of the rhizome is exarch with the metaxylem composed of pitted tracheids. The xylem on the whole is very small in extent, being usually composed of one or two compact layers of tracheids only. The phloem is massive, surrounds



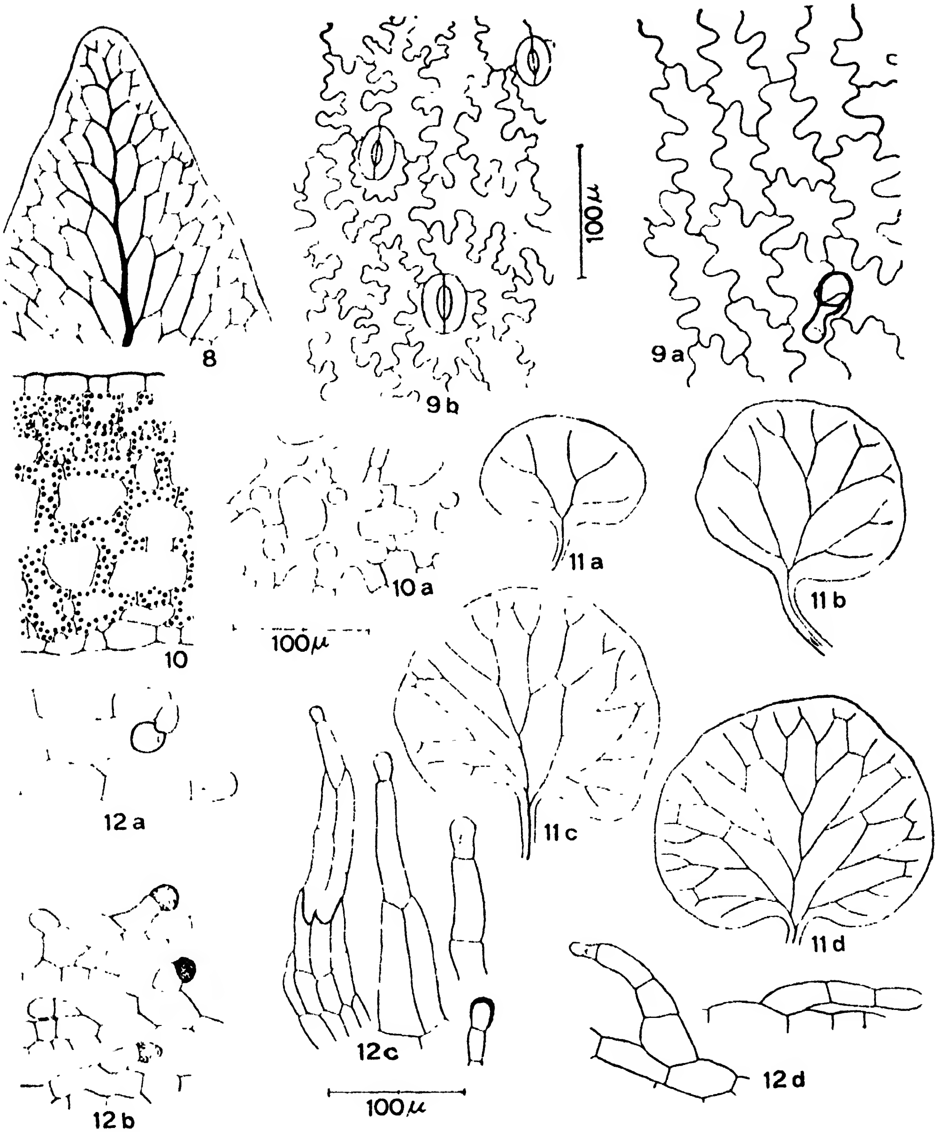
Text-Figs. 1-7. Fig. 1. Palea from rhizome. Fig. 2. Tip of same in detail showing glandular apical cells. Fig. 3 (*a*). Hair from petiole. Fig. 3 (*b*). Paleæ from petiole. Fig. 4. T.s. of petiole (portion only) showing lateral aerating tissue; *a*, aerating tissue; *c*, parenchymatous inner cortex; *e*, epidermis; *en*, endodermis; *mx*, metaxylem; *prx*, protoxylem; *scl*, cortical sclerenchyma. Fig. 5 (*a*). T.s. of petiole base showing configuration of xylem band. Fig. 5 (*b*). Configuration of the xylem band in petiole of sterile sub-hastate leaf from region of attachment to rhizome to base of lamina showing origin of first pair of lateral veins and branch to foliar bud (Reconstructed from serial transverse sections); *l*, lateral vein. Fig. 6. T.s. portion of lamina base showing foliar bud in l.s.; *br*, vascular strand supplying bud; *e*, upper epidermis of leaf; *e′*, lower epidermis; *m*, apical meristematic cell of bud; *p*, paleæ; *sp*, spongy parenchyma; *vb*, vascular bundle of leaf (first lateral vein). Fig. 7 (*a*). Glandular foliar hair. Figs. 7 (*b*), (*c*). Non-glandular foliar hairs.

the xylem and is composed of thin-walled cells with large lumen, mixed with small parenchyma cells. Endodermis is continuous and thin-walled, the cells being smaller than the adjoining cortical cells. The latter as well as the pith cells have faintly thickened dark-brown walls and dark contents with included starch grains. Epidermis is thin-walled and irregular.

Roots are profuse, highly branched, dark-brown, with persistent root hairs and a diarch strap-shaped xylem core with phloem masses on either flat surface. The endodermis is thin-walled and the cortex is uniform, consisting of radially arranged parenchymatous cells with slightly darkish thin walls and not demarcated into two regions as is usual in higher ferns.

Leaves are borne spirally on the rhizome and are non-articulated. The petiole is dark-brown, shining, bearing paleæ shading off into hairs (Fig. 3, *a* & *b*) and with a median longitudinal groove on the adaxial surface. The epidermal- and 3 to 4 layers of hypodermal,- cells are sclerenchymatous except on the lateral sides of the petiole where they are thin-walled and with prominent intercellular air spaces, constituting the aerating system (Fig. 4). Towards the centre is the single vascular bundle, which at the base of the petiole has two separate xylem bands oriented at an angle to each other, with their abaxial margins converging (Figs. 5 *a*, 5 *b–i*) and each with two protoxylem regions, one at either margin. The protoxylem at the lower (abaxial) margins of the two bands curve away from each other. During their course up the petiole, the abaxial margins of the xylem bands gradually approach each other (Fig. 5 *b-ii*). Half way up the petiole the two bands meet and fuse at the metaxylem regions lying next to the protoxylem on the abaxial surface (Fig. 5 *b–iii*). The confluent band thus formed is " X "-shaped in t.s., with the downward (abaxial) arms of the " X " much smaller than the adaxials (Fig. 5 *b-iv*). Vascular connections to the lateral veins are given off marginally. Generally the first pair of lateral branches originates towards the distal end of the petiole (Fig. 5 *b–v*) and are the strongest, appearing in some leaves (especially the fertile ones) as prominent as the midrib itself and behaving in the same manner in giving off lateral secondary branches. Where this condition occurs the leaf lamina tends to be sub-hastate with the main lateral vein on either side forming a midrib to the basal auricles. (More commonly the lamina is ovate-cordate and the main lateral veins are not distinct.) One of these basal lateral veins (usually the first formed one) soon after entering the lamina gives off a branch which turns towards the upper epidermis and enters a vegetative bud (Fig. 5 *b-vi*, *br*; Fig. 6). The bud remains dormant and appears to be seated on the midrib towards its base though by origin it is lateral. The first leaf formed by the vegetative bud is on the side of the bud facing the midrib of the parent leaf. Under optimum conditions leaf buds with 3 to 4 developed leaves may be seen attached to the parent leaf. The buds are separated by decay of the latter and start off as new plants.

The lamina is simple, coriaceous and with the under-surface covered by hairs. The hairs are multicellular, uniseriate, either ending

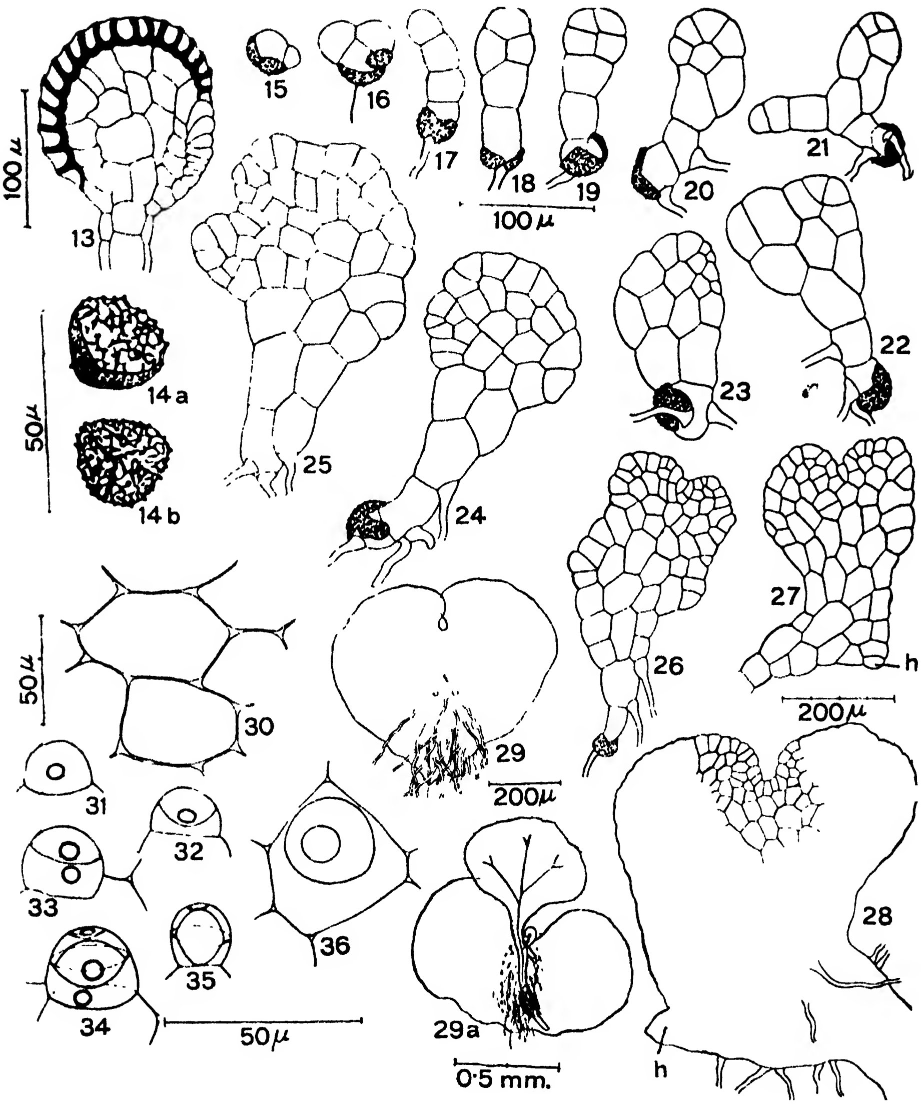


Text-Figs. 8–12. Fig. 8. Tip of adult leaf showing venation. Fig. 9 (*a*). Surface view of upper epidermis. Fig. 9 (*b*). Same of lower epidermis. Fig. 10. T.s. of portion of sterile leaf. Fig. 10 (*a*). Mesophyll cells in surface view. Figs. 11 (*a*)–11 (*d*). Successive stages in the progression of juvenile leaves. Fig. 12 (*a*), Trichomes on petiole of first juvenile leaf. Fig. 12 (*b*). Same on lamina. Fig. 12 (*c*). Trichomes on petiole of third and fourth leaves. Fig. 12 (*d*). Same on lamina.

in glands like those on the petiole and rhizome (Fig. 7 *a*) or smaller with a terminal non-glandular acicular cell (Figs. 7 *b*, 7 *c*). Some of the larger hairs have broad bases. All hairs are brownish with the transverse septæ thickened. Margin of the leaf is entire and slightly curved on the lower surface. Venation is reticulate with a prominent midrib bearing inconspicuous (except the basal pair in cordate-hastate leaves already mentioned) lateral veins on either side alternately. Each lateral vein soon after origin forks unequally into a stronger anterior branch proceeding obliquely across the lamina and a weaker posterior one proceeding perpendicular to it. The former forms a branch on the anterior side which proceeding parallel to the midrib, fuses with the first posterior branch of the main lateral vein next in succession, forming a confluent vein which runs parallel to the main lateral veins, equidistant from them. This vein and the main lateral veins fork and fuse at regular intervals, forming obliquely placed polygonal aereolæ, which are smaller towards the margin of the lamina than near the midrib (Fig. 8). The reticulations are regular with closed meshes and the size of aereolæ decreases gradually towards the margin. The extreme tips of the veinlets end blindly just below the margin. there being no intramarginal commissure. The midrib dichotomises into two equal branches at the extreme tip of the lamina. Epidermis of the lamina is thin-walled and in surface view the cells have a zig-zag outline with sharp bends (Figs. 9 *a*, 9 *b*). Cells of the lower epidermis are narrower and more irregular compared to the upper. Chloroplasts are present in the cells of the lower epidermis but not of the upper. Stomata are restricted to lower epidermis on adult leaves while on juvenile ones they occur sparsely on the upper also. Each stoma is oval with the posterior half engulfed by an epidermal cell while the anterior is dovetailed into the corners of two to three cells. The mesophyll is undifferentiated and is composed of prominently armed chlorophyllous parenchyma (Figs. 10, 10 *a*), the hyopodermal layers on the upper surface being more compact than other mesophyll cells.

The first juvenile leaf of the sporophyte is spatulate to reniform (with a smooth margin) and supplied by a single vein dichotomising equally once or twice (Fig. 11 *a*). The next leaf has the medianly placed branch of the second dichotomy more prominent and dividing 2 or 3 times more than the other branches (Fig. 11 *b*). Generally the fourth leaf develops a cordate base and aereolæ but no definite midrib (Fig. 11 *c*). The first semblance of the midrib is found usually in the seventh leaf in which the lamina is broader than long (Fig. 11 *d*). The petiole and lamina of the juvenile leaves bear uniseriate multicellular glandular hairs (Figs. 12 *a*–12 *d*). Flattening of the lower regions of these to form paleæ occur generally on the lower regions of the petiole of the third or fourth leaf onwards. Vegetative buds are not found on juvenile leaves.

Fertile leaves are produced seasonally on mature plants. They are erect, with petiole 3 to 4 times longer than those of sterile ones and lamina hastate with three main diverging veins at the base. Vegetative buds are absent. Sporangia are distributed all over the lower



TEXT-FIGS. 13–36. Fig. 13. Sporangium. Figs. 14 (*a*), (*b*). Spores. Figs. 15–28. Stages in the development of prothallus. Fig. 29. Young cordate prothallus four months old. Fig. 29 (*a*). Mature prothallus with attached sporophyte. Fig. 30. Wing cells of mature prothallus showing collenchymatous thickenings. Figs. 31–35. Stages in development of antheridium (optical sections) Fig. 26. Mature antheridium in surface view showing intact opercular cell.

surface of the lateral veins and form reticulate patterns following the venation. The extreme margin of the lamina (with free ending veinlets) is free of sporangia and shows a slight tendency to fold downwards. Young fertile leaves have lamina rolled on the nether surface while the lamina of sterile ones is folded on the upper surface inwards (conduplicate). Lamina is recurved on the petiole in both. Hairs characteristic of the sterile leaves occur, profusely over the surface, even between sporangia, on fertile leaves.

The sporangia (Fig. 13) are of the usual leptosporangiate type, though with a tendency to have a pear-shaped head as in *Cheilanthes*. The annulus is 16 to 18 cells long. continuous with a 6 to 8-celled stomium which does not extend up to the stalk and is separated from it by 1 to 3 thin-walled cells. Wall of the sporangium is composed of a large number of small cells as in *Cheilanthes*, etc., and the stalk is three cell thick at the top. Rarely the annulus is interrupted by thin-walled cells. The spores (Figs. 14 *a*, 14 *b*) are tetrahedral, 50 to 60 μ in diameter, dark-brown, devoid of episporium and with an indistinct triradiate mark. The exine bears prominent, dark-brown, ridge-like, irregular thickenings which protrude out giving a semblance of incomplete reticulations. Spore germination occurs within a week in culture. The intine protrudes out as a germ papilla at the region of the triradiate mark where the exine has ruptured. The germ papilla is densely chlorophyllous and is accompanied by a rhizoid (Fig. 15). In liquid media formation of a rhizoid may sometimes be delayed. Rhizoids are colourless and have a slightly swollen base. The germ papilla elongates and forms a 3- to 5-celled germ filament with short barrel-shaped cells (Fig. 17). The exine remains attached to the base of the filament as three more or less triangular pieces or in some cases may be shed off. The germ filament branches occasionally by the apical dome-shaped cell undergoing a longitudinal division followed by the two daughter cells continuing as separate filaments (Figs. 16, 21). Under healthy conditions flattening is initiated at the 4-celled stage of the filament (Figs. 18, 19), by the intercalary cells of the filament dividing longitudinally. All cells including the basal one, take part in the flattening under optimum conditions of growth. Finally the apical dome-shaped cell divides longitudinally producing two wedge-shaped daughter cells, both of which undergo further divisions resulting in a spatulate prothallus (Figs. 20, 22). The diffused meristematic activity of the apex later becomes restricted to one side of the gametophye (Fig. 23) where finally a two-celled lateral meristem is established (Fig. 24) which proceeds to form a cordate prothallus (Fig. 25). A hump, the size of which depends on the extent of activity of the original diffused meristem, is found invariably at the base of the cordate prothalli opposite to the point where the marginal meristem originated (Figs. 25, 27, 28-*h*). Rarely gametophytes growing under crowded, unhealthy conditions develop a single meristematic cell laterally rather than a group as usual (Figs. 26, 27). In such cases the growth of the gametophyte simulates the conventional type with an obconical apical cell, but the tell-tale hump towards the base betrays its lateral origin. Later in development this single cell ceases to function and a meristem is formed by nearby daughter cells. About 4 months after germination a well-formed cordate thallus devoid of a midrib is established, under cultural conditions. Rhizoids are marginal in early stages of development of the prothallus but later become restricted to the middle regions. The mature gametophyte (Fig. 29) is cordate, broader than long and with the margins of the wings curved upwards. The midrib is prominent, 8 to 10 cells thick, and bears rhizoids intermixed with sex organs on the nether surface. Trichomes of all sorts are absent. The cells of the wings are thin-walled and have collenchymatous thickenings at the corners (Fig. 30). Chloroplasts are ovoid to globular and line the peripheral walls.

Vigorously growing, five months old, gametophytes produce antheridia before the formation of a midrib. Antheridia are restricted to the central region of the gametophyte on the ventral surface. They are globular and follow the general pattern of development for " Polypodiaceæ "[(Davie, 1951) Figs. 30–35]. Each has a basal saucer- or cup-shaped cell, a short annular cell, a more or less disc-shaped opercular cell and a central cell. The opercular cell is single (Fig. 36) and opens like a lid to release the sperms. Archegonia, which are of the usual type in higher ferns, are formed after antheridia (though both occur mixed in earlier stages) and initiate midrib formation.

DISCUSSION

Diels (1902) includes *Hemionites* Linn. under the Gymnogrammineæ of Pterideæ (Family Polypodiaceæ), quite distinct from *Cheilanthes* and allies. Bower (1928) considers it a member of the central group of his Gymnogrammoid ferns, which as a group according to him might have evolved from forms like *Plagiogyria* Mett. (Plagiogyriaceæ Bower), *Todea* Wild. (Osmundaceæ R. Br.), *Mohria* Sw. (Schizæaceæ Mart.) and *Anemia* Swartz (Schizæaceæ). It is considered to be more advanced than *Onychium* Kaulf. and *Pityrogramma* Link., but more primitive than *Cheilanthes* Swartz or *Adiantum* Linn.

Christensen (1938) includes *Hemionites* under his Gymnogrammeæ (Lepidopterids) of Subfamily Gymnogrammeoideæ along with *Coniogramme* Fee, *Pityrogramma*, etc., quite distinct from *Cheilanthes*, *Adiantum* and *Onychium*. Ching (1940) includes *Hemionites* in his Tribe Gymnopterideæ of Family Gymnogrammaceæ Ching, showing affinities to Sinopteridaceæ Koidzumi and Pteridaceæ Ching. Copeland (1947) regards the genus as a Cheilanthoid of his complex family Pteridaceæ Gaudichaud. According to him *H. arifolia* (Burm.) Moore shows striking resemblance to *Syngramma* J. Sm., a Lindsæoid derivative. Holttum (1947, 1949) follows Bower in his conception of the Gymnogrammoid ferns, including *Hemionites*, considering them under his Adiantaceæ.

Hemionites agrees with most other Gymnogrammoids in being a fern of dry and arid localities, in having paleæ shading into hairs and attached by a broad base and in having a short solenostelic rhizome. The paleæ differ from those of Cheilanthoids, *Adiantum*, etc., in having a terminal gland. *Actinopteris* Link. shows the closest resemblance in characters of paleæ to *H. arifolia.* The xylem band of the leaf trace bundle originating as a V-shaped strand with protoxylem on the curved adaxial surface and splitting into two curved strands which later fuse together by the metaxylem regions bringing the protoxylem on the abaxial surface of the bundle is characteristic of *H. arifolia*, *Cheilanthes*, *Aleuritopteris*, etc. This tendency of the xylem band to form the X-shaped bundle of the petiole is absent in *Adiantum*, *Actinopteris*, *Onychium*, *Pityrogramma*, etc. In those species of the former where two separate traces fuse they do so by the abaxial margins so that the protoxylem regions meet together first and continue to be on the adaxial side. In the latter genera the leaf trace is single from the beginning and is broadly U-shaped (in t.s.) with the protoxylem on the adaxial surface. Even in cases where due to expansion up the petiole the xylem band disintegrates as in *Onychium*, etc., the splitting on the abaxial side is irregular and reunions are always effected by fusions of the nearby margins as in *Pteris* and allies. The peculiar shape of the xylem band of the leaf bundle in *Hemionites arifolia* finds its parallel in *Lygodium* (Schizæaceæ). In both cases there are four protoxylem points and the metaxylem is mesarch. In *Plagiogyria* with which Bower suggests relationship the leaf bundle is broadly V-shaped. The venation of the lamina too can be traced back to *Lygodium* and Schizæaceæ. [Some species of *Lygodium* and *Anemia*—like *A. Phyllitidis* (L.) Swartz—possess reticulate venation closely resembling that of *H. arifolia.*] Presence of vegetative buds at the base of the lamina is a unique feature, not found in other Gymnogrammoids. Both *Anemia* and *Adiantum* form foliar buds replacing the terminal pinnule, *i.e.*, terminating the main vascular strand of the leaf. The bud in *Hemionites arifolia* cannot be compared with these because of its lateral position at the base of one of the main lateral veins of the lamina. A closer resemblance may be found with leaf buds of *Ampelopteris elegans* Kunze (in which buds occur in the axils of some of the pinnules, attached to their bases). The simple leaf form in *H. arifolia* might have evlolved from a pinnate leaved ancestor by reduction in which all except the terminal pinnule were reduced. But in those leaves with three basal nerves the first pair of prominent lateral veins represent a pair of pinnules confluent with the terminal one and the vegetative bud at the base of one of them thus occupies the position identical to that of *Ampelopteris.* Fertile leaves are in all cases three-nerved but do not bear vegetative buds. In some species of *Plagiogyria* like *P. pycnophylla* Kunze in which stolons are present the leaf sometimes fuses with the stolon to some extent (*see* Bower, 1928: Fig. 545). Such a fusion of a stolon with the leaf could have explained the position of the vegetative bud in *H. arifolia* but for the anatomy where the vascular supply to the bud distinctly originates form one of the lateral veins.

First juvenile leaves in *Pityrogramma* and *Onychium* are palmatisect with the main vascular bundle dichotomising to supply one veinlet to each lobe. In *H. arifolia* as in *Aleuritopteris* the cotyledonary leaf is simple with radially dichotomising veins. A midrib is evolved as in *Onychium*, *Pityrogramma*, *Lygodium*, etc., by the median branch of the initial dichotomy becoming more prominent. Even in the leaves of the adult plant the dichotomising pattern is kept up in spite of the reticulations. The glandular trichomes found on the juvenile leaves especially those on the cotyledonary leaf are similar to those on the leaves of *Aleuritopteris* and *Pityrogramma*. In *Hemionites* the hairs gradually become elaborated into paleæ with glandular tips while in others the glandular hairs remain as such secreting a waxy substance, even on adult leaves, the paleæ being elaborations of non-glandular hairs.

Sporangia originate marginally in Schizæaceæ but in some of the genera like *Lygodium*, they may become pushed towards the superficial surface. But in all cases they terminate the fertile vein. In *Hemionites* on the other hand the extreme tips of veinlets (near the leaf margin) are sterile, sporangia being found on the surface of veins in other regions only. This along with the extreme low number of sporangia per "sorus" in Schizæaceæ presents a difficulty in deriving *Hemionites* from them. On the other hand the sporangia are superficial on veins and compare favourably with *Hemionites* in *Plagiogyria*. The annulus is not continuous with the stalk which is three cell thick at the top in *Hemionites* as in Cheilanthoids, *Actinopteris*, etc. But the sporangial head is not pyriform and composed of a very large number of cells as in the former. Development of the prothallus with a tendency to formation of a marginal meristem without the intervening apical cell stage is found in *Actinopteris*.

Hemionites thus appears to be better considered as distinct from Cheilanthoids, *Onychium*, *Pityrogramma*, *Adiantum* and *Actinopteris*, though showing resemblances to them in some character or other, the closest being to Cheilanthoids.

SUMMARY

Hemionites arifolia (Burm.) Moore is a small fern of moderately dry localities with erect, hard, solenostelic rhizome covered by leaf bases, roots and paleæ. Paleæ shade off into hairs and have glandular tips. Petiole and lamina bear hairs and simple paleæ of the type on the rhizome. Leaf traces at their origin are simple gutter-shaped strands with an intact band of xylem which on entering the leaf base splits into two curved bands facing away from each other and each having two protoxylem strands one at either margin. Passing up the petiole the xylem bands fuse by the metaxylem regions above the abaxial margins, resulting in a characteristic X-shaped (in t.s.) bundle which on entering the lamina gives off lateral veins marginally. The first formed lateral veins on some of the sterile leaves are prominent and soon after entering the lamina one of these may bear a vegetative bud on the adaxial surface. The venation is reticulate, without included veinlets, and with free vein endings near the margin. Juvenile leaves are simple with dichotomising veins and the trasition to adult form entails only increase in size and establishment of a reticulate venation with a midrib. Fertile leaves are slightly different from sterile ones and the sporangia are spread over the veins on the abaxial surface

of the lamina occuring mixed with foliar trichomes. The annulus and stomium are separated from the stalk by unthickened wall cells of the sporangium. The stalk is three cell thick at the top and the sporangial wall is of large number of small cells. Spores are dark brown, tetrahedral and with irregular ridge-like protrusions on the exine. On germination a germ filament consisting of 3 to 5 short cells is formed which soon flattens by longitudinal divisions of all cells including the basal and terminal ones, resulting in a spatulate prothallus where a marginal lateral meristem is soon developed. An apical cell with two cutting faces is not developed but under unhealthy conditions the marginal meristem may be represented by a single ceil. In all cases a hump is developed towards the base opposite to the point where the lateral meristem is developed. Mature prothalli are cordate, devoid of trichomes, having a well-developed midrib and developing sex organs on the nether surface.

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MORPHOLOGY OF THE PACHYTENE CHROMOSOMES AND MEIOSIS IN *SORGHUM SUBGLABRESCENS*, A EU-SORGHUM

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Introduction

Our present knowledge of the morphology of the pachytene chromosomes in the genus *Sorghum* reveals that the pachytene chromosomes in Eu-Sorghums, which include the economically important grain Sorghums, are characterized by differential stainability and distinct centromeres, while in the rest of the Sorghums they are uniformly stained with acetocarmine with no marked accumulation of stain in any one region of the chromosome (Garber, 1947, 1950). In 1937, Longley and later Garber (1950) made some observations on the pachytene chromosomes of *Sorghum vulgare*, a Eu-Sorghum. In this, the regions immediately adjacent to the distinct centromeres were found to be heavily stained and the quality of staining decreased noticeably beyond these regions until the remainder of the chromosome was almost unstained especially at the end of each arm. More recently, Harpstead, Ross and Franzke (1954) studied the pachytene stage in *S. vulgare* during the course of their investigations on colchicine-induced variants in *Sorghum*. The photomicrographs of nuclei at the pachytene stage stained in propionocarmine presented in their paper clearly show the heavily stained proximal and the lightly stained distal regions of the chromosomes. The above authors, however, made no reference to these features in the text, their object of study of this stage being only to determine if any gross chromatin rearrangement was responsible for the origin of variant plants obtained by colchicine treatment.

So far no complete account of the morphology of pachytene chromosomes of the entire complement in any Eu-Sorghum is available. As the Eu-Sorghums form an economically important crop in the agriculture of many countries a detailed cytological study of several species belonging to them has been undertaken in this department for such a knowledge will considerably aid cytogenetical studies and will lead to a fuller understanding of the genetics of the grain Sorghums. During the course of these studies we found that *Sorghum subglabrescens* Schw. et Asch., to be very suitable for a study of the morphology of the pachytene chromosomes and it was possible to analyse the entire complement enabling the identification of all the chromosomes in each of ten nuclei analysed. The pachytene chromosomes in this species could be exceptionally well spread out using the acetocarmine squash technique and they could be followed from one end to the other as done earlier in a few plants like *Zea mays* (McClintock, 1931; Longley, 1938, 1941; Rhoades, 1950), *Secale cereale* (Lima-de-Faria, 1950, 1952), *Lycopersicum esculentum* variety Sutton's Best of all (Brown, 1949; Barton, 1950), and *Plantago ovata* (Hyde, 1953).

Results obtained in the present study on the morphology of the pachytene chromosomes and other meiotic stages in *Sorghum subglabrescens* are presented in this paper. Some observations made on the pachytene chromosomes and meiosis in *S. roxburghii* Stapf, another Eu-Sorghum, are also included here for comparison.

MATERIALS AND METHODS

Seeds of *Sorghum subglabrescens* were obtained from the Agriculture Research Station, Nandyal, Andhra State, and cultures were raised in the Andhra University Botanical Gardens at Waltair.

For the study of pachytene chromosomes the modified acetocarmine technique developed by Lima-de-Faria (1948) for rye, was found very suitable. The young inflorescences were fixed in 1 : 4 acetic alcohol for 12–24 hours and then transferred to 95% alcohol overnight, after which the material was stored in 70% alcohol in a refrigerator until used for study. The preparations made according to this method showed a clear definition of the differentially stained parts of the pachytene chromosomes in almost unstained cytoplasm. The technique of iron alum mordanting prior to staining with acetocarmine originally developed for staining tomato chromosomes by Dr. Marta S. Walters, and later successfully employed by Brown (1949) and Barton (1950) was also tried but did not prove suitable as the cytoplasm was darkly stained obscuring details of the pachytene chromosomes.

All photomicrographs presented in this paper were taken from preparations when they were still fresh using a Leica camera with an attachment for photomicrographic work.

Measurements of lengths of entire chromosomes and of the heavily and lightly stained parts were made from camera lucida drawings of the pachytene chromosomes from completely analysable nuclei with the aid of a map measurer.

PACHYTENE CHROMOSOMES

The ten chromosomes of *Sorghum subglabrescens* at the pachytene stage are characterized by (*i*) distinct and well-defined centromeres, (*ii*) deeply staining segments of varying length in each arm adjacent to the centromere followed by (*iii*) lightly staining distal regions of different lengths (Text-Fig. 1 and Plate XIX, Figs. 1–3). The above characteristics are considered below in detail.

The centromeres are oval-shaped and seem to resemble somewhat in their structure those described in rye by Lima-de-Faria (1949). The structure of the centromere could not be made out clearly in

Sorghum subglabrescens, but in a few favourably stained preparations of *S. roxburghii* there seem to be present a pair of lightly stained chromomeres in its centromere. More intensive study, using fixatives other than those involving acetic acid which Lima-de-Faria (1950) found not suitable for study of centromere structure, is needed before definite conclusions can be reached.

The heavily stained regions of the chromosomes consist of chromomeres which stain deeply and the lightly stained distal regions show very feebly staining chromomeres, which are difficult to differentiate from the cytoplasm in which they were spread out in the squash preparations. The transition between the proximal deeply staining and the distal lightly staining segments in each arm is rather abrupt except in the case of two chromosomes of the complement in which the region of transition consists of 3 or 4 chromomeres capable of being stained noticeably and were arranged in a characteristically seriated manner. This feature proved particularly useful in individually recognising the two chromosomes from the rest of the complement. In another chromosome of the complement almost the entire short arm is constituted by the deeply stained segment. In *S. roxburghii* which has also been examined for comparison, the structure of the differentially stained chromosomes is essentially similar except that in it the deeply stained segments are more pronounced (Plate XIX, Figs. 2 and 3).

There are no knobs and no pronounced chromomeres at the ends of the chromosomes. The longest chromosome (ch. I) of the complement is the nucleolus organising chromosome, the nucleolus organizing body being situated very near to the centromere in the short arm.

PACHYTENE PAIRING

Pre-pachytene stages proved difficult to study. However, in a number of nuclei it was clearly observed that the pairing was regularly initiated in the deeply staining segments and the parts immediately adjacent to them. At this stage the pairing was not evident in the lightly stained regions. At a later stage the pairing becomes complete all along the length of the chromosomes. In late pachytene and early diplotene, the split threads fall apart earlier in the zones corresponding to the deeply staining and adjacent regions. Frequently the centromeres were found still attached to each other with a loop on either side of it.

The pairing properties of the pachytene bivalents observed in the present study show a striking similarity to the pairing behaviour of the differentially condensed pachytene chromosomes of *Agapanthus* (Darlington, 1933), in which the proximal parts are in advance. . .the distal parts in the process of condensation which has been ascribed to earlier assumption of spiral in the condensed parts. In *Agapanthus* (Darlington, 1933) also, as in *S. subglabrescens*, corresponding to the early synapsis of the over-condensed parts there is an earlier appearance of the secondary split in the same region accompanied by earlier falling apart of the chromosomes.

Mitotic stages from the root tip cells of *S. subglabrescens* particularly at prophase showed the middle deeply stained regions followed by lightly stained regions towards the chromosome ends. In this respect, *S. subglabrescens* resembles tomato (Brown, 1949) and *Plantago ovata* (Hyde, 1953) in which also the mitotic chromosomes show differentially stained segments. Earlier, Darlington (1933) made some observations on the mitotic chromosomes in the pollen grain division in *Agapanthus* which, however, did not show any differential regions in them, although the meiotic chromosomes are differentiated into deeply stained and lightly stained regions.

Frequent non-homologous association of the centromeres takes place during the meiotic prophase. Association of two non-homologous centromeres is common while that of three is not infrequent in both the species investigated. Plate XIX, Fig. 3, shows a case of non-homologous association of centromeres observed in *S. roxburghii.* Similar observations have been made in *Agapanthus* (Darlington, 1933) and in tomato by Brown (1949). Darlington (1933) considered the cases of non-homologous association of centromeres in *Agapanthus* as due to interlocking of the non-persistent kind. In the light of the accepted concept relating to the common forms and functions of the centromeres, it appears to us that they exert an attraction leading to fusion in a certain sense more favourably in differentially condensed chromosomes in which a lapse of repulsion exists between the deeply stained segments consequent upon the lower surface charge they are supposed to carry (Darlington, 1937, pp. 315 and 498).

DIAGNOSTIC FEATURES OF PACHYTENE CHROMOSOME COMPLEMENT

Based upon the average values of lengths obtained by complete analyses of chromosomes in ten entire nuclei, the ten pachytene chromosomes of *S. subglabrescens* have been designated in the order of their decreasing length as chromosome one to chromosome ten, chromosome one being the longest and chromosome ten being the shortest in the complement following the method of numbering originally adopted by McClintock (1929) in *Zea mays* and later by Barton (1950) in tomato. Table I shows the measurements based on the analyses of all the pachytene chromosomes in each of ten entire nuclei.

The following is a description of the individual pachytene chromosomes of the complement giving their chief diagnostic morphological features which proved particularly useful in identifying them individually.

Chromosome 1.—This is the longest of the complement, measuring on an average 80·38 microns, and has an attachment to the nucleolus very near to the centromere in the short arm. The nucleolar organising region is spherical in shape and distinctly greater in diameter than the adjoining deeply stained segments. Another characteristic feature of this chromosome is the presence of a deep staining chromomere terminating the heavily stained region in the long arm.

TABLE I

Average values of lengths in microns of the pachytene complement obtained from the complete analysis of ten cells in S. subglabrescens

Chromosome	Long arm			Short arm			Total Chromosome‡	Arm ratio S.A./L.A.
	H.S.R.*	L.S.R.†	Total arm	H.S.R.	L.S.R.	Total arm		
1	3·75	40·60	45·07	2·71	32·02	35·31	80·38 (2·35)	0·78
2	4·88	36·06	41·69	3·77	19·39	23·69	65·38 (1·66)	0·57
3	4·07	30·71	35·50	3·61	21·51	25·65	61·15 (2·77)	0·724
4	4·81	25·14	30·19	6·21	15·68	22·89	53·08 (1·67)	0·758
5	4·21	21·69	26·82	5·91	13·04	19·53	46·35 (0·95)	0·73
6	5·77	28·93	35·33	5·31	1·10	6·90	42·23 (1·13)	0·195
7	3·77	21·80	26·20	3·61	11·82	15·92	42·12 (1·34)	0·61
8	4·78	16·51	21·64	3·43	16·08	19·94	41·58 (1·07)	0·92
9	4·90	16·74	22·27	4·62	10·83	15·96	38·23 (0·97)	0·72
10	4·42	13·11	18·10	3·17	11·04	14·67	32·77 (1·04)	0·81

* Heavily stained region.

† Lightly stained region.

‡ Standard errors for entire lengths of the chromosomes are given in parentheses.

Chromosome 2. The chief feature which proved most useful in the identification of this chromosome is that the long arm is approximately twice the length of the short arm. The heavily stained parts in both arms show an abrupt transition to the lightly stained zones. The heavily stained region in the long arm is slightly greater than that in the short arm.

Chromosome 3.—This is difficult to distinguish from the succeeding chromosome particularly in nuclei where it cannot be followed from end to end, due to the fact that both of them come close to one another in length. In some of the cells analysed it is even lesser in length than chromosome 4 while in still others it is slightly more in length than chromosome 2. However, the presence of a deep staining chromomere terminating the heavily stained part in the short arm comparable in size to that seen in chromosome 1 makes its identification certain.

Chromosome 4.—The ready identification of this chromosome on the basis of length alone is difficult for the reasons already mentioned under chromosome 3. The deeply stained chromomere terminating the heavily stained segment in the long arm and the presence of a series of four small chromomeres in the transition region of the short arm capable of being well stained together form a reliable diagnostic basis.

Chromosome 5.—This is marked by the presence of a series of three small chromomeres in the transition region in the short arm like that described under the preceding chromosome. This chromosome measures on an average 46·35 microns.

Chromosome 6.—This is the easiest chromosome to identify in the complement due to the marked asymmetry of its arms. The long arm is about five times the length of the short arm. Also the short arm is completely stained deeply but for a small terminal part of about 1·1 microns in length. The average length of the chromosome is 42·23 microns.

Chromosome 7.—This is chiefly distinguished from the rest of the long chromosomes by the comparative short length of the lightly stained segment in the short arm. The short arm measures about half the length of the long arm (arm ratio - 0·61).

Chromosome 8.—This is readily recognised from the rest of the complement by the nearly equal length of its arms. Although in this feature chromosome 10 comes very near to it, in none of the cells analysed it comes near to this chromosome in total length there being a difference of 8·8 microns on an average.

Chromosome 9.—The quick recognition of this chromosome among the short chromosomes of the complement is facilitated by the characteristic presence of two deeply stained chromomeres terminating the heavily stained region in either arm. Its arm ratio is 0·72.

Chromosome 10.—This is the shortest chromosome of the complement measuring 32·77 microns long on an average. The arm lengths in many of the nuclei analysed have been found to be approximately equal, although on an average a difference of more than three microns was found.

Basing on the quantitative data presented in Table I the diagram of the 10 chromosomes (Text-Fig. 2) has been constructed to bring about the diagnostic features of the individual chromosomes that have been considered particularly useful in tracing their identity in the complement.

DIAKINESIS AND METAPHASE I

The differentially stained regions can be followed through diplotene to the late diakinesis stage both in *S. subglabrescens* and *S. roxburghii.*

It was possible to observe chiasmata in early and late diakinesis, metaphase I and even in early diplotene stages. Altogether 45 nuclei could be analysed in *S. subglabrescens* and 75 in *S. roxburghii* (Table II). It is clear from the data given in Table II that there is a decrease in the number of chiasmata per nucleus from diplotene to metaphase I. This is further borne out by the values of terminalisation coefficient at metaphase I given in the last column of Table II for the two species.

TABLE II

Chiasma frequencies at late-diplotene to metaphase I stages in Sorghum subglabrescens *and* S. roxburghii

Stage	No. of cells analysed	Bivalents with 4Xta	3Xta	2Xta	1Xma	Total Xta	Average No. of Xta per nucleus	Average No. of Xta per bivalent	Terminalisation coefficient
			S. subglabrescens						
Late diplotene	3	7	14	8	1	87	29·0	2·9	0·15
Early diakinesis	14	..	54	83	3	331	23·64	2·36	0·22
Late diakinesis	12	..	..	116	4	236	19·66	1·97	0·45
Metaphase I	16	..	..	153	7	313	19·56	1·96	0·79
			S. roxburghii						
Late diplotene	3	2	17	11	..	81	27·0	2·70	0·12
Early diakinesis	9	1	26	62	1	207	23·0	2·30	0·20
Late diakinesis	16	..	..	153	7	313	19·56	1·96	0·57
Metaphase I	47	..	..	446	24	916	19·50	1·95	0·75

It can be seen from these values that the process of the terminalisation in both the species is incomplete. In this respect the two species of Eu-Sorghum studied resemble plants like *Agapanthus*, *Avena* and *Zea mays* (Darlington, 1933 *a*, 1933 *b* and 1934) and *Lycopersicum esculentum* (Brown, 1949).

From the analyses of the nuclei at diakinesis (Table III) it was found that of the total of 260 bivalents in *S. subglabrescens* and 250 in *S. roxburghii*, 253 in the former and 242 in the latter are of the ring type.

TABLE III

Frequency of rod and ring bivalents at diakinesis and metaphase I

Species	Stage	Ring bivalents Number	Ring bivalents Per cent.	Rod bivalents Number	Rod bivalents Per cent.	Total bivalents
S. subglabrescens	Diakinesis	253	97·3	7	2·7	260
	Metaphase I	153	95·6	7	4·4	160
S. roxburghii	Diakinesis	242	96·8	8	3·2	250
	Metaphase I	446	94·9	24	5·1	470

Thus, in more than 90% of the nuclei at least one chiasma in either arm of each chromosome of the complement is formed irrespective of any differences in them. On the assumption that there is no localisation and that chiasma formation is at random, there should be a proportion of the chiasma in the short arm of chromosome 6 which is almost entirely constituted by its deeply stained segment, the distal light staining region measuring 1·10 microns only while the total length of the short arm is 6·90 microns on an average. On the general assumption that the number of chiasmata formed is proportional to the length of the chromosome, $6{\cdot}90/35{\cdot}33 \times 2{\cdot}17 = 0{\cdot}42$ chiasma should be formed in the short arm of chromosome 6 and $1{\cdot}10/6{\cdot}9 \times 0{\cdot}42 = 0{\cdot}07$ should be located in the light staining distal region of the arm alone, the rest being formed in the proximal dark staining region. On these considerations it may be inferred that it is very likely that there is no localislation of chiasmata in *S. subglabrescens* such as present in tomato (Brown, 1949 and Barton, 1951) and *Plantago ovata* (Hyde, 1953). Since the general inferences made by us in this respect are not directly correlated with any observations on any one of the identified bivalents on the origin and behaviour of chiasmata, a more certain evidence such as those obtained by Brown (1949) with reference to the nucleolar chromosome and by Barton (1951) on the experimental basis in tomato is necessary before establishing this point of view. Until such direct evidence as in tomato is obtained with reference to *Sorghum* it is to be considered that chiasmata are formed at random all along the length of the chromosome in *Sorghum subglabrescens.*

Other meiotic stages of divisions I and II show normal features and at the end of the two divisions the microspore nuclei show ten chromosomes in each of them.

DISCUSSION

The striking differential stainability of the pachytene chromosomes is a characteristic found in all the Eu-Sorghums so far investigated namely *Sorghum vulgare* (Longley, 1937 and Garber, 1950), *S. subglabrescens* and *S. roxburghii* (present report) and serves to distinguish them from the rest of the Sorghums studied (Garber, 1950).

As in the differentiated chromosomes of *Antirrhinum* (Ernst, 1938, 1939), tomato (Brown, 1949; Barton 1950) and *Plantago ovata* (Hyde, 1953) the pachytene chromosomes show proximal darkly staining segments followed by distal lightly staining ones in each arm. These differential regions can be followed until late diakinesis stage is reached in the meiotic cycle. In *S. subglabrescens* these regions can also be seen in mitotic chromosomes in the root tip cells. In *Plantago ovata,* Hyde (1953) was able to identify morphologically the chromosomes of mitotic prophase with those of pachytene. He concluded that this continuity suggests that the differentiation is inherent in each individual chromosome and is controlled by its submicroscopic structure.

In 1928, Heitz originally described the differentially stained regions in the chromosomes of some plants and designated the material in the darkly staining regions as heterochromatin and that in the lightly staining regions as euchromatin. He also specifically suggested that heterochromatic segments are genetically inert and euchromatic active. Although in *Drosophila* this hypothesis with some modifications has been substantiated, in plants, however, it remains in doubt due to the fact that only a very few plants have yet been found with differentiated chromosomes in which critical cytogenetic work on the gene content of the heterochromatin is possible. So far, only in *Antirrhinum* and in tomato a detailed knowledge of the differentiated pachytene chromosomes made cytogenetic work possible. As detailed study of morphology of the pachytene chromosome complement leading to individual identification of the chromosomes has now become possible in *S. subglabrescens* and as it is possible to acquire similar knowledge in more Eu-Sorghums in the near future, it is hoped that Eu-Sorghums would prove to be very favourable material for critical cytogenetic work on the gene content of the material in the deeply staining regions which seem to be similar in certain respects to heterochromatin in plants.

Although the structure of the meiotic chromosomes of tomato resembles closely those regarded as differentiated into zones containing hetero and euchromatin, Brown (1949) used the terms 'chromatic' and 'achromatic' as the latter seem to shorten markedly without acquiring an appreciable capacity to stain deeply, unlike the typical euchromatin described by Heitz (1928) which acquires during prophase a marked capacity for deep staining and also because the various chromatic zones in tomato seemed to show a differential behaviour during the resting stage. In view of the fact that the lightly stained zones in *S. subglabrescens* do not acquire a marked capacity to stain deeply as they contract and that the differential parts show deviations from those described in tomato in their synaptic properties and in the formation of chiasmata, simple terms 'heavily stained or deeply stained' and 'lightly stained or feebly stained' have been used.

Pairing properties of the differentiated regions of the chromosomes vary in different organisms. In tomato, Brown (1949) found that pairing is initiated during late zygotene or early pachytene stages in the achromatic zones followed later by pairing in the chromatic zones. It was not possible for him to study the separation of the split sister chromosomes at the diplotene stage. In *Plantago ovata*, Hyde (1953) recorded that pairing is initiated regularly in the middle segments while separation of the divided sister chromosomes takes place, however, in the end segments during the early diplotene stage. Earlier, in his studies on the synapsis of the differentially condensed chromosomes in *Agapanthus* and *Fritillaria* Darlington (1933, 1935) showed that pairing initially takes place during pachytene in the condensed proximal regions followed by separation of the split chromosomes at diplotene in the same parts. In its pairing properties of the differentially stained regions, *S. subglabrescens* shows a close similarity to *Agapanthus* and *Fritillaria*. In *Fritillaria* the earlier pairing in proximal deeply staining regions is believed to be associated with localisation of chiasmata in the regions adjacent to the centromere. Consequently, an assumption of a timing difference at meiosis in that the proximal parts are in advance to the distal parts with a possible relation of the former to the centromere satisfactorily explains the behaviour of heavily and lightly stained regions of the pachytene chromosomes of *S. subglabrescens*. In the Eu-Sorghums investigated during the present study, however, there does not seem to be any localisation of chiasmata as in *Fritillaria*.

It has been observed in several plants with differentiated chromosomes that the chiasmata are localised in the lightly stained regions. In 1933, Geitler found in *Agapanthus* the formation of as many as four chiasmata per bivalent, all in the euchromatic regions. Barton (1951) concluded, on the basis of experimental evidence, that chiasmata probably do not occur in the chromatic zones of tomato. More recently, Hyde (1953) made similar observations in *Plantago ovata* and concluded that chiasma formation does not take place in the deeply staining middle segments. As already pointed out in this paper, on the basis of observations on the distribution of chiasmata particularly with reference to the almost entirely deeply staining short arm of chromosome 6 in *S. subglabrescens*, there does not seem to be any apparent localisation of chiasmata in the lightly stained distal regions. Thus, in Eu-Sorghums the chromomeres of the deeply stained segments do not seem to be inherently different from those in the lightly stained regions in the capacity of the recombination of the genic material in them.

SUMMARY

S. subglabrescens Schw. et Asch., a Eu-Sorghum, is found an exceptionally favourable material for the study of pachytene chromosomes with special reference to their differential staining reaction. The differential segments can be clearly seen up to diakinesis stage in the meiotic cycle. The mitotic chromosomes in the root tip cells are also observed to show the differentially stained regions. A careful and critical study of the heavily stained proximal segments and the distal lightly stained regions, the relative lengths, arm ratios in the pachytene chromosomes proved very useful in identifying each of the ten chromosomes of the complement. Diagnostic features of each one of the pachytene chromosomes and diagram based on them are presented.

Studies on the pairing properties of the differentially stained parts show that synapsis takes place initially during early prophase in the heavily stained regions and is followed by the earlier separation of the split chromosomes in the same regions at diplotene. An assumption of timing difference at meiosis in that the proximal parts are in advance to the distal lightly stained parts is considered to be satisfactory to explain the observations as has been already done in other plants like *Agapanthus*.

Detailed studies on the distribution of chiasmata in *S. subglabrescens* and *S. roxburghii* show no apparent localisation of these in the lightly stained regions indicating thereby that the deeply and lightly stained regions show no differentiation of the chromomeres constituting them in their capacity to recombine.

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Explanation of Plate XIX

Fig. 1. Pachytene in *S. subglabrescens*, ×ca. 1,500.

Fig. 2. Pachytene in *S. roxburghii*, showing the relatively more pronounced heavily stained regions adjacent to centromeres, ×ca. 1,500.

Fig. 3. Another cell at pachytene in *S. roxburghii*, showing a case of non-homologous association of centromeres, ×ca. 1,500.

Figs. 4–6. Early diakinesis, late diakinesis and metaphase I respectively in *S. subglabrescens*, showing the relative contraction of the differentially stained regions in the bivalents, ×ca. 1,000.

1

2

TEXT-FIGS. 1–2. Fig. 1. Explanatory diagram drawn from Plate XIX, Fig. 1, showing the individual chromosomes (for details of description see text). Fig. 2. Diagram of the pachytene complement in *Sorghum subglabrescens*, showing the average lengths of the chromosomes and the relative lengths of the heavily and lightly stained regions in each. The nucleolar organising region in chromosome 1 is represented by a circle, and centromeres by gaps.

1

2

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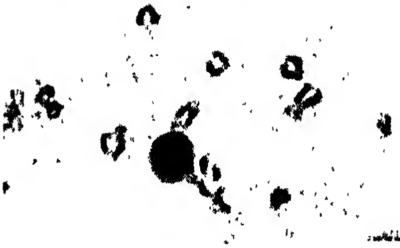

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J. Venkateswarlu & V. Ramakrishna Reddi

CONTRIBUTION TO THE ECOLOGY OF TEAK (*TECTONA GRANDIS* LINN. f.) IN MADHYA PRADESH

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Introduction

Teak is the most important timber tree of Madhya Pradesh and the Forest Department has, therefore, been much interested in its ecology and silviculture and several reports and papers have been published. The position prior to 1920 was written up by Troup (1921) and subsequent works have been summed up by Hewetson (1941 and 1951). He directed attention to the lack of data on the relationship of teak to the habitat, particularly the soil. Some observations made by Puri (1951) suggested that teak is probably a calcicolous species showing its best development on base rich soils and on this basis attempts were made to explain its distribution in this country.

With a view to understand the various ecological aspects of this species a study was undertaken during 1952-54 at a number of places in Madhya Pradesh. These include Allapalli (S. Chanda Division), Bori Reserves and Kheli Range (Hoshangabad Division), Punassa and West Kalibhet Ranges (Nimar Division), Hirdaygarh (Chindhwara Division) and various ranges of Sagar Division.

The detailed results of these studies have been recently published (Bhatia, 1955) and the present note embodies details of this contribution on the subject.

(1) *Discontinuous distribution.*—Teak is indigenous to vast areas of South and South-East Asia and has been successfully introduced in areas far removed from its natural limits of distribution (Trinidad, South Africa and Northern India). Throughout the range of its distribution teak forests are rarely pure except where purposive felling of other tree species has been executed; moreover, its distribution is not continuous.

In the State of Madhya Pradesh teak is distributed in a discontinuous manner chiefly in the Satpura Range. At altitudes above 3,000 feet in the Satpuras the discontinuity is due to geomorphological barriers. The changes in the climatic conditions brought about by an increase in altitude does not seem to be suitable for teak. They,

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on the other hand, favour the development of tropical sub-montane forests with semi-evergreen tree species.

In most cases that have been studied the discontinuity is due to edaphic factors in which surface geology and soil play an important part. This had been earlier indicated by Kulkarni (1951). The most spectacular case is to be found at Hirdaygarh. In this region long narrow trap-dykes run through the basal Gondwana sandstones. Teak is confined to narrow bands along the trap intrusions and the phenomenon is repeated at Bori on a more massive scale. Again at Kheli Range, the Satpuras rise abruptly from the plains of Narsinghpur. On the northern slopes of the ranges teak flourishes on the Bagra conglomerates of the Gondwana system forming about 30% of the crop. Further interior on the Jabalpur sandstone teak is predominantly absent. In the same area igneous intrusions bear teak on them. Similar interesting relationships between teak distribution and geological formations have been given by Stamp (1925) in Burma and Kadambi (1951) for Mysore.

The conclusion is that teak requires those minerals which are present in the igneous rock and which have been lost in the Gondwana sandstones. The author's investigation (Bhatia, 1955) show that these minerals include the bases chiefly calcium which is abundantly found in soils derived from igneous rocks. The matrix of Bagra conglomerates contains sufficient amount of calcium and so a good growth of teak is present on them. This brings to the forefront the role of surface geology and soil in the growth and distribution of teak. The present investigation has therefore shown that most soils derived from rocks that contain appreciable amounts of bases support teak (Table I).

Earlier Kulkarni (1951) had stated that "the occurrence of teak is largely confined to soils with pH values ranging from 6·5–7·5" and that intolerance develop "suddenly within a very brief fall of pH value from 6·5 6·0". In the author's investigations (Bhatia, 1955 *b*) he showed that teak occurs in a large number of soil samples between 6·0 6·5. The narrow range of pH tolerance, as indicated by Kulkarni (1951), appears rather insignificant when we consider that his pH determinations were carried out with soil indicator outfit. It has been found that the average exchangeable calcium of 38 samples of soils with pH 6·1-6·5 is 0·39%. This is much above the critical level and most of the good teak stands are supported on these. Thus the statement of De Silva (1934) that the calcicolous plants may occur on soils which are acidic in reaction is largely true for teak. Very few situations have been encountered with pH values between 8·5–9·0 but teak was found to grow well even on such soils.

Besides the bases, soil phosphorus appears to check teak regeneration and distribution over areas where the mineral is likely to be deficient. The suitability of trap soils for teak forests is not only due to the greater water retaining capacity of these soils as pointed out by Champion (1938) but is also due to the higher amounts of soil phosphorus they

TABLE I

The average pH values and the amounts of exchangeable calcium and magnesium in the soils derived from different geological formations of Madhya Pradesh and the teak growth on them

Geological formations	Teak growth	pH	CaO %	$Mg_2P_2O_7$ %
1 Granites and gneisses ..	Medium to good	6·2	0·41	0·28
2 Vindhyan sandstones, shales and conglomerates	Medium to poor	6·0	0·37	0·25
3 Quartzites ..	Poor	6·0	0·26	0·25
4 Gondwana sandstones :				
(*a*) Talchirs, Moturs and Barakars	Poor to nil	5·8	0·24	0·14
(*b*) Bagra conglomerates	Medium	6·6	0·37	0·33
(*c*) Jabalpur sandstones	No teak	6·0	0·23	0·20
(*d*) Pachmari sandstones	No teak	5·6	0·24	0·13
5 Igneous rocks :				
(*a*) Deccan trap	Good	7·1	0·73	0·32
(*b*) Dykes and sills	Good to best	6·3	0·50	0·38
6 Calcareous crystalline	Medium to good	7·6	0·76	0·54
7 Alluvial soils :				
(*a*) Calcareous (with lime)	Good to best	8·3	2·38	0·33
(*b*) Non-calcareous	Best	6·3	0·56	0·46

contain, which is mostly derived from the mineral apatite which forms as much as 1% of trap rocks.

However, the relation of teak distribution to surface geology is not a simple one. At Allapalli (S. Chanda Division) the soils are derived from granite, gneisses and in a few cases from quartzites. These soils are not very rich in bases yet they support good quality teak. This observation opens up another field of study and work on the uptake of minerals under varying environmental conditions is likely to yield results of some value on the physiologico-ecological aspects of the species.

(2) *Concept of teak soils.*—While the present study has helped to bring about the lower limits of various elements of the soil below which teak would not grow the feasibility of building up a concept of teak soils as Hewetson (1941) had pointed out is futile. This is largely due to the fact that many tree species are suited to the average climatic and edaphic conditions of Madhya Pradesh. Which one of these will dominate over a particular area? The answer must be sought not in the soils. Hewetson (private communication) has emphasised this point and explained a few cases where certain species form almost

pure crop while in similar soils derived from the same geological formation in other localities they are prominently absent. Although the role of soil humus, exchangeable bases and moisture can never be under-estimated the underlying explanation of all such cases is a favourable combination of environmental factors which would include in the main the climate. These may occur once in a great number of years but whenever they do combine we have in time and space an almost pure forest of that particular species.

"We can take a tree like Bija (*Pterocarpus marsupium*) with a hard testa. This has to be rotted away before the seeds can germinate freely. This can happen in a year in which there are showers throughout May. Such a year we may imagine, to coincide with a good Bija seed year. What are the chances? Suppose a year with rains in May comes twice a century and a good Bija seed year once every 5 years: the chances of the two coinciding are small. If we further suppose that for the Bija seedling to survive the following rains must be good and last up to October. Such combination of favourable factors may happen once in 100,000 years but if they do and other things are favourable, then you may get a pure Bija forest in one place."

(3) *Calcicolous habit of teak.* –Following Olsen's (1942) concept of a calcareous plant, teak is definitely a calciphyte, showing best growth and completing all phases of its life on soils with high concentration of exchangeable calcium.

The high foliar calcium content (3 6%) in teak further confirms its calcicolous habit.† This shows that calcium plays an important part in the growth and distribution of teak in the State.

(4) *Divergent physiological behaviour.*- Many of the difficulties are in part due to the lack of correct information on the uniformity of teak population. This prevents generalisation over larger areas. Studies on foliar calcium is a definite pointer in this direction. As has been stated earlier (Bhatia, 1955) the divergent results of the various investigators may be due either to the different physiological races present in nature or that the nutritive balance of the plant is disturbed when introduced in areas outside its natural limit. Definite information on either of these points is very important. It is natural to expect complexities in a mixed population, while on the other hand, information on the nutrition of teak when planted away from its 'home' is of immense practical value to the forester.

(5) *Significance of calcicolous habit.*- Chandler (1939) has classified trees with foliar calcium up to 3% as 'soil improvers' because of the relatively large amounts of calcium they deposit on the soil surface each year. This is largely true of acidic soils with low lime content in the northern temperate zone. In our conditions there are, however, indications to show that such a view may not be tenable in teak areas.

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† The values obtained for teak leaf is high when compared with calcium content of other forest trees worked out by Puri and Gupta (1950). Chandler (1939) considers values above 3% as high.

Teak makes a heavy demand on soil calcium and removes a good amount from the soil. If for some reason or the other the amount of calcium stored in the leaf is not returned to the soil the nutrient capital of the soil may greatly diminish and a good percentage of this element shall have to be written off. Such adverse circumstances are in fact many. It is well known that due to sparse undergrowth in teak forest the top soil is subject to easy erosion (Laurie and Griffith, 1941). The repeated summer fire reduces the litters to ash which is either blown off or washed away with the first downpour of rain. Much of the bases concentrated at the top may thus be lost.

Again, Brandis (1921), in one of his notes on teak, had recorded that the white mineral deposits in wood cavities of teak is "as far as known mainly consists of calcium phosphate". Although no data on the total calcium locked up in the wood is available at the moment, nevertheless, the observation is of particular interest. The amount of calcium present in the wood is perhaps lost to the soil after the trees are felled and removed.

Puri (unpublished) has observed that the plantation of teak in sal (*Shorea robusta*) area has led to the depletion of soil calcium as teak makes a higher demand on soil calcium, ... "ultimately when the sub-soil has become acidic, teak will probably suffer and may naturally give place to sal seedlings." This observation is in line with the present contention that soils under teak may in course of time, under circumstances mentioned, lose its bases.

Taking this view, it is possible to explain the results of Laurie (1931). He found no significant difference between teak and non-teak soils of Anamalai Hills, Madras. He obtained uniformly acid conditions under both (average pH value for teak area is 5·56 and for non-teak soil is 5·68) and the soils were deficient in lime. It is possible that these conditions have developed later on as a result of the depletion of bases, for these soils do not seem to represent ideal conditions for the growth and distribution of teak and that the present crop may be the last after which teak would be replaced by other less exacting species, as in the adjoining areas.

Again, it is possible to explain, on basis of high calcium demand, the reason why the species does not occur gregariously.

There have in fact been many opinions about the deterioration of soils under teak (Casten, 1933 and Laurie and Griffith, 1941), but till now no direct explanation has been put forward. It now appears likely that it may be due to the depletion from the soil of calcium salts that are locked up in the wood or largely removed from the top layer by sheet erosion.‡

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‡ Subsequent work carried out at Dehra Dun on mineral economy in teak plantation has shown that there are no chances of calcium depletion. However, the investigation has brought out the possible depletion of the important soil mineral phosphate since it is stored in fairly large quantities in the wood and indications are there to shew that the depletion of this mineral may lead to failure in regeneration, discontinuous distribution and deterioration of forest site leading to fall in quality class.

(6) *Practical importance of the present results.*—Griffith and Gupta (1947) by their study of some teak soils of Nilambur plantation found that "calcium and magnesium are usually high in alluvial soils where good quality teak exists and this may be ameliorative to soil conditions even though it may not be essentially needed for teak" (Table II). They developed a method to forecast the quality of teak on the ratio of SiO_2/RZO_3, dispersion coefficient, depth of permanent moisture availability and aspect.

Using their 'four factor' index many of the Gondwana soils in Madhya Pradesh may be classified as good teak soils. But these soils rarely support teak (Table I) for the simple reason that they do not contain sufficient amount of exchangeable bases. Thus, it appears from the evidence derived from the distribution of teak on calcareous soils and from foliar analysis, that calcium is involved in the metabolism of teak.

The importance of soil bases was emphasised by Diebold (1935) who stated that the soil characteristics of the greatest importance for tree growth would include, besides others, the lime content of the entire soil profile.

It will yet take much investigation to bring out the precise role of calcium in the metabolism of the species, nevertheless, the results of the investigations of Griffith and Gupta (1947) for the Nilambur Plantations (Table II) and those of the present studies, clearly shows that calcium could be correlated with better growth of teak and greater frequency distribution. It is, therefore, clear that unless calcium is included as an important soil characteristic for the forecast of teak quality, it is doubtful if the results of Griffith and Gupta (1947) would have a wider field of application.

Other factor that favours the development of the species is soil phosphorus which from the view-point of plant nutrition is much more important than the bases and the consideration of this fact will necessitate better understanding of the factor where widespread afforestation of teak forests is likely to be undertaken.

ACKNOWLEDGEMENTS

My gratitude is due to Prof. R. Misra, under whose able guidance the present investigation was undertaken. I am also indebted to Dr. G. S. Puri, Ecologist, Forest Research Institute, Dehra Dun, and Dr. C. E. Hewetson, Deputy Chief Conservator of Forests, Madhya Pradesh, for their interest in my work and for their valuable suggestions received from time to time.

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TABLE II

The relation of soil calcium to planted teak quality in Nilambur (compiled from Griffith and Gupta, 1947)

Name of plantation	Soil type	Aspect and topography	Teak quality classes	Total CaO % classes									Total No. of soil samples studied
				0·1 — 0·3	0·31 — 0·60	0·61 — 0·90	0·91 — 1·20	1·21 — 1·50	1·51 — 1·80	1·81 — 2·10	2·10 — 2·50	Above	
Kanhiraka dara ..	Alluvium	..	Good	..	3	1	3	4	1	..	..	..	12
do	do	N. Aspect	Good	..	..	4	4	1	..	2	..	1	12
Walluvasseri Comptt., 151–53	do	Foot-hill	Good	..	2	2	1	4	..	..	..	..	10
Pennengode Comptts., 134–35 and 137	do	..	Best	..	..	5	..	..	..	..	..	..	5
do Comptt. 120,	do	..	Good	..	1	1	..	1	..	..	..	..	3
Nellicutter Comptts., 431–34	do	..	Best	..	..	1	..	2	..	1	..	..	4
Pennengode Comptts., 134–35 and 137	Thin alluvium overlying Laterite	..	Poor	..	2	3	..	..	..	..	..	..	5
do	do	..	Failed	4	1	..		..	..	..	..	..	5
Kanhiraka deva ..	No alluvium	Hill-top	Poor	2	12	5	2	1	..	..	..	..	24
Walluvasseri Comptts.1951-53	do	Hill-top	Little teak	1	3	..	..	..	..	..	..	..	4
do	do	..	Little teak	4	1	..	..	..	..	..	..	..	5
Nellicutter Comptts., 431–34	do	Foot-hill and S.W. slopes	Poor	..	6	3	..	..	..	..	..	..	9
do	do	Hill-top S.E. and E. slope	Deteriorated teak	6	4	..	..	..	..	..	..	..	10
Walluvasseri Comptts., 151–53	Laterite	..	Failed	10	2	..	..	..	..	..	..	..	12
Pennengode Comptts., 120	Swamp	Hill-top	No teak	6	3	..	..	..	..	..	..	..	9

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GLOEOTILOPSIS PLANCTONICA GEN. ET SP. NOV., A NEW MEMBER OF THE ULOTRICHACEAE*

By M. O. P. Iyengar and M. T. Philipose

(Received for publication on September 9, 1956)

The alga forming the subject of this paper came up in cultures of silt-algae from a pond at Madras. The cultures were made by placing some silt collected from the centre of the pond in wide round glass jars with 4–5 inches of filtered pond water above it. About a fortnight after starting the cultures, the alga appeared in the culture as a green scum on the surface of the water. The alga was later on found in the pond also. A small quantity of the alga was then transferred to separate culture vessels containing sterilised Richter's solution. It was also grown on agar plates. The alga grew well in both the media.

The alga is free floating near the surface of the water and consists of short filaments of 1–6 cells. Occasionally filaments up to 16 cells long were seen. The cells are elongate-cylindrical, 3–5 μ or occasionally up to 7·5 μ broad and 8–24 μ or occasionally even up to 55 μ long. The poles of the cells are broadly rounded and the adjacent cells of the filament are in contact along only a part of their surface. The filaments are not enclosed in a mucilaginous envelope.

The cell has a thin cell-wall and contains a single nucleus and a parietal plate-like chloroplast with a single or occasionally two pyrenoids. The chloroplast occupies the whole length of the cell and encircles about three-fourths of the circumference of the cell (Text-Fig. 3).

REPRODUCTION

Vegetative reproduction.—The alga readily fragments into smaller pieces and often into individual cells.

Asexual reproduction.—One to eight or occasionally 16 biflagellate zoospores are formed in each cell. The zoospores (Text-Fig. 15) are ovate with a small papilla at the front end, an irregularly cup-shaped

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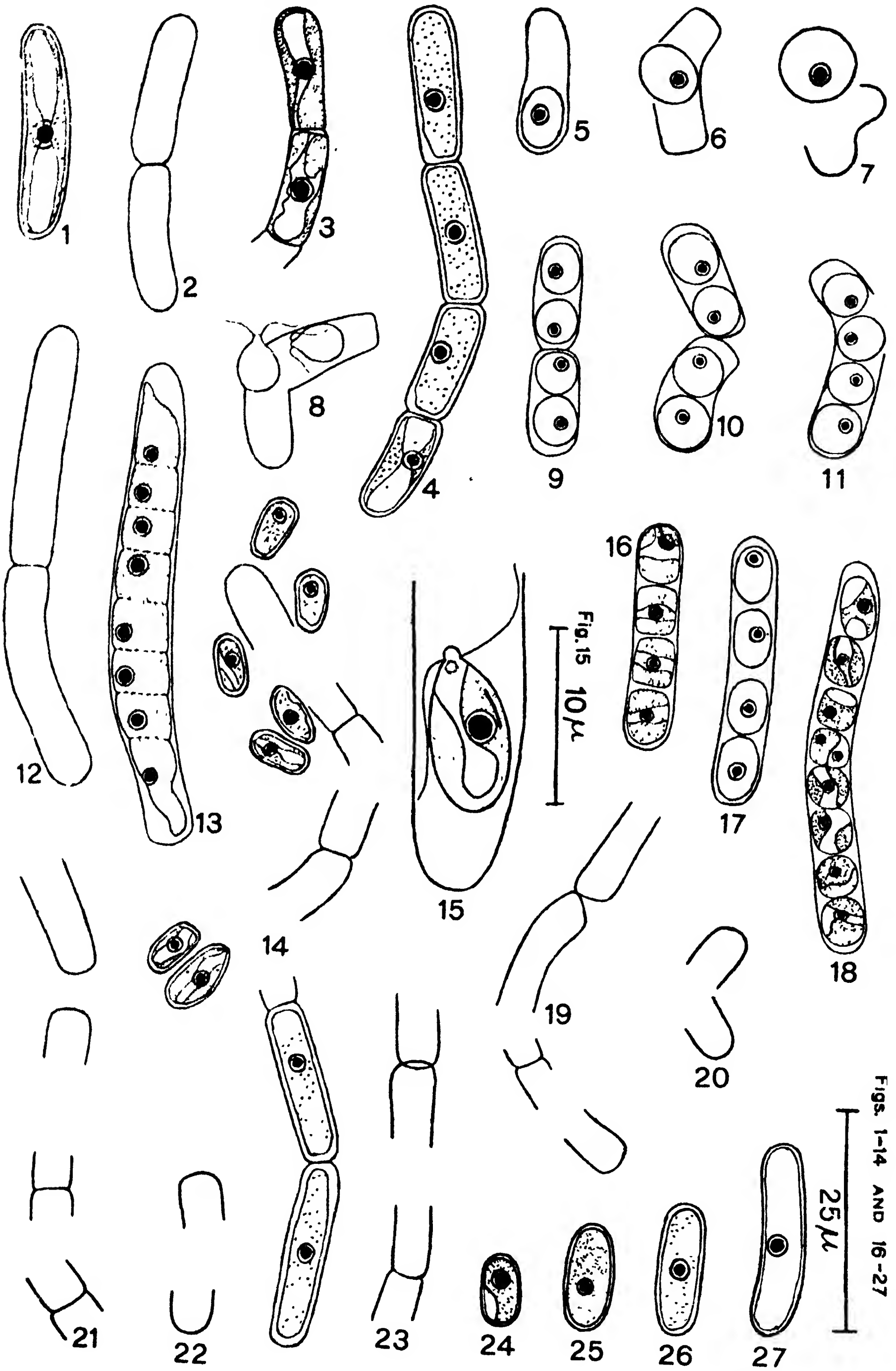
* From the University Botany Laboratory, Madras.



TEXT-FIGS. 1–27. *Gloeotilopsis planctonica* gen. et sp. nov. Fig. 1. Single celled plant. Figs. 2, 12. Two-celled filaments. Fig. 3. Two cells of a filament showing the shape of the chloroplasts. Fig. 4. Four-celled filament. Figs. 5–7. A cell forming a single aplanospore. Fig. 8. A cell forming two zoospores which escape by a median rupture of the cell-wall. Figs. 9, 10. Cells forming two aplanospores each. Figs. 11, 16, 17. Cells forming four aplanospores. Fig. 13. Contents of a cell dividing into eight parts. Fig. 14. A five-celled filament in which the top three cells have broken into H-shaped pieces, after liberating the aplanospores formed in them. Fig. 15. A zoospore inside a ruptured cell and about to escape. Fig. 18. A cell with eight aplanospores. Figs. 19–23. Ruptured cell-walls after the escape of zoospores. Figs. 24–27. Germlings in various stages of elongation.

chloroplast with a single lateral pyrenoid and a streak-like, bright red eye-spot which is supramedian in position. The zoospores are 2·6–4·3 μ broad and 5·2–10·3 μ long.

Zoospore formation generally takes place early in the morning between 5 and 7 a.m. The zoospores are liberated by a circumcissile break of the wall in the middle of the cell (Text-Figs. 8, 20) or a little to one side of the middle of the cell (Text-Fig. 19). When the cells of a filament break up in this manner, a number of H-shaped pieces of the cell-wall are left behind (Text-Figs. 19, 21 and 23). The H-shaped pieces owe their origin not to any peculiar structure of the cell-walls as seen in *Microspora*, but are merely due to the dissolution of the lateral wall of the cell along an equatorial line bringing about a circumcissile break of the wall. Filaments of the alga heated in dilute caustic potash solution, and washed in water and stained in methylene blue do not show the characteristic H-shaped structure seen in the walls of *Microspora*.

The zoospores after liberation swim for some time and then become quiescent, lose their flagella and soon surround themselves with a cell-wall. The germination of the settled zoospore was followed in a hanging drop culture of the filtered pond water. By the third day the germlings began to elongate and by about the sixth day they had elongated considerably. The elongated cell then divided into 2 by the formation of a transverse wall.

Very often aplanospores are formed in the place of zoospores (Text-Figs. 5–7, 9–11 and 16–18). Usually 2–8 aplanospores are formed in a cell, but occasionally only a single aplanospore is formed in a cell (Text-Figs. 5–7). The aplanospores are set free by a circumcissile break of the cell-wall (Text-Fig. 6) as in the case of the zoospores. The aplanospores, after becoming free, ultimately grow into shorter or longer filaments.

No sexual reproduction was observed in the alga.

DISCUSSION

The main features of the present alga are: (1) the filaments are very short and fragment into shorter pieces, often into individual cells; (2) the filaments do not have a mucilaginous sheath round them; (3) the cells of the alga are cylindrical and long, with more or less broadly rounded ends, the adjacent cells of the filament being in contact along only a part of their surface; (4) the chloroplast is a parietal plate which occupies the whole length of the cell and encircles nearly three-fourths of the circumference; one or occasionally two pyrenoids are present in each chloroplast; (5) usually two to eight zoospores are formed in a cell; and the zoospores escape by a circumcissile break of the lateral wall across the cell, the empty walls of the cells of the filament forming a number of H-shaped pieces.

The alga resembles *Stichococcus* in having very short filaments of a few cells only which readily fragment into shorter pieces and often into individual cells. But it differs from *Stichococcus* in the nature of its chloroplast. The chloroplast in *Stichococcus* does not encircle more than half the cell-wall and is devoid of a pyrenoid (Heering, 1914, p. 51; Oltmanns, 1922, p. 289; Printz, 1927, p. 165; West and Fritsch, 1927, p. 158; Fritsch, 1935, p. 208; Smith, 1950, p. 145), whereas in the present alga the chloroplast encircles about three-fourths of the circumference of the cell and possesses a definite pyrenoid. It differs again from *Stichococcus* in possessing zoospores which are unknown in *Stichococcus*.

The alga shows a certain resemblance to *Hormidium* in fragmenting into shorter pieces, in having a pyrenoid in its chloroplast, in having biflagellate zoospores and in the filaments not being attached to any substratum by a basal cell. But the chloroplast in *Hormidium* does not encircle more than half of the circumference of the cell and generally occupies only about half the length of the cell (Heering, 1914, p. 41; Oltmanns, 1922, p. 289; Printz, 1927, p. 166; West and Fritsch, 1927, p. 154; Fritsch, 1935, p. 205; Smith, 1950, p. 146), whereas in the present alga the chloroplast occupies the whole length of the cell and encircles nearly three-fourth of its circumference. Again the cells in the present alga are broadly rounded at the poles and the adjacent cells of its filaments are in contact along only part of their surface, whereas in *Hormidium* the cells are not rounded at the poles and the adjacent cells of the filament are in contact along their whole surface. The zoospores in *Hormidium* are liberated through a pore in the lateral wall of the cell (Heering, 1914, p. 42; Printz, 1927, p. 166; Smith 1950, p. 147) whereas, in the present alga, they are liberated not through a pore in the lateral wall but by a circumcissile break of the lateral wall.

The present alga resembles *Gloeotila* Kützing in the tendency of the thread to break into shorter lengths, in the ends of the cells being rounded and the adjacent cells of the filament being in contact along only a part of their surface and in having biflagellate zoospores (Heering, 1914, p. 48; Printz, 1927, p. 165; Fritsch, 1935, p. 206). But it differs from *Gloeotila* in having a definite pyrenoid and in its filaments not having a gelatinous sheath round them (Heering, 1914, p. 48; Oltmanns, 1922, p. 289; Printz, 1927, p. 165; Fritsch, 1935, p. 206).

It resembles *Ulothrix* in its chloroplast occupying more or less the whole length of the cell (West and Fritsch, 1927, p. 152; Fritsch, 1935, p. 201) and in having a pyrenoid in the chloroplast. It also resembles *Ulothrix* in forming one or more zoospores in each cell, unlike in *Gloeotila* and *Hormidium*, where only a single zoospore is formed in each cell. But it differs from *Ulothrix* in the manner of the liberation of the zoospores from the cell. In *Ulothrix* the zoospores are liberated through a round opening in the lateral wall of the cell, whereas in the present alga they are liberated through the circumcissile break of the lateral wall of the cell. Moreover, the present alga, unlike *Ulothrix*, is not attached by a basal cell.

It resembles *Microspora* in forming a number of H-shaped cell-wall pieces after the liberation of the zoospores, but the H-shaped pieces of the present alga are not formed by the separation of the overlapping H-shaped portions of the cell-wall as in *Microspora*, but are formed merely by a transverse dissolution of an equatorial portion of the cell-wall, thereby bringing about a break of the wall in a circumcissile manner. Again the chloroplast in *Microspora* is reticulate and without any pyrenoid, whereas in the present alga the chloroplast is not reticulate and has a definite pyrenoid in it (Hazen, 1902, p. 167; Heering, 1914, p. 147; Printz, 1927, p. 170; Fritsch, 1935, p. 210; Smith, 1950, p. 149).

Thus the present alga, while showing resemblance to a number of genera of the Ulotrichaceae in certain features, does not agree fully with any one of them. Moreover, it shows certain special features of its own. The alga may, therefore, be placed in a new genus in the Ulotrichaceae by name *Gloeotilopsis* and the alga itself may be called *Gloeotilopsis planctonica* gen. et sp. nov.

DESCRIPTION

Gloeotilopsis gen. nov.

Alga hæc efformat brevissima filamenta, quæ faciliter rumpuntur in breviora fragmenta, atque sæpe in cellulas individuas. Filamenta non includuntur opertorio mucoso. Cellulæ elongatæ, cylindricæ, polis late rotundatis; cellulæ adjacentes in filamento inter se contingunt tantum per partem aliquotam superficiei. Cellulæ continent nucleum unicum atque chloroplastum parietalem disciformem, pyrenoideo unico chloroplasta occupant *plus* minusve totam longitudinem cellulæ, atque extenduntur per tres quartas partes circumferentiæ. Reproductio per fragmentationem filamentorum atque per zoosporas biflagellatas, quarum 1–8 in singulis cellulis producuntur. Zoosporæ præditæ macula oculari definita; liberantur vero per circumcissionem parietis lateralis, parietibus vacuis efformantibus fragmenta instar litteræ H. Aplanosporæ sæpe formatæ loco zoosporarum. Reproductio sexualis ignota.

Gloeotilopsis planctonica spec. nov.

Characteres ut in genere. Cellulæ 3–5 μ latæ, 8–24 μ longæ.

Typus lectus in cultura limosa algarum ex lacu in Museo Gubernii, in civitate Madras.

Gloeotilopsis gen. nov.

Alga forming very short filaments which readily fragment into shorter pieces and often into individual cells. Filaments not enclosed in a mucous envelope. Cells elongate cylindrical with broadly rounded poles, the adjacent cells of the filament being in contact along only a part of their surface. Cells containing a single nucleus and a parietal plate-like chloroplast with a pyrenoid. Chloroplast occupying more or less the whole length of the cell and extending to nearly three-fourths of the circumference. Reproduction by fragmentation of the filaments and by biflagellate zoospores, of which 1–8 or more are formed in each cell. Zoospore provided with a definite eye-spot. Zoospores liberated by a circumcissile break of the lateral wall across the cell, the empty walls of the cells of the filament forming H-shaped pieces. Aplanospores often formed instead of zoospores. Sexual reproduction not known.

Gloeotilopsis planctonica sp. nov.

Characteristics same as those of the genus. Cells 3–5 μ broad and 8 24 μ long.

Habitat.—Found in a culture of silt algae from a pond in the Government Museum, Madras.

The authors' sincere thanks are due to Rev. Father H. Santapau for the Latin diagnoses of the new genus and the new species.

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ON SEXUAL REPRODUCTION IN A NEW SPECIES OF *GOLENKINIA*

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(With 12 Text-Figs.)

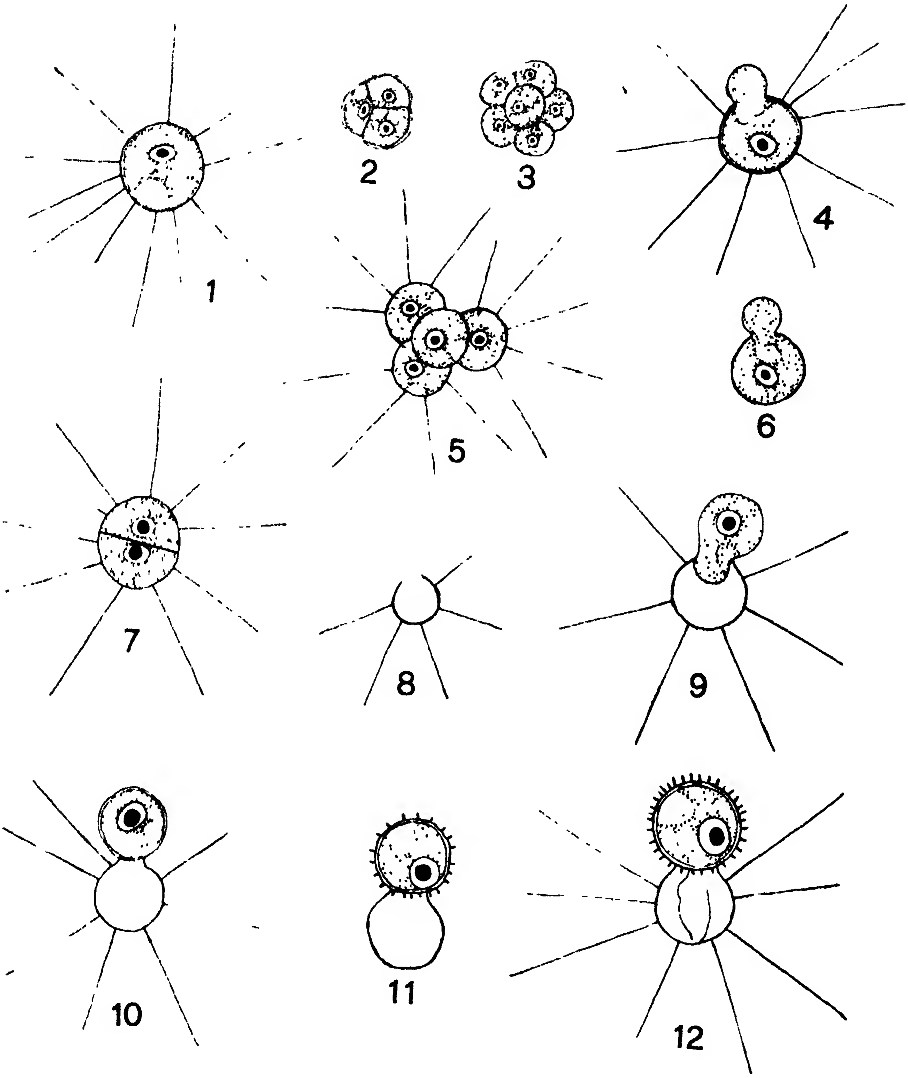
(Received for publication on September 9, 1956)

Until quite recently, no case of oogamous reproduction was known in the Chlorococcales. Korschikoff (1937) was the first to observe oogamous reproduction in the order. He described the details of oogamous reproduction in *Golenkinia longispina* Korsch., *G. solitaria* Korsch. and *Micractinium pusillum* Fres. Iyengar and Ramanathan (1940) described in detail oogamous reproduction in *Dictyosphaerium indicum* Iyengar & Ramanathan. Nygaard (1949. pp. 36–37) and Lund (1954, pp. 84–85) observed probable oospores in *Micractinium pusillum* Fres. But they did not observe any of the stages of sexual reproduction leading to the formation of the oospores. Recently the authors, while examining some formalin material of plankton algae from a temporary rain-pool near Lake Pashan, Poona, observed several stages of oogamous reproduction in a *Golenkinia* which appears to be a new species, and which has been named by them *Golenkinia minutissima* sp. nov. A brief account of this alga and the details of its reproduction are given below.

The cells of the alga are solitary, small and round and measure 4·5 to 6·5 μ in diameter. Its cell-wall is thin and bears a number of fine bristles all over the surface. The bristles are difficult to see in unstained material, but can be seen fairly clearly after staining in dilute aqueous solution of basic fuchsin or safranin. They are 7·5 to 10·5 μ long. The chloroplast is cup-shaped with a single pyrenoid (Fig. 1).

Asexual Reproduction.—Two, four or eight autospores are formed in a cell. The mother-cell-wall breaks up into two or more pieces releasing the daughter-individuals, which develop the characteristic bristles after liberation.

Sexual Reproduction.—A number of oogonial cells with the antherozoids fusing with the eggs was found in the material (Figs. 4, 6). But no cells were found showing the division of their contents to form the antherozoids. On the other hand, a number of small empty cells from which the contents had escaped were found in the material (Fig. 8). The size of these small empty cells (3·5 to 4 μ in diam.) corresponded very closely with the size of the antherozoids (about



Text-Figs. 1–12. *Golenkinia minutissima* sp. nov. Fig. 1. A single cell. Fig. 2. Formation of 4 daughter-cells. Fig. 3. Formation of 8 daughter-cells. Bristles not shown in Figs. 2 and 3. Fig. 5. A group of four daughter-cells before separation. Fig. 7. A cell showing division of its contents into two protoplasts. Figs. 4 and 6. Fusion of the antherozoid with the egg-cell. Bristles not shown in Fig. 6. Fig. 8. Probably the empty wall of a male cell after the escape of the antherozoid. Fig. 9. Zygote just escaping out of the oogonial wall. Fig. 10. Zygote which has covered itself with a smooth wall and is attached to the open end of the empty oogonial wall. Figs. 11 and 12. Zygotes with a spiny wall.

Figs. 2, 3, 6, 9, 10, 11 and 12, × 1,600.

Figs. 1, 4, 5, 7 and 8, × 1,000.

$3{\cdot}5\,\mu$ in diam.) which were fusing with the eggs. It is very probable that the antherozoids which were fusing with the eggs came out of these small but now empty cells. If this should prove to be the case, then these small cells must be considered as male cells, each producing a single antherozoid.

After the fusion of the antherozoid with the egg, the zygote emerges from the oogonium (Fig. 9) and remains attached to the empty oogonial wall and soon covers itself with a wall (Fig. 10). The wall of the oospore then forms numerous short spines all over its surface (Figs. 11, 12). The ripe oospore has a firm wall which bears numerous short spines. The oospore is 6 to 7 μ in diameter, and the spines are 1 to 1·5 μ long.

DESCRIPTION

Golenkinia minutissima sp. nov.

Cells solitary, spherical, with a thin but firm wall bearing a number of fine bristles. Chloroplast cup-shaped with a single pyrenoid. Cells 4·5 to 6·5 μ in diameter. Bristles 7·5 to 10·5 μ long. Asexual reproduction by 2, 4 or 8 autospores. Sexual reproduction oogamous. Oospore verrucose 6 to 7·5 μ in diameter. Spines 1 to 1·5 μ long.

Habitat.—Planktonic in a rain-pool near Lake Pashan, Poona, Leg. M. S. Balakrishnan.

Golenkinia minutissima sp. nov.

Cellulæ solitariæ, sphæricæ, ornatæ tenui sed firmo pariete nonnullas subtiles setas supportante. Chloroplastum cyathiforme, unico pyrenoideo præditum. Cellulæ 4·5 to 6·5 μ diameter. Setæ 7·5 to 10·5 μ longæ. Reproductio asexualis per 2, 4, vel 8 autosporas. Sexualis vero reproductio oogama. Oosporæ verrucosæ, 6 to 7·5 μ diameter. Spinulæ 1 to 1·5 μ longæ.

Typus lectus in lacuna pluviosa planktonica ad lacum Pashan prope urbem Poona, a M. S. Balakrishnan.

The authors' sincere thanks are due to Rev. Father H. Santapau for kindly rendering into Latin the diagnosis of the new species. The junior author wishes also to thank Prof. T. S. Mahabale for kind facilities and encouragement.

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OBSERVATIONS ON THE ANATOMY, CYTOLOGY, DEVELOPMENT OF THE REPRODUCTIVE STRUCTURES, FERTILIZATION AND EMBRYOLOGY OF *PELVETIA CANALICULATA* DCNE. ET THUR.*

Part I. Anatomy of the Thallus and Somatic Mitosis

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Introduction

While many species of the Fucales have been dealt with in regard to their various aspects such as their structure, cytology and life-history, there are only very few accounts dealing with similar aspects of *Pelvetia canaliculata*; and even these are not comprehensive (Hansteen, 1892; Henckel, 1912; and Thuret et Bornet, 1878). Fritsch (1945 *b*, p. 355) has pointed out the desirability for a reinvestigation of the Fucales with fresh material by new methods. While engaged on a biological study of *Pelvetia canaliculata* in the Isle of Man, the author, at the kind suggestion of Dr. Margery Knight, made a detailed study of this alga both from fresh material and from carefully fixed and microtomed preparations.

In the present paper, an account of the methods adopted, the anatomy of the thallus and the mitotic division of the nucleus in the somatic cells are given. The development of the conceptacles and the sexual organs, the liberation of the sexual products, fertilization of the ova and embryology will be described in later accounts.

Material and Methods

The material for the investigation was collected in the Isle of Man. Some material was fixed in the field and some was brought to the Laboratory (Marine Biological Station, Port Erin) and fixed there. Plants up to 1 cm. were fixed whole, and plants of larger size were cut into bits 3 to 4 mm. long to aid proper fixation. Sporelings were grown in cultures in the laboratory for the study of their early developmental stages.

Several fixing fluids were employed, the chief among them being Flemming's weak formula with osmic acid and Allen's modification of Bouin's fluid (PFA_3) with urea (Johansen, 1940; Gatenby and

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Painter, 1946). The latter proved to be the best. Osmic acid was used for certain stages of fertilization.

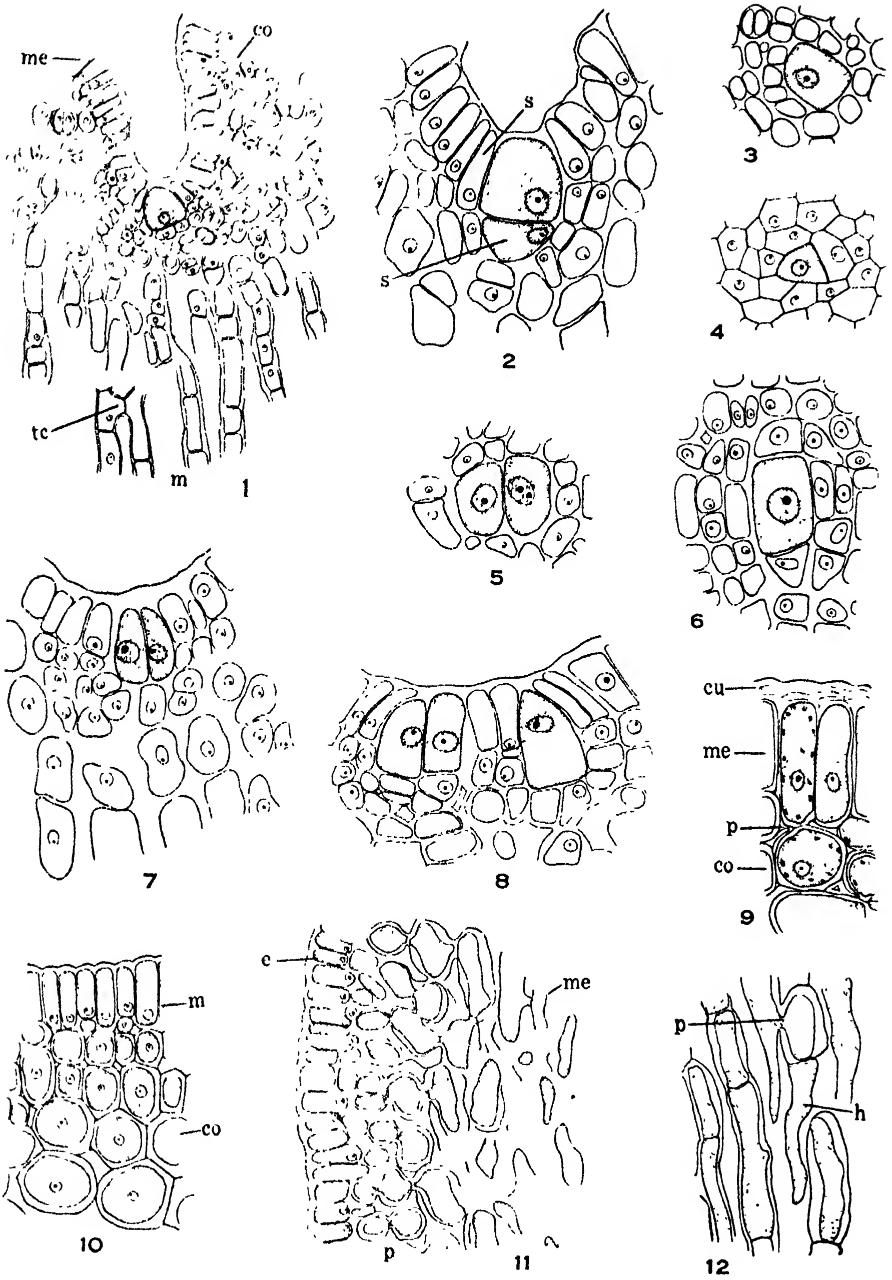
The material fixed in PFA_3 was washed first in several changes of 50% alcohol and then in 70% alcohol, and when the alcohol no longer extracted any picric acid, the material was taken up the alcohol series to absolute alcohol, leaving it in each grade overnight, particularly if the material happened to be the receptacles or older portions of the thallus.

The enormous quantity of mucilage present in the material appears to interfere with the proper dehydration, clearance and infiltration with paraffin wax. Many of the conventional methods of treatment usually described for the Fucaceæ (Chamberlain, 1933; Johansen, 1940) proved of no avail with the present alga as the material slipped out of the paraffin ribbon during microtoming. After a series of experiments the following procedure gave good results. The material was left in the absolute alcohol for 3 to 7 days, changing the alcohol once a day. Then the absolute alcohol was quickly replaced by thin cedar wood oil which was changed twice in the course of two days. The material now becomes very transparent. The cedar wood oil was next replaced by xylol which was changed three times in the course of 2 days. The material was infiltrated by the addition of paraffin wax (m.p. 49° C.) little by little and finally embedded in the usual manner. Sections were cut 3 to 15 μ in thickness and stained in iron-alum-hematoxylin. Saturated solution of picric acid in water was used for differentiating the stain and slides were washed for at least 6 hours in running water. Orange G and Light Green dissolved in oil of cloves were used as counter stains in certain instances. Permanent mounts were made in Canada balsam. The use of PFA_3 as a fixing fluid and cedar wood oil for clearing does not appear to have been tried for the Fucales.

ANATOMY

Apical Growth and Differentiation of Tissues

The study was commenced on the adult plants met with on the shore (Pl. XX, Fig. 1). Like the other members of the Fucales, *Pelvetia* is characterised by apical growth. In median longitudinal sections at right angles to the flat surface, the apical cell is seen situated at the bottom of a furrow which is filled with mucilage (Text-Fig. 1). The apical cell, in longitudinal section, appears 3-sided, the apex of the triangle pointing upwards (Text-Fig. 1). Occasionally, the apex appears somewhat depressed (Text-Fig. 2). It has a very conspicuous nucleus and is rich in cytoplasm and devoid of plastids, so much so, that it has a strikingly lighter colour as compared with the adjacent cells. In transverse sections the apical cell is rectangular with more or less rounded corners (Text-Fig. 6). In some instances, in transverse sections, the apical cell has one of the corners more rounded than the other 3 when it shows a resemblance to the same in some longitudinal sections (Text-Fig. 3; compare with Text-Fig. 2). Very rarely, in the adult



Text-Figs. 1–12. *Pelvetia canaliculata*. Anatomy of the thallus. Fig. 1. L.s. perpendicular to the flat surface of the thallus at the apex of an adult plant showing the apical cell situated at the bottom of the apical furrow, and the tissues near the apex. Fig. 2. L.s. perpendicular to the flat surface of the thallus showing apical cell with a basal segment cut off. Figs. 3 and 6. T.s. of apices showing apical cells of different shape. Fig. 4. T.s. of an apex showing three-sided apical cell (rare in adult plant). Fig. 7. L.s. parallel to the flat surface showing apical cell divided into two segments, probably a division initiating a branch. Fig. 8. L.s.

parallel to flat surface showing early stages of branching; initials have already cut off segments. Fig. 9. L.s. a little lower down the thallus; note contents of cells, pits on the walls of the cortical cells, lamellations of the 'cuticle'. Fig. 10. L.s. near apex showing tissues, meristoderm, cortex and medulla; note thickened walls of cortical cells. Fig. 11. L.s. of thallus parallel to the flat surface in the hypha producing region; note hypa-cells. Fig. 12. L.s. parallel to the flat surface showing a portion of the medulla in the central region. (Figs. 1, 9, 11 and 12, × 210; 2-8, ×450; and 10, ×300.)

plant, it presents a triangular appearance in transverse sections (Text-Fig. 4) and in this respect it resembles the primary apical cell differentiated in the sporeling.

In a median longitudinal section parallel to the flat surface of the thallus, the apical cell is seen situated at the centre of the furrow which is not as deep as it appears in longitudinal sections taken at right angles to the flat surface. On either side of it are seen segments cut off by the apical cell (Pl. XX, Fig. 2). Sometimes it is difficult to distinguish the apical cell from the segments cut off by it, since all of them resemble one another very closely for some time. The difficulty in distinguishing the apical cell from its own segments and the irregular forms exhibited by the apical cell have been referred to by Oltmanns (1889, pp. 27-28). By an examination of a large number of sections in all planes, it was observed that the apical cell has the form of a truncated pyramid with 4 sides and a base, all the 5 sides contributing to the growth of the thallus.

The apical cell cuts off a segment first towards the base (Text-Fig. 2) and then on each of the 4 sides (*cf.* Oltmanns, *op. cit*). The basal segment by one or more divisions parallel to the first division (periclinal division) and then at right angles to it (anticlinal division) forms a small group of cells immediately below the apical cell. The lowermost of the cells thus cut off gradually lengthens and contributes to the formation of medullary elements. The lateral segments of the apical cell undergo more anticlinal than periclinal divisions. The resulting daughter cells again divide anticlinally, and, as they lengthen by growth cut off occasionally some cells towards the base. They always remain longer than broad and, owing to the repeated anticlinal divisions form a "palisade-like" superficial layer of cells which lines the sides of the furrow and extends further outwards (Text-Figs. 1 and 2; Pl. XX, Fig. 4). This surface layer of cells is covered by a fairly thick mucilaginous "cuticle" (Pl. XX, Fig. 4, *cu*). Each cell of this tissue possesses a nucleus which is situated at the centre or base of the cell, and a large number of yellowish-brown chromatophores. The cells undergo longitudinal divisions which increases the surface of the thallus, and occasionally also cut off cells from the base which add to the cortex. The meristematic activity of this layer of cells extends to some distance down the apex of the frond and, because of its meristematic nature, this layer is designated *meristoderm* (Fritsch, 1945 *a*, p. 4).

The cells cut off towards the base by the lateral segments of the apical cell also behave somewhat in the manner as the basal segment cut off by the apical cell. They appear to undergo one or more periclinal divisions and the lowermost cell lengthens into a medullary element. The upper cells by anticlinal divisions contribute a little towards the formation of the cortex; but, the majority of the constituents of the cortical tissue is derived from the basal cells cut off by the superficial layer of cells. The cortex rarely exceeds 4 cells in thickness (Text-Figs. 1, 2 and 7; Pl. XX, Figs. 2 and 4). The cells show a prominent nucleus situated at the centre. Near the apical region they may function as an assimilatory tissue for a time as they contain a number of chromatophores. The walls of the cortical cells become thickened very early so that one often sees the contents of the cells as a rounded mass. Intercellular spaces also are seen in the tissue. The cortex in this alga is not a very well differentiated tissue as it is in *Fucus* (Oltmanns, 1922, p. 211, Figs. 1 and 2) or *Halidrys* (Fritsch, 1945 *a*, p. 3, Fig. 1).

The cells of the medulla show progressive elongation from apex downwards and are seen in longitudinal files as a result of the early thickening of their lateral walls, secretion of mucilage between them and continued transverse divisions. The transverse walls remain thin. Each cell possesses a nucleus and a few chromatophores. Connexions with adjacent filaments also are seen very near the apex itself (Text-Fig. 1) so much so a net-like appearance of the medulla results (Pl. XXI, Fig. 7). This point will be referred to again later.

Thus, it will be seen that the differentiation of the tissues takes place very near the apex itself. There are (1) an outermost layer of "palisade-like" cells, the *meristoderm*; (2) a narrow zone of hexagonal to round cells, never exceeding four cells in thickness, the *cortex*; and (3) the *medulla*, which comprises by far the greater portion of the thallus, presenting a filamentous condition due to the development of an enormous quantity of mucilage.

Branching of the Thallus

Branching of the thallus becomes apparent as soon as the thallus shows flattening. Branching is initiated by the apical cell dividing longitudinally in a plane at right angles to the flat surface of the thallus. This is clearly seen in sections parallel to the flat surface of the thallus (Text-Fig. 7) and in transverse sections (Text-Fig. 5). The segment thus cut off is almost half the initial cell and assumes the form and function of an apical cell. Each apical cell then gives rise to one limb of a branch and soon a mound of tissue separates them (Pl. XX, Fig. 6) dividing the apical furrow into two. Fritsch (1945 *b*, p. 351 *et seq.*) has reviewed in detail the modes of branching in the several families of Fucales and it may be mentioned here that the branching is stated as dichotomous in *Fucus* and the same is supposed for *Pelvetia* also (Oltmanns, 1889). In *Fucus vesiculosus* and *F. serratus* Knight and Parke (1950, pp. 458–59) describe the branching as a monopodial system in which the lateral branch initial arises in the immediate vicinity of the apical cell, simulating a dichotomy. In *Himanthalia lorea*, Naylor (1951, p. 511 and 529) states that the branching is dichotomous. The branching in *Pelvetia canaliculata*, as far as can be seen from a detailed study of its origin, is not a case of true dichotomy (as in *Dictyota*) but a case of false dichotomy brought about by a lateral segment cut off by the apical cell developing vigorously and producing a branch which is similar to the main axis in all respects and thus giving an appearance of dichotomy.

The Mature Thallus

Primary Changes

Longitudinal and transverse sections of the thallus taken a few millimetres below the apex show several changes taking place in the tissues. The meristoderm divides more anticlinally than periclinally. The former divisions go to increase the surface of the thallus considerably, while the latter add to the cortex. The meristoderm functions in this manner over a great extent of the thallus, nearly a third in the case of a well grown large plant and to a greater extent in the smaller ones. Soon their lateral walls undergo a certain amount of thickening, as also the transverse walls. In the latter instance, sometimes, small areas of the walls towards the inside are left unthickened and with a similar occurrence on the wall of the cortical cell adjacent to it, pit connections arise (Text-Fig. 9). Viewed from above (in sections taken parallel to the surface of the thallus) the cells of the meristoderm appear square or round. Some of the cells show a thin wall traversing them which indicates recent division. The lamellations of the mucilaginous "cuticle" increase from the apex downwards. The cells show a nucleus and several chromatophores. The chromatophores become fewer in them in the older portions of the thallus.

The cortical cells also undergo anticlinal divisions occasionally. The cells of the cortex (Text-Fig. 9) progressively increase in size towards the centre and the innermost elements appear to pass into the medulla. The gradual increase in the size of the cells, the thickening and secretion of mucilage between the walls make it difficult to draw a line as to where the cortex ends and where the medulla begins. The walls of the cortical cells also, during thickening, leave small unthickened areas, more commonly in the transverse plane and such areas of adjacent cells coincide giving rise to pit connexions (Text-Fig. 9). The middle lamella could be seen on careful examination separating the contents of two such adjacent cells; no cytoplasmic continuity, however, through the pits could be established (*cf.* Hick, 1885; Hansteen, 1892). Each cell possesses a nucleus and a number of chromatophores. Traversing down the thallus the cortical cells are seen with their walls progressively thickened.

The changes that take place in the medullary region are more striking. In transverse sections (Pl. XX, Fig. 3) the cells appear as though embedded in mucilage. Individual cells cut across appear round and sometimes several may be seen in an irregularly arranged series (Text-Fig. 14). In longitudinal sections at right angles to the flat surface, the medulla presents a somewhat compact appearance. In longitudinal sections parallel to the flat surface, the medullary elements have a net-like appearance (Text-Fig. 13; Pl. XXI, Fig. 7) and this appearance has been rightly likened to that presented by the conjugating filaments of *Spirogyra* (Hansteen, 1892, p. 331). The mucilage development is very abundant. The medullary elements appear to increase owing to additions from the cortex also. A nucleus is cleraly seen in each of the cells and with increasing distance from the apex the chromatophores become scarcer and scarcer.

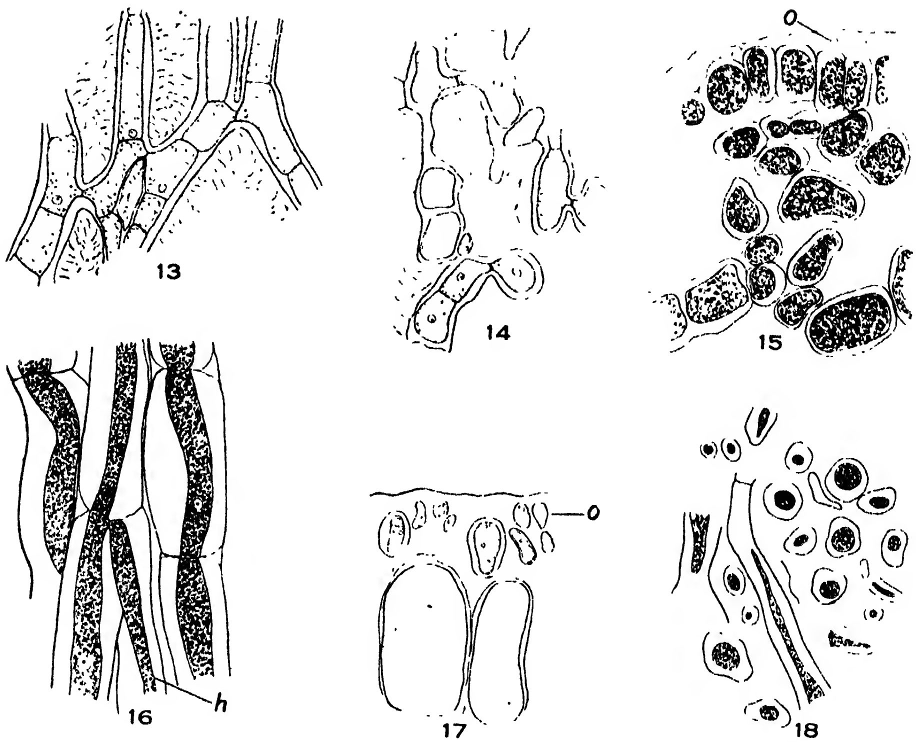
It may be interesting to mention here some indications as to how the filamentous net-like condition of the medulla could have arisen. If there is no production of mucilage at all, then we should have a compact tissue, the individual cells having pits on their longitudinal walls, almost resembling the condition in *Halidrys* (Fritsch, 1945 *a*, p. 13, Fig. 18). But, in *Pelvetia*, owing to the development of mucilage between the thickened portions of the walls, the cells become drawn apart; the pit areas, however, remain in contact. As there happens to be pit connexions on several parallel rows of medullary filaments a net-like appearance results. Also, the activity of the meristoderm adds to the tissues inside; and this, coupled with the profuse development of mucilage, appear to pull the medullary elements apart. The mucilage after being fully formed becomes toughened as it were and becomes strongly lamellated, and helps to keep the medullary cells in position (Text-Figs. 13 and 14). At about the same time, the meristoderm ceases to be active and hyphal production (see below) starts in the medullary region.

Secondary Changes

As the thallus gets older, secondary changes take place in its different tissues, medulla, cortex and meristoderm.

Secondary changes in the medulla.—Secondary changes in the medulla are mainly centered around the production of hyphæ in that region. It is very difficult to trace their origin. Some insight into their origin could be obtained only from longitudinal sections parallel to the flat surface of the thallus in the region where they are fewer in number. They appear as outgrowths from the lower ends of the medullary cells (Text-Fig. 12, *h*). They have also been observed to arise from the sides of the medullary cells and take a downward course. None were seen directed upwards. They are composed of very long cells which grow, occasionally divide transversely and become multicellular, and take a tortuous downward course. The walls of the hyphæ cells are more or less of the same thickness as those of the medullary cells and the contents of the cells also appear almost identical. The only difference noticeable is that the cells are narrower. In transverse sections they present a round or oval outline and several appear embedded amongst the larger medullary cells.

As one examines the thallus downwards, one notices the striking addition to the medullary tissue through the production of hyphæ. The loose net-like appearance of the medullary tissue in the younger



Text-Figs. 13–18. *Pelvetia canaliculata.* Anatomy of the thallus. Fig. 13. L.s. parallel to flat surface showing a portion of the medulla with network of medullary cells, transverse connexions and copious development of mucilage. Fig. 14. A portion of the T.s. of the thallus of adult plant in the same region as that shown in Fig. 13. Fig. 15. L.s. about 2 cm. from the base of the thallus of an adult plant; note thickened walls of cells, parasites in the cuticular layer, development of mucilage, etc. Fig. 16. L.s. of the thallus in the older portion, about 2–3 cm. from base; note medullary elements, hyphæ and thick nature of cell-walls. Fig. 17. Outermost portion of the thallus shown in Fig. 15, to show the parasites. Fig. 18. A portion of the holdfast in T.s. (Fig. 17, ×650; rest, ×210).

portions of the thallus is gradually lost as one proceeds downwards and the medulla presents a more and more compact appearance (Pl. XXI, Fig. 7 and Pl. XX, Fig. 5). The hyphæ run prevalently in a longitudinal direction but in the older parts they appear to change their course to an oblique or even transverse direction. In longitudinal sections a few are seen cut transversely and obliquely, and in transverse sections quite a large number appear cut in a longitudinal plane. The walls of the medullary elements as well as those of the hyphæ show considerable thickening progressively downwards, and when closely examined appear lamellated; the contents become more dense with stained bodies and unstained brown globular bodies. A nucleus could also be made out on careful examination (Text-Fig. 16).

Near the base of the thallus (about 2 cm. or so from the holdfast) the majority of the medullary elements consists of the hyphæ, the medullary cells proper being hardly recognizable (Pl. XXI, Fig. 8). More of the hyphæ are cut obliquely and longitudinally in longitudinal and transverse sections respectively indicating the zig-zag and transverse course of these elements near the base. No clear case of branching of the hyphæ was observed and their enormous numbers near the basal parts appear to be due to increased production of these structures by the medullary cells and those growing down the thallus from higher levels. The network of hyphæ and the thickened nature of their walls indicate a mechanical function for those elements (the "mechanical system" of Hansteen, 1892 and Henckel, 1912). Also the dense contents of these hyphæ and the medullary cells suggest that they probably function as a storage tissue as well.

Secondary changes in the cortex.—The cortical tissue shows some striking changes when examined progressively downward. The inner elements of the tissue tend to be drawn out in a longitudinal plane and some merge with the medulla proper. A few of these elongated cells give rise to hyphæ. Pit connexions occur in plenty and development of mucilage also takes place between the cells (Text-Fig. 11). The walls of the cortical cells show considerable thickening and lamellations. The cells possess rich contents (storage material?) and the nucleus is seen only on careful examination. In the lower part of the plant, the cortical cells do not have the compact and regular arrangement seen in the upper portion, but appear very irregularly arranged owing to the profuse development of mucilage round them (Pl. XX, Fig. 5 and Pl. XXI, Fig. 8; Text-Fig. 15). There are no indications of division taking place in them adding to the tissue.

Secondary changes in the meristoderm.—The compact arrangement of the cells of the meristoderm seen at the apical region is lost progressively downwards. The cells soon appear to lose their capacity for division and to function only as an epidermis in these regions. Their walls become increasingly thicker and their contents become similar to those of the cortex. At a few centimetres above the base, the outermost cells of the layer are hardly recognizable from those of the cortex. Near the base of the thallus the epidermis has a worn out appearance (Pl. XXI, Fig. 9). The mucilaginous "cuticle" appears thicker and within it are seen enclosed, structures which appear to be the fruit bodies of some fungus (*o* in Text-Fig. 17). It may be mentioned here that even within the cortical region in the older parts fungal mycelia are abundantly seen traversing the intercellular spaces. Sutherland (1915) has recorded several species of fungi from the thallus of *Pelvetia canaliculata*.

Changes in the basal part.—Very near the basal parts, the characteristic channel of the thallus becomes shallower and between the holdfast and the first forking very little of it is evident. The thallus shows in this region more or less an elliptical outline in transverse sections, and a little below and just above the flattened holdfast the transverse sections appear more rounded (Pl. XXI, Fig. 11). The epidermis is absent in this region and its place is taken by the outermost cortical elements. At the periphery, these cortical elements are seen rather dispersed owing to profuse mucilage development between them. Their walls are very thick and lamellated. The major portion of the thallus in this region which is almost a transition to the holdfast proper, is composed of hyphæ which traverse in all directions towards the surface; at the centre many still have a longitudinal course. The walls of the hyphæ are very highly thickened and the elements at the centre are conspicuous on this account; it appears as though there is a central core of tissue in the thallus in this region (Pl. XXI, Fig. 11). The increase in thickness of the thallus noticed in this region as well as of the holdfast appears to be due to the enormous production of hyphæ in the medullary region. The region of the production of hyphæ appears to shift more and more to the periphery of the medulla as the age of the thallus advances.

It may be interesting to mention here that Oltmanns (1889, p. 29) has stated that hyphæ in *Pelvetia canaliculata* are confined to the basal parts of the plants, to about 2 to 3 cm. height, where they are seen to lie equally distributed in the tissues. Hansteen (1912, p. 333) found hyphæ in a section of the thallus taken at about 3 cm. height and on this basis states that they may occur much higher. The author, in order to find out where exactly hyphal development occurs in the present alga, took hand sections at different levels in plants of various sizes. He found that small plants, measuring less than 3 cm., show no hyphæ anywhere in the thallus except very near the holdfast; and, as the individuals grow and increase in size, the hyphæ are seen starting higher up. In very large plants, measuring 14 to 15 cm., hyphæ may be seen starting as high up as 10 to 12 cm. from the base or even higher.

The Holdfast

None of the published papers give a complete picture of the holdfast or the region immediately above it. These are the most difficult regions of the thallus to microtome. After repeated attempts, both longitudinal and transverse sections were obtained (Pl. XXI, Fig. 10 and Text-Fig. 18). In longitudinal sections, the medullary region of the holdfast appears spread out and the whole of the region is composed of interwoven hyphæ, the cells of which have thick lamellated walls. The contents of the cells do not take up any stain and are dense and yellowish-brown in colour. Even if there is any cortical tissue left in this part of the thallus, it is very difficult to distinguish it from the central mass of hyphal tissue. There is no trace at all of the epidermis which appears to have already ceased to exist higher up above.

A comparison of the longitudinal section with the transverse section of the holdfast shows that more hyphæ are cut transversely in the former and longitudinally in the latter. The hyphæ, as they near the substratum appear to take more and more a transverse course, and obviously this arrangement helps to spread the disc-like holdfast and secure a firmer attachment to the substratum. The tough sticky mucilage evidently helps to give further hold on the rock.

Adventitious Branches

Adventitious branches are formed whenever any part of the thallus is injured badly, particularly in the younger portions of the plant. Artificial injury also induces the production of these adventitious branches (Subrahmanyan, unpublished, 1948 *a*). These observations are in close agreement with those of Oltmanns (1889, pp. 74-75) on this alga. The adventitious branches show the same structure as that of the thallus (Pl. XXI, Fig. 12).

SOMATIC MITOSIS

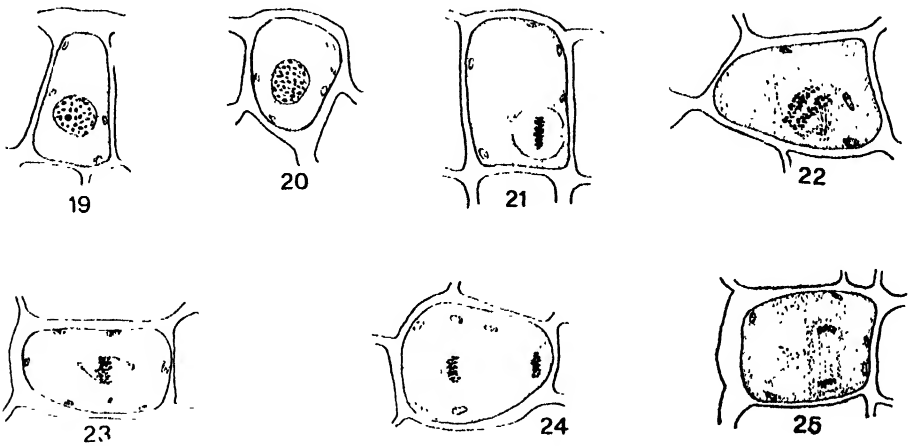
Material fixed at different hours of the day showed mitotic figures. And so it could not be stated definitely that the division of the nucleus was more frequent at any particular time of the day. Division figures were quite frequently observed at the apical region, the meristoderm, the cortex and occasionally in the medulla also. Division of the nucleus in the apical cell would have been the best for study, but unfortunately it was hard to come by. The nucleus in this cell was seen in a prophasic condition quite often but the later stages were not observed. The following account, therefore, refers to the division of the nucleus in the cells of the meristoderm and the cortex. The early stages seen in the apical cell agree with those in the cells of the other parts of the thallus.

The size of the nucleus varies from 3 to 6 μ in the thallus cells and from 5 to 8 μ in the apical cell. In the resting condition, the nucleus is bounded by a nuclear membrane and shows usually one nucleolus, occasionally two. The nucleolus is very darkly stained unlike the reticulum. On very careful examination, the reticulum shows a granular structure. During prophase the reticulum stains more deeply and thin chromosomal threads become discernible in the nucleus; and in late prophase, a large number of dot-like chromosomes are seen distributed more or less uniformly in the nuclear space (Text-Fig. 19). By about this time the nucleolus generally disappears (Text-Fig. 20), but sometimes it persists a little longer. At metaphase the chromosomes are seen arranged rather compactly at the equator of the spindle (Text-Fig. 21). The spindle is intranuclear. The nuclear membrane persists till metaphase; at the poles of the spindle, however, it is not quite evident. During anaphase two sets of daughter chromosomes move towards the poles of the spindle (Text-Figs. 22, 23 and 24) which later become rather a compact mass in which individual chromosomes are very difficult to recognize (Text-Fig. 25); and in telophase two daughter nuclei are organized.

No centrosomes were seen during this division of the nucleus. It is very difficult to determine the number of chromosomes owing to their large number and compact arrangement both at metaphase and the subsequent stages. An attempt at estimation could be made only in late prophase stages and even here owing to the smallness of the nucleus it was not possible to reckon the number definitely. About 40 ($2n$) chromosomes could be counted.

The details of mitotic division described here are in agreement in essentials with those recorded by Roy (1938) in the same alga and those of Yamanouchi (1909) in *Fucus vesiculosus*. Roy has not recorded centrosomes during mitotic division; but Yamanouchi has observed them in *Fucus*.

It is not possible to state how the division of the cytoplasm is effected to form the two daughter cells. After the two daughter nuclei are organized, a thin line is seen at first separating the two daughter nuclei. A critical examination indicates that this appearance is presented by a very narrow cleft separating the two daughter protoplasts. This is probably brought about by a centripetal cleavage of the cytoplasm, a cellulose wall being laid down later on.



TEXT-FIGS. 19–25. *Pelvetia canaliculata*. Mitotic division of the nucleus in the thallus cells. Figs. 19 and 20. Prophase stages. Fig. 21. Metaphase, nuclear membrane not completely disappeared, spindle intra-nuclear. Figs. 22 and 23. Early anaphase stages. Figs. 24 and 25. Late anaphase stages (Figs. 19 and 20, × 650; 21–25, × 790.)

DISCUSSION

Like the other members of the Fucales *Pelvetia canaliculata* is characterised by apical growth. Growth takes place by means of a truncated pyramidal apical cell and a differentiation of the tissues, meristoderm, cortex and medulla is attained very near the apex itself. Growth and additions to the tissues continue some way down the apical region owing to the activity of the meristoderm and to a lesser extent by the cortical cells. This region is variable with the size of the plants. Then, a series of secondary changes are initiated by the production of hyphæ in the medullary region, leading to complicated changes in the structure of the tissues as witnessed from the apex downwards. The changes noticed in the tissues are somewhat similar to those observed in *Fucus* by Oltmanns (1889) and Reinke (1876). No cytoplasmic continuity through pores in the transverse walls could be substantiated though Hansteen (1892) represents such. Compared with the parenchymatous structure seen in the Cystoseiraceæ (Fritsch, 1945 *a*) and the gelatinization and thickening of the walls, though to a lesser extent, seen in *Fucus* (Oltmanns, 1889), the structure of *Pelvetia* with its thick lamellated cell-walls and profuse production of mucilage within its body, appears to be an adaptation to its higher habitat on the shore where it is left exposed for considerable periods during low tides. It has been pointed out that the rate of loss of water is considerably lower in *Pelvetia* as compared with the other members of the Fucaceæ (Issac, 1933; Zaneveld, 1937).

It may be of interest to recall here the designations employed by the earlier workers (Hansteen, 1892; and Henckel, 1912) to describe the tissues of the mature thallus of *Pelvetia canaliculata* and the structures comprised in such terms.

The "assimilatory system", according to Hansteen (1892, p. 321), consists of a single layer of cells radially stretched with plenty of phæoplasts. This corresponds to the "meristoderm" described in the foregoing pages. According to him (*op. cit.*, p. 324) there is no sharp morphological difference between this system and the "storage system"; and, the assimilatory system exists in the older parts as well, even near the holdfast though the contents are identical to those of the structures inside. Henckel (1912, p. 76) includes a few of the inner layers of cells in the "assimilatory system"; otherwise their descriptions agree as to the behaviour of this tissue. In their account of the other systems or cells, "storage system", "conducting system" and "mechanical system" (Hansteen, *op. cit.*), "storage cells", "conducting cells" and "hyphæ" (Henckel, *op. cit.*), there appears to be fair agreement between them.

The observations of the author indicate that it may not be quite correct to employ such physiological terms to describe the tissues in *Pelvetia canaliculata*, for, it is seen from the nature of the tissues that one tissue may have more than one function or it may behave differently in a different part of the plant. The outermost layer of cells is found to be active to some distance down from the apex of the thallus and shows anticlinal and periclinal divisions which add to the tissues of the thallus and because of its meristematic nature was termed "meristoderm" (*cf.* Fritsch, 1945 *a*). It has been already pointed out in that context that the meristoderm may discharge an assimilatory function as well, as the cells contain abundant chromatophores. The cells of the cortex also function in a similar manner, for they too contain chromatophores. An exclusive assimilatory function cannot be attributed to the meristoderm alone. In the young plants the outermost layer is meristematic over the whole of the plant excepting the region of the holdfast. In the adult plant, from the region where hypha production begins and downwards, the meristoderm does not appear to function as a meristematic tissue, particularly, in the lower regions, and, wherever it is present it may be termed "epidermis" or "outer layer"—the term employed by Oltmanns (1889). The cells may carry on assimilation in the upper portions of this region but in the lower portions they show such dense contents that they are hardly different from the cortical elements. Their function appears to change into one of storage apart from being a protective layer. In the region of the holdfast and a little above it, it is doubtful whether the epidermis exists as such. The outermost elements of the cortex function as an epidermis.

The cortex in the apical region does not show, as far as it could be judged from physical appearances, any denseness of contents to warrant any designation, such as "storage system". From the region where hyphal production begins and downwards the cortical cells stain more deeply, their contents become denser progressively downwards and the tissue, to all external appearance, acts as a storage tissue. Also in young plants where no hypha production manifests itself so early, the cortical cells may appear with dense contents. In the older parts of the mature plants the contents of the medullary elements too, including the hyphæ, as pointed out earlier, have a similar appearance. It appears, therefore, misleading to employ the term "storage system" when referring to the cortex alone.

Again, a section of a very young plant shows the chromatophores distributed uniformly in all the cells of the plant and no demarcation between cortex and medulla is possible; and, it is not improbable that the whole thallus of the plant here functions as an assimilatory tissue, and to designate the outermost layer alone as assimilatory tissue and the inner as "storage" is misleading.

The hyphæ are distributed throughout the medullary region of the old plants and do not form a compact tissue as they do in the midrib of *Fucus* (Oltmanns, 1889). Only a few millimetres above the holdfast is there any indication of a central "core". The nature of their walls and their abundant presence in the older parts reinforcing the mucilaginous portions of the medullary region certainly indicate that they give mechanical strength to the thallus of the plant.

As will be evident from the above remarks, the nature, structure and function of the tissues in *Pelvetia canaliculata* change with the age of the plant. It, therefore, appears that the tissues in *Pelvetia* have not attained such a degree of organization so as to be designated by physiological terms.

In the light of observations carried out on this alga in a study relating to the rate of growth and the cycle of reproduction (Subrahmanyan, 1948 *a*; 1948 *b*), a few words may be added here about the storage of materials in this plant. Very little is known about the chemical nature of the contents stored in the tissues in the older parts and how far they are used up again if so, though it is generally presumed that they are reserve food. During its life-cycle, *Pelvetia* does not show any "resting period" to tide over unfavourable seasons (*cf.* Knight and Parke, 1931, pp. 15–16). The plant (Subrahmanyan, 1948 *a* unpublished) shows more or less uniform growth for the first 2 years and with the onset of reproduction in the third year or so, a rhythm sets in, with a period of growth alternating with a period of reproduction; then, as the plant becomes older, growth begins to decline and all the vegetative apices are transformed into receptacles and the plant ultimately dies. As there is no appreciable vegetative growth during the reproductive period, the metabolism of the plant, it is permissible to assume, is diverted in the interests of reproduction. Examination of the thallus before, during and after reproduction in the region where the contents are dense (cortical and medullary regions in the older parts) does not reveal any difference in their condition as far as it could be ascertained by examination under a microscope. Only further research into the physiology and biochemistry of the plant will decide this point. It may be of interest to mention here that Hass and Hill (1929) have found a small amount of a free reducing sugar, probably a pentose, and mannitol in *Pelvetia canaliculata*. Further, it is well known that many of the brown seaweeds contain alginic acid, which is of great economic importance. No tests, however, could be made during the present investigation as to this aspect as it was beyond the scope of this work.

SUMMARY

1. The anatomy of the thallus of *Pelvetia canaliculata* Dcne. et Thur. growing in the Isle of Man is described in detail.

2. The thallus grows by means of a truncated pyramidal apical cell, which cuts off segments on each of its 5 sides. The segments give rise to 3 tissues, the meristoderm, the cortex and the medulla.

3. The primary changes in the tissues differentiated and the secondary changes that are brought about by the production of the hyphæ are described.

4. The structure of the holdfast is described for the first time.

5. Details of the somatic mitotic division in the thallus cells are dealt with. The number of chromosomes appears to be over 40 (2 *n*).

6. The designations employed by the older authors to describe the tissues are discussed in the light of the present investigation.

ACKNOWLEDGEMENTS

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EXPLANATION OF PLATES

PLATE XX

FIG. 1. Photograph of *Pelvetia canaliculata.* Note profusely branched and channelled nature of the thallus, ×0·7 (Photograph by courtesy of Dr. M. Knight.)

FIG. 2. L.s. of the apex parallel to the flat surface of the thallus of a plant about 2 cm. size. Note apical cell and its segments at the bottom of the furrow, ×203.

FIG. 3. T.s. of the thallus (a portion). Note the three tissues and the copiously developed striated mucilage in the medulla, × 457.

FIG. 4. L.s. at right angles to the flat surface of the thallus of an adult plant. Note the tissues and 'cuticle', mucilage developed between the lateral walls of the medullary cells and their progressive lengthening from apex downwards, × 70.

FIG. 5. L.s. parallel to the flat surface of the thallus of an adult plant, more than half way down the apex. Note dense contents of the cells and a rather more compact nature of the medullary elements due to hyphal production, × 70.

FIG. 6. L.s. of a young plant showing branching of the thallus, × 45.

PLATE XXI

FIG. 7. L.s. parallel to the flat surface of the thallus of an adult plant, near apex. Note network arrangement of medullary cells, × 27.

FIG. 8. L.s. at right angles to the flat surface of the thallus of an adult about 2–3 cm. from the base. Note worn out epidermis, dense contents of the tissues and medullary elements cut in all planes due to zig-zag course of the hyphæ, × 35.

FIG. 9. L.s. of portion of the thallus of adult plant, at right angles to the flat surface, about 1 cm. from holdfast. Note medullary cells cut in all planes, dense contents of the cells, few cortical cells and absence of the epidermis. Bulk of tissue, very probably hyphæ, × 35.

FIG. 10. L.s. of holdfast of an adult plant. For explanation see text, × 13.

FIG. 11. T.s. of thallus of an adult plant through the region where the holdfast begins to spread out. Note the rounded outline, the somewhat compact nature of the innermost elements forming a sort of 'core', formed mainly by the hyphæ, × 13.

FIG. 12. L.s. of apex of a young plant showing adventitious branches. Note the branch cut in median plane, × 32.

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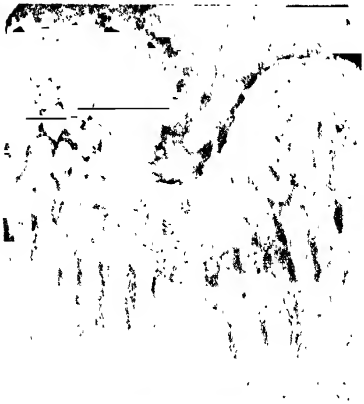

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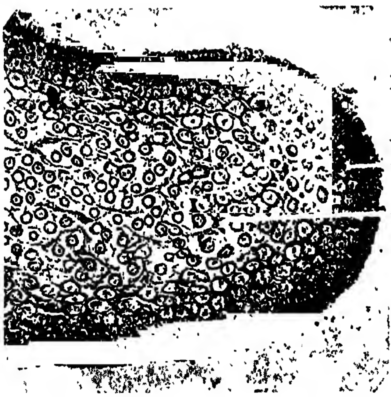

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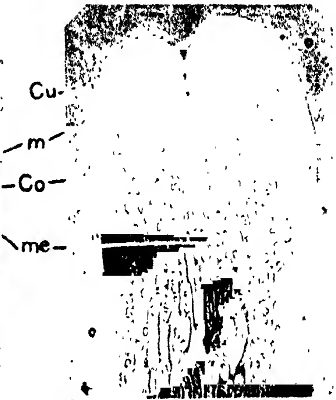

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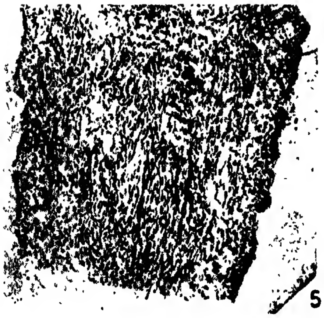

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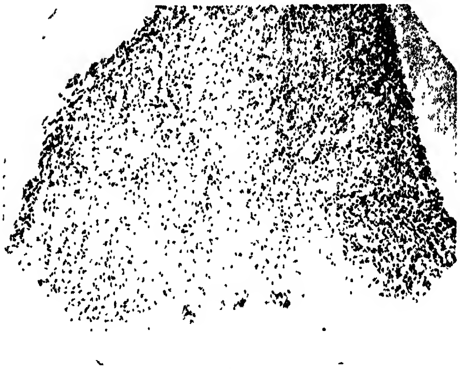

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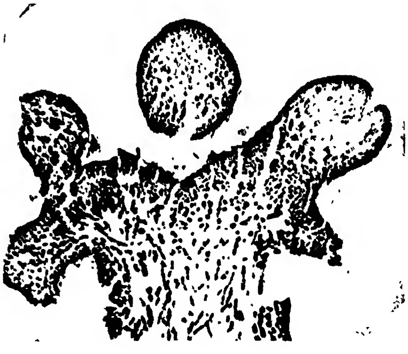

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R Subrahmanyan

THE VEGETATION OF PATNA DISTRICT (BIHAR)

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(Received for publication on June 29, 1956)

The vegetation of the Patna District is described in the *Patna District Gazetteer* (1907) and that of the Shahabad-Gaya-Patna-Monghyr-Bhagalpur area in Haine's *Botany* (1921–25); but these descriptions are very meagre and based on very old observations, some made as early as the first quarter of the last century. A study of the flora of this district by Srivastava (1954) and Srivastava and Mehta (1956 *a*, *b*) showed the introduction of a large number of species and the disappearance of many. These changes in the flora have certainly been possible because the original set-up has been disturbed. A thorough study of the present-day vegetation had therefore become necessary and this was made during the author's stay at Patna in the period 1949-54.

Location and Physical Features

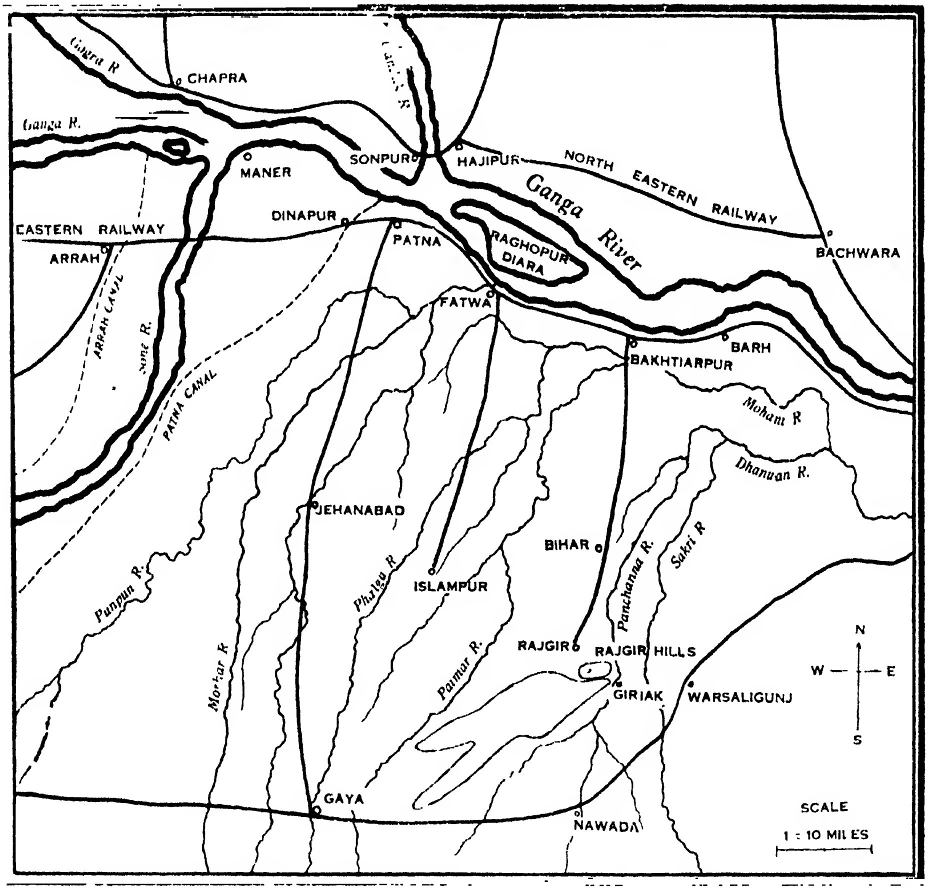
Patna District, situated between 24° 97′-25° 57′ N. latitude and 84° 44′-86° 4′ E. longitude, has a total area of 2,075 square miles. It occupies an almost central place in the province.

Topographically the district may roughly be divided into three separate areas: (1) In the north is a narrow strip of somewhat elevated land, 173–80 feet above sea-level, about 4 miles wide, but very narrow near Fatwa. This runs along the southern bank of the Ganga River, and gently slopes to the south. It is made of Kankar (nodular limestone) and is very fertile. Most of the important townships are located on this strip and the major highways and the Eastern Railways run over this strip. (2) The south-east of the district is much higher (about 300 feet above sea-level) and here the Rajgir hills rise above the surrounding country. The soil layer is thin, coarse and sandy and just below it lie rocks. (3) Between these two raised strips, there is a vast low plain forming the major part of the district. This has no eminences and undulations, and it gently slopes to the north-east. This portion is extremely fertile and except for the scattered towns and villages, is a vast cultivated area, interspersed with mango-topes and palm-groves besides being intersected by the rivers and their old channels.

The Rajgir hills are the only hillls present in the district. They form part of a range some 40 miles long running north-east from near Bodh-Gaya and forming a part of the boundary between Patna and Gaya Districts. The Rajgir hills proper are two parallel and close ranges between Rajgir and Giriak, opening out south of the Rajgir town to enclose a valley in which was located the ancient town of Rajgriha, the capital of the Magadha State in the days of Bimbisar. The northern range here rises into a peak called Ratna giri about one thousand feet high. The sides of the hills as a whole are rugged and precipitous.

The river Ganga bounds the district in the north (please see map) and the Sone River, forming the north-western boundary, meets the Ganga at Maner. Besides these two, there are seven others, *viz.*, Punpun, Morhar, Dardha, Phalgu, Paimar, Panchanna and Sakri, all of which arise in the Chota Nagpur plateau and after passing through the Gaya District, intersect Patna District in a north-easterly direction, but sooner or later, they take a turn to the east. They are all rainy-season streams, the larger part of the water brought down by them is diverted into

Patna District



TEXT-FIG. 1

irrigation channels and reservoirs to be distributed among the fields. Many of them thus get completely lost, a few join one of the bigger rivers; only the Punpun and the Phalgu retain their identity, the former joins the Ganga near Fatwa, and the latter meets the Ganga near Lakhi-Sarai (Monghyr District).

The strip of raised land along the bank of the Ganga, which diverts these rivers to the east, is an obstruction to natural drainage, therefore in Patna Sadar, Patna City, Bihar and Barh subdivisions, hundreds of miles of low lands annually get inundated as soon as the water-level in the rivers rises. This also fills up many of the abandoned channels of the rivers, which, after the receding of the flood-waters, appear as long deep canals or as chains of small lakes and ditches. The inundated areas annually receive a layer of fine silt, they are therefore extremely fertile.

The rivers, particularly the Sone, have been changing their course quite often. The Sone has been gradually shifting to the west (*vide* Rennel, 1788). Its two abandoned channels still to be seen are: (1) the "Serpentine" running from near Phulwari Railway Station to near the Patna High Court. Its eastern part, the "Jalla" lying just south of the Patna-Bankipur town is now only a chain of small lakes and ditches collecting the local drainage and the sewerage of a part of the town, (2) an almost clogged up channel, running parallel to and north of the Serpentine, starts from near Patna-Gaya Road and runs to the Digha Ghat to discharge in the Ganga. The Serpentine is joined to this second channel near the Patna High Court.

Of all the rivers, only the Ganga is wide enough to have any islands in it. There are several huge ones; their shapes, sizes and heights vary from year to year. These islands are formed near either bank and the bigger ones are usually intersected by narrow streams. The two islands forming part of the Patna District now, are located (1) between Dinapur and Sadakat Ashram, (2) between Bakhtiarpur and Barh. They are very low and get completely submerged during floods, and emerge out afterwards, covered either with a layer of silt or of sand, depending on the vagaries of the river.

CLIMATE

Patna possesses a monsoon type of climate. The hot wet season is from the 15th of June to the 30th of September. The rainfall is about 44·44″ per annum, the heaviest portion in July-August. An interesting point observed is that the rainfall has been slowly decreasing and has also been very irregular, varying from 31 to 67″ per annum and most of the time it falls in torrents rather than in steady showers. The mean maximum temperature in April-June is about 100° F. and the mean minimum temperature in January is about 50° F. The relative humidity is 51 in May and 86–87 in July-August. The summer temperatures have gradually been rising and the relative humidity falling, so that there are signs of a slow desiccation in the area. From October to May, the wind blows from the west, during April and May this is very hot and dry. From July to September, the Bay of Bengal current of the monsoon blows from an easterly direction and brings rains.

VEGETATION

For convenience in study, the district was taken up zone-wise.

1. *The Rajgir hills and the valley enclosed by them.*—The Rajgir hills formed part of a private Zamindari, and as such there was no protection to vegetation and unrestricted felling of trees and grazing reduced the forest to a scrub-jungle. At the lower levels, the rocks became quite bare and only few xerophytes could grow up in the crevices of the rocks. Now, with the coming in of the "Bihar Private Protected Forests Act, 1946, 1950", the vegetation is bound to improve and the condition of "dense jungles with scattered sal on the precipitous sides, and thick low brush-wood everywhere else, broken only by irregular path ways" (*District Gazetter*, 1907) may return soon, and already the induced scrub is giving place to less thorny species.

The tops of the hills and the rugged precipitous sides are covered with a scrub-jungle interspersed with small trees, especially *Boswellia serrata* Roxb., *Cleistanthus collinus* (Roxb.) Benth., *Sterculia urens* Roxb., *Cassia fistula* Linn., *Lannea coromandeliana* (Houst.) Merr., *Diospyros melanoxylon* Roxb. *Cochlospermum religiosum* (Linn.) Alston, *Bridelia tomentosa* Bl., *Cordia dichotoma* Forst. f., and *Mitragyna parvifolia* (Roxb.) Korth. The shrubs are *Hamiltonia suaveolens* Roxb., *Securinega virosa* (Roxb. ex Willd.) Pax. & Hoffm., *Gardenia latifolia* Ait., *Ficus lacor* Buch-Ham., *Ficus glabella* Bl., *Ficus tomentosa* Roxb., *Carissa paucinerva* A. DC., and *Murraya paniculata* (Linn.) Jack., *Bridelia stipularis* (Linn.) Bl., *Acacia canescens* Graham, *Acacia torta* (Roxb.) Craib, *Zizyphus œnoplia* (Linn.) Mill., *Olax scandens* Roxb., and *Ichnocarpus frutescens* R. Br., are the chief scramblers and climbers. The annually cleared areas near the temples and along the paths are occupied during the rainy season and winter with tall grasses, *e.g.*, *Apluda aristata* Linn., *Heteropogon contortus* (Linn.) Beauv., *Pennisetum polystachyon* Schltz. and *Dieclomis fastigiata* (Swartz) Kunth. Among these grow up *Hyptis suaveolens* (Linn.) Poit., *Anisomeles ovata* (Linn.) O.Ktz., and other erect and climbing annual dicots. Several lichens, mosses, *Selaginella rupestris* Spring. *Selaginella flaccida* Spring, *Lygodium flexuosum* Sw., *Adiantum lunulatum* Burm., *Cheilanthus tenuifolius* Sw., and many other plants grow under the shade of the trees and on damp banks. The few shrubs growing in the crevices of the rocks in the lower regions of the hills are *Murraya paniculata* (Linn.) Jack., *Dendrocalamus strictus* Nees., *Acacia canescens* Graham, *Acacia torta* (Roxb.) Craib. *Nyctanthes arbor-tristis* Linn., *Pavetta indica* Linn., *Indigofera elliptica* Roxb., *Holarrhena antidysentrica* (Linn.) Wall., *Helicteres isora* Linn., *Diospyros montana* Roxb.. *Carissa opaca* Stapf, and others. The scramblers are *Combretum decandrum* Roxb. and species of *Acacia*. The herbs are *Desmodium gangeticum* (Linn.) DC., *Anisochilus carnosus* Wall., *Aerva sanguinolenta* (Linn.) Bl., *Waltheria* *indica* Linn., *Hibiscus micranthus* (Linn. f.), *Celosia argentea* Linn., and some few grasses.

The vegetation of the valley is predominantly of the thorn-scrub forest type with *Dendrocalamus strictus* Nees. predominating. With it are associated *Capparis zeylanica* Linn., *Zizyphus mauritiana* Lamk. var. *fruticosa* (Haines) Srivastava, *Zizyphus œnoplia* Mill., *Gymnosporia spinosa* (Forsk.) Fiori, and *Sterblus asper* Lour. These shrubs grow in clumps separated from each other by coarse grasses, *Helicteres isora* Linn., species of *Sida* in the irregular path ways.

Just a small bit of the land is kept under cultivation by the hill-tribes.

2. *The rivers and the canals.*—In the Patna canal and its branches, the water is mostly always turbid, as a consequence thereof very few plants can grow; the same is the case with the rivers during the rains, though lots of rooted and floating aquatic plants are collected from tanks and ditches by the flood-waters and carried along. During winter and in early summer there is very little water in most of the rivers, but in Ganga, there is plenty of clear water and in it some plants are seen particularly where it is shallow and has less flow. Here grow *Potamogeton pectinatus* Linn., *Vallisnaria spiralis* Linn., *Chara* sp., *Nitella* sp., etc. Sometimes masses of the first two are uprooted and carried to sheltered spots where the growth continues. Such spots also harbour masses of *Spirogyra* spp. The wooden piles along the banks, and the masonry of the bathing ghats show a thick growth of attached algæ in early summers. In the Sone, Phalgu and the Punpun rivers there is some vegetation only in the few pools of water seen here and there.

3. *The banks of the river Ganga.*—The left bank of the Ganga near Patna is much higher than the right and for a considerable distance along the town it is lined with bricks, with many *pukka* ghats in between. During the floods, these banks are submerged, but they get exposed by the first week of October, when the water starts receding. They remain damp for months afterwards. Soon after the water has receded, *Ranunculus sceleratus* Linn., *Verbascum coromandelianum* (Vahl.) Ktz., *Rumex maritimus* Linn., *Rumex dentatus* Linn., *Salvia plebeia* R. Br., *Nepeta hindostana* (Roth) Haines, *Polygonum stagnium* Buch-Ham., *Polygonum hydropiper* Linn., *Polygonum barbatum* Linn., *Polygonum glabrum* Willd., *Lippia geminata* H.B. & K., various sedges, *Cyperus michelianus* (Linn.) Link, subsp. *pygmœus* (Rottb.) Aeschers and Griseb, *Alternanthera echinata* Sm., and other amphibious and wet-meadow plants begin growing from between the bricks. By early summer, these plants are dead and replaced by dry-meadow plants like *Scoparia dulcis* Linn., *Verbena officinalis* Linn., *Nicotiana plumbaginifolia* Viv., and *Argemone mexicana* Linn,

On the sand-covered high banks as near Ranighat, grow *Sagittaria sagittifolia* Linn., *Sagittaria guayanensis* H.B. & K., *Ranunculus sceleratus* Linn., *Polygonum glabrum* Willd., *Polygonum barbatum* Linn., and many other plants as are found on the brick-lined banks.

4. *The islands in the river Ganga and its annually inundated low banks.*—Soon after the water has receded and if it has not spread any sand over the land, there grow up nearer water *Ranunculus sceleratus* Linn., *Alternanthera sessilis* R. Br., *Scirpus maritimus* Linn., var. *affinis* Clarke, other sedges, *Cæsulia axillaris* Roxb., *Rumex maritimus* Linn., and *Rumex dentatus* Linn. Lands away from the edge of water grow various blue-green algæ and liverworts, followed by wet-meadow plants like *Juncellus michelianus* (Linn.) Link subsp. *pygmæus* (Rottb.). Aeschers and Græbn, *Heleochloa schœnoides* Host, *Gnaphalium pulvinatum* Del., *Grangea maderaspatana* (Linn.) Poir, *Alternanthera echinata* Sm. and others. Later on appear *Mollugo lotoides* (Linn.) O. Ktz., *Lindernia crustacea* (Linn.) Mueller, *Lindernia sessiliflora* (Benth.) Wettst, *Lindernia verbenæfolia* (Colsm.) Pennell, *Lindernia parviflora* (Roxb.) Haines, *Gnaphalium luteo-album* Linn., *Gnaphalium indicum* Linn., *Gnaphalium purpureum* Linn., *Blumea amplectans* DC.. *Blumea wightiana* DC., *Phyla nodiflora* (Linn.) Green, *Xanthium strumarium* Linn., and *Eragrostis gangetica* Steud., *Alhagi camelorum* Fisch., *Equisetum debile* Roxb., *Balanites ægyptiaca* (Linn.) Del., and *Tamarix* spp. are seen even farther away from water. A stray plant of *Salix tetrasperma* Roxb. may be seen near an inland pool of water.

Those lands that were under water for a very short while, show dry-meadow plants like *Polypogon monspeliensis* Desf., and *Saccharum spontaneum* Linn. The lands that are higher still and never get inundated show *Croton bonplondianum* Baill., *Calotropis procera* R. Br., *Scoparia dulcis* Linn., *Solanum xanthocarpum* Schrad & Wendl., *Euphorbia hirta* Linn., *Launea asplenifolia* DC., *Launea nudicaulis* Les., and many annual grasses. *Ficus* spp. are occasional on steep banks and mounds.

But most of these lands are kept under cultivation. The lands above the highwater mark are sown with biennial castor and pigeon-pea; those below it, as near Fatwa, grow, before the onset of the floods, a crop of maize and various vegetables. These lands, and the still lower ones, grow in winter, a crop of wheat and barley. Wherever irrigation by tube-wells is available, vegetable crops are grown. The weeds in the cultivated fields are those found in the wet-meadows and the dry-meadows such as *Gnaphalium indicum* Linn., *Centaurium roxburghii* (Don) Druce, *Canscora diffusa* R. Br.. *Ammania baccifera* Linn., *Biophytum sensitivum* (Linn.) DC., *Mollugo pentaphylla* Linn., species of *Blumea*, *Leucas lavendulæfolia* Rees, *Eragrostis* spp., *Cynodon dactylon* (Linn.) Pers., *Alysicarpus bupleurifolius* (Linn.) DC. and many others.

5. *The "Serpentine" and the "Jalla".*—The shallower portions which hold water for a very short while, are sown with paddy. The deeper portions are either cleared of their natural vegetation and sown with water-chestnut, or allowed to have the natural cover, when they show, towards the middle where the water is deep, *Nymphæa esculenta* Roxb., *Nymphæa pubescens* Willd., *Limnanthemum cristatum* (Roxb.) Griseb emend Thwait., *Aponogeton natans* (Linn.) Engler, *Aponogeton crispum* Thunb., *Potamogeton crispus* Linn., *Hydrilla verticillata* (Linn. f.)

Presl., *Najas graminea* Del., *Utricularia flexuosa* Vahl., *Utricularia stellaris* Linn. f., *Ceratophyllum demersum* Linn., and others. Towards the shallow banks grow *Neptunia oleracea* Lour., *Jussiæa repens* Linn., *Eichhornia crassipes* Solms., *Pistia stratioides* Linn., *Lemna* spp., *Wolffia arrhiza* Linn., and *Azolla pinnata* R. Br. Plants like *Ipomœa aquatica* Forsk., *Pseudoraphis brunoniana* Griff., *Leersia hexandra* Swartz, *Paspalum scrobiculatum* Linn., *Paspalum vaginatum* Swartz, *Paspalidium geminatum* (Forst.) Stapf, *Paspalidium conjugatum* Stapf, *Marselia minuta* Linn., and others grow on the muddy banks but their branches float on water. Besides the above, *Sesbania paludosa* Prain, *Aeschynomene indica* Linn., *Melochia corchorifolia* Linn., *Pentapetes phœnicea* Linn., *Polygonum stagnium* Buch-Ham., *Polygonum limbatum* Meissn., *Polygonum glabrum* Willd., *Asteracantha longifolia* (Linn.) Nees., *Lippia geminata* H.B. & K., *Jussiæa linifolia* Vahl., *Jussiæa suffruticosa* Linn., *Jussiæa perennis* (Linn.) Brenan, *Phragmites maxima* Chiovenda, *Arundo donax* Linn., and *Sclerostachya fusca* (Roxb.) A. Camus (at places planted) grow on the muddy banks. *Ipomœa obscura* (Linn.) Ker-Gawl, *Merrimia emarginata* (Burm. f.) Hallier, sometimes also *Operculina turpethum* (Linn.) Silva Manso climb up on these. Some shallow ditches have only *Scirpus articulatus* Linn. in the middle and *Alternanthera sessilis* R. Br. on the margins, whereas others show nothing else but *Ottelia alismoides* (Linn.) Pers.

In drains and other places with excessive organic matter, *Eichhornia crassipes* Solms. grow so thick as to choke out all other plants.

Due to the excessive cultivation of vegetable crops with high water requirements such as potato, carrot, radish, turnip, etc., the Jalla water is led away for irrigation and certain portions which would otherwise remain filled with water, get dried up. With the pressure of the increasing population and the consequent expansion of cultivation, the dumping of garbage in the ditches, and the making of a central underground sewerage in the Patna-Bankipur town, a time will soon come when the Jalla will become dry.

6. *The ditches dug along the roads and the railways.*—Such ditches as are seen along the Patna High Court Dinapur Road and along the railway between Phulwari and Dinapur railway stations, hold water only during the rains. The old ditches show, in the rainy season, submerged and emersed hydrophytes like *Nymphœa* spp., *Ipomœa aquatica* Forsk., *Potamogeton crispus* Linn., *Aponogeton crispum* Thunb., *Aponogeton natans* (Linn.) Engler, and many other plants which spring up from dormant root-stocks and rhizomes as soon as there have been some rains. These ditches also show *Limnophila conferta* Benth., *Limnophila indica* (Linn.) Druce, *Eriocaulon setaceum* Linn., *Eriocaulon sieboldianum* Sieb. & Zucc., and *Utricularia* spp. On the sides they may show *Hydrolea zeylanica* (Linn.) Vahl., *Jussiæa suffruticosa* Linn., *Jussiæa linifolia* Vahl., *Polygonum barbatum* Linn., and *Polygonum limbatum* Meissn. After the rainy season, when the water has dried up, the beds of these ditches show a rich rice field flora. The newly dug ditches show only *Spirogyra* spp. and other algæ during the rains and

a poor rice field flora later on. *Polycarpon indicum* (Retz.) Merr., *Ammania baccifera* Linn., *Ammania multiflora* Roxb., *Rotala leptalea* Koehne, *Rotala indica* (Willd.) Koehne and many other plants are seen in the beds of the old ditches. Some grasses may appear later on if the bed of the ditch was not much disturbed by buffaloes and pigs when it was wet. Grasses like *Eragrostis unioloides* (Retz.) Nees., *Eragrostis gangetica* (Roxb.) Steud are seen in early summer on the sides of these ditches. Besides the above, may be seen, if the ditch was dug several years back, *Vetiveria zizanioides* (Linn) Nash., *Lippia geminata* H.B. & K., *Melochia corchorifolia* Linn., and other perennials.

7. *The low-lying lands.*—The annually inundated low lands in Patna City, Patna Sadar, Bihar and Barh subdivisions are of two types: (1) Those from where the water recedes very early and where late paddy is sown. (2) Other lands from where water recedes much later. Potato is sown in these fields during the winter. Lands left fallow show, during the rains, a rich amphibious vegetation consisting of various sedges and grasses. *Cæsulia axillaris* Roxb., *Cyanotis axillaris* Roem. & Schultz. and others.

If any such land is left uncultivated in winter also, it shows a profuse growth of wet-meadow plants like *Rotala indica* (Willd.) Koehne, *Ammania baccifera* Linn., *Hygrophila polysperma* (Roxb.) T. Anders., and later on *Stemodia viscosa* Roxb., *Mazus japonicus* (Thunb.) O. Ktz., *Bergia ammanioides* Roxb., *Phyllanthus simplex* Retz., *Eragrostis japonica* (Thunb.) Trin., *Eragrostis diarrhena* (Schultz.) Steud. and *Eragrostis pilosa* (Linn.) Beauv. Still later it shows *Mollugo pentaphylla* Linn., *Biophytum sensitivum* (Linn.) DC., *Euphorbia hirta* Linn., *Euphorbia parviflora* Linn., *Eragrostiella bifaria* (Vahl.) Bor, *Eclipta alba* (Linn.) Hassk., *Cynodon dactylon* (Linn.) Pers., *Blumea* spp., *Dichanthium annulatum* (Forsk.) Stapf, *Dichanthium caricosum* (Linn.) A. Camus, *Bothriochloa pertusa* (Willd.) A. Camus, and other dry-meadow plants.

Some of the lands with defective drainage, as between Bihar Town and Silao, are developing alkalinity. They are either devoid of vegetation, or have the typical saline-soil plants like *Chenopodium album* Linn., *Portulaca oleracea* Linn., *Portulaca quadrifida* Linn., and others.

8. *The ruins of the houses, the dust-heaps, and the building-sites in the town.*—The ruins of houses show a luxuriant growth on the walls of *Lindenbergia indica* (Linn.) O. Ktz., *Chloris virgata* Sw., *Brachiaria reptans* (Linn.) Gard. et Hubb., *Peristrophe bicalyculata* (Retz.) Nees, *Cyanotis axillaris* Roem. & Schultz, *Commelina benghalensis* Linn., *Tridax procumbens* Linn., *Mollugo oppositifolia* Linn., *Bœrhaavia diffusa* Linn., *Trianthema monogyna* Linn., *Aristida adscenscionis* Linn., *Pennisetum setosum* Rich., and other xerophytic grasses. On older ruins, there are seen *Ficus benghalensis* Linn., *Ficus glomerata* Roxb., *Ficus religiosa* Linn., *Trema orientalis* (Linn.) Bl., and occasionally *Zizyphus mauritiana* Lamk.

The dust-heaps and the garbage dumps show a variety and luxuriance not seen elsewhere. Most of the common weeds of the district are there, particularly *Croton bonplondianum* Baill., also most such plants whose seeds are used in the household, such as *Gynandropsis gynandra* (Linn.) Briq., *Cleome viscosa* Linn., *Nigella sativa* Linn., *Fœniculum vulgare* Linn., sometimes *Chenopodium ambrosioides* Linn. Ultimately *Argemone mexicana* dominates.

In Patna, the new building-sites are invariably low lands. They show the wet-meadow plants first; and as the depressions get filled up and the land hardens, the dry-meadow plants appear, *e.g.*, *Tragia involucrata* Linn., *Cassia occidentalis* Linn., *Cassia tora* Linn., *Cassia sophera* Linn., *Croton bonplondianum* Baill., *Solanum xanthocarpum* Schrad. & Wendl., and many grasses.

9. *The fallow lands, lands along the roads, railways and canals; also protected lands in the Railway-yards.*—These are dry-meadows, being covered with grasses like *Heteropogon contortus* (Linn.) P. Beauv., *Iseilema laxum* Hack., *Bothriochloa intermedia* (R. Br.) A. Camus, *Saccharum spontaneum* Linn. and *Erianthus benghalensis* (Retz.) Hubbard; mixed up with these grow, just after the rains, *Sonchus* spp., *Launea nudicaulis* Les., *Cassia tora* Linn., *Cassia sophera* Linn., *Andrographis paniculata* Nees. and *Ruellia tuberosa* Linn. *Hyptis suaveolens* (Linn.) Poit, and *Anisomeles indica* (Linn.) O. Ktz. are abundant in localities away from human habitation as along the Patna-Digha railway line. *Lantana camara* Linn. var. *aculeata* is fast encroaching upon all such lands.

On lands which are protected from grazing, there grow perennial grasses like many listed above, also *Rottbœllia exaltata* Linn. f., *Cymbopogon jwarancusa* (Jones) Schultz and *Cymbopogon nardus* (Linn.) Rendle, along with which grow *Desmodium gangeticum* DC., *Crotalaria mysorensis* Roth. and other tall, erect dicotyledonous herbs giving a true grass land population.

With protection continued for a longer period, a scrub-jungle appears consisting of species like *Prosopis spicigera* Linn., *Capparis zeylanica* Linn., *Acacia arabica* (Lamk.) Willd., *Acacia canescens* Graham, *Zizyphus œnoplia* Mill., and *Zizyphus mauritiana* Lamk., sometimes also *Zizyphus rugosa* Lamk. and *Zizyphus xylopyra* (Retz.) Willd., *Aegle marmelos* (Linn.) Correa, *Limonia acidissima* Linn., *Salmalia malabarica* (DC.) Schott & Endlich., *Trewia polycarpa* Benth., Climbers like *Cardiospermum halicacabum* Linn., *Bryonia amplexicaule* Lamk., *Abrus precatorius* Linn., *Cayratia trifolia* (Linn.) Gagnep, and *Ipomœa quamoclit* Linn. grow up on these during the rains and early winter.

10. *The mango orchards and other fruit gardens.*—These, particularly the neglected ones like the Mahuar Bagicha, those in the Kankarbagh-Kumhrar area and beyond the Patna City, show the most mesophytic type of vegetation. In the beginning are seen *Ageratum conyzoides* Linn., *Desmodium gangeticum* DC., *Triumfetta pentandra* A. Rich., *Urena lobata* Linn., *Achyranthes aspera* Linn., various commelinas, sedges and grasses, particularly *Oplismenus burmanni* (Retz.) Beauv. Later on appear *Pithecellobium dulce* (Roxb.) Benth.,

Dalbergia sissoo Roxb., *Lannea coromandeliana* (Houst.) Merrill., *Morinda tinctoria* Roxb., *Trewia polycarpa* Benth., *Ehretia lævis* Roxb., *Cordia dichotoma* Forst. f., and a stray borassus- or date-palm. Climbers are those of the last zone as also *Dioscorea bulbifera* Linn. and *Dioscorea* spp., *Cryptolepis buchanani* Roem. & Schultz, *Ichnocarpus frutescens* R. Br. and many others. Thus a pioneer monsoon forest is formed.

Due to the growing demand for fruits, the mango orchards and other gardens are being taken care of, and most of the plants mentioned above are missing in many orchards, as in the Digha area.

11. *The lawns and the parks.*—The lawns like the Gandhi Maidan which are not protected against grazing and are also much frequented by man, are in a slightly different condition from those in the Science College, where grazing is not allowed but where cutting by man is permitted. In the latter case, the succulent grasses are almost completely scraped out and the ground left bare for colonization by the coarser types of grasses. In the unprotected lawns, the grasses are kept closely grazed and here only such species grow as can stand the heavy trampling under the feet, *e.g.*, *Cynodon dactylon* (Linn.) Pers., *Dactyloctenium ægyptium* (Linn.) Beauv., and *Eleusine indica* (Linn.) Gaertn., or coarse grasses like *Chrysopogon aciculatus* (Retz.) Trin., which are not browsed upon. Along with these grow various prostrate species of dicots like *Alysicarpus monilifer* DC., *Indigofera linifolia* Retz., *Indigofera enneaphylla* Linn., *Desmodium triflorum* (Linn.) DC., *Hybanthus enneaspermus* Muell., *Polygala* spp., *Convolvulus pluricaulis* Choisy, *Convolvulus microphyllus* Sieb., *Evolvulus nummularius* Linn., and *Bœrhaavia diffusa* Linn., rarely *Polygonum plebeium* R. Br. Here and there, especially in sheltered spots, as under the benches and near the railings, grow *Vernonia cinerea* (Linn.) Les., *Achyranthes aspera* Linn., *Amaranthus spinosus* Linn., *Amaranthus viridis* Linn., and other erect plants. During and after the rains, are also seen many sedges such as *Cyperus rotundus* Linn., *Bulbostylis barbata* Kunth., *Bulbostylis capillaris* Kunth., *Fimbristylis junciformis* (Retz.) Kunth., *Fimbristylis diphylla* (Retz.) Vahl. and others. Thus wet-meadow and dry-meadow plants succeed each other. In the Science College lawns the more xerophytic grasses, *e.g.*, *Paspalidium flavidum* (Retz.) A. Camus, *Sporobolus diander* (Retz.) Beauv., *Dichanthium annulatum* (Forst.) Stapf., *Bothriochloa pertusa* (Willd.) A. Camus, and *Imperata cylindrica* (Linn.) Beauv. and others are gradually replacing the doob grass.

The parks are less open and as such are damper. They are also protected against grazing, therefore the grasses have a very luxuriant growth and are represented by a large number of moisture-loving species; the xerophilous species are not to be seen. On the trees grow up various climbers particularly *Cocculus hirsutus* (Linn.) Diels, and *Pergularia dæmia* (Forsk.) Blatt. & McCann. The neglected Government quarters and the cemeteries also bear a similar flora.

12. *The cultivated lands.*—About 95 per cent. of the land in the district is under cultivation. In the rainy season, the low lands

grow paddy and the higher lands grow maize, millets and pigeon-pea. All fields grow in winter a crop of wheat, barley, gram, pea, various pulses and oilseeds. In the lands near the towns, potato, carrot and other vegetable crops are sown. In sandy areas many cucurbits, chillies, tobacco and turmeric are grown. During the winter the following weeds are seen in the cultivated fields: *Sonchus arvensis* Linn., *Sonchus asper* (Linn.) Hill, *Chenopodium album* Linn., *Amaranthus viridis* Linn., *Portulacca oleracea* Linn., rarely *Asphodelus tenuifolius* Cavan.

Stray trees of mango, babul, fan- or date-palm can be seen here and there. Nearer villages there are present mango-orchards and bamboo-clumps. Date-palm and fan-palm form a prominent part of the landscape near the towns where are also seen neem, sahijan, pipal and bargad.

The elevated plains in the south-west of the district have not only a poor soil but also have no irrigation facilities. Paddy is sown on them during the rains and just some pulses and barley during the winter. In years of drought, both the crops are lost.

SUMMARY

Duthie (1908) had included areas up to the west of the Sone River in his "Upper Gangetic Plains" region. The present paper shows that the progressive desiccation brought about due to the interaction of various factors, mainly the biotic one, has made the Patna District, which lies further east, to acquire the same type of succession and vegetation as are typical of the eastern districts of the upper gangetic plains, *e.g.*, Allahabad (Dudgeon, 1919–20) and Banaras (Misra, 1946).

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A PRELIMINARY ACCOUNT OF THE SOIL DIATOM FLORA OF KOLHAPUR

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Introduction

Very little is known of the Soil Diatom Flora of India and especially of Kolhapur, hence the author endeavours to present an account of the same.

The material for the study was collected from different parts of the city during the rainy seasons of 1952–55. It occurred in the form of brownish scum on the wet surface of the soil. On examination, the material showed a preponderance of species of *Hantzschia* or *Nitzschia*, associated with other forms included in this paper, which occurred in lesser numbers or as stray specimens.

The classification of forms is done according to Hustedt's (1930) monograph and the identification with the additional help of Cleve-Euler's (1951 55) monograph. The measurements given for each form are those actually recorded.

In all, thirteen forms have been described in this paper of which eight are new records for India.

BACILLARIOPHYTA (DIATOMEÆ)

A. Order CENTRALES

I. Suborder DISCINEÆ

1. *Family* *COSCINODISCACEÆ*

(*a*) *Sub-family* COSCINODISCOIDEÆ

Genus **Cyclotella** Kützing 1834

1. *Cyclotella meneghiniana* Kütz. v. *genuina* A. Cl. f. *binotata* Grun.
Cleve-Euler, A., *Diat. von Schwed. u. Finn*—I, p. 48, fig. 63 *c*; Gandhi, H. P., *Freshwater Diat. S.-W. India*, p. 196, fig. 1.

Frustules rectangular in girdle view with undulated sides. Valves discoid, 10–15 μ in diameter. Central field large, finely punctate in radial rows with two conspicuous dots on one side. Striæ coarse 9–10 in 10 μ.

Distribution.—India– Dharwar (Gandhi, 1956); Kolhapur—Saniwar-peth, Rajaram College (Science side) compound and Laxmipuri.

This form is a distinctive one on account of two conspicuous dots being present in the central field. Such dots have also been recorded by Van Heurck in some of his specimens, which he retained under the species *C. meneghiniana* Kütz. (Van Heurck, *Treat. Diat.*, p. 447, pl. 22, fig. 656). However, the present author considers it fit to separate such bistigmate specimens from the type and thus agrees with Cleve-Euler's view.

B. Order PENNALES
1. Suborder BIRAPHIDINEÆ
1. *Family* *NAVICULACEÆ*
(*a*) *Sub-family* NAVICULOIDEÆ
Genus **Neidium** Pfitzer 1871

2. *Neidium affine* (Ehr.) Cl. v. *longiceps* (Greg.) Cl.
(Fig. 1)

Hustedt, *Bacil.*, p. 244, fig. 378; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—IV, p. 112, fig. 1163 *a-d* [= *N. longiceps* (Greg.) A. Cl. v. *typicum* A. Cl. inclusive of f. *minuta* A. Cl.].

Valves small, linear or feebly concave in the middle with constricted broadly produced rounded ends, length 18–25 μ and breadth 4·5–5 μ. Raphe thin and straight with central pores bent in opposite directions. Axial area very narrow; central area small. Striæ finely punctate, 24–26 in 10 μ, slightly radial in the middle and somewhat perpendicular to the middle line at the ends, crossed by a faint longitudinal furrow near the margins.

Distribution.—India—Kolhapur—Sahu Road side, Science side compound and garden.

Genus **Anomœneis** Pfitzer 1871

3. *Anomœneis styriaca* (Grun.) Hust.
(Fig. 2)

Hustedt, *Bacil.*, p. 265, fig. 432.

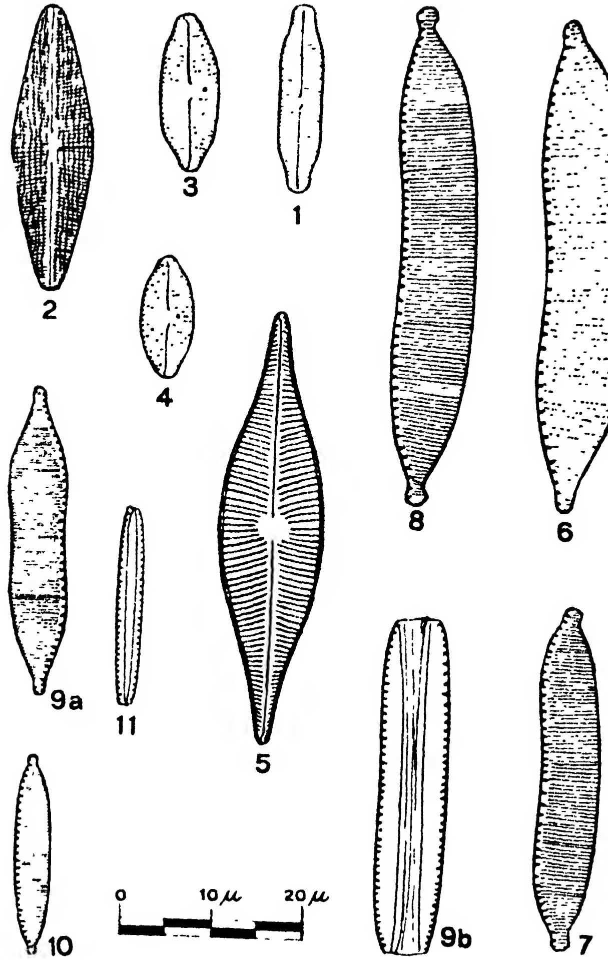
Valves rhombic-lanceolate with broadly rounded ends, length 15–30 μ and breadth 6–7·7 μ. Raphe thin and straight with central pores wide apart. Axial area very narrow; central area constricted in the middle, small. Striæ about 26–29 in 10 μ, punctate, radial and crossed by many longitudinal, wavy hyaline bands.

Distribution.—India—Kolhapur—widely distributed.

Cleve-Euler has described this form as *A. decipiens* A. Cl. v. *typica* A. Cl. (Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 200, fig. 923 *a-b*), but the illustrations do not agree with either Hustedt's or the present form. On the other hand, Cleve-Euler's illustration "923 *e*", which agrees well in the outline, etc., with Hustedt's and present one, is being called as *A. decipiens* v. *hybrida* n. v., in the index to figures (p. 254) of which no description or name is available in the text.

Genus **Navicula** Bory 1822

Section ***Naviculæ orthostichæ*** **Cleve**



Figs. 1–11. Fig. 1. *Neidium affine* (Ehr.) Cl. v. *longiceps* (Gerg.) Cl. Fig. 2. *Anomœoneis styriaca* (Grun.) Hust. Figs. 3–4. *Navicula mutica* Kütz. Fig. 5. *Navicula gothlandica* Grun. Fig. 6. *Hantzschia amphioxys* (Ehr.) Grun. v. *pusilla* Dippel. Fig. 7. *Hantzschia amphioxys* (Ehr.) Grun. v. *densestriata* (Font.) A. Cl. Fig. 8. *Hantzschia amphioxys* (Ehr.) Grun. v. *capitata* O. Müll. Fig. 9 (*a*) *Nitzschia thermalis* Kütz. v. *minor* Hilse. Fig. 9 (*b*) *Nitzschia thermalis* v. *minor* in girdle view. Fig. 10. *Nitzschia palea* (Kütz.) W. Sm. Fig. 11. *Nitzschia palea* in girdle view.

4. *Navicula cuspidata* Kütz.

Donkin, A. S., *Brit. Diat.*, p. 39, pl. VI, fig. 6; Van Heurck, *Treat. Diat.*, p. 214, pl. 4, fig. 190; Hustedt, *Bacil.*, p. 268, fig. 433; Tiffany and Britton, *Alg. Illinois*, p. 254, pl. 68, fig. 789.

Valves broadly lanceolate with somewhat produced ends, length 50–77 μ and breadth 18–22 μ. Axial area narrow. Transverse striæ

15–16 in 10 μ, almost perpendicular to the middle line, longitudinal striæ 20–22 in 10 μ.

Distribution.—India—Burma (West and West, 1907), Ceylon (West and West, 1902), Panjab (Majeed, 1935), Bombay and Salsette (Gonzalves and Gandhi, 1954), Kolhapur—widely distributed.

5. *Navicula mutica* Kütz.

Section *Naviculæ mesolciæ* Cleve

(Figs. 3–4)

Van Heurck, *Treat. Diat.*, p. 206, pl. 4, fig. 167; Hustedt, *Bacil.*, p. 274, fig. 453 *a*; Tiffany and Britton, *Alg. Illinois*, p. 254, pl. 67, fig. 773; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 193, fig. 907 *a* [= *N. mutica* Kütz. v. *cohnii* (Hilse) Grun.].

Valves elliptic-lanceolate with constricted, produced, broadly rounded ends, length 12–16·6 μ and breadth 5–6·7 μ. Raphe thin and straight with somewhat unilaterally bent central pores. Axial area narrow; central area very large somewhat widened towards the margins with an isolated punctum on one side. Striæ 18–20 in 10 μ radial, clearly punctate and somewhat closer at the ends.

Distribution.—India—Burma (West and West, 1907), Biswas's list no. 348; Kolhapur—widely distributed.

6. *Navicula cryptocephala* Kütz.

Section *Naviculæ lineolatæ* Cleve

Donkin, A. S., *Brit. Diat.*, p. 37, pl. 5, fig. 14; Van Heurck, *Treat. Diat.*, pp. 180–81, pl. 3, fig. 122; Hustedt, *Bacil.*, p. 295, fig. 496; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 154, fig. 813 *a-e* (= *N. cryptocephala* v. *genuina* A. Cl.).

Valves lanceolate with constricted, produced, somewhat capitate ends, length 25–28 μ and breadth 5·5 μ. Striæ 16–17 in 10 μ, radial in the middle and convergent at the ends, indistinctly lineate.

Distribution.—India—Himalaya (Dickie, 1882), Burma (West and West, 1907), Calcutta (Skvortzow, 1935), Bombay and Salsette (Gonzalves and Gandhi, 1954), Partabgarh (Gandhi, 1955), Bengal (Grunow, 1865), Biswas's list no. 310; Kolhapur—widely distributed.

7. *Navicula gotlandica* Grun.

(Fig. 5)

Hustedt, *Bacil.*, p. 296, fig. 499; Cleve-Euler, A., *Diat. von Schwed. u Finn.*—III, p. 158, fig. 819 *a–c* (= *N. gotlandica* Grun. v. *genuina* A. Cl. and v. *minor* A. Cl.).

Valves broadly lanceolate with narrowed, produced, acutely rounded ends, length 40–47·5 μ and breadth 9·5–10 μ. Raphe thin and straight. Axial area narrow, linear; central area small, rounded. Striæ 14–16 in 10 μ in the middle and upto 18 in 10 μ at the ends, radial in the middle and convergent at the ends, lineate.

Distribution.—India—Kolhapur—Rajaram College gardens and Science side compound.

This form also agrees well with the type given by Cleve-Euler in all respects except that its dimensions are intermediate between *N. gotlandica* Grun. v. *genuina* A. Cl. and its other variety *minor* A. Cl. Here, therefore, Cleve-Euler's types have been regarded the same as Hustedt's.

(*b*) *Sub-family* GOMPHOCYMBELLOIDEÆ

Genus **Amphora** Ehrenberg 1840

8. *Amphora veneta* Kütz.

Hustedt, *Bacil.*, p. 345, fig. 631; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—III, p. 96, fig. 682.

Frustules broadly elliptical with truncate ends, 12–17 μ long and 7–7·5 μ broad. Valves lunate with obtuse ventrally bent ends. Striæ finely punctate, radial, wider apart in the middle, 20–25 in 10 μ.

Distribution.—India—Madras (Krishnamurthy, 1954). Kolhapur—Rankala-vesh, Saniwar-peth and Science side.

2. *Family* *NITZSCHIACEÆ*

(*a*) *Sub-family* NITZSCHIOIDEÆ

Genus **Hantzschia** Grunow 1880

9. *Hantzschia amphioxys* (Ehr.) Grun. v. *pusilla* Dippel

(Fig. 6)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 48, fig. 1419 *l*.

Valves somewhat arcuate, linear, strongly narrowed, constricted and produced towards the ends, length 40–52 μ and breadth 6·5–8·2 μ. Keel excentric with small keel punctæ, 7 in 10 μ. Striæ punctate, 15–17 in 10 μ.

This form agrees well with the type given by Cleve-Euler, except that some slightly larger forms were also recorded.

Distribution.—India—Kolhapur—Saniwar-peth, Sukrawar-peth, Tarabai park, Rankala-vesh and Laxmipuri.

10. *Hantzschia amphioxys* (Ehr.) Grun. v. *densestriata* (Font.) A. Cl.

(Fig. 7)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 49, fig. 1419 *n–p*.

Valves slightly arcuate, linear with narrowed, constricted somewhat broadly rostrate, backwardly bent ends, length 25–37 μ long and 5–5·5 μ broad. Keel excentric, keel punctæ small, 9–11 in 10 μ. Striæ fine, 23–25 in 10 μ.

Distribution.—India—Kolhapur—Padma-Raje park, Rajaram College (Science side) garden and compound.

11. *Hantzschia amphioxys* (Ehr.) Grun. v. *capitata* O. Müll.
(Fig. 8)

Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 49, fig. 1419 *t*.

Valves linear, arcuate with strongly narrowed, constricted capitate rounded ends, length 30–50 μ and breadth 7·5–8 μ. Keel excentric, keel punctæ small, 8–9 in 10 μ. Striæ 20–22 in 10 μ.

This form agrees well with the type given by Cleve-Euler, except that it is slightly a broader form.

Distribution.—India—Kolhapur—Rajaram College (Science side) compound and garden.

Genus **Nitzschia** Hassall 1845

Section *Dubiæ* Grunow

12. *Nitszchia thermalis* Kütz. v. *minor* Hilse
(Fig. 9 *a–b*)

Hustedt, *Bacil.*, p. 403, fig. 772; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 64, fig. 1445 *g–h*.

Frustules linear with truncate ends in girdle view. Valves linear with concave sides and wedge-shaped, constricted produced ends, length 30–33·5 μ and breadth 6·6 μ. Keel excentric, keel punctæ very small, 12–14 in 10 μ. Striæ very fine, almost indistinct, about 35 in 10 μ.

Distribution.—India—Kolhapur—Rankala-vesh, Rajaram College (Science side) compound and garden, Kolhapur filter-house area and Laxmipuri.

Section *Lanceolatæ* Grunow

13. *Nitzschia palea* (Kütz.) W. Sm.
(Figs. 10–11)

Van Heurck, *Treat. Diat.*, p. 401, pl. 17, fig. 554; Hustedt, *Bacil.*, p. 416, fig. 801; Cleve-Euler, A., *Diat. von Schwed. u. Finn.*—V, p. 90, fig. 1504 *a–b* (= *N. palea* v. *genuina* A. Cl. inclusive of f. *minuta* A. Cl.).

Frustules narrowly linear with slightly narrowed turnctate ends in girdle view. Valves linear-sublanceolate with narrowed, constricted, feebly capitate ends, length 16·5–25 μ and breadth 3–4 μ. Keel excentric, keel punctæ small 12–14 in 10 μ. Striæ fine and almost indistinct, about 35 in 10 μ.

This form agrees well with the type described by Hustedt and other, except that some smaller forms were also recorded.

Distribution.—India—widely distributed.

SUMMARY

For the first time soil Diatomaceæ has been investigated from Kolhapur of which an illustrated account is presented in these pages.

In all, thirteen forms have been recorded from this area of which eight are new records for India.

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GROWTH OF *COLLETOTRICHUM CAPSICI* IN PURE CULTURE

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(Received for publication on September 1, 1956)

Colletotrichum capsici (Syd.) Butl. & Bisby, the causal organism of "fruit rot" and "die-back" of chillies has a wide distribution throughout the tropics and is very common in Southern India. Although the fungus was first reported by Sydow (1913) on chillies from Coimbatore and has since then been reported and described from several parts of the world (Butler, 1918; Dastur, 1921; Bertus, 1927; Thompson, 1928; Higgins, 1931; Marchionatto, 1935; Hansford, 1938; Ling and Lin, 1944; and Ramakrishnan, 1954), little is known about its physiology and growth in pure culture. Studies on the growth and sporulation of the fungus were, therefore, undertaken.

EXPERIMENTAL

Methods.—The fungus was isolated in October 1955 from diseased fruits of chillies collected from Tirunelveli District and a single spore isolate obtained from this culture was used in this study. Standard mycological methods (Rawlins, 1933) were used throughout.

RESULTS

Medium.—In preliminary work, the fungus was grown in four different media: Horne and Mitter's, Czapek's, Coon's and Richard's. It was found that the fungus sporulated best in Coon's medium as determined by hæmocytometer counts of the spores. Maximum mycelial growth of the fungus was in Richard's medium which was, therefore, used in further studies. There was no growth in Czapek's medium.

Incubation Period.—The optimum incubation period for good growth of *C. capsici* was then investigated. Mycelial weight of the fungus grown in Richard's medium was determined by harvesting the fungal mat every alternate day from the day of inoculation for a period of 30 days (Table I). The maximum dry weight of mat was obtained on the 11th day after inoculation. The mat weight was constant thereafter till the 31st day. It was also noticed that at the end of 11 days' incubation the pH of the medium rose to 7·0 from an initial 4·5 and at the end of 31 days it was 8·0.

Effect of pH.—The effect of pH on the growth of the fungus was determined by adjusting the pH of the medium at different levels, *viz.*, pH 3, 4, 5, 6, 7 and 8 with solution of N/10 NaOH and N/10 HCl. Maximum mat weight was obtained at pH 7·0, which was taken as the optimum pH for the growth of the fungus (Table II). At the end

TABLE I

Showing the rate of growth of C. capsici

No. of days	Final pH of the medium	Average weight of mycelium (mg.)
1	4·5	..
3	5·0	16
5	6·0	150
7	6·5	190
9	6·8	240
11	7·0	310
13	7·3	300
15	7·5	300
17	8·2	296
19	8·3	294
21	8·5	300
23	8·5	300
25	8·6	278
27	8·6	278
29	8·6	280
31	8·6	295

of 11 days' incubation the final pH of the various treatments was observed to be between 7 and 8 thus indicating a general tendency for the medium to become neutral or slightly alkaline following the growth of the fungus, irrespective of the original pH.

TABLE II

Showing the initial and final pH of the medium and the growth of C. capsici

Initial pH	Final pH	Average weight of mycelium (mg.)
3	6·5	279
4	7·5	294
5	7·5	288
6	7·5	308
7	7·6	359
8	7·8	354

Carbon sources.—The fungus grew well in Richard's medium with sucrose as the carbon source. Its growth response to the following carbon sources was studied in detail:—

Pentoses: Arabinose, Rhamnose.
Hexoses: Glucose, Mannose, Lævulose.

Disaccharides: Sucrose, Lactose, Maltose.
Trisaccharides: Raffinose.
Polysaccharides: Starch, Cellulose (Acetate), Inulin.
Alcohols: Mannitol, Absolute alcohol.

These were supplied at the 5% level (on weight basis) individually as sole sources of carbon in Richard's medium. The results are given in Table III. The order of suitability for growth of the more important carbon sources was: Sucrose > Glucose > Starch. Sucrose gave the maximum dry weight. The mycelial mats were pure white in colour with all carbon sources except sucrose where it was dark grey.

TABLE III

Showing the growth of C. capsici *with different carbon sources*

	Source of carbon	Average weight of mycelium (mg.)
Pentoses—	Arabinose	23
	Rhamnose	57
Hexoses—	Glucose	316
	Mannose	314
	Lævulose	329
Disaccharides—	Sucrose	370
	Lactose	81
	Maltose	241
Trisaccharides—	Raffinose	267
Polysaccharides—	Starch	281
	Cellulose (acetate)	0
	Inulin	270
Alcohols—	Mannitol	29
	Absolute alcohol	22
Without any carbon source		0

Nitrogen sources.—The growth response of the fungus to the following nitrogen sources was investigated:—

Nitrate nitrogen: Sodium nitrate, Potassium nitrate, Calcium nitrate.

Nitrite nitrogen: Sodium nitrite.

Inorganic ammoniacal nitrogen: Ammonium sulphate, Ammonium chloride, Ammonium nitrate, Ammonium phosphate.

Organic ammoniacal nitrogen: Ammonium tartrate, Ammonium oxalate.

Organic nitrogen: Urea, Asparagine.

TABLE IV

Showing the growth of C. capsici *with different nitrogen sources*

Source of nitrogen		Average weight of mycelium (mg.)
Nitrite—	Sodium nitrite	69
Nitrate—	Sodium nitrate	166
	Potassium nitrate	310
	Calcium nitrate	123
Ammoniacal— (Inorganic)	Ammonium sulphate	169
	Ammonium chloride	201
	Ammonium nitrate	151
	Ammonium phosphate	436
Ammoniacal— (Organic)	Ammonium tartrate	275
	Ammonium oxalate	338
Organic Nitrogen—	Urea	389
	Asparagine	361
Without any nitrogen source		5

These were supplied as sole sources of nitrogen in Richard's medium, the nitrogen being supplied in each case at the rate of 1,400 mg. of N/1. As the majority of the compounds gave a low initial pH to the medium, all the treatments were adjusted to pH 7 before autoclaving. The results are given in Table IV. Nitrogen from nitrite was not suitable for growth. Organic nitrogen sources, *viz.*, urea and asparagine produced the maximum growth. Among the ammoniacal nitrogen sources, ammonium phosphate gave the maximum mycelial growth; but ammonium nitrate, ammonium chloride and ammonium sulphate were not suitable. An explanation for this is to be sought in future work which is in progress.

DISCUSSION

Some interesting points emerging from this preliminary study of the physiology of *Colletotrichum capsici* may be briefly discussed. It has been shown that the fungus grows best at a pH of 7·0 and it has also been observed that irrespective of the initial pH of the medium the pH invariably drifts to the neutral point or to a point slightly on the alkaline side. The differences in the mat weight observed in media adjusted to pH 3, 4, 5, 6, 7 and 8 are not very considerable and this is obviously due to the ability of the fungus to bring the pH to the neutral point at which it grows best. Unfortunately little is known about the drift in pH in the case of media supplied with sodium nitrate, calcium nitrate, ammonium sulphate and ammonium nitrate as sole sources of nitrogen in which growth of the fungus was poor. The nitrogen requirements of this fungus are best met from ammonium phosphate, urea, asparagine and ammonium oxalate and similarly, the most suitable carbon sources are hexoses and disaccharides, the alcohols and pentoses being unsuitable. There is no doubt that *Colletotrichum capsici* is a very interesting organism for physiological investigation and a more detailed study, particularly, of its growth response to different C/N ratios in the media and also the drift in pH of the media taking place with different nitrogen sources is important. This should ultimately be linked with the chemical composition of the host tissues prior to and following infection and the physiological changes accompanying the disease. Further work on these lines is in progress and will be reported elsewhere.

SUMMARY

An isolate of *Colletotrichum capsici* was studied in pure culture Richard's medium was found to be the best for its growth. Maximum mycelial weight was recorded 11 days after inoculation The growth of the fungus in the medium was accompanied by an increase in the pH of the medium. The optimum pH for growth of the fungus was 7·0. Among the various carbon sources tried, sucrose was found to be the best, followed by the hexoses (glucose, mannose and lævulose). Among nitrogen sources studied, ammonium phosphate produced the maximum mycelial growth followed by organic nitrogen sources (urea and asparagine), ammonium oxalate and potassium nitrate.

ACKNOWLEDGEMENTS

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AMINO ACID CHANGES IN THE HEALTHY AND 'FOOT-ROT' INFECTED RICE (*ORYZA SATIVA* L.)

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Much emphasis has been laid in recent years on a study of amino acid distribution in plants, particularly during pathogenicity and in this laboratory root exudates have also been screened for amino acids (Andal *et al.*, 1956). However, rice plants suffering from 'Foot-rot' disease caused by *Fusarium moniliforme*, despite its practical importance, have not been examined for amino acid distribution in the healthy and diseased states. The present investigation presents our recent findings in this field.

Materials and Methods

Rice plants (resistant var. GEB. 24 and susceptible var. MTU. 9) were grown in sterilised, *F. moniliforme* infested and uninfested soils. Free amino acids of these plants were determined on the 6th and 12th days after germination. The 12-day old infected plants were sampled for analysis in 2 categories, *viz.*, (*a*) those showing typical 'Bakanæ effect' (elongation of aerial parts) and (*b*) those showing chlorosis of leaves (typical 'foot-rot' symptoms). The 12-day old resistant plants grown in infested soil were analysed for comparison with the healthy ones of the same age grown in uninfested soil. 5 g. root and shoot samples were washed with several changes of glass-distilled water and ground with 75% ethyl alcohol. The extract was centrifuged and the supernatant concentrated for analysis. The technique of ascending chromatography (Williams and Kirby, 1948) as modified in this laboratory (Lakshminarayanan, 1955) was used.

Results

Presence or absence of free amino acids in roots and shoots of healthy resistant and susceptible rice plants at different ages is indicated in Table I.

Increase in age did not alter the free amino acid composition of roots and shoots of the resistant and susceptible varieties, except for the appearance of lysine in the 12-day old resistant shoots. Glutamic acid, tyrosine, methionine, tryptophane and lysine present in the roots of the resistant variety at both age levels were also present in the roots of susceptible plants. However, the roots of susceptible variety at both age levels had two more amino acids: alanine and aspartic acid. The amino acid content of shoots of resistant and susceptible varieties was similar except for the presence of proline in the latter.

TABLE I

Free Amino Acids in the Healthy Resistant and Susceptible Rice Plants

Amino acids	ROOT				SHOOT			
	6 days		12 days		6 days		12 days	
	R	S	R	S	R	S	R	S
1 Aspartic acid ..	−	+	−	+	+	+	+	+
2 Alanine ..	−	+	−	+	+	+	+	+
3 Proline .	−	−	−	−	−	+	−	+
4 Lysine ..	+	+	+	+	−	+	+	+
5 Glutamic acid ..	+	+	+	+	+	+	+	+
6 Tyrosine ..	+	+	+	+	+	+	+	+
7 Methionine ..	+	+	+	+	+	+	+	+
8 Tryptophane ..	+	+	+	+	+	+	+	+

+ : Amino acid present.
− : Amino acid absent.

R : Resistant var.
S : Susceptible var.

TABLE II

Free Amino Acids in the 12-Day Old Infected and Resistant Rice Plants Grown in Infested Soil

Amino acids	BAKANÆ		CHLOROTIC		INFESTED RESISTANT	
	Root	Shoot	Root	Shoot	Root	Shoot
1 Aspartic acid ..	+	+	+	+	−	+
2 Alanine ..	+	+	+	+	−	+
3 Proline ..	−	−	−	−	−	−
4 Lysine ..	+	+	+	+	+	+
5 Glutamic acid ..	+	+	+	−	+	+
6 Tyrosine ..	+	+	+	+	+	+
7 Methionine ..	+	+	−	−	+	+
8 Tryptophane ..	+	+	+	+	+	+
9 Phenyl alanine ..	−	−	−	+	−	−
10 Glycine ..	−	−	+	+	−	−
11 Serine ..	−	−	+	+	−	−
12 Unidentified ..	+	−	−	+	−	−

+ : Amino acid present.
− : Amino acid absent.

Table II summarises the free amino acid composition in roots and shoots of 12-day old infected plants—(*a*) those showing 'Bakanæ effect' and (*b*) those showing chlorosis. This table also shows the amino acid content of 12-day old resistant plants growing in infested soil.

A comparison of free amino acid content of 12-day old infected plants with the healthy plants of the same age showed little change except for the appearance of an unidentified new ninhydrin positive substance, possessing low R*f* values in roots, and the disappearance of proline in shoots of plants showing 'Bakanæ' symptoms. The roots of 12-day old infected plants showing chlorosis of leaves showed presence of serine and glycine while methionine (present in the 12-day old healthy susceptible roots) was absent. In the 12-day old infected shoots, showing typical chlorosis, serine, glycine and phenyl alanine, and the unidentified ninhydrin positive substance appeared instead of glutamic acid, proline and methionine present in the healthy susceptible shoots of the same age. The amino acid composition of resistant plants grown in infested and uninfested soil was similar.

DISCUSSION

From an analysis of the results, it is evident that there is a derangement in the amino acid content during different stages of pathogenicity. The appearance of serine, glycine, phenyl alanine and the unidentified ninhydrin positive substance during disease, reflects the possible breakdown of proteins with the onset of infection.

SUMMARY

Free amino acid composition of healthy rice varieties, resistant and susceptible to *F. moniliforme* showed little change with age. The susceptible variety had over the resistant ones, alanine and aspartic acid in roots and proline in shoots. In the diseased condition, however, the susceptible variety, whilst showing the typical 'Bakanæ' effect, had no proline in the shoots, although this was present in the healthy state. Plants showing chlorosis of leaves (with little 'Bakanæ' effect) had three more amino acids, *viz.*, serine, glycine and phenyl alanine appearing instead of glutamic acid, proline and methionine present in the healthy controls.

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We are grateful to Professor T. S. Sadasivan for guidance and Dr. C. V. Subramanian for valuable suggestions.

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THE EMBRYO SAC AND ENDOSPERM OF *BLYXA ORYZETORUM* HOOK. f.

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(Received for publication on July 3, 1956)

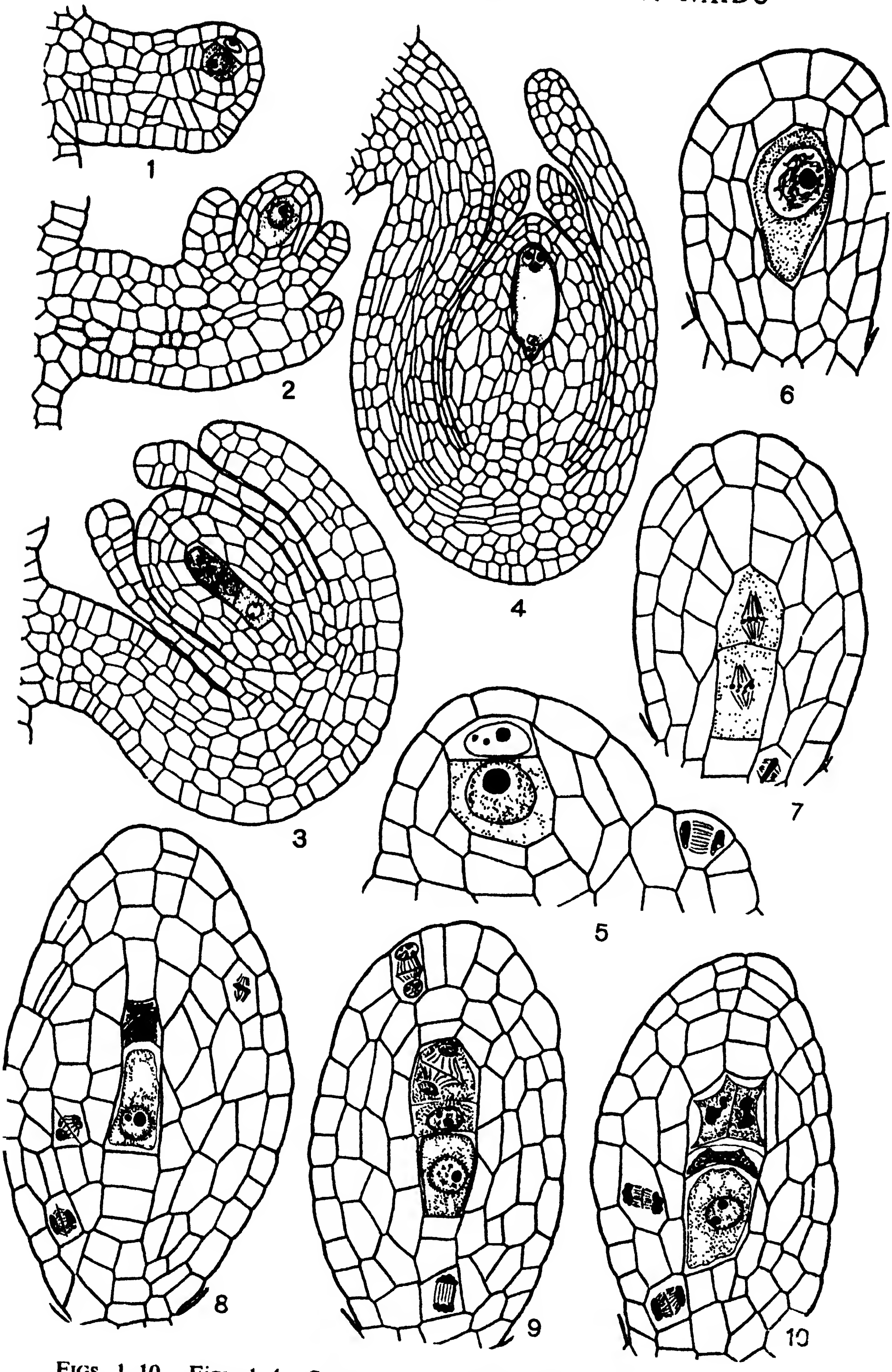
Several interesting features in the method of pollination, distribution and floral morphology have been reported among the members of the Hydrocharitaceæ.

Considerable work has been done on the embryology of this family. The earlier work has been summarized by Schnarf (1931). Kausik (1940, 1941), in his papers on *Enalus acoroides* has reviewed the previous work and described the development of gametophytes, endosperm and embryo of that species. Rangasamy (1941) recorded the development of gametophytes, endosperm and embryo in *Blyxa echinosperma.* A few errors and misconceptions regarding some plants of this family have been pointed out and corrected by Maheshwari (1943). The nature of persistent pollen tube met within a couple of members of the Hydrocharitaceæ has been recently discussed by Maheshwari and Johri (1950). The present investigation is based on the material collected near Londa, Karnatak and deals with the development of the female gametophyte and endosperm of *Blyxa oryzetorum.*

Observations

Ovary and ovules.—The inferior ovary is tricarpellary, syncarpous and unilocular. A large number of ovular primordia develop from the 3 parietal placentæ and give rise to anatropous, bitegmic and crassinucellate ovules. The inner integument becomes differentiated after the organization of archesporium in the ovular primordium. This is followed by the formation of the outer integument (Figs. 1–2). During early stages the outer integument remains short (Fig. 3) but soon develops vigorously and overgrows the inner integument (Fig. 4). Both the integuments take part in the formation of the micropyle. At the mature embryo sac stage the inner integument consists of 2 layers of cells except at the micropyle and the outer integument is made up of 4–5 layers of cells (Fig. 4).

Megasporogenesis and female gametophyte.—A hypodermal archesporial cell is organised early in the ovular primordium. It undergoes a periclinal division giving rise to a primary parietal cell and a megaspore mother cell (Fig. 5). The primary parietal cell undergoes an anticlinal division and results in two juxtaposed cells (Fig. 6). These undergo a periclinal division and produce four parietal cells in two tiers of two cells each. Meanwhile the cells of the nucellar epidermis at the micropylar end undergo periclinal divisions giving rise to 2–3 layers of cells (Figs. 7–10).



FIGS. 1–10. Figs. 1–4. Stages in the development of the ovule, Figs. 1 and 3, ×243; Fig. 2, ×25; Fig. 4, ×146. Fig. 5. L.s. nucellus with primary parietal

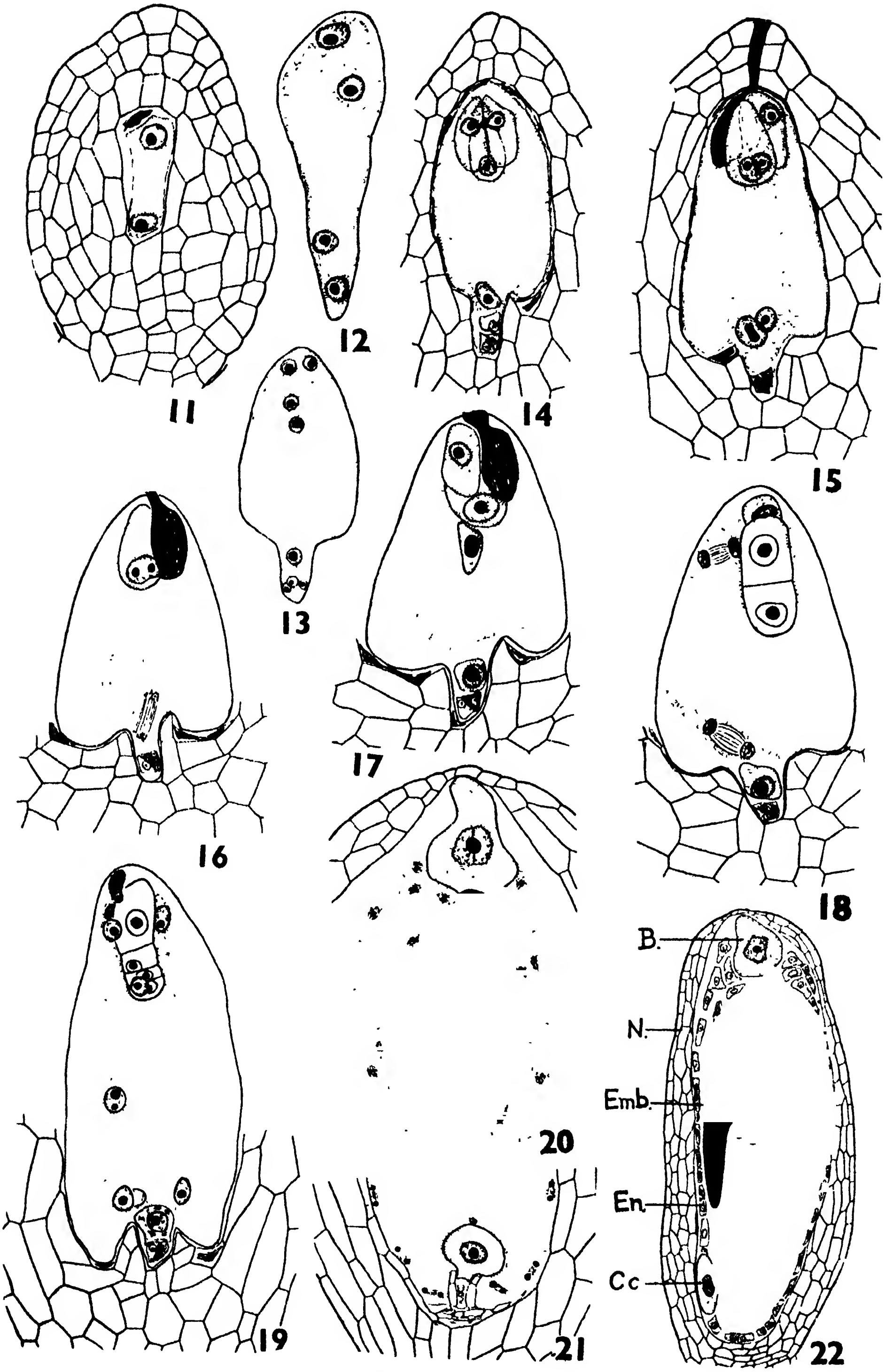
cell and young megaspore mother cell, ×970. Fig. 6. Megaspore mother cell, ×697. Fig. 7. Division of the dyad cells, ×697. Fig. 8. Linear tetrad of megaspores, ×697. Fig. 9. Early division of the lower dyad cell, ×697. Fig. 10. T-shaped tetrad of megaspores, ×697.

The presence of parietal cells and the periclinal divisions of the nucellar epidermis at the micropylar end are commonly met within members of Hydrocharitaceæ. Rangasamy (1941) records that the primary parietal cell in *Blyxa echinosperma* does not undergo any further divisions and remains as a single cell even in later stages of seed development. In the present species, however, 4 parietal cells are formed. Formation of a parietal tissue is also recorded in *Enalus acoroides* (Kausik, 1940). Rangasamy's drawings (*cf.* Figs. 15, 17), however, appear to indicate the presence of more than 1 parietal cell some of which have been interpreted as megaspores. While his sketches (*cf.* Figs. 14, 17, 18) also suggest the possibility of periclinal divisions of the cells of the nucellar epidermis at the micropylar part no mention is made of these in the text. His "single persistent parietal cell" appears to be one of the cells derived from the nucellar epidermis by periclinal divisions.

The megaspore mother cell which now becomes deep seated, enlarges and undergoes the reduction divisions. After the first meiotic division a transverse wall is laid down giving rise to the dyad. The cells of the dyad undergo a simultaneous transverse division and produce a linear tetrad of megaspores (Figs. 7, 8). Very frequently the division of the upper dyad cell is either oblique or vertical resulting in an oblique T or T-shaped tetrad of megaspores (Figs. 9, 10). Occasionally the lower dyad cell divides earlier than the upper one (Fig. 9). The three upper megaspores in the tetrad degenerate and the lowermost one functions in the development of the embryo sac. It enlarges further and its nucleus divides. The two daughter nuclei are pushed apart to the opposite poles by the appearance of a central vacuole (Fig. 11). After two more nuclear divisions at the two ends of 8-nucleate embryo sac of the Polygonum type is produced (Figs. 12–14) as in other members of Hydrocharitaceæ. The embryo sac broadens during its development leaving a short pouch at the chalazal end (Figs. 12–14). Such a pouch has been recorded in *Elodea canadensis* (Wylie, 1904), *Hydrilla verticillata* (Maheshwari, 1933), *Enalus acoroides* (Kausik, 1940) and *Blyxa echinosperma* (Rangasamy, 1941).

The mature embryo sac remains within the nucellus (Fig. 14). The egg apparatus consists of two synergids and an egg. The antipodals are organised as small cells and are confined to the chalazal pouch. They usually persist for a long time during seed development (Figs. 16–19). The polar nuclei fuse together and the secondary nucleus becomes situated at the lower region above the antipodal cells.

Fertilization.—The pollen tube passes in between the cells of the nucellus and enters the embryo sac. It destroys one of the synergids and liberates the two male nuclei, one of which fuses with the egg giving



FIGS. 11–22

FIGS. 11–22. (*B.* Basal cell of the embryo; *C.c.* Chalazal chamber of endosperm; *En.*, Cellular endosperm; *Emb.*, Embryo; *N.*, Nucellus). Fig. 11. L.s. nucellus with a 2-nucleate embryo-sac, ×453. Fig. 12. 4-Nucleate embryo-sac, ×647. Fig. 13. 8-Nucleate embryo sac, ×453. Fig. 14. Mature embryo sac, ×453. Fig. 15. A stage in double fertilization, ×453. Figs. 16–17. First division of primary endosperm nucleus, ×453. Fig. 18. 2–4 Nuclear division in the large micropylar chamber of endosperm, ×453. Fig. 19. Embryo sac with 8-nucleate micropylar and uninucleate chalazal endosperm chambers. Note the persistent antipodal cells, ×323. Figs. 20–21. L.s. micropylar and chalazal parts respectively of an embryo sac. Note the cytoplasmic sheath around the embryo in the former and the persistent chalazal chamber in the latter, ×194. Fig. 22. L.s. nucellus of an old seed, ×94.

rise to the zygote and the other unites with the secondary nucleus producing the primary endosperm nucleus (Fig. 15). The surviving synergid very often persists during the early stages of endosperm development (Figs. 17, 18).

Endosperm.—The primary endosperm nucleus which lies near the antipodal cells divides earlier than the zygote (Fig. 16) as in *B. echinosperma.* This division is followed by a delicate transverse wall as a result of which two endosperm chambers are formed (Fig. 17). The extremely small chalazal chamber lies just above the antipodal cells and might be mistaken for one of them. It remains uninucleate with dense cytoplasm and persists as such up to a very late stage in the development of seed and finally becomes crushed by the developing embryo (Figs. 18, 19, 21, 22). A similar feature has been noticed in *Vallisneria spiralis* (Maheshwari, 1943). The nucleus in the large micropylar chamber moves upwards and divides. No cell wall is laid down after this division. The two daughter nuclei move apart and divide simultaneously (Fig. 18). The four nuclei undergo further free nuclear divisions producing a considerable number of nuclei which remain embedded in the peripheral layer of cytoplasm (Figs. 19–21). A thin sheath of cytoplasm with a few nuclei is observed around the developing embryo (Fig. 20). At a late stage of seed development cell wall formation takes place in the endosperm. The amount of endosperm produced is scanty and even this is consumed by the developing embryo. A similar condition has been observed in *Vallisneria spiralis* (Maheshwari, 1943). However, according to Rangasamy (1941) there is no cell wall formation in the endosperm of *B. echinosperma.*

SUMMARY

The tricarpellary inferior ovary bears a number of anatropous crassinucellate bitegmic ovules on the three parietal placentæ.

The hypodermal archesporial cell undergoes a periclinal division producing the primary parietal cell and the megaspore mother cell. The primary parietal cell produces a parietal tissue. The epidermal cells of the nucellus towards the micropyle undergo periclinal divisions and give rise to 2–3 layers of cells. The deep seated megaspore mother cell undergoes the usual reduction divisions. Linear, oblique and T-shaped tetrad of megaspores have been recorded. The chalazal megaspore develops into an 8-nucleate embryo sac of the Polygonum type. A chalazal pouch of the embryo sac has been observed. The

antipodals are organised as small cells and persist during the post-fertilization stages. The secondary nucleus lies at the lower region in the embryo sac.

Double fertilization has been observed.

The mode of endosperm development is Helobial. The extremely small chalazal endosperm chamber remains uninucleate and persists as such till a very late stage during seed development. Cell wall formation takes place in the endosperm at a late stage. The small amount of endosperm formed is finally consumed by the developing embryo.

We are highly thankful to Professors K. N. Narayan and S. B. Kausik for their guidance during this investigation.

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SPORELING GERMINATION AND VEGETATIVE REPRODUCTION IN *CHILOSCYPHUS HIMALAYENSIS* KASH. AND *COLOLEJEUNEA* SP.

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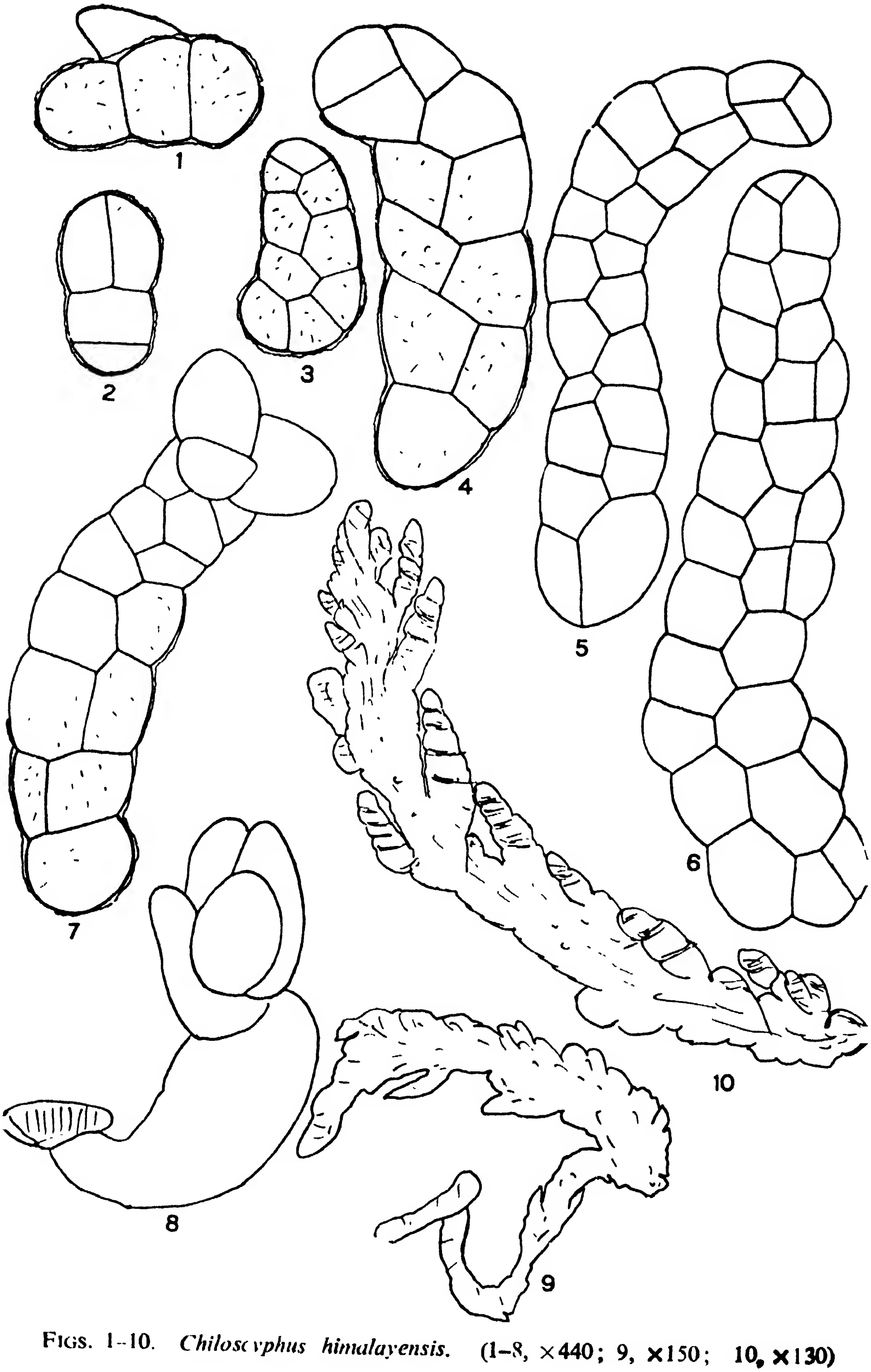
(Received for publication on April 25, 1956)

(*a*) *Chiloscyphus himalayensis* Kashyap (Lophoziaceæ) is epiphytic and was collected on 31–9–1954 from Chandmari (Gauhati—Assam). The thalli are branched and often all are displayed on the same side due to unilateral illumination. The leaves are about 0·5–0·75 mm. long and 0·25 mm. broad; the plants measure up to 0·5 cm. long, light green, forming a thick felt and growing on adhering soil within the furrows and creaks of the branches of deciduous trees.

The spores are about 6–8 μ in diameter, tetrahedral, exine more or less smooth and elaters about 160 μ long. The capsule has the structure usual for leafy Jungermanniales. The spore germinates while still within the capsule and later develops within the felt formed by the main thallus (the sporelings described here are those that were formed among the fruiting plants).

The spore is already green and continues to elongate; a few walls are laid at right angles to the long axis forming a 3-4-celled structure (Fig. 1) in which later the terminal cell may undergo a vertical division (Fig. 2), or a few more walls perpendicular to the main axis are laid and later each cell undergoes a division parallel to the main axis forming a multicellular flat sporeling (Fig. 3) with usually 9 cells—the basal cell with or without a division. Probably at this stage the exine breaks, towards the side facing the illuminated side, due to further growth of the sporeling (Fig. 4). Meantime an apical cell with 2 cutting faces develops and this results in elongation of the sporeling (Fig. 4). Each segment thus cut off from the apical cell again divides by a wall more or less parallel to the long axis of the thallus and the secondary thallus becomes 4 cells broad (Fig. 7). After sometime the apical cell becomes transformed into an apical cell with 3 cutting faces and gives rise directly to a leafy shoot with no *intermediate stages* (Figs. 7, 8). The first formed leaves are small, ovate-acute and plane, these are followed by the leaves characteristic of the genus.

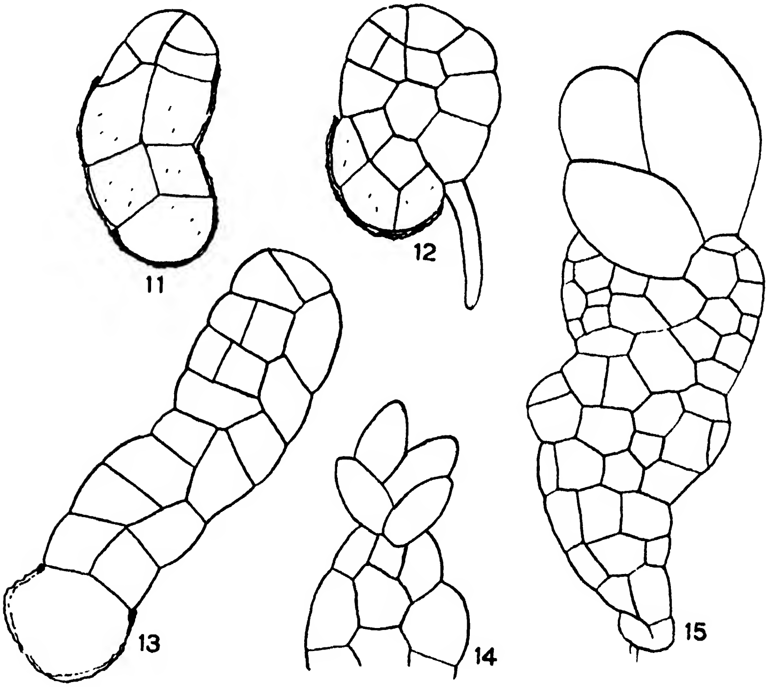
Uncommonly additional walls are formed in some cells of the thallus so that it becomes more than 2 cells broad (Fig. 6). This recalls a similar occurrence in *Ceratolejeunea spinosa* (G.) Steph. (Fulford, 1944).



Figs. 1–10. *Chiloscyphus himalayensis.* (1–8, ×440; 9, ×150; 10, ×130)

Vegetative propagation is by means of propagules in the development of which the leaf cell gives rise directly to a propagulum without the interpolation of a protonemal structure. Such shoots usually develop from the dorsal surface and become very long, are thickly beset with 2 rows of 1 cell thick multicellular 'finger-like' projections (Fig. 10), each of which develops later into a leaf. The nature of the basal region of the propagules depends on the gregariousness of the branches of the plant. In thickly set aggregations it becomes cylindrical and very long (Fig. 9).

(*b*) *Cololejeunea* sp. (Lejeuneaceæ) is also epiphytic and was collected from Shillong (Assam) during 1953. The spore germinates while within the capsule and develops into a 8-celled sporeling while the exine is still intact. The functional apical cell is formed rather early (Fig. 11) and in rare cases results in a thalloid structure (Fig. 12).



FIGS. 11–15. *Cololejeunea* spp. × 410.

Usually, however, it becomes longer and may be more than 2 cells-broad towards the apex (Fig. 13). Later it delimits a characteristic apical cell and the first leaves are ovate-acuminate or broad (Figs. 14, 15) showing some resemblance to *Ceratolejeunea flagelliformis* (Fulford, 1944).

I am grateful to Prof. Aaron J. Sharp for his encouragement.

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SOME ABNORMAL POLLEN GRAINS OF *PICEA SMITHIANA* BOISS.

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(Received for publication on January 18, 1956)

Introduction

Abnormal pollen grains with variation in the number of wings have been noticed in quite a few species of the winged-grained Abietineæ as listed in Table I below. So far there is no record of the occurrence of abnormal pollen grains in the genus *Picea* in which like other winged-grained Abietineæ the normal grains are characterised by having a round body bearing two large bladdery wings, one on each side of the distal furrow. In May 1955 one of the authors (Nair) collected a few twigs of *Picea Smithiana* Boiss. (*P. Morinda* Link.) with male

Table I

Occurrence of abnormal pollen grains in Abietineæ

Species	Age	No. of wings	Reference
Abies nobilis ..	Recent	1—2	Wodehouse, 1935, p. 266
Abies sp. ..	Pleistocene	1—4	Wodehouse, 1935 *a*, p. 4
Cedrus deodara ..	Recent	1—2	Chatterjee, 1943
Pinus excelsa ..	Recent	1—4	Puri, 1945
P. silvestris ..	Post-Glacial	1—4	Florin, 1936, p. 638
P. tuberculata ..	Recent	2—4	Wodehouse, 1935, p. 258
P. Banksiana *P. Strobus* or *P. resinosa* ..	Pleistocene	2—4	Wilson and Webster, 1944, p. 183
P. Khasya *P. longifolia* *P. Merkusii* ..	Recent	2—3	Chatterjee, 1943

cones from Gulmarg, Kashmir. The pollen slides of this material prepared in glycerine jelly stained with safranin show that in addition to the majority of normal 2-winged pollen grains there are also some abnormal grains with 1, 3, or 4 air-sacs.

DESCRIPTION

A large majority of the grains are 2-winged as seen in Fig. 1. They have a biconvex corpus, round or broadly triangular in polar view, measuring 68–94 μ in diameter. The bladders are of varying size. Bladders included, the total breadth of the grains varies from 85–156 μ, the average being about 136 μ.

Figure 2 shows a 1-winged grain. The corpus is large, 102–120 μ in diameter, with a single air-sac almost encircling it. The total breadth of such grains varies from 144–166 μ.

In Fig. 3 is shown a 1-winged grain with an additional notch in the air-sac. By the deepening of this notch it is easy to conceive how a 2-winged grain may result from the 1-winged condition. Similarly Fig. 4 shows 3 notches which can ultimately lead to the 3-winged condition. In Fig. 3 the appearance of 2 more invaginations, 1 on each side of the grain, will result in a 4-winged grain.

3-Winged and 4-winged grains are shown in Figs. 5 and 6 respectively.

In addition to the above types, there are a few abortive grains with 2 or 3 wings attached to a very much reduced body (Fig. 7).

A total count of 5461 grains has shown that about 97% of them are normal (2-winged) and the rest are abnormal. Amongst the abnormal grains more than half are 1-winged, quite a few 3-winged and very few 4-winged.

DISCUSSION

Among modern seed plants saccate pollen grains are unknown except in some genera of the Abietineæ and Podocarpineæ. Sacci or saccoid excrescences are also found in the spores of some of the modern ferns and Lycopods. In fossil plants the earliest occurrence of sacci is met with in the spores of some Palæozoic Lycopodiales and Cycadofilicales (Wodehouse, 1935, p. 243) and the pollen grains of Cordaitales (Florin, 1936). The winged grains of Cordaitales are characterised by having a single air-sac surrounding the corpus. Similar 1-winged pollen grains have also been reported from the Palæozoic conifers *Lebachia* and *Ernestiodendron* (Florin, 1951, p. 336). Seeing the antiquity of the plants in which winged spores were found it seems apparent that the occurrence of air-sacs is a primitive character.

About the winged pollen grains Florin (1951, p. 337) has remarked that "The study of the earliest conifers of the Northern Hemisphere appears to have shown that pollen grains with a single balloon air-sac and a distal germinal furrow are relatively primitive in this class of gymnosperms and that—in the Pinaceæ and the Podocarpaceæ—pollen grains with 2 or 3 smaller sacs, or with no air-sac at all. are more or less reduced structures". He has suggested that the suppression of the different parts of a single air-sac may result in 2, 3 or more air-sacs. In support of this view some of our 1-winged grains with 2, 3 or 4 invaginations may well illustrate the intermediate stages in the formation of 2-, 3- or 4-winged pollen grains.

Mme. Van Campo-Duplan (1950) has traced the trends of evolution of various characters of the pollen grains in the Abietineæ. About air-sacs she (*loc. cit.*, p. 49) agrees with Florin that a single air-sac is primitive and that by reduction of the "system anemochorique" the unsaccate condition is finally reached.

An important question arises out of observations like the present. What is the significance of abnormalities? One probable answer has been given by Prof. Sahni (1925, p. 207): "When the normal equilibrium in the life of an organism is upset by adverse conditions, adjustment is often effected by a 'fall-back' upon the surer basis of past experience." This suggests that certain abnormalities are reminiscences of the past. It may be that adverse conditions took our plant back to the ancestral stage when the original single air-sac was trying to evolve into a number of bladdery wings and had not quite reached the modern 2-winged condition.

ACKNOWLEDGEMENT

The authors are thankful to Prof. G. Erdtman for very kindly going through the manuscript.

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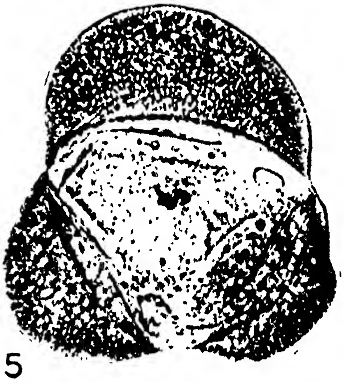

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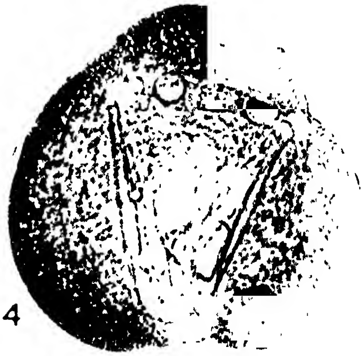

4

R. N. Lakhanpal and P. K. K. Nair

EXPLANATION OF THE PLATE

Picea Smithiana

(All figures are ×260)

FIG. 1. A 2-winged pollen grain.

FIG. 2. A 1-winged pollen grain with one notch in the air-sac.

FIG. 3. A pollen grain with two notches in the air-sac.

FIG. 4. A pollen grain with three notches in the air-sac.

FIG. 5. A 3-winged pollen grain.

FIG. 6. A 4-winged pollen grain.

FIG. 7. An abortive pollen grain with two air-sacs and very much reduced corpus.

PLANT TYPES OF THE PONDS OF THE LOWER DAMODAR VALLEY

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(Received for publication on July 25, 1956)

Introduction

The lower Damodar Valley comprising the districts Burdwan and Hooghly of West Bengal, has numerous ponds. Nearly all of these are artificial, and present opportunities for botanical investigation especially for studies on invasion of plants, the rate of plant succession and the kinds of plant communities in new impoundments. In management of these water collections such problems as fish culture and control of mosquitoes have developed quite lately. This investigation was initiated with the object of obtaining information in solving the latter problem. A detailed account of association of aquatic vegetation with anopheline breeding has been given by the author elsewhere [Neogy and Kachroo, 1956 (unpublished)] and this communication is only restricted to the botanical aspects of the problem.

Ponds for this investigation were selected from a few villages with as much diverse physical, chemical and biotic conditions as possible. 150 ponds were visited but the main observations were confined to 20 selected ponds within the District of Burdwan during 1954-55.

Previous history of the water collections was not taken into consideration and in this study only habitat factors such as pH, temperature and water level were taken into account. Plants with flowers, fruits and with well marked vegetative characters were collected and are with the author. The total list of plants encountered is about 134 (the varieties are considered under main species in this paper). The list of species is appended. 148 species of algæ were collected (Kachroo, 1956) and their taxonomic distribution is given below (Table I).

Table I shows that *Chlorophyceæ*, *Bacillariophyceæ* and *Myxophyceæ* comprise the bulk of the forms and that the majority of them belong to *Chlorophyceæ*. This is obvious as in *Chlorophyceæ* a large number of forms are non-motile, they either form microscopic thalli or aggregate in such amounts as to be very conspicuous and are either large or have some striking morphological characters.

Terminology.—Forel (1892–1904) regarded all bodies of standing water, irrespective of size, as lakes. Welch (1952), however, draws a clear demarcation between a lake and a pond (*loc. cit.*, pp. 15–16), the latter he describes as a "very small shallow body of standing water in which relatively quiet water and extensive plant occupancy are common

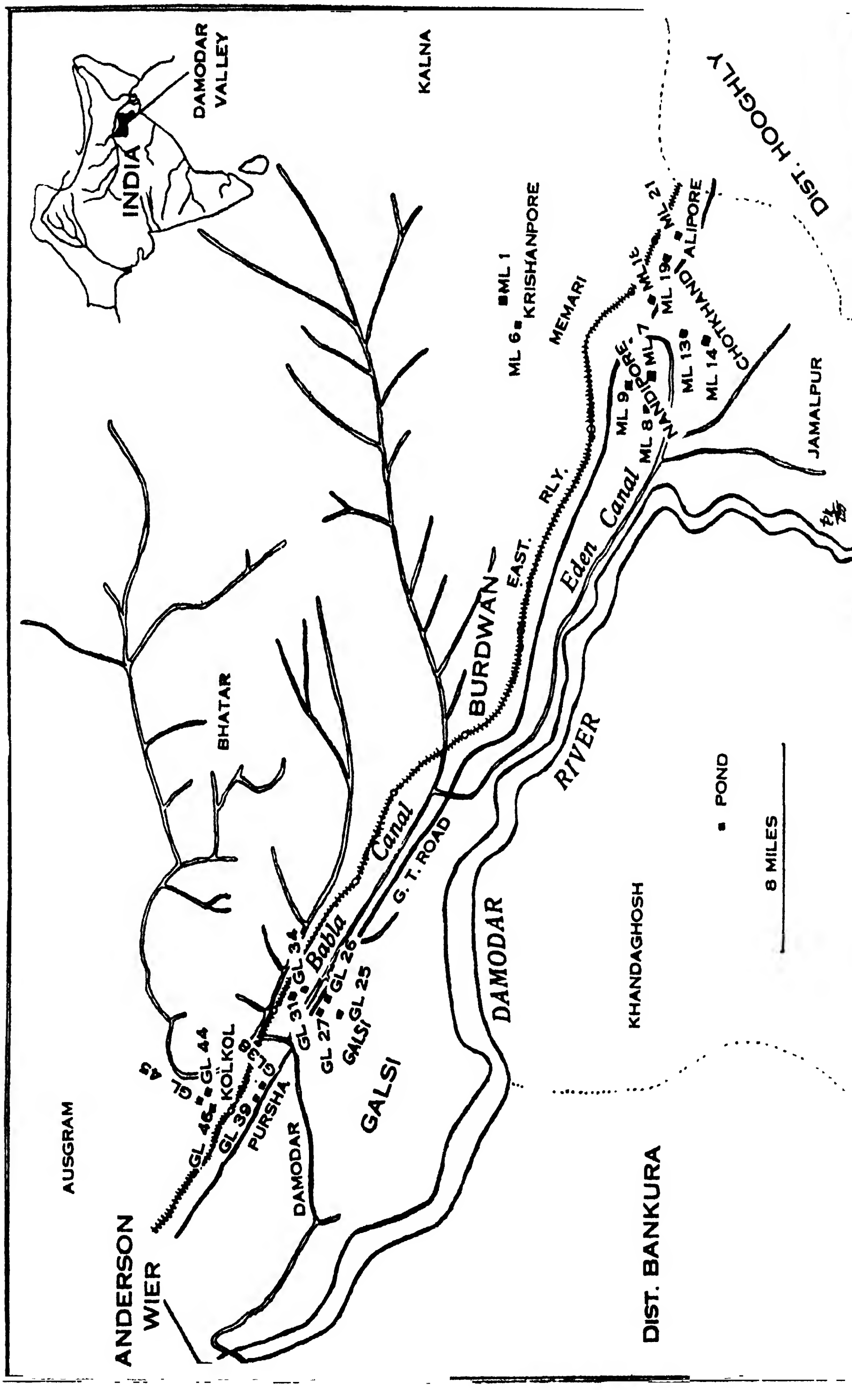

FIG. 1. Sketch map of a portion of district of Burdwan (W. Bengal) showing the location of the selected ponds and villages.

TABLE I

Taxonomic distribution of algæ within the Lower Damodar Valley (District Burdwan)

Groups	Orders	Families	Genera	Species	Percentage
Myxophyceæ ..	3	6	15	35	18·6
Chlorophyceæ ..	9	22	47	73	38·8
Xanthophyceæ ..	1	2	3	4	2·1
Chrysophyceæ ..	1	1	1	1	0·53
Bacillariophyceæ ..	2	5	14	20	10·6
Cryptophyceæ ..	1	1	1	1	0·53
Dinophyceæ ..	1	1	1	2	1·06
Euglenineæ ..	0	2	4	4	2·1

characteristics". On the basis of this definition most of the bodies of standing water, locally called: *dighi* (big pond), *pukur* (small pond) and *doba* (still smaller pond) could be classified as ponds, including also the permanent depressed fallow lands. The *dighi* and *pukur* are normally permanent bodies but sometimes the *dobas* (usually containing some water throughout the year) squeeze to the bottom and dry up completely during winter (*cf.*, *æstival* ponds of Welch) or they conform to some extent with what Welch calls *vernal autumnal* ponds.

DESCRIPTION OF PONDS

As most of the aquatic flora, in the district of Burdwan and Hooghly, is similar, detailed work was confined to Burdwan District. For this purpose an extensive survey was undertaken in a few irrigated and unirrigated villages lying west and east of Burdwan town. The various villages were: Galsi, Boinchi (23 ponds); Nandipur, Krishnapur, Memari (33 ponds); Pursha, Kolkol (12 ponds); Chotkhand, Alipur (20 ponds) (Text-Fig. 1). Besides, intensive observations were also made at Salimpur (10 ponds), Baidyapur (15 ponds) and Burdwan suburbs (15 ponds).

Nearly all these ponds are artificial and some of them very old. Mostly water is clear but there are some with turbid conditions, caused either by the soil formations or other causes. As this region does not experience much variance in climate much diversity was not to be expected in the aquatic flora.

Wind action is not a factor affecting the vegetation nor is the macro-temperature since variations in water temperature are not so great 21–34·7° C. Although pH does not show any correlation with the growth of vegetation, (it varies from 6–7·5) yet it is possible to some extent to group the various selected ponds on basis of their salinity (Table II).

TABLE II

Grouping of the selected ponds according to their pH

pH variation		Pond numbers
1	6–6·2	ML 14
2	6–6·5	ML 13, 6, 18 ; GL 25, 26
3	6–6·9	ML 7, 8, GL 34
4	6·3	GL 27, 45
5	6·5–7·5	ML 1, 9 ; GL 31, 38
6	6·8–7 (7·4)	GL 44, 46
7	7·1–7·5	GL 39

Water level, however, controls the growth and gregariousness of aquatic flora. Most of the ponds experience a considerable rise during the months of September–November, and a notable recession during January–June (Table III). This shows a direct bearing on growth and activities of the plant species (Table IV), which thrive best during the September–December period.

PLANT TYPES*

The typical zonation of the ponds is nearly the same in all the ponds. The *flood zone* (when present) is occupied by terrestrial communities, most of the species being non-resistant to water; the *post-monsoon pool-level zone* is characterized by wetland communities, emergent, submerged, floating and rooted aquatics and the *recession zone* (where it occurs) has wetland and terrestrial weeds, mostly resistant to water and flowering before the next monsoon; and the *continuous water zone* area is occupied by emergent, floating and submerged aquatics.

With respect to water level it is observed that recession in post-monsoon pool-level is a major factor determining the plant populations (of emergent belt, in particular). Thus, in a constant pool a narrow belt of wetland plants occurs in the environs of the post-monsoon pool-level and emergent floating leaf and submerged aquatics occur as a belt in the progressively deeper water. During recession [March-(June)-July] the various zones (from shore-line to middle of pond) are exposed to air, resulting in destruction of such plants, as well as emergent floating and submerged species. This base area is now available for ecesis of terrestrial wetland weeds.

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* Hall and Hess (1945) and Penfound (1953) are followed in broad classification of plant types.

TABLE III

Depth of water in selected ponds for August–December 1954

Ponds	Irrigated area									
	GL 25	26	27	31	34	ML 1	6	7	8	9
August ..	9′–1″	9′–4″	7′–1″	5′–11″	10′–0″	7′–4″	10′–4″	6′–3″	7′–6″	6′–6″
September ..	9′–4″	10′–6″	8′–0″	6′–3″	10′–5″	8′–9″	11′–2″	7′–6″	7′–8″	7′–10″
October ..	9′–8″	12′–0″	9′–2″	6′–3″	10′–7″	9′–2″	..	7′–4″	8′–3″	8′–0″
November ..	9′–5″	11′–7″	9′–3″	6′–5″	10′–4″	8′–4″	11′–11″	7′–0″	7′–9″	6′–8″
December ..	9′–0″	11′–2″	9′–0″	5′–11″	10′–2″	7′–4″	11′–5″	7′–6″	7′–7″	7′–4″

Ponds	Unirrigated area									
	GL 38	39	44	45	46	ML 13	14	18	19	21
August ..	8′–9″	9′–7″	6′–7″	5′–9″	7′–9″	5′–3″	5′–5″	6′–0″	6′–11″	8′–7″
September ..	9′–9″	11′–1″	6′–8″	6′–1″	7′–11″	6′–4″	6′–0″	not	8′–4″	10′–6″
October ..	10′–8″	11′–0″	6′–0″	5′–10″	7′–11″	6′–8″	7′–0″	taken	9′–3″	10′–4″
November ..	11′–4″	9′–7″	6′–2″	5′–7″	7′–6″	6′–4″	6′–4″		8′–9″	9′–8″
December ..	11′–0″	9′–11″	5′–10″	5′–3″	7′–4″	5′–10″	6′–0″		8′–3″	9′–3″

′ = feet, ″ = inches

Flood and post-monsoon pool-level zone

As most of the ponds have a raised shore-line the *flood zone* does not occupy much of the area, nevertheless, it is an area which remains, for most part of the year, under moist conditions. Most of the plants under this zone are non-resistant to flood level, *e.g.*, *Mikania scandens*, *Euphorbia hirta*, *Malvastrum tricuspidatum*, *Andropogon aciculatus*, *Aerua lanata*, *Desmodium gangeticum* and *Croton sparsiflorus*; these are often 'caught up' in the flood. The resistant species include: *Merremia hederacea*, *M. emarginata*, *Vitis trifolia*, *Sida veronicifolia*, *Evolvulus nummularius*, *Eclipta alba*, *Alternanthera sessilis*, *Aeschynomene aspera*, *Cyperus haspan*, *Scirpus articulatus*, *Panicum* spp.

The *post-monsoon pool-level zone*, though smaller in vertical area (5–7 feet), is rich in both emergent and submerged species. The latter either have emergent flowering shoots: *Cardanthera triflora*, *Ottelia alismoides*, *Oldenlandia corymbosa* (flowering shoots on exposed shore), *Aponogeton crispum*, *A. monostachyon*, *Sagittaria guayanensis*, *Limnophila heterophylla*, *L. racemosa* and a few more species *Butomopsis lanceolata*; or while they remain submerged they branch profusely and flower only when the water level recedes, the prominent species are: *Merremia emarginata*, *Oldenlandia corymbosa*, *Evolvulus nummularius*. *Hydrilla*, *Vallisneria*. *Najas*, *Ceratophyllum* and *Chara* are not uncommon in this shallow water zone. Most of the emergent grasses are: *Andropogon aciculatus*, *A. squarrosus*, *Paspaladium punctatum*, *Panicum colonum*, *Pasplum scrobiculatum*, *Fimbristylis*, *Kyllinga monocephala*, *Setaria glauca*, *Cyperus haspan* and spp. (most of these continue to grow in absence of water as well), or species like *Monochoria vaginalis*, *M. hastifolia*, *Aeschynomene aspera*, *Neptunia oleracea* and *Polygonum* (various species).

Commelina salicifolia and *Enhydra fluctuans* predominate throughout autumn and winter in a few ponds, and as the former dries up along the shore-line it is replaced by *Sphæranthus indicus*.

Of the floating species common are: *Azolla*, *Salvinia*, *Utricularia*, *Hygrorhiza*. *Eichhornia* etc. (except *Utricularia* and *Hygrorhiza* the others are cornered here due to wind action from the *continuous water zone*).

Recession zone

In many ponds such a zone is insignificant but where it occurs it results in destruction of all prominent aquatic species so prominent in the previous zone. On this wetland fringe will appear wetland and terrestrial weeds like: *Ammania baccifera*, *Aneilema nudiflorum*,† *Euphorbia hirta*, *Emilia sonchifolia*, *Commelina benghalensis*, *Hygrophila spinosa*‡ (such species occur otherwise as well, without consideration to any zones), *Justicia procumbens*, *Leersia hexandra*.

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†*Aneilema* proper does not occur in most parts of India, it is the genus *Murdannia* Royle.

‡ Usually placed under *Asteracantha longifolia* (Personal communication from Dr. Santapau).

TABLE IV

Monthly incidence of some common aquatic plants during 1954–55

Species (*cf.* Biswas and Calder, 1937)	1954					1955						
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July
1 *Nymphæa lotus*	NC	C	VC	N	VC	NC	R	R	R-T	R	R	R
2 *Nelumbium speciosum*	NC	C	VC	VC	VC	NC	R	R	R	R	R	R
3 *Aeschynomene aspera*	NC	C	VC	VC	C	C	NC	NC	NC	NC–R	T	R–NC
4 *Neptunia oleracea*	?	R	C–VC	N	VC	R–T	O	O	?	?	?	?
5 *Myriophyllum indicum*	R	R	VC	N	R–T	T	O	O	O	O	O	O
6 *M. tuberculatum*	..	..	..	..	..	..	..	..	..	..	..	..
7 *Jussiæa repens*	C	VC	VC	VC	NC	R–T	R–T	R	NC	NC	NC	NC
8 *Limnanthemum cristatum*	NC	NC	VC	VC	NC	R	R	R	R	R	R	R
9 *L. indicum*	..	..	..	..	..	..	..	..	..	..	..	..
10 *Ipomæa aquatica*	R	R	C	VC	NC	R	R	R	R–T	O–T	O–T	O–T
11 *Limnophila* spp.	T	R–NC	C	N	VC	NC	NC	T	O	O	O	O
12 *Utricularia* spp.	R	NC	C	VC	R	R	T	O	O	O	O	O–T
13 *Cardanthera triflora*	O–T	T–R	NC–C	VC	NC	R–O	O	O	O	O	O	O–T

4	*Polygonum* spp.	R	NC	C–VC	NC	NC–R	T	T	R	R	R	R	R
5	*Ceratophyllum demersum*	NC	NC	NC	C	VC	VC	VC	NC	NC	NC	NC	R
6	*Hydrilla verticillata*	R	NC	NC	VC–N	VC–N	N	N	N	C	NC	NC	R
17	*Lagarosiphon roxburghii*	T	T	C	VC	C	?	?	?	?	?	?	?
8	*Vallisneria spiralis*	?	?	R	VC	VC	C	T	?	?	?	?	?
9	*Eichornia speciosa*	R	C	VC	VC	N	VC	NC	NC	NC	R	R	R–T
20	*Commelina salicifolia*	R	NC	N	N	VC	NC	R–T	T	O	O	O	O
21	*Pistia stratiotes*	R	VC	VC	N	N–C	NC	NC	NC	NC	NC–R	R	R
22	*Lemna minor*	NC	NC	N	N	N	C	NC	NC	NC	NC	NC	NC
23	*Sagittaria guayanensis*	O	R	C	VC	NC	NC	R	R–T	T–O	O	O	O
24	*Aponogeton monostachyon*	R	R	NC	C–VC	NC	NC	NC	NC–R	R	R	R–T	R–T
25	*A. crispum*	..	..	..	..	..	..	..	..	..	..	..	..
6	*Scirpus articulatus*	NC	NC	C–VC	N	N	N	VC	VC	C	R	NC	NC
7	*Hygrorhiza aristata*	NC	NC	VC	VC–N	N	N	NC	R	R	R	R–T	R
28	*Marsilea quadrifoliata*	NC	VC	N	N	C	R	R	R	R	R	NC	NC
9	*Salvinia natans*	R	NC	N	C–VC	N	VC	NC	R–T	R–T	R	R	R
0	*S. cucullata*	R	NC	VC	N	NC	?	?	?	?	R–T	R–T	R–T
1	*Azolla pinnata*	R	NC	NC	VC	N	VC–C	NC	NC	NC	R–T	R–T	R–T

Explanation of symbols.—T, trace (1–5); R, rare (5–15); NC, not common (15–50); C, common 50–100); VC, very common (100–200); N, Numerous (over 200). (Numbers within brackets are the numerical value of each symbol.)

Continuous water zone

Floating leaf.—Only a few aggregations were observed. The floating parts rise and fall with the water level. The common features of ponds with such a community is that the shore-line is either without much vegetation or colonized by a belt of grasses with a number of minor associates like *Salvinia, Sagittaria, Utricularia* or a pure association of grasses with *Chara, Hydrilla.* The central association is between *Nelumbium* and *Pistia* (either predominating); however, the more common association is that of *Limnanthemum indicum, L. cristatum* and a marginal belt of the same species—*Jussiæa-Scirpus* or a grass belt; or *Limnanthemum-Nymphæa* association with marginal *Hydrilla, Najas, Ceratophyllum, Utricularia, Pistia, Salvinia* and *Azolla* (or with marginal *Enhydra fluctuans* floating-mat). Pure associations of *Nymphæa* are not uncommon but even in these cases the marginal belt is characterized by emergent grasses, floating leaf and submerged species.

Flexuous.—This aggregation is taken here to denote a maized emergent-floating—marginal-stray floating leaf and submerged vegetation. In this case generally the centre of the pond is clear. The flexuous portions may rise and fall with the water level. The marginal belt is a mixture of leafy grasses, *Limnophila, Polygonum* (most common), *Aeschynomene, Neptunia, Marsilea,* etc. and some erect leafy shoots like *Scirpus articulatus.*

Floating-mat.—These species are rooted in the shallow water near the shore-line and extend later on the water surface. The much branched stem forms a mat. The various associations are those of *Hygrorhiza aristata, Jussiæa repens, Ipomæa aquatica, Enhydra fluctuans,* but none of them are found as pure colonies in any pond, and they provide best shelter for the less prolific species. Thus, a mat of *Jussiæa* would provide screen for *Utricularia, Azolla, Salvinia,* etc.; *Hygrorhiza* often with *Hydrilla*; *Ipomæa* with *Utricularia, Lemma* and *Azolla*; and *Enhydra* with *Marsilea, Jussiæa* and *Pistia.* It is not uncommon to observe some depressed lands having a beautiful mat of pure *Utricularia* during October–November, yielding place to *Ipomæa aquatica* in November-December.

Carpet.—*Pistia, Eichornia* and *Salvinia* form complete carpets over ponds at some stage of the year; *Pistia* usually in November–December, *Eichornia* in December–February and *Salvinia* in August–February. These associations are greatly detrimental to the development of submerged flora and usually exist without complementary marginal belt. When the latter does occur such species as grasses, *Commelina* and *Marsilea* predominate.

Submerged.—There is hardly a pond without some or other trace of submerged vegetation but scarcely a pond with pure submerged flora. Thus, they always occur as complementary flora. However, in certain ponds a meagre percentage of *Aponogeton* and *Alisma* do form pure colonies without any emergent flora. The most predominant species of submerged type are: *Hydrilla, Lagarosiphon, Vallisneria,*

***Ceratophyllum*, *Limnophila*, *Najas*, *Cardanthera*, *Myriophyllum*, *Aponogeton*, *Butomopsis*,** etc.

Pleuston.—Mats are formed by minute plants such as *Lemna*, *Azolla* in a number of situations; particularly where water is foul, usually with organic impurities and effusing bad odour. *Azolla* usually forms reddish-brown or purplish cover over water surface. In most of the *Lemna* ponds occurs a scum usually formed by decaying diatoms or blue green algæ, making the already foul water more obnoxious.

Microscopic.—Red scums are formed by degenerating diatoms or blue green algæ with or without a complementary marginal flora of erect naked grasses. Green scums are formed by masses of *Chlorella*, *Volvox*, *Microcystis*, *Merismopedia*, etc.

ASSOCIATION OF AQUATIC PLANTS WITH ALGÆ

Most of the plants harbour a number of epiphytic algæ or have a close association with algæ in common habitat. Thus, a 7 × 1 mm. piece cut from a floating stem of *Panicum fluitans* (?) collected during March 1955, from a depressed land at Burdwan, showed the presence of *Cladophora sauterii* fixed as radiating rays from a central focussing point on the ventral surface of the floating stem and as green balls attached to the dorsal surface of the same. On the ventral surface were also discernible *Cladophora glomerata*, *Cosmarium granatum*, *Closterium monoliferum*, *Coleochæte* spp., *Pinnularia viridis*, *Oscillatoria amphibia* and a number of unidentified algal spp., spores and cysts. Association of a few more aquatic plants with algæ is tabulated in Table V.

TABLE V

Association of some aquatic plants with algæ for a few months during 1955

(*a*) *Ipomœa aquatica* (from pond-laboratory, Burdwan)

	Algal species	Monthly incidence*					
		March	April	May	June	July	August
1	*Pediastrum tetras* ..	O	O	NC	O	O	?
2	*Cœlastrum sphericum* ..	O	O	N	NC	R-T	O
3	*Cladophora glomerata* ..	N	C	O	O	O	T
4	*Desmidium swartzii* ..	R	O	O	O	O	O
5	*Synedra ulna* ..	NC	NC	R	R	?	?
6	*Chæmosiphon siderphilus*	O	O	O	O	T	O
7	*Anabæna sphærica* ..	O	O	O-T	NC	NC	NC
8	*Oscillatoria amphibia* ..	O	O	T	T	O	T

(*b*) *Limnanthemum indicum* (pond—Chanda singh, Burdwan)

		March	April	May
1	*Pleurococcus* spp.	O	O	T
2	*Microspora* spp.	O	O–T	NC
3	*Cladophora glomerata*	R	C	N
4	*Oedogonium decipiens*	O	T	R
5	*Bulbochæte* spp.	O	O	T
6	*Closterium moniliferum*	O	O	T
7	*Penium* spp.	T	R	NC
8	*Pinnularia viridis*	C	NC	NC
9	*Synedra ulna*	NC	N	N
10	*Anabæna sphærica*	N	NC	R
11	*Oscillatoria princeps*	C	NC	NC–R
12	*Phormidium* spp.	NC	T	O

(*c*) *Enhydra fluctuans* (ML 18, Chotkhand)

		Aug.	Sept.	Oct.
1	*Sphærella lacustris*	NC	NC	C
2	*Chlorococcum humicolum*	T–R	NC	R
3	*Scenedesmus quadricauda*	NC	R	R
4	*Coleochæte* spp.	?	R	T
5	*Oedogonium decipiens*	C	NC	R
6	*Spirogyra neglecta*	N	VC	NC
7	*Closterium ralfsii*	C	NC	C
8	*Cosmarium reniforme*	NC	NC	C
9	*Staurastrum dejectum*	NC	NC	NC
10	*Micrasterias foliacea*	R	NC	?
11	*Cylindrospermum* spp.	C	NC	NC
12	*Anabæna linkia*	VC	NC	R

(*d*) *Commelina salicifolia-Alternanthera sessilis-Limnophila* spp. (general, Chotkhand)

	Aug.	Sept.	Oct.	Nov.
1 *Chlorococcum humicolum*	C	NC	R	NC
2 *Eudorina elegans*	R	R–NC	R	O
3 *Cœlastrum sphericum*	?	R	T	R
4 *Cladophora glomerata*	C–N	NC	R	O
5 *Oedogonium oblongellum*	?	C	NC	O
6 *Phycopeltis epiphyton*	R	C	NC	T–O ?
7 *Spirogyra neglecta*	N	N	C	NC–C
8 *Zygnema* spp.	R	R–T	O	O
9 *Closterium monoliferum*	NC	C	NC	NC
10 *C. ralfsii*	NC–C	C	NC	NC
11 *Cosmarium granatum*	NC	NC	R–T	O
12 *Staurastrum* spp.	R	R–NC	NC	R
13 *Desmidium aptogonum*	?	R	R–NC	NC
14 *Euglena viridis*	N	NC	R	R
15 *Cylindrospermum* spp.	?	NC	R–O	?
16 *Nostoc linkia*	R	NC	R	?
17 *Oscillatoria major*	T	R–NC	R–T	O

(*e*) *Jussiæa repens* (pond Mene, Chotkhand)

		Sept.	Oct.	Nov.
1	*Chlamydomonas braunii* ..	C	C	NC
2	*Chlorococcum humicolum* ..	NC	C	NC
3	*Pediastrum tetras* ..	NC	NC	NC–T
4	*Tetraspora* spp. ..	VC	NC	?
5	*Scenedesmus quadricauda* ..	NC	NC	R
6	*Cladophora glomerata* ..	NC	C	T
7	*Phycopeltis epiphyton* ..	NC	C	NC–T
8	*Oedogonium decipiens* ..	C	C	NC–R
9	*Spirogyra maxima* ..	C	NC	NC–R
10	*Closterium moniliferum* ..	NC	C	NC–T
11	*Cosmarium granatum* ..	C	C	C
12	*Staurastrum dejectum* ..	C	C	NC
13	*Phacus pleuronectes* ..	R	R	?
14	*Euglena viridis* ..	NC	R–O	R–T
15	*Merismopedia tenuissima* ..	?	NC	C
16	*Oscillatoria splendida* ..	NC	NC	R

* Legend as in Table IV.

SUMMARY

Aquatic vegetation of the ponds and other water collections within lower Damodar Valley (Districts of Burdwan and Hooghly) has been studied. Water level controls the growth and gregariousness of the aquatic flora. Recession in the post-monsoon pool-level is a major factor in determining plant communities as borne out by a study of depth of water and monthly incidence of some aquatic plants in about 20 ponds. Most of the ponds have a zonation into: flood, post-monsoon pool-level, recession and continuous water zones—the latter exhibiting various plant types: floating leaf, flexuous, floating mat, carpet, submerged, pleuston and microscopic. In each zone the preponderance of species is enumerated.

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APPENDIX

The following is a complete list of plants collected by the author from the various ponds within the districts of Burdwan and Hooghly of West Bengal. The arrangement of the genera and species within then is alphabetical (for convenience). A single star (*) after a name indicates that it also occurs in _post-monsoon pool-level zone_, a (†) shows that it also occurs in the _recession zone_ and a (‡), that it also occurs in the _continuous water zone_.

Flood Zone

Adiantum lunulatum Burm.
*†_Aeschynomene aspera_ L.
Aerua lanata Juss.
*†_Alternanthera sessilis_ Br.
†_Amaranthus gangeticus_ L.
†_A. tenuifolius_ Willd.
*†_Andropogon aciculatus_ Retz.
*†_A. squarrosus_ L.
Bonnaya antipoda Druce
B. brachyata Hook.
Cassia tora L.
†_Causulia axillaris_
Centranthera humifusa Wall.
*†_Commelina salicifolia_ Roxb.
†_Croton sparsiflorus_ Morong.
Cyathodium tuberosum Kashyap
†_Cyperus compressus_ L.
Desmodium gangeticum DC.
Dopatrium junceum Ham.
D. nudicaule Ham.
*_Echinocloa colonum_ Link.
†_Eclipta alba_ (L.) Hassk.
Emilia sonchifolia DC.
Eriocaulon sieboldianum Sieb. & Zucc.
E. truncatum Ham.
*†_Evolvulus nummularius_ L.
*_Fimbristylis dichotoma_ Vahl.
*_F. diphylla_ Vahl.
F. monostachya Hassk.
*†_Hymenachne amplexicaulis_ Nees.
Impatiens balsamina L.
Kyllinga monocephala Rottb.
Leersia hexandra Sw.
*_Limnophila conferta_ Benth.
*_Linderia cordifolia_ (Colsm.) Merr.
L. angustifolia (Benth.) Wettst.
*_Lobelia trigona_ Roxb.
Mazus rugosus Lour.
Malvastrum tricuspidatum A. Gray
Melochia corchorifolia L.
Mikania scandens Willd.
*_Merremia emarginata_ Hallier.
M. hederacea (Burm. f.) Hall. f.
Notothylas orbicularis (Sch.) Sull.
*_Polygonum flaccidum_ Meissn.
*†_P. orientale_ L.
*_P. tomentosum_ Willd.
Rumex maritimus L.
*_Riccia_ spp.
Saccharum spp.
Saccolepis indica A. Chase
Solanum xanthocarpum Schrad. & Wendl.
Selaginella spp.
Sida rhombifolia L.
S. veronicæfolia Lamk.
†_Smithia sensitiva_ Ait.
Tridax procumbens L.
Urena lobata L.
Vitis trifolia L.
Zizyphus ænoplia Mill.

Post-Monsoon Pool-Level Zone

Aponogeton crispum Thunb.
A. monostachyon L.
‡_Azolla pinnata_ R. Br.
‡_Butomopsis lanceolata_ Kunth.
Cardanthera triflora Ham.
Ceratopteris thallictroides (L.) Brongn.
Cyperus haspan L.
C. platyphyllus R. & S.
‡_Eichornia speciosa_ Kunth.
‡_Enhydra fluctuas_ Lour.
‡_Hydrilla verticillata_ Casp.
‡_Hygrorhiza aristata_ Nees.
‡_Ipomæa aquatica_ Forsk.
‡_Jussiæa repens_ L.
Legarosiphon roxburghii Benth.
‡_Lemna minor_ L.
Limnophila racemosa Benth.
L. heterophylla Benth.
Lindera hysopioides
Marsilea quadrifoliata L.
Monochoria hastæfolia Presl.
M. vaginalis Presl.
†_Myriophyllum indicum_ Willd.
‡_M. tuberculatum_ Roxb.
‡_Naias foveolata_ A. Br.
Neptunia oleracea Lour.
†_Oldenlandia corymbosa_ L.
†_O. diffusa_ Roxb.
†_Panicum colonum_ L.
P. flavidum Retz.
P. fluitans Retz.
†_P. paludosum_ Roxb.
Paspaladium punctatum A. Camus.
†_Pogonatherum_ spp.

†*Paspalum scrobiculatum* L.
P. flavidum A. Camus.
†*Phragmites karka* Trin.
‡*Potomogeton crispus* L.
Saccolepis interrupta Stapf.
Sagittaria guayanensis H.B.K.
‡*Salvinia cucullata* Roxb.
‡*S. natans* Hoffm.
Scirpus articulatus L.
S. grossus L.
Sesbania palludosa Prain.
Setaria glauca Benth.
‡*Trapa bispinosa* Roxb.
‡*Utricularia bifida* L.
‡*U. flexuosa* Vahl.
‡*U. racemosa* Wall.
‡*U. stellaris* L.
‡*Vallisneria spiralis* L.

Recession Zone

Ammania baccifera L.
Commelina benghalensis L.
Justicia procumbens L.
Oldenlandia heynei H.K.f.
Hygrophila spinosa T. Anders.
Mikania scandens Willd.
Murdannia malabaricum (L.) Santapau
M. vaginatum (L.) Buck.
Sphaeranthus indicus L.

Continuous Water Zone

Ceratophyllum demersum L.
Limnanthenum cristatum Griseb.
L. indicum Thw.
Nelumbium speciosum Willd.
Nymphaea cyanea Roxb.
N. esculenta Roxb.
§*N. lotus* L.
N. rubra Roxb.
Ottelia alismoides Pers.
Pistia stratiotes L.

§ *N. lotus* L., the true lotus flower, does not occur in India; it is an Egyptian plant. I do not know which is the species of *Nymphaea* meant by you (Santapau, personal communication). Biswas and Calder (1937) is followed for identifying this plant.

HYPHOMYCETES—II

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19. *Trichosporium aterrimum* Massee

Trichosporium aterrimum was described by Massee (1899, p. 167) as follows: "Hyphis sterilibus repentibus, pallidis, septatis, 3½–4 μ crassis, vage ramosis, fertilibus subsimplicibus, hyalinis; conidiis ellipsoideis, glabris, brunneo-olivaceis, acrogenic, 7-8 × 4 μ. Hab. in cortice Mori indicæ, Changa Manga, Punjab Indiæ or. (Gamble)."

T. aterrimum Massee is a later homonym of *T. aterrimum* (Corda) Sacc. in Saccardo, 1884, p. 289 (≡ *Colletosporium aterrimum* Corda). Saccardo later, however, proposed a nom. nov. for Massee's fungus, naming it *T. masseei* Sacc. (Saccardo 1913, p. 1356).

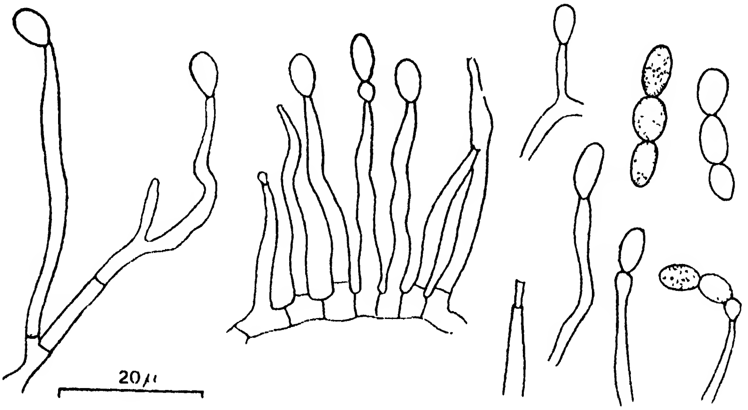

FIG. 1. *Phæoscopulariopsis aterrima* from type specimen, Herb. M.U.B.L. 1584: conidiophores and conidia.

I have examined type material of the fungus, ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1584). The colonies on the substratum are effuse, greenish black and pulverulent. The vegetative hyphæ are subhyaline, thin-walled, septate, branched, and up to 3 μ wide. They produce phialides laterally and terminally; the phialides are simple, long-subulate, thin-walled, subhyaline, 14–42 μ long, 1·4–3·0 μ wide at the base, and about 1·5 μ wide at the apex which appears to have a distinct collarette. The conidia are mostly ellipsoidal, smooth-walled, greenish black, one-celled, produced in simple unbranched basipetal chains at the apex of the phialides, up to 7 μ long and 2·8–3·5 μ wide.

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* Hyphomycetes—I, appeared in *J. Indian bot. Soc.*, 1956, **35**: 53–91.

It is obvious that the conidial chains escaped the notice of Massee. Since the fungus produces dark one-celled phialospores in basipetal chains, it is not a *Trichosporium.* I think that the fungus is best classified in *Phæoscopulariopsis* Ota which, according to Hughes (1953), is an earlier name for *Masoniella* Smith. I am, therefore, proposing the following combination:—

Phæoscopulariopsis aterrima (Massee) Subramanian comb. nov.

- *Trichosporium aterrimum* Massee, 1899, *Kew Bull.*, **1899:** 167; Saccardo, 1902, *Sylloge Fungorum*, **16** : 1052 [non *Trichosporium aterrimum* (Corda) Sacc., 1884, *Sylloge Fungorum*, **4** : 289].

≡ *Trichosporium masseei* Saccardo, 1913, *Sylloge Fungorum*, **22** : 1356.

Type specimen: on *Morus indica*, Changa Manga, Punjab, coll. F. Gleadon, January 1898 ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1584—slide).

20. *Cladosporium buteacolum* Cooke

Cladosporium buteacolum was described by Cooke (1876 *b*, p. 15) as follows: "Effusum, subolivaceum, tenue; floccis tenuibus, rectis, elongatis; sporis fusiformibus, demum uniseptatis. On legume of *Butea frondosa*, coll. Hobson (113) (Saccardo, 1884, p. 353, as *C.* '*butæcolum*'). In a note after the diagnosis Cooke added: "Externally very much like *C. herbarum*, but the long slender flocci are much more delicate, scarcely at all nodulose or constricted; spores fusiform, very variable in length, diameter not exceeding that of the flocci, from ·01–·03 mm. long, and about ·005 mm. broad (Plate 74, Fig. 10)."

I have examined the type specimen which is labelled: *Cladosporium buteacolum* Ckc., on *Butea frondosa* pod, E. Indies, 1876, coll. Hobson, Herb. M. C. Cooke, ex Herb. R.B.G., Kew. I find that this is hardly distinct from *Cladosporium herbarum* of which it may be considered a synonym.

21. *Cladosporium delicatulum* Cooke

Cladosporium delicatulum was described by Cooke (1876 *b*, p. 17) as follows: "Epiphyllum, maculæforme. Floccis tenuibus, flexuosis, septatis; sporis ellipticis, subfusiformibus, demum uniseptatis. On dead leaves. Coll. Hobson (No. 23). Forming irregular fuliginous spots, consisting of erumpent tufts of slender flexuous septate flocci, which are not constricted or nodulose. Spores elliptical, pointed at the ends, becoming fusiform and uniseptate, pale amber-coloured spores ·012–·018 × ·006 mm." I have examined the specimen ex Herb. R.B.G., Kew "on *Codiæum*, coll. Hobson, India ex Herb. Mycol. M. C. Cooke 1885"; it is poorly preserved. The general appearance, however, of what little is left on the specimen, strongly suggests *Cladosporium herbarum* and if this is correct it would mean deletion of one more name from the list of Indian species of *Cladosporium*.

22. *Cladosporium scopæforme* Berk.

Berkeley (1854, p. 208) described *Cladosporium scopæforme* as follows: "471. Cladosporium scopæforme n.s.; cæspitulis parvis orbicularibus; floccis erectis simplicibus nodosis; sporis clavatis elongatis curvis subhyalinis. Hab. on the underside of leaves of Myristica churra, Khasia (Dr. Hooker). Erumpent; spots small. orbicular, sometimes scutellæform, consisting of a tuft of erect, simple flocci, which are more or less waved, and repeatedly though not sharply geniculate above. Spores clavate, elongated, attenuated below, nearly colourless, 1/1000–1/500 of an inch long. A very pretty and distinct species, with the habit of a minute *Circinotrichum*. If the spores were septate, it would come very near to Corda's genus *Helicocoryne*."

On the same page, in a footnote, Berkeley described *Cladosporium congestum*: "cæspitulis parvis orbicularibus, floccis. erectis simplicibus, sporis brevioribus clavatis curvis subhyalinis. Hab. on the underside of the leaves of Litzæa, Ceylon (G. H. K. Thwaites). Spores not exceeding 1/1000 of an inch. Thread even. not nodulose. Closely allied but distinct."

Petch (1919) made a study of both these species. *Cladosporium congestum* is known only from the Ceylon collection on *Litsea*, but *C. scopæforme*, according to Petch, is represented in Herb. R.B.G., Kew, by three specimens from Ceylon, *viz.*, a Ceylon specimen without date and collection number; another, Thwaites 424; and a third, Thwaites 485. Petch did not study the Indian specimen of *C. scopæforme*, which is the type, but after a study of the Ceylon specimens of this species and of *C. congestum*, he stated that they were identical.

I have examined the Indian specimen (type) of *C. scopæforme* [on *Myristica* (possibly *M. gibbosa* Hk.f. & Th. fide Petch, 1919, p. 37) Khasia, Herb. M. J. Berkeley ex Herb. R.B.G., Kew [Herb. M.U.B.L. 1580)] and also the Ceylon specimen of the same species on *Cinnamomum zeylanicum* [G. H. Thwaites, Ceylon, ex Herb. M. J. Berkeley ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1579)]. I find that both these are the same and since Petch (1919) has already stated that the Ceylon specimen of *C. scopæforme* is identical with *C. congestum*, I consider both the species to be identical. Berkeley's description of *C. congestum* appeared, as already mentioned, in a footnote, following the description of *C. scopæforme* and the latter, therefore, may be accepted as the valid name for this fungus. *C. congestum* is, therefore, a synonym of *C. scopæforme.*

The Ceylon specimen of *C. scopæforme* is better preserved and I am giving below a description of the fungus based on a study of this specimen.

The colonies are separate, scattered, sometimes confluent, dark brown, of variable size, up to 3 mm. in diameter, circular or irregular in outline, and forming no spots. It appears to be a hyperparasite on mycelium of Meliolineæ on the undersurface of the leaves. The conidiophores are densely crowded and fasciculate, mostly simple, up to 560 μ long, erect, straight or bent or variously curved, somewhat of uniform thickness and about 4·2–5·6 μ wide, thick-walled, pale to dark brown, many-septate, markedly geniculate in zig-zag fashion in some parts. The conidia are produced acrogenously and singly from the tips of the conidiophores. Successive production of conidia by renewed lateral growth of conidiophore, regularly to the left and right, immediately below scar of fallen conidium, gives the fertile part of the conidiophores the zig-zag appearance already referred to. The conidia are subhyaline to pale or golden brown in colour, somewhat fusiform or elongate-fusiform, broadest in the middle or sometimes nearer the base, becoming progressively narrower above, have somewhat caudate or smoothly rounded subhyaline tips or bluntly rounded apices, thick-walled, smooth, usually 3–4 septate, straight or curved or more often gradually and twice bent in opposite directions, somewhat in S-fashion. They are 26·6–63·0 μ long, 7–10 μ where they are widest, 2·1–2·8 μ wide at the flat base and 2·1–3·5 μ wide at the apex.

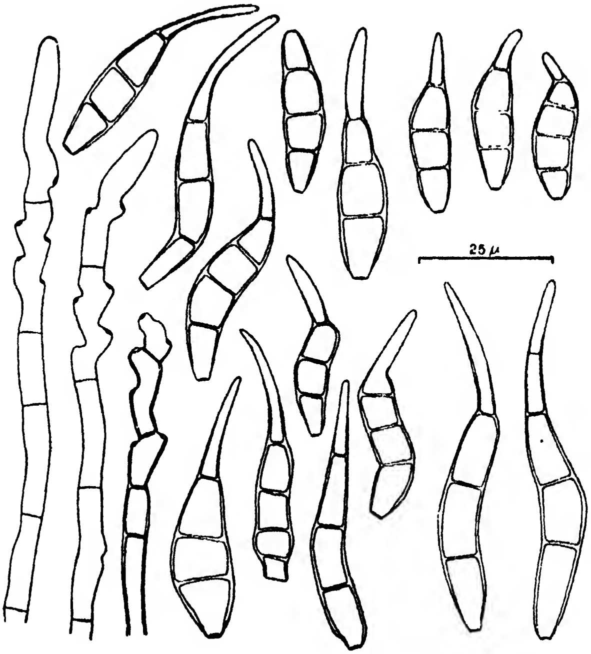

Fig. 2. Conidiophores and conidia of *Helminthosporium scopæforme* from Herb. M.U.B.L. 1579.

It will be clear from the above description, as well as the accompanying figure, that the fungus is not a *Cladosporium*. The markedly geniculate and simple conidiophores and the phæophragmospores produced singly and acrogenously suggest that it is best classified as a *Helminthosporium*. Certain observations made by Petch (1919) are pertinent here. Berkeley and Broome (1873) enumerated *Meliola zigzag* Berk. & Curt. in Fungi of Ceylon, No. 1177, citing Thwaites' numbers 424 and

485. Petch stated that these are the numbers included in Herb. R.B.G., Kew, under *Cladosporium scopæforme* and that in the cover of *Meliola zigzag* in Herb. R.B.G. there is only part of Thwaites 424. *Meliola zigzag* (as *zigzac*) was described by Berkeley (1869, p. 392) as "Floccis repentibus confervoideis, articulis utrinque emarginatis obliquis; peritheciis setis acutis tenuibus curvulis cinctis; sporidiis magnis, conidiis helminthosporoideis triseptatis utrinque appendiculatis. On leaves. Sporidia 0·002 inch long; conidia 0·0016. The flocci are very peculiar." According to Petch (1919) the greater part of the Ceylon specimen of *Meliola zigzag* in Herb. R.B.G. is *Cladosporium congestum*. He also observed some immature perithecia (? of *Dothidea orbis*) amongst a basal layer of interwoven, thin black hyphæ. Indeed, these hyphæ are evident also in the specimens of *Cladosporium scopæforme* examined by me. Petch has further stated that there is nothing in the Ceylon specimen of *C. congestum* approaching *Meliola zigzag* as re-described by Gaillard (*Le Genre Meliola*, p. 81) from the type specimen, Fungi Cubenses, No. 882. The interesting point that emerges from these observations is the close association of *Cladosporium scopæforme* (= *C. congestum*) with Meliolineæ.

I consider *C. scopæforme* to be a *Helminthosporium* hyperparasitic on Meliolineæ. Accordingly, I am proposing the combination:—

Helminthosporium scopæforme (Berk.) Subramanian comb. nov.

Cladosporium scopæforme Berk., 1854, *Hooker's J. Bot.*, 6 : 208; Saccardo, 1884, *Sylloge Fungorum*, 4 : 358.

= *Cladosporium congestum* Berk., 1854, *Hooker's J. Bot.*, 6 : 208; Saccardo, 1884, *Sylloge Fungorum*, 4 : 359.

Specimens seen: on *Myristica*, Khasia (Churra), India, Herb. M. J. Berkeley, ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1580—slide), TYPE; on *Cinnamomum zeylanicum*, G. H. Thwaites, Ceylon, Herb. M. J. Berkeley, ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1579—slide).

23. *Glenospora didyma* Cooke

Glenospora didyma was described by Cooke (1876*a*, p. 117) as follows: "Epiphylla. Maculis atris, irregularibus, subconfluentibus; floccis repentibus, ramosis, divaricatis, lateraliter papillatis; sporis ellipticis, brunneis, endochromate bipartitis. On fading leaves of some undetermined plant, Kolapore, Bombay (Coll. Julian Hobson). Forming irregular black patches on the upper surface of the leaves. Threads creeping, brown, branched, divaricate, with lateral papillæ to which the spores are attached; spores elliptical ·016–·018 × ·009 mm., brown, endochromate bipartite."

Saccardo compiled this species in his *Sylloge* (Saccardo, 1884), as *Cladotrichum glenosporoides* Sacc. [non *C. didymum* (K. & Schm.) Sacc.]. Butler and Bisby (1931) listed it under this name.

I have examined the type specimen ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1581—slide). I find that there is no hyphomycete on the specimen, but only one of the Microthyriaceæ with hyphopodiate mycelium, stromata with radial covers and 2-celled ascospores. Indeed, Cooke's figures show the hyphopodiate mycelium with didymospores borne at the tips of the hyphopodia and the characteristic stromata with the radial centrally ostiolate cover (Plate 63, Figs. 11 and 12 in Cooke, 1876 *a*). The didymospores shown as borne acrogenously and singly at the tips of short branches are obviously ascospores, and the short branches the hyphopodia. In a note after the diagnosis, Cooke stated: "In the original diagnosis of this genus (*i.e.*, *Glenospora*—C. V. S) the spores are characterised as globose; but the Rev. M. J. Berkeley does not regard this as an essential character of his genus, which will have to be modified accordingly, as all the features of the present species indicate its close affinity with *Glenospora melioloides*, B. & Curt.; even to the curious discoid bodies composed of radiating flocci, the relation of which to the creeping threads has not yet been accurately determined. Probably they are early stages of the sporiferous threads."

The fungus is not a hyphomycete and since it is based on a Microthyriaceous fungus, Cooke's name for it, as well as Saccardo's, should both be rejected and deleted from the list of Indian fungi.

24 *Gliocladium compactum* Cooke & Massee

Gliocladium compactum was described by Cooke & Massee (apud Cooke, 1887, p. 16) as follows: "cæspitulis minutis, punctiformibus, ferrugineis; hyphis erectis, congestis, cæspitulos compactos efformantibus, septatis, plerumque simplicibus; capitulo conidiorum cuneato, pallide fusco, diu muco obvoluto; conidiis conglutinatis, oblongis, concatenatis, 5×3 μ, hyalino fuscis. Hab. in charta uda ex India" (Saccardo, 1892, p. 528).

Petch (1939) studied type material of this fungus and wrote as follows: "In the type in Herb. Kew, the tufts are more or less circular, and consist of a mixture of rough or spinulose red-brown hyphæ, 1·5 μ in diameter, and ellipsoid, verrucose spores, pale yellow, brownish yellow in mass, 4×3 μ. The spores are not held together by mucus, but some are contained in oval or wedge-shaped asci, about 10×7 μ. The fungus appears to be a *Eurotium*, similar to *E. orientale*, with the perithecia disintegrated and collapsed. It no doubt occurred on plants in drying papers, and parts of the fungus adhered to the paper."

My study of the type material ex Herb. M. C. Cooke ex Herb. R.B.G., Kew, has confirmed Petch's observations. *Gliocladium compactum* is based on an ascomycete and the name should be rejected.

25. *Rhinocladium corticolum* Massee

Rhinocladium corticolum Massee is based on a collection on the bark of a living mango (*Mangifera indica* Linn.) made from Poona, Bombay State. Massee's (1901, p. 153) description of the fungus was as follows: "Acervuli orbiculares, vel irregulares, 2–3 cm. diam., effuso-superficiales, velutini, nigro-olivacei. Hyphæ steriles repentes, dense intricato-ramosæ, septatæ, olivaceæ, 5–7 μ crassæ, hic inde hyphas fertiles gerentes; hyphæ fertiles erectæ, concolores, apices versus pallescentes. Conidia ad apice producta, globosa, olivacea, episporio densissime et minutissime tuberculata, 15–18 μ diam. Bombay Presidency. On the bark of a living mango, Mangifera indica Linn., Poona, Woodrow. The numerous patches of the fungus at times almost cover the bark at diseased spots."

I have examined the type specimen of this fungus ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1576—slide). The material is very meagre. I could only make out compact aggregations of deep brown cylindrical hyphæ which are intricately ramose, the branches usually arising at right angles to the parent hyphæ. They are septate, thick-walled and up to 7·2 μ thick. Although the material is meagre. I could still find a few one-celled, dark brown, somewhat globose conidia (aleuriospores) which varied from 12·6–19·8 μ in diameter. The conidia are produced terminally and singly on lateral branches or branchlets of the hyphæ and are thinner-walled than the vegetative hyphæ. I could not confirm Massee's description of the conidial epispore as minutely tuberculate; indeed, the few conidia seen by me had perfectly smooth walls.

Through the courtesy of the Government Mycologist, Coimbatore, I have been able to examine some other specimens labelled *R. corticolum* and collected on twigs of *Mangifera indica* from various parts of Southern India (ex Herb. Government Mycologist. Coimbatore):—

M.U.B.L. 1601	..	Sholavandan, Madura District, coll. Agricultural Demonstrator, 31–3–1937.
M.U.B.L. 1602	..	Panora, Wynaad, South Malabar, coll. W. McRae, 16–11–1909.
M.U.B.L. 1603	..	Pollachi, Coimbatore District, coll. R. N., June, 1923.
M.U.B.L. 1604	..	Received from Mr. Anstead on 18–12–1918 (locality not stated).
M.U.B.L. 1605	..	Manjeri, Malabar District, coll. C. R. V., 18–7–1941.

All these specimens are similar but M.U.B.L. 1601 appeared to be good material for detailed study; it is described below.

The colonies are somewhat extensive and spreading on the substratum, and deep black in colour. The fungal growth consists of black, flat masses of spreading repent hyphæ interspersed with vertical, erect, straight or bent or curved, somewhat stilboid aggregations of hyphæ which converge above. In the basal spreading stratum of repent hyphæ, the hyphæ are very closely aggregated and are not easily separable for microscopic examination and study. They are deep brown in colour and of somewhat uniform thickness, being up to 3·5–5·4 μ

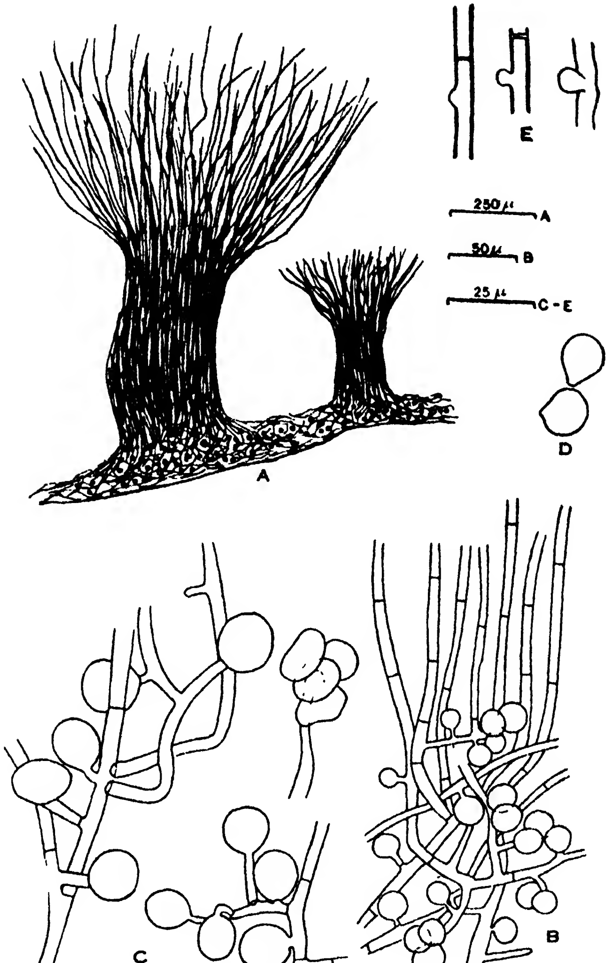

FIG. 3. *Peziotrichum corticolum* from Herb. M.U.B.L. 1601. A, the basal stratum of hyphæ and the synnema-like growths; B, intricately branched basal stratum of hyphæ and aleuriospores; C, D, conidiophores and conidia (aleuriospores); E, early stages in the formation of conidia.

wide. They are profusely and sometimes repeatedly branched, the branches often being close to each other and mostly arising at right angles to the parent hypha; they may or may not be cut off by septa. The conidia are produced singly and terminally at the tips of some of the branches and branchlets. The young branches and branchlets are usually paler in colour than the parent hyphæ, being sometimes even subhyaline; their length is variable. The conidia are one-celled, pale to dark brown in colour, somewhat globose, smooth, dry, and 12·6–18·0 μ in diam. The scattered erect vertical aggregations of hyphæ mentioned earlier arise from the spreading stratum of repent hyphæ.

They are composed of numerous hyphæ closely clustered together but spreading out above into the individual hyphæ, and are up to 2·1 mm. long and up to 420 μ wide at the base. These hyphæ are septate, mostly unbranched, sterile, and 3·5–5·0 μ wide.

Although type material of *Rhinocladium corticolum* is very meagre, it is sufficient to indicate that it is hardly different from Herb. M.U.B.L. 1601 on which the description just given is based. It appears likely that the material on which Massee based his description was immature and had only the basal stratum of repent conidiophores and conidia, the vertical fascicles of sterile hyphæ being absent. It may be mentioned here that in a note on the occurrence of this fungus in Calcutta, Bal and Banerjee (1921) have figured the tufts of sterile hyphae. The systematic position of Massee's fungus, therefore, has to be reconsidered.

M.U.B.L. 1601 appears to have close similarities to *Botrpotrichum* Sacc. & March. which is classified in the Dematiaceæ-Amerosporæ by Lindau (1900), Clements and Shear (1931) and Ainsworth and Bisby (1954). However, *B. piluliferum* Sacc. & March., the type species, is a moniliaceous fungus according to Blochwitz (1914). The fertile hyphæ are hyaline, septate and very little branched. The aleuriospores are acrogenous, borne either single on short, undifferentiated lateral branches or in whorls or in racemose clusters, hyaline, globose, 10–21 μ in diam., and smooth. Downing (1953) has reported a phialospore stage also, the phialospores being produced in a single chain which sometimes slimes down, and are elliptic, hyaline, and smooth. The sterile hairs are borne singly or in tufts on the creeping, aerial hyphæ and are olive-grey to brownish, simple and septate. M.U.B.L. 1601 is not, therefore, congeneric with *B. piluliferum.*

The question of assigning M.U.B.L. 1601 to the genus *Peziotrichum* was then considered. *Peziotrichum* was first described by Saccardo (1893) as a subgenus of *Botryotrichum* and is based on *Botryotrichum* (*Peziotrichum*) *lachnella* Sacc., collected on living branches and spines of *Bursaria spinosa* from Victoria, Australia. Saccardo's description (from Saccardo, 1895, pp. 614-15) was as follows: "Hinc inde gregarium, umbrino-fuscum; cæspitulis ex hyphis dense circulariter fasciculatis compositis, Pezizulam hirtam (ex. gr. Lachnellam barbatam revocantibus) 1 mm. diam., subinde confluentibus; hyphis sterilibus erectis, rigidulis, septulatis, 0·7 mm. longis, 3–4 μ cr., apicem versus pallidioribus, acutiusculis, basi ramos fertiles, flexuosos, inæqualiter ramulosos pallidiores gerentibus; conidiis sphæricis, levibus, subhyalinis, intus granulosis, 12 μ diam., ad ramulos acropleurogenis, subinde stipitellatis." Saccardo even suggested that it may be necessary to raise it to generic rank and, indeed, Lindau did so in 1900 (Lindau, 1900). In a critical discussion of the genera *Botryotrichum* and *Peziotrichum*, Petch (1927) indicated that the two genera are distinct since *Peziotrichum lachnella*, unlike *Botryotrichum piluliferum*, has dark-coloured hyphæ. Examination of type material of *Peziotrichum lachnella* by Downing (1953, p. 938) revealed "a growth composed of reddish brown, smooth, septate, sterile hairs which are occasionally branched and rebranched, and which are always borne at the circumference of a circular depressed acervulus; they measure 608–1040×3·9–5·2 μ. No spores were seen at this time. The growth is confined to small areas and shows no spreading mycelium".

There is no doubt that M.U.B.L. 1601 is not a *Rhinocladium*, in so far as that genus is poorly known. On the other hand, it has resemblance to *Peziotrichum lachnella*, although the colonies in the former, in contrast to those of the latter, are spreading and the sterile hairs do not appear to be confined to the circumference of the so-called acervuli; but these characteristics do not certainly warrant generic separation of M.U.B.L. 1601 from *Peziotrichum lachnella*. Thus, it would appear that M.U.B.L. 1601 and the four other collections (M.U.B.L. 1602–1605) are best classified in *Peziotrichum*. As mentioned earlier, the type material of *Rhinocladium corticolum* is very much like an immature specimen of M.U.B.L. 1601 without the vertical fascicles of sterile hyphæ. The measurements, and the nature of the vegetative hyphæ, the spore-bearing branches and the aleuriospores are similar. This fact, coupled with its occurrence on the same host, strongly suggests that Massee's fungus is an immature specimen of, and essentially the same as, M.U.B.L. 1601. Accordingly, I propose to classify provisionally all these specimens in one species in the genus *Peziotrichum* as:

Peziotrichum corticolum (Massee) Subramanian comb. nov.

= *Rhinocladium corticolum* Massee, 1901, *Kew Bull.*, **1901**: 153; Saccardo, 1906, *Sylloge Fungorum*, **18** : 572.

The name is only provisional. The 'aleuriospores' found in all collections seen are not usually shed and it is not unlikely that these may prove to belong to *Septobasidium* as, indeed, was hinted by Petch (1927) in the case of *Peziotrichum lachnella*.

26. *Helminthosporium obclavatum* Massee

Helminthosporium obclavatum was described by Massee (1899, p. 166) as follows: "Hyphæ rigidulæ, simplices, fasciculares, fuscæ, opacæ, sursum attenuatæ, 350–400×12–14 μ, maculas aterrimas velutinas formantes. Conidia elongato-obclavata, 7–11-septata, pallide olivacea, 80–120×18–20 μ. N.-W. Provinces. On branches of *Helicteres isora* Linn., Siwalik Hills, Gamble 26,477. Resembling *H. velutinum* Link, but differing in the larger pale conidia."

I have examined the type specimen ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1574). The colonies are effuse, spreading and covering the substratum, black, markedly velutinous, consisting of an abundance of crowded conidiophores. The conidiophores are simple, erect, straight or bent, cylindrical, 518–910 μ long, stromatic at the base (the stromatic base being 25·2–50·4 μ tall and 25·2–43·2 μ wide), 14·0–18·2 μ wide immediately above the stromatic base, 11·2–12·3 μ wide in the middle, and 9·8–11·2 μ wide at the tip which is rounded and has a distinct scar showing the point of attachment of the fallen conidium. They are brown, darker below, paler above, thick-walled and many-septate, the septa being farther apart towards the base than above. The conidia are produced acrogenously and singly at the tips of the conidiophores and are obclavate, widest nearer the base than above, tapering above into a somewhat prolonged, narrow, cylindrical tip, many-septate (up to 17-septate), pale to golden brown in colour, thick-walled, sometimes constricted at one or more septa, and each having a prominent, flat, dark scar at the base indicating the point of attachment to the conidiophore. The conidia are 84–118 μ long, 14·0–18·2 μ where they are widest, 5·6–7·7 μ wide at the flat base, and 2·8–5·6 μ wide towards the apex.

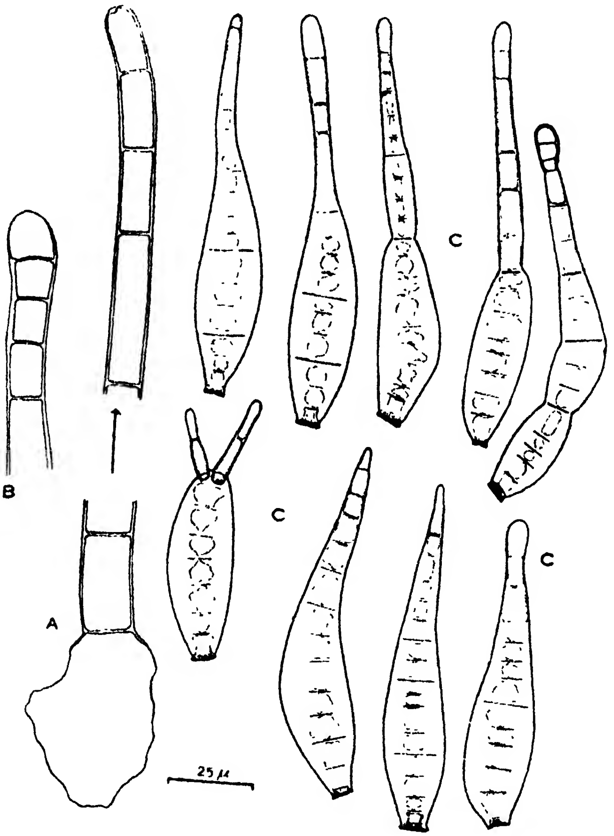

FIG. 4. *Helminthosporium siwalikum* from type specimen, Herb. M.U.B.L. 1574. A, conidiophore; B, tip of conidiophore; C, conidia.

H. obclavatum Massee (1899) may be retained in *Helminthosporium*; but it is a later homonym of *H. obclavatum* Saccardo, 1877 (Saccardo, 1884, p. 416) which is based on a collection on dead wood of *Alnus glutinosa* from Italy. Saccardo's *Helminthosporium* was described as having solitary acrogenous conidia which are 18–24-septate, obclavate-fusoid with long attenuate tips and 90×15 μ; its conidiophores were stated to be 60–70 μ long and 6–7 μ wide. It would appear, therefore, that Massee's fungus is not the same as Saccardo's. Accordingly, I propose a new name for the former:

Helminthosporium siwalikum Subramanian nom. nov.

= *Helminthosporium obclavatum* Massee, 1899, *Kew Bull.*, **1899**: 166 (Saccardo, *Sylloge Fungorum*, **16**: 1063) non *Helminthosporium obclavatum* Saccardo, 1877, *Michelia*, **1**: 85 (Saccardo, *Sylloge Fungorum*, **4**: 416).

Type specimen: on branches of *Helicteres isora* Linn., Siwalik Hills, India, coll. J. S. Gamble, January 1898, ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1574—slide).

27. *Helminthosporium bambusæ* Cooke

Cooke (1892, p. 91) described *Helminthosporium bambusæ* as follows: "Cæspitulis compactis, convexis, atris, gregariis, plerumque sphæriæformibus; hyphis fasciculatis, erectis, teretibus, septatis, pallide fuscis v. subfuligineis; conidiis acrogenis, lanceolatis, superne acutis, 3-5-septatis, nec constrictis pallide fuscis, 60–70 × 12 μ, episporio tenui. Hab. in *Bambusa spinosa*, Assam (Mann)."

I have examined type material of this species ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1572) and the following description is based on a study of it.

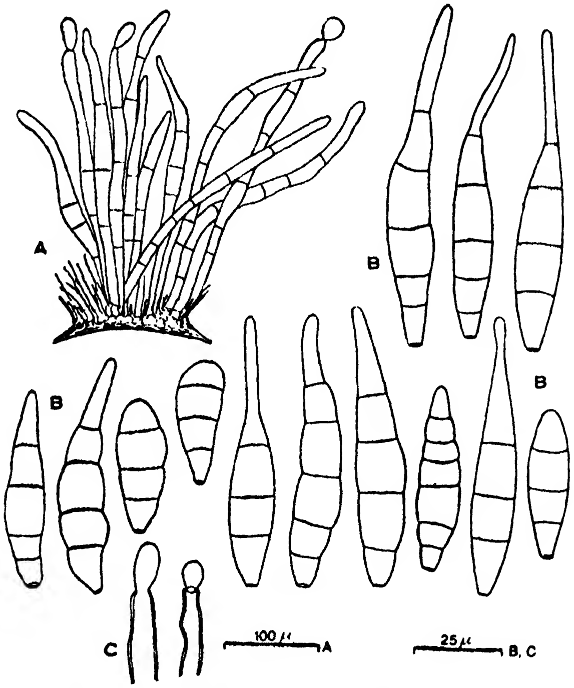

Fig. 5. *Exosporium bambusæ* **from type specimen, Herb. M.U.B.L. 1572. A, luster of conidiophores; B, mature conidia; C, method of production of conidia.**

The colonies are separate, rarely confluent, dark brown in colour, velutinous, circular to irregular in outline, up to about 0·5 mm. wide, and composed of closely aggregated conidiophores arising from a stromatic base. The conidiophores are simple, erect, straight or bent or flexuous, long, somewhat cylindrical and of uniform thickness throughout, smooth-walled, septate, dark brown in colour, paler towards the apex, up to 240 μ long and up to 14 μ wide. The conidia are produced acrogenously and singly at the tips of the conidiophores and are pale to golden brown in colour, thin-walled, long-obclavate or lanceolate, sometimes with a prolonged narrow apex, widest somewhat in the middle or immediately below, mostly 3–5-, but rarely up to 6-septate, sometimes faintly constricted at the septa and broad-based with a scar at the point of attachment to the conidiophore. They are 35–91 μ long, 11·2–14·0 μ wide where they are widest, 2·5–3·5 μ wide at the flat base and 2·1–2·8 μ wide towards the tip.

On the basis of the description just given and of Cooke's diagnosis of the fungus, I consider that the fungus is better classified in *Exosporium* as:

Exosporium bambusæ (Cooke) Subramanian comb. nov.

= *Helminthosporium bambusæ* Cooke, 1892, *Grevillea*, **20**: 91; Saccardo, 1892, *Sylloge Fungorum*, **10**: 616.

Type specimen: on *Bambusa spinosa*, Assam, G. Mann, ex Herb. R.B.G., Kew (Herb. M.U.B.L. 1572—slide).

28. *Helminthosporium cantonense* Saccardo

Helminthosporium cantonense was described by Saccardo in 1921 from a collection on *Bambusa* sp., from Canton, China (Saccardo, 1921, 1931). He described the fungus as follows (Saccardo, 1921, p. 604): "Effusum, olivaceo-nigrum, adpressum, maculiforme; conidiophoris erectis, simplicibus, ratione brevibus, 80–95 × 6 subseptatis, apice obtusiusculis, pallidioribus; conidiis obclavatis, 7- ad 9-septatis, ochraceo-fuligineis, 50–62 × 8, sursum obtusule cuspidatis, pallidioribus, sæpe curvulis."

I have examined type material of this species ex National Fungus Collections, U.S.D.A. (Herb. M.U.B.L. 1589). The following description is based on a study of the type specimen.

The colonies are blackish brown, effuse and covering large patches on the substratum. The repent hyphæ are pale brown, septate and branched. The conidiophores arise laterally from cells of the repent hyphæ, or may be terminal. They are decumbent or erect, straight or bent or curved, simple, somewhat cylindrical and of the same width throughout, dark brown in colour, paler above, septate (septa 7–21 μ apart), up to 294 μ long, 3·5–4·9 μ wide at the base, and 2·8–4·2 μ wide above. The conidia are phæophragmospores borne acrogenously and singly at the tips of the conidiophores; they are obclavate, straight or curved and bent variously, the curvature being sometimes abrupt, narrowed towards the base to a flat scar, widest immediately above, and narrowing further up, often with a somewhat prolonged and narrow cylindrical caudate tip, brown in colour, darker towards the base and paler above, and 4–13-septate. The conidia are 28–95 μ long, 7·0–8·4 μ wide where they are widest, and 2·1–4·2 μ wide at the flat base and towards the apex.

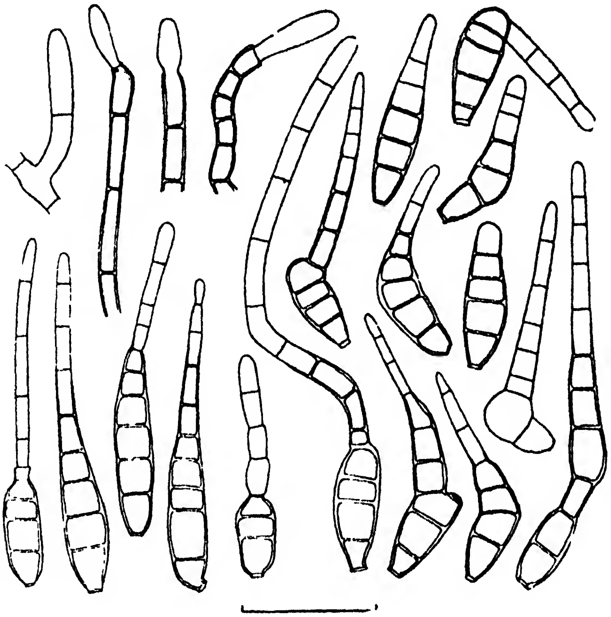

FIG. 6. Conidiophores and conidia of *Sporidesmium cantonense* from type specimen, Herb. M.U.B.L. 1589.

On the basis of this description, I think the fungus is better classified in *Sporidesmium* than in *Helminthosporium*:

Sporidesmium cantonense (Saccardo) Subramanian comb. nov.

- *Helminthosporium cantonense* Saccardo, 1921, *Philipp. J. Sci.*, **18** : 604; Saccardo, 1931, *Sylloge Fungorum*, **25** : 821.

Type specimen: on *Bambusa* sp., Kwang Tung, Canton, Reinking 4689, May 7, 1919, ex National Fungus Collections, U.S.D.A. (Herb. M.U.B.L. 1589—slide).

29. *Helminthosporium stahlii* Stevens

Helminthosporium stahlii was described by Stevens (1917) from a collection on leaves of *Passiflora fœtida* from Puerto Rico. It was described as follows: "Maculis foliicolis parvis et irregularibus quandoque latis et diffusis, supra pallidis infra obscuris; conidiophoris numerosis, laxis, longis, 155 μ, curvis, et stramineis flavis, coacervatis obscuris, simplicibus v. ramosis; conidia forma magnitudine conformibus 24×6–7 μ, elongato ellipsoideis v. piriformibus, uno apice rotundatis altere angustiore apiculatis, juventute continuis dein 1-septatis maturis 3-septatis" (from Saccardo, 1931, p. 829).

I have examined type material of this fungus, ex National Fungus Collections, U.S.D.A. (Herb. M.U.B.L. 1591). The spots on the leaves are yellowish to brownish. The conidiophores are fasciculate and arise from a stromatic base; they are lax, simple or branched, brownish at the base, paler in colour above, subhyaline towards the tip, septate, up to 170 μ long, 4·2–5·6 μ wide at the base, 2·8–4·2 μ wide and geniculate towards the tips. The conidia are produced acrogenously and singly at the tip of the conidiophore, but a succession of conidia is produced by renewed growth of the conidiophore from immediately below scars of fallen conidia. The conidia are short and cylindrical to slightly obclavate or long and typically scolecospores, subhyaline, 0–3-septate, thin-walled, and 18·2–50·4×2·8–7·0 μ.

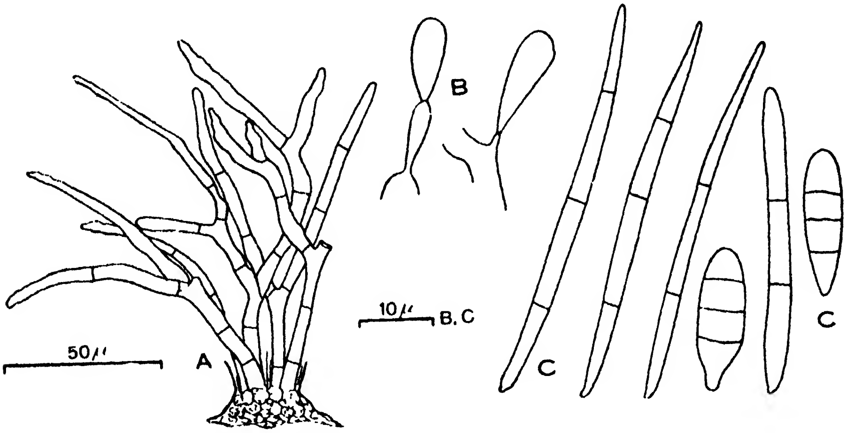

FIG. 7. *Cercospora stahlii* from type specimen, Herb. M.U.B.L. 1591. A, conidiophores; B, production of conidia; C, conidia.

It will be clear from this description and the accompanying figure that the fungus is not a *Helminthosporium*. The conidia are considerably longer and thinner than what they were described to be by Stevens. Since the conidia are typical scolecospores, I think that this fungus is best classified as a *Cercospora*. Accordingly, I propose the following combination:

Cercospora stahlii (Stevens) Subramanian comb. nov.

≡ *Helminthosporium stahlii* Stevens, 1917, *Trans. Ill. Acad. Sci.*, **10** : 208; Saccardo, 1931, *Sylloge Fungorum*, **25** : 829.

Specimens seen: on leaves of *Passiflora fœtida*, Preston's Ranch, Puerto Rico, coll. F. L. Stevens, 31–12–1913, No. 6670 Porto Rican Fungi, Univ. of Illinois Herb., TYPE (Herb. M.U.B.L. 1591—slide); on

Passiflora fœtida, Morovis Grove, Vega Baja, Puerto Rico, 26–4–1938, coll. W. A. McCubbin, det. E. E. Dicks (Herb. M.U.B.L. 1592—slide) (In this latter specimen, a slip attached to the packet adds in pencil "*Cercospora*?" after the name, *Helminthosporium stahlii* Stevens.) Both specimens, ex National Fungus Collections, U.S.D.A.

30. *Helminthosporium rostratum* Drechsler, 1923, *J. agric. Res.*, **24** : 724, *ic.*

This species is represented in Herb. M.U.B.L. (No. 1058) by one collection on dead stubble from Madras. A description, based on this material, follows: The colonies are effuse, somewhat velutinous and dark brown in colour. The conidiophores are erect, straight or bent, simple, dark brown below, becoming paler towards the tip, golden brown and geniculate towards the tip, somewhat cylindrical but gradually and slightly becoming narrower above, septate (septa 25·2–54·0 μ apart), and 430–575 × 7–16 μ. The conidia are produced acrogenously and singly at the apex of the conidiophore; successive production of conidia following renewed growth of conidiophore from immediately below scars of fallen conidia results in a geniculate apical portion. The conidia are fusiform to long-elliptical, widest in the middle or rarely immediately above or below the middle, gradually narrowing both above and below, with a basal cell which is crucible-shaped but with a narrowed, mamillate base with a distinct scar, with the apical cell broadly and smoothly rounded, straight or faintly or

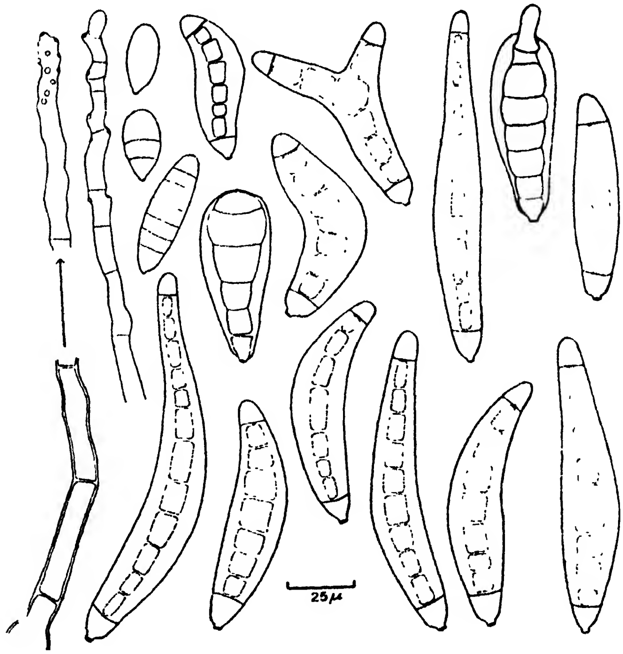

FIG. 8. Conidiophores and conidia of *Helminthosporium rostratum* from Herb. M.U.B.L. 1058.

markedly curved, rarely with a forked tip, pale olivaceous to brown in colour, many-, (up to 14-) septate, the lowermost and the topmost septa being usually thickened and prominent. The conidia are 56–140 μ long, and 12·2–26·3 μ wide where they are widest; the conidial scar at the base is about 3·5 μ wide.

Helminthosporium rostratum Drechsler (1923) was described as having simple conidiophores which are 1–6-septate, 40–180 μ long and 8 μ wide; the conidia were stated to be rostrate, 8–15-septate, 32–184 μ long and 14–22 μ wide. The conidiophores in M.U.B.L. 1058 (on dead stubble, Guindy, Madras, coll. T. S. Sadasivan, 17-12–1953) are very much longer (430–575 μ) and thicker (7–16 μ); however, the conidia are rostrate and in size, shape and septation are similar to those of *H. rostratum*. I have, therefore, assigned M.U.B.L. 1058 to *H. rostratum*.

H. rostratum is reported here for the first time from India.

31. **Helminthosporium longirostratum** sp. nov.

This fungus was collected on dead leaves of *Borassus flabellifer*, from Sevvapet, near Madras. The colonies are deep brown in colour and effuse. The conidiophores are simple, erect, straight or bent, dark brown in colour, thick-walled, cylindrical and of somewhat uniform width throughout, but slightly narrower towards the apex, swollen at the base, and many-septate. They are up to 350 μ long, 10·8–14·0 μ wide at the swollen base, 8·4–10·8 μ wide in the middle and 5·6–8·4 μ wide at the apex. The conidia are produced acrogenously and singly at the tips of the conidiophores. They are long-obclavate with an elongate and narrow apical portion, widest immediately above the base, with a prominent mamillate base showing the point of attachment to the conidiophore, straight or curved or sometimes even sharply bent, many- (up to 22-) septate, pale brown in colour, slightly paler towards the apex which is smoothly rounded, and germinating at the apical or the basal cell. The conidia are up to 310 μ long, 12·6–21·0 μ wide where they are widest, 8·4–10·5 μ wide at the basal cell and 5·6–7·7 μ wide towards the tip; the basal scar of the conidium is 2·8–3·5 μ wide.

The fungus is easily classified in *Helminthosporium*. From a study of literature, comparison of my fungus with the following three species of *Helminthosporium* appeared necessary, *viz*., *H. rostratum* Drechsler (Drechsler, 1923, p. 724), *H. giganteum* Heald & Wolf (Heald & Wolf, 1911, p. 21) and *H. makilingense* Sydow (Sydow, 1920, *Ann. mycol.*, **18** : 103). The conidial measurements and septation of these species (from descriptions) and of my fungus (Herb. M.U.B.L. 888) are:

Species	Length	Width	Septation
H. rostratum ..	32–184 μ	14–22 μ	8–15
H. giganteum ..	300–315 μ	15–21 μ	5
H. makilingense	100–300 μ	10–12 μ	12–18
M.U.B.L. 888 ..	up to 310 μ	12–21 μ	up to 22

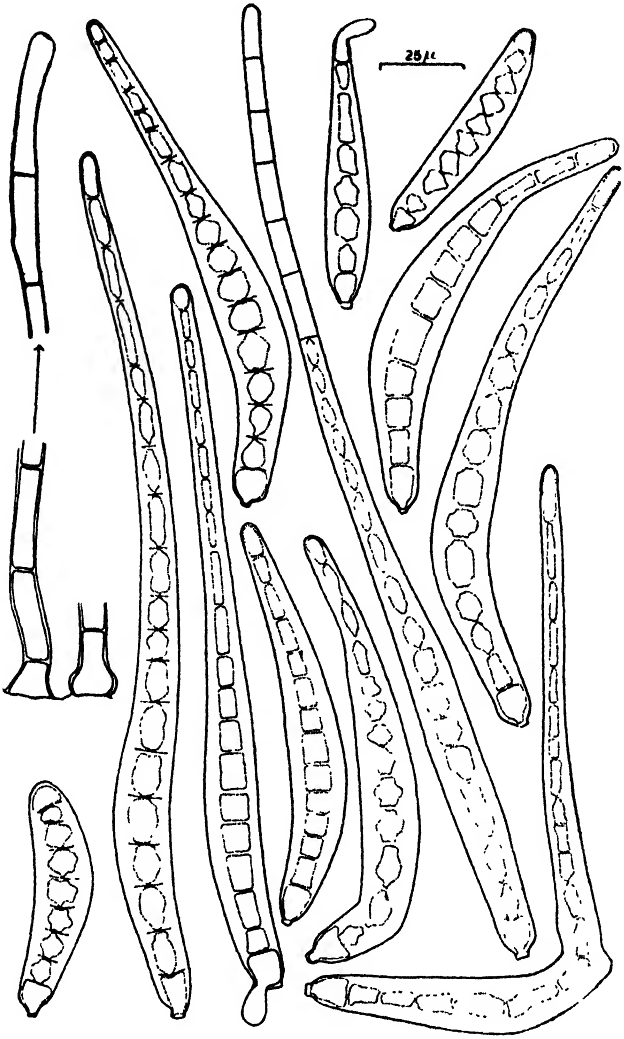

FIG. 9. Conidiophore and conidia of *Helminthosporium longirostratum* from type specimen, Herb. M.U.B.L. 888.

It is obvious that in conidial length M.U.B.L. 888 closely approaches *H. giganteum* and *H. makilingense*, but not *H. rostratum*. M.U.B.L. 888 differs, however, from *H. giganteum* in having conidia with a considerably higher septation, and from *H. makilingense* in having considerably stouter spores. M.U.B.L. 888 does not, therefore, appear to be conspecific with the three species just mentioned or, for that matter, with species so far compiled in *Helminthosporium*. Accordingly, I am classifying it as a new species:

Helminthosporium longirostratum Subramanian sp. nov.

Coloniæ fusce brunneæ, effusæ. Conidiophori simplices, erecti, recti vel curvi, fusce brunnei, crassis parietibus præditi, cylindrici, septati, usque ad 350 μ longi, 10·8–14·0 μ lati ad basim tumescentem, 8·4–10·8 μ lati ad medium, 5·6–8·4 μ lati ad apicem. Conidia producta acrogene atque singulariter ad apices conidiophororum, longo-obclavata portione apicali elongata atque angusta, rotundata ad apicem, latissima supra ipsam basim, mamillata ad basim, recta vel curva vel nonnumquam acute flexa, usque ad 22-septata. pallide brunnea, tenuiter pallidiora ad apicem, usque ad 310 μ longa, 12·6–21·0 μ crassa ad partem latissimam. 5·6–7·7 μ lata ad apicem; cellula basalis conidii 8·4–10·5 μ ampla, cicatrice basali 2·8–3·5 μ lata.

Typus lectus in foliis emortuis *Borassi flabelliferi* Linn. in loco Sevvapet, in regione Chingleput, in Statu Madras, die 10 aprilis anni 1953 a C. V. S. et positus in herbario M.U.B.L. sub numero 888.

32. *Helminthosporium sigmoideum* Cavara

Helminthosporium sigmoideum was described by Cavara (1889) from a collection on *Oryza sativa* made in Italy. He described the fungus as follows:—

"Effusum, atrum; hyphis fertilibus sparsis erectis, rigidiusculis, hinc inde nodulosis 8–10-septatis, simplicibus. olivaceis. 100–150 × 5 μ; gonidiis magnis, falcato sigmoideis, utrinque obtusis, triseptatis, cellulis mediis crassioribus, granulosis, dilute olivaceis, extimis hyalinis 55–65 × 11–14 μ.

"Sur les graines, les feuilles. les tiges de l'*Oryza sativa.* Environs de Pavie Été et automme. Forme voisine du *H. hyalophlæm* Sacc. (Fung. Ital. 814). Qui a cependant des hyphes fasciculees et des gonidies plus petites et point sigmoides de forme." (Cavara, 1889, p. 185).

Tullis (1933) made a detailed study of the fungus and showed that it is the conidial stage of *Leptosphæria salvinii* Catt. and *Sclerotium oryzæ* Catt. He made a comparative study of isolates of *Sclerotium oryzæ* from the United States, Japan and India and concluded that they were similar and the majority of them produced a conidial stage agreeing with *Helminthosporium sigmoideum.* The identity of the conidial stage with Cavara's *Helminthosporium* was confirmed by an examination of an exsiccatum distributed by Cavara under this name. On the basis of his study, Tullis (1933, p. 683) described the conidial stage as follows: "Conidiophores dark-coloured, septate, erect, simple or sparsely branched, 4–5 μ by 100–175 μ; conidia borne singly on sharp pointed sterigmata, fusiform, typically three-septate, simply curved or slightly sinuous; intercalary cells Prout's brown, densely granular; terminal cells lime-green, less granular than intercalary cells; apical cell frequently longer and less acutely pointed than basal cell; spores occasionally constricted at middle septum, 9·9 μ–14·2 μ by 29–49 μ, mostly 11–12·5 μ by 34–40 μ. Habitat on leaves and culms of *Oryza sativa* and *Zizaniopsis miliacea.*"

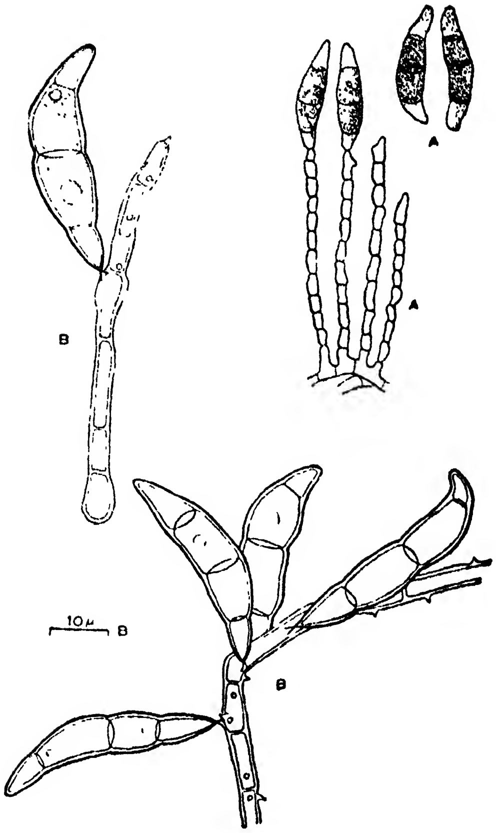

FIG. 10. *Vakrabeeja sigmoidea*: A, conidiophores and conidia, redrawn from Cavara's figures (sub. *Helminthosporium sigmoideum*) as reproduced in Tullis (1933, p. 680); B, conidiophores and conidia (also sub. *Helminthosporium sigmoideum*) redrawn from Tullis' (1933, p. 681) figure. (Magnification for A not stated.)

Cavara's and Tullis' illustrations are reproduced here (Fig. 10).

Tullis' critical and thorough study has obviated the need to restudy material of this fungus. His description and figure indicate that the conidia are typically like those of species of *Curvularia* Boedijn—*lunata* group (Boedijn, 1933) since they are characteristically bent or curved and have the middle cells darker coloured than the cells towards the apex and the base. Another interesting feature of the fungus is the production of conidia on distinct sterigmata on the conidiophore. Indeed, this is not a feature found in typical *Helminthosporium* or *Curvularia*. *Helminthosporium sigmoideum*, therefore, is neither a *Helminthosporium* nor a *Curvularia*. Since I know of no genus where it can be suitably classified, I propose a new one for it. The generic name *Vakrabeeja* is derived from Sanskrit: वक्र (*vakra*) = curved, bent; and बीज (*beeja*) = seed, spore, indicative of the curved conidia which are typical of the fungus.

Vakrabeeja Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Dematiaceas, Phragmosporas. Conidiophori erecti, brunnei, septati, simplices vel ramosi, sterigmatibus acutis. Conidia phæophragmospora, producta singulariter e sterigmatibus, fusiformia, curva vel flexa, cellulis centralibus fuscis, apicalibus vero pallidioribus. Similis *Curvulariæ* Boedijn a qua tamen differt conidiis productis e sterigmatibus acutis.

Fungus imperfectus, Moniliales, Dematiaceæ, Phragmosporæ. Conidiophores erect, brown, septate, simple or branched, with pointed sterigmata. Conidia phæophragmospores, produced singly on the sterigmata, fusiform, bent or curved, the central cells dark-coloured, end cells paler in colour. Similar to *Curvularia* Boedijn, but differs in having conidia produced on pointed sterigmata.

Type species:

Vakrabeeja sigmoidea (Cavara) Subramanian comb. nov.

Helminthosporium sigmoideum Cavara, 1889, *Rev. Mycol.*, **11** : 185, *ic.* On grains, leaves and culms of *Oryza sativa* Linn. Pavia, Italy.

Conidial stage of *Leptosphæria salvinii* Catt. and *Sclerotium oryzæ* Catt.

33. *Brachysporium senegalense* Speg.

Spegazzini described the fungus in 1914 from a collection on Gramineæ from Africa. The following is a description of the fungus (from Saccardo, 1931, p. 835): "Dense gregarium, velutinum, atrum; conidiophoris confertis, erumpentibus, erectis, simplicibus, gracilibus, 3–6-septulatis, basi subbulbosis, atris sed pellucidis, 209–300 × 6–8 μ, leniter flexuosis, apice integris monospermis; conidiis solitarie acrogenis, mox deciduis, ellipsoideo-fusoideis, utrinque acutiusculis, rectis vel inæquilateris, 4-septatis, ad septa leniter constrictis, 22–28 × 10–12 μ loculis extimis hyalinis, mediis olivascentibus, centrale majore atro-olivaceo."

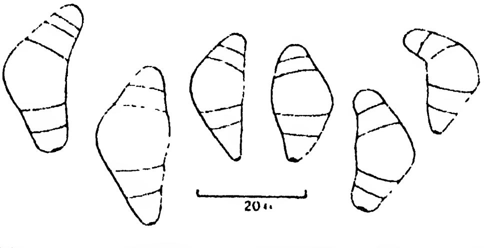

FIG. 11. Conidia of *Curvularia senegalensis* from type specimen, Herb. M.U.B.L. 1612.

I have examined type material of this fungus, ex Colecciones Micologicas, Museo-Instituto Spegazzini (Herb. M.U.B.L. 1612). The material has been well preserved. A study of the material showed that the conidia are mostly 4-septate, as indeed was described by Spegazzini, and typically like those of *Curvularia* Boedijn. They are straight or more often curved, widest in the middle and becoming narrower towards either end. The central cell of the conidium is the darkest, widest and longest; the apical and the basal cells are paler in colour and sub-hyaline. The apical cell is rounded at the tip, and the basal cell is crucible-shaped with a somewhat flattened base and distinct basal scar indicating the point of attachment to the conidiophore. The conidia are 21–31 μ long and 8·4–12·6 μ wide where they are widest. The conidiophores are geniculate towards the tip and this indicates successive production of acrogenous conidia by renewed growth of the conidiophore from immediately below scar of previous fallen conidium. It is obvious that the fungus is not a *Brachysporium*; it is clearly a *Curvularia* of the *Geniculata* group (Boedijn, 1933). A comparison of this fungus with descriptions or material of the various species of *Curvularia* belonging to this group indicates that it is the same as *Curvularia falcata* (Tehon) Boedijn [= *Acrothecium falcatum* Tehon (Tehon, 1919)]. In a discussion of this group of fungi, Groves & Skolko (1945) considered the relation of two other names to *Curvularia falcata*, *viz.*, *Helminthosporium caryopsidum* Sacc. and *H. curvulum* Sacc., both of which were stated to have spores of the *Curvularia* type. On the basis of material available to them under these names, they pointed out that, should further critical studies prove it to be so, *Helminthosporium caryopsidum* (1914) would provide the earliest name for *Curvularia falcata*. In any case, *Brachysporium senegalense* has to be classified in *Curvularia* and, as far as our present knowledge goes, provides, in my opinion, the earliest name for *Acrothecium falcatum* Tehon.

Curvularia senegalensis (Speg.) Subramanian comb. nov.

Brachysporium senegalense Speg., 1914, *Anal. Mus. nac. Buenos Aires*, **26** : 133; Saccardo, 1931, *Sylloge Fungorum*, **25** : 835.

= *Acrothecium falcatum* (as *flacatum*) Tehon, 1919, *Bot. Gaz.*, **67** : 509, *ic.*; Saccardo, 1931, *Sylloge Fungorum*, **25** : 813.

= *Curvularia falcata* (Tehon) Boedijn (as *C. flacata*), 1933, *Bull. Jard. bot. Buitenz.*, Ser. III, **13:** 130; Groves, J. W. & Skolko, A. J., 1945, *Canad. J. Res.*, C., **23** : 99, *ic.*

The fungus was recorded earlier from this country as *Curvularia falcata* (Subramanian, 1953 *b*).

34. *Polydesmus indicus* Subramanian

35. *Septonema intercalare* Cash & Watson

I consider it necessary to discuss these two species together.

Polydesmus indicus was described by me two years ago (Subramanian, 1954) from a collection on dead spathe of *Cocos nucifera* from the T.-C. State, India. The specific diagnosis was as follows: "Colonies effuse, black, powdery. Repent hyphæ brown, branched, septate, up to 5 μ broad. Conidiophores arising laterally from cells of repent hyphæ, short, mostly simple, subhyaline to pale brown, septate, thin-walled, often torulose, up to 25 μ long, up to 5 μ broad. Conidia dark brown, 1–4-celled, mostly 2–3-celled, thick-walled, faintly verrucose, acrogenous, produced acropetally in unbranched or branched chains from the tip of the conidiophore, connected with each other by an isthmus (separating cell), 9–20 × 4·8–7·2 μ; isthmus small, narrow, pale brown, 1-celled, produced singly from any part of apical or other cells of each conidium, or often up to 4 from the apical cell of conidium, resulting in branched chains of conidia, 3·2–4·0 × 3·2 μ" (Subramanian, 1954, pp. 33–34).

Septonema intercalare was described by Cash & Watson (1955) recently from several collections on Orchidaceæ from the United States. They described the fungus as follows: "Closely compact chains of cells forming pulverulent masses on the host surface; no well-developed conidiophores, the conidial chains originating from 2–3 toruloid, subglobose, pale greenish-brown basal cells 2–3 μ in diameter; conidial filaments 150–175 μ long, simple or 2–3-branched; conidia thick-walled, oblong-ellipsoid, at first pale olivaceous, becoming dark brown, simple to 5-septate, developed acropetally, 11–25 × 4–6 μ, mostly 12–14 × 5–6 μ, excluding the intercalary cells; intercalary cells 1–2, globose, 2–3 μ in diameter, hyaline to subhyaline, developing at the distal end of each conidium and remaining attached to the conidium after the chain breaks up; branching of chain occurring where two intercalary cells are formed on a single conidium and a new conidium is developed from each" (Cash and Watson, 1955, p. 744).

A comparison of the descriptions of *Polydesmus indicus* and of *Septonema intercalare* shows that they are congeneric, but specifically distinct. The production of branched acropetal chains of phæophragmospores which are individually linked by characteristic "intercalary cells" or "isthmi" or "separating cells" is, of course, the notable feature of both the species. A further common feature is the possession of short, somewhat toruloid conidiophores. I consider that the systematic position of these two interesting fungi has to be re-considered on the basis of these features. I do not consider *Septonema intercalare* to be congeneric with *S. secedens* Corda (the type species of *Septonema* Corda) since *S secedens* does not possess the intercalary cells which are so characteristic of *S. intercalare* (see Hughes, 1951 *a*, for an excellent description of *S. secedens*). Indeed, it was on the basis of the presence of such intercalary cells that I classified my fungus on *Cocos nucifera* in the genus *Polydesmus* Mont. and not in *Septonema*. Its resemblance to *Torula* is superficial since *T. herbarum* (Pers.) Link. ex Fr. (the type species) lacks the intercalary cells. As I pointed out in my earlier paper (Subramanian, 1954), *Polydesmus* is considered by some authors to be synonymous with *Alternaria*, and I now think, especially in view of the occurrence of a fungus similar to *Polydesmus indicus* in America on a number of different hosts, that the genus *Polydesmus* should not be used as a repository for any fungus until that genus is better known. I consider it necessary, therefore, to propose a new genus to accommodate *Polydesmus indicus* and *Septonema intercalare*. The generic name proposed, *viz.*, *Bahusandhika*, is derived from Sanskrit: बहु (*bahu*) = many, and संधिक (*sandhika*) = joint, indicative of the many joints (intercalary or separating cells) which are characteristic of the fungi.

Bahusandhika Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Dematiaceæ, Phragmosporas. Conidiophori decumbentes vel erecti, simplices vel ramosi, sæpe torulosi. Conidia brunnea, ter vel pluries cellulata, producta in catenulas acropetas, simplices vel furcatas, quarum aliæ ab aliis per isthmum discernuntur. Isthmi simplices, singulariter producti ex parte quavis cellularum apicalium vel aliarum uniuscuisque conidii vel sæpe usque quaterni ex cellula apicali conidii, hoc vero originem dat catenis ramosis conidiorum.

Fungus imperfectus, Moniliales, Dematiaceæ, Phragmosporæ. Conidiophores decumbent or erect, simple or branched, often torulose. Conidia brown, 3-many-celled, produced in acropetal, simple or branched chains, connected with each other by an isthmus (= separating cell). Isthmi simple, produced singly from any part of apical or other cells of each conidium or often up to 4 from the apical cell of conidium, resulting in branched chains of conidia.

Type species

Bahusandhika indica (Subram.) Subramanian comb. nov.

= *Polydesmus indicus* Subramanian, 1954, *J. Indian bot. Soc.*, 33 : 33, *ic.*

Type specimen: on dead spathe of *Cocos nucifera* L., Ernakulam, Travancore-Cochin State, 16–5–1953, coll. C. V. S., Herb. M.U.B.L. 963.

Septonema intercalare is also placed in this genus as:

Bahusandhika intercalare (Cash & Watson) Subramanian comb. nov.

= *Septonema intercalare* Cash & Watson, 1955, *Mycologia*, 47: 744.

Specimens (not seen by me): on leaves, stems and pseudobulbs of Orchidaceæ: *Cattleya bowringiana*, Canal Zone (San Fransisco, California, 26493, Nov. 1949, A. S. Johnson); *Lælia* sp. Venezuela (Brownsville, Texas, 62939, TYPE, October 1946, R. A. Alexander); *Odontoglossum* sp., Costa Rica (San Fransisco, 27438, Nov. 1950, L. J. Lefebvre & F. M. Thompson); *Oncidium sphacelatum*, Mexico (El Paso, Texas, 51249, Aug. 1948, E. Smith).

36. **Septonema bombayense** sp. nov.

This fungus was collected on dead stems by me from Castle Rock, Bombay State, during a visit in 1954. A description of the fungus follows: the colonies are dark brown in colour, effuse and powdery. The conidiophores, which arise from repent hyphæ, are closely crowded, repent, decumbent or sometimes erect, straight or curved, septate (septa 4·2–16·8 μ apart), dark brown in colour, somewhat cylindrical, simple or branched, branches arising immediately below septa, constricted at the septa towards the apex and imperceptibly merging into the conidial chains which are acrogenous; the conidiophores are markedly verru-

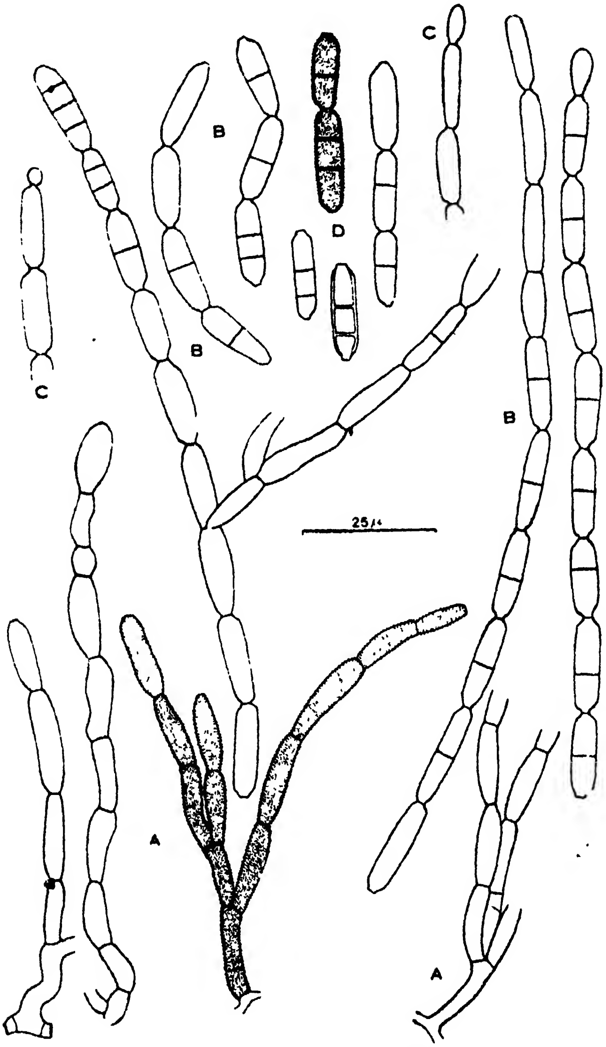

FIG. 12. *Septonema bombayense* from type specimen, Herb. M.U.B.L 1179. A, conidiophores; B, chains of conidia; C, tips of conidial chains showing acropetal development of conidia; D, conidia.

cose especially towards the apex and are up to 140 μ long and 2·8–4·9 μ wide. The conidia are produced acrogenously on the conidiophore and its branches, and form acropetal chains. The conidia break apart readily and are somewhat similar to those of *Septonema secedens* Corda in shape, being oval-oblong or oblong, usually a little wider at the upper end, often very slightly waisted in the middle, with a slightly raised flat scar about 2·1–2·8 μ wide at either end, thick-walled, mostly 1-septate, often 2–3-septate, not constricted at the septa, subhyaline to pale brown in colour, minutely verrucose, 14–21 μ long, and 2·8–5·0 μ wide. In microscopic preparations, conidial chains composed of up to 13 conidia and up to 184 μ long have been seen.

The fungus is obviously congeneric with *Septonema secedens* Corda, as described in detail by Hughes (1951 *a*), despite the fact that the conidial chains are composed largely of 1-septate, but less frequently of 2–3-septate conidia. It is, however, specifically distinct since its conidia are shorter, thinner, and paler in colour than those of *S. secedens*. Further, the conidia in my fungus are verrucose whereas in *S. secedens* they are smooth. A comparison with descriptions of species of *Septonema* so far known indicated some resemblance to *S. toruloides* Berlese (1892), but Berlese's figures of his fungus (Berlese, 1892, Plate X, Figs. 18–20) strongly suggest *Torula herbarum* (Pers.) Link ex Fr. I have not found a suitable name for my fungus in *Septonema* and I am, therefore, proposing a new name for it.

Septonema bombayense Subramanian sp nov.

Coloniæ fusce brunneæ, effusæ, pulverulentæ. Conidiophori emergentes ex hyphis repentibus, arcte aggregati, repentes, decumbentes vel nonnumquam erecti, recti vel curvi, plus minusve æquæ latitudinis ex basi ad apicem, septati (septis 4·2–16·8 μ inter se distantibus), fusce brunnei, simplices vel ramosi, ramis sub ipsa septa insertis, constricti ad septa, verrucosi atque sensim sine sensu desinentes in catenulas conidiales ad apicem, usque ad 140 μ longi, 2·8–4·9 μ lati. Conidia producta acrogene in catenulas acropetas ad apices conidiophororum atque ramorum, sat faciliter decidentia in partes, ovato-oblonga vel oblonga, sæpe tenuissime constricta ad medium, cicatrice paulum elevata 2·1–2·8 μ latâ ad utrumque apicem ornata, crassis parietibus prædita, ut plurimum semel septata, sæpe bis vel ter septata, non constricta ad septa, subhyalina vel pallide brunnea, minute verrucosa, 14–21 × 2·8–5·0 μ. Catenulæ conidiales usque ad 184 μ longæ.

Typus lectus in ligno emortuo, ad Castle Rock, in Statu Bombay, die 29 mensis decembris anni 1954, a C. V. S. et positus in herbario M.U.B.L. sub numero 1179.

37. **Dendrographium interseminatum** sp. nov.

The fungus was recently collected by me on dead twigs from Madras. The colonies are composed of numerous synnemata, and are deep brown in colour. The synnemata are erect, straight or bent, conspicuous, separate or sometimes crowded and 350–730 μ tall. Each synnema has a distinct, somewhat cylindrical dark stalk, a swollen base, and a capitate, expanded apical head composed of radiating free hyphæ (conidiophores) bearing conidia. The stalk is composed of closely aggregated, simple, dark brown, septate, parallel hyphæ 2·8–4·2 μ wide; it is of variable length, 35–140 μ wide at the base and 28–168 μ wide immediately below the expanded apical crown of free conidiophores. The capitate apical expanded part of the synnema is 98–196 μ tall and 98–350 μ wide. The conidiophores are the free ends of the hyphæ of the synnema, becoming lax and radiating above; they are brown, darker below, paler above, septate, with characteristic knee-like joints and prominent scars left by fallen conidia, simple or branched, the branches always arising at the joints, minutely verrucose and 4·2–7·0 μ wide. The conidia are acropleurogenous and confined to the knee-like joints, formed in short, easily seceding acropetal chains, dark brown, somewhat cylindrical-oblong with only a flat basal scar and a rounded apical portion or sometimes with flat scars at either end, thick-walled, verrucose, mostly 3-septate, 21·0–25·2 μ long and 5·6–7·0 μ wide.

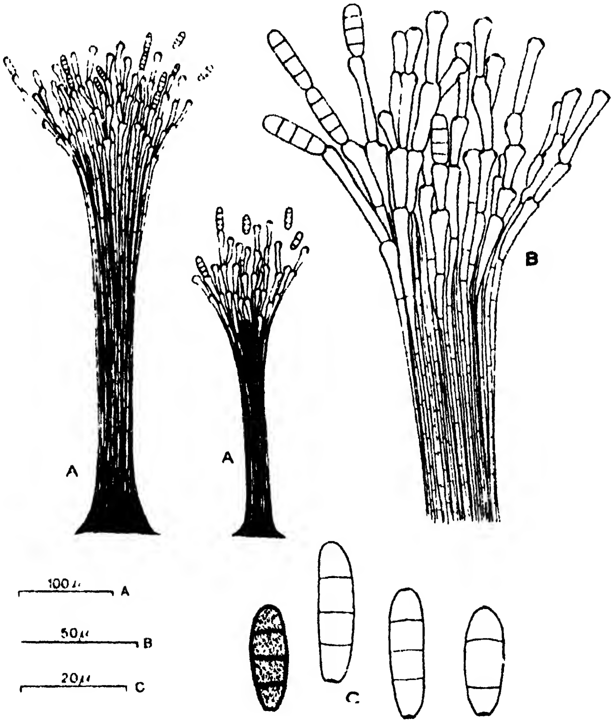

FIG. 13. *Dendrographium interseminatum* from type specimen, Herb. M.U.B.L. 1474. A, synnemata; B, upper part of a synnema; C, conidia.

I have noticed variation in the nature of the synnemata: they may be composed of closely compacted parallel hyphæ or may sometimes simulate somewhat lax fascicles of parallel hyphæ. Nevertheless, as may be seen from the accompanying figure, the fungus is easily recognised as one of the Stilbaceæ. The conidial chains are not persistent but easily fragment into single conidia, but I have no doubt that they are produced in chains. My fungus comes closest to the genus *Dendrographium* Massee (*Grevillea*, **21** : 5, 1892) and since it appears to differ from species of this genus so far known, I am giving it a new name. The specific epithet *interseminatum* has been chosen mainly because the conidiophores and conidia of the fungus show a striking resemblance to those of *Dendryphion interseminatum* (Berk. & Rav.) Hughes.

Dendrographium interseminatum Subramanian sp. nov.

Synnemata erecta, recta vel curva, singula vel gregaria, 350–730 μ alta, singula ornata stipite distincto et apice capitato, expanso, constanti ex hyphis liberis radiantibus (conidiophoris) quibus conidia insidunt. Stipes aliquantum cylindricus, tumescens atque 35–140 μ latus ad basim, constans ex hyphis arcte aggregatis, simplicibus, fusce brunneis, septatis, parallelis, 2·8–4·2 μ latis, 28–168 μ latus sub ipso apice fertili expanso. Pars apicalis dilatata synnematis 98–196 μ alta, 98–350 μ lata. Conidiophori brunnei, septati, characteristice geniculati, et cicatricibus prominentibus ornati post abscissionem conidiorum, simplices vel ramosi, ramis semper e nodis surgentibus, minute verrucosi, 4·2–7·0 μ lati. Conidia acropleurogena atque limitata ad nodos geniculatos, efformata in catenulas breves, acropetas secedentes, fusce brunnea, cylindrico-oblonga, rotundata ad apicem, plana cicartrice basali vel planis cicatricibus ad utrumque apicem ornata, crassis parietibus prædita, ut plurimum ter septata, verrucosa, 21·0–25·2 × 5·6–7·0 μ.

Typus lectus in virgulis emortuis quibusdam, in loco Marina Universitati opposito, ad Chepauk, in urbe Madras, die 6 decembris anni 1955 a C. V. S. et positus in herbario M.U.B.L. sub numero 1474; lectus etiam in culmis emortuis *Clitoriæ ternateæ* L., in campo Laboratorii Botanici Universitatis, in urbe Madras, die 18 augusti anni 1955 a C. V. S. et positus in herbario M.U.B.L. sub numero 1319.

38. **Dwayamala prathilomaka** gen. et sp. nov.

The fungus is represented in Herb. M.U.B.L. by two collections, one from Madras and the other from the Nilgiris. The colonies are deep brown in colour and are composed of somewhat dense groups of conidiophores. The conidiophores arise laterally from cells of repent hyphæ which are subhyaline to brown, septate, branched and 2–5 μ wide. They are brown in colour, erect, straight or bent or curved, cylindrical, widest and darkest at the base, becoming narrower and paler above, thick-walled below, thinner-walled above, septate [septa 14·4–68·4 μ apart, farther apart above than below], simple or branched, usually with conspicuous knee-like joints, verrucose towards the apex, producing conidia on sporogenous cells, 300–700 μ long, 8·4–11·2 μ wide at the base, up to 7 μ wide in the middle and 3·5–6·3 μ wide at the apex. The conidiophore branches, when present, are paler in colour than the main stipe; they may arise from any part of the conidiophore, but usually from immediately below septa, and largely confined to the upper two-thirds of the conidiophore. The branching is usually racemose, but not always so. The sporogenous cells are borne directly on the cells of the main stipe and branches; they arise below septa, usually immediately below them, often elsewhere, singly or in groups of more than one and up to several. They are concolorous with the main stipe or branches on which they are borne, or slightly paler. They

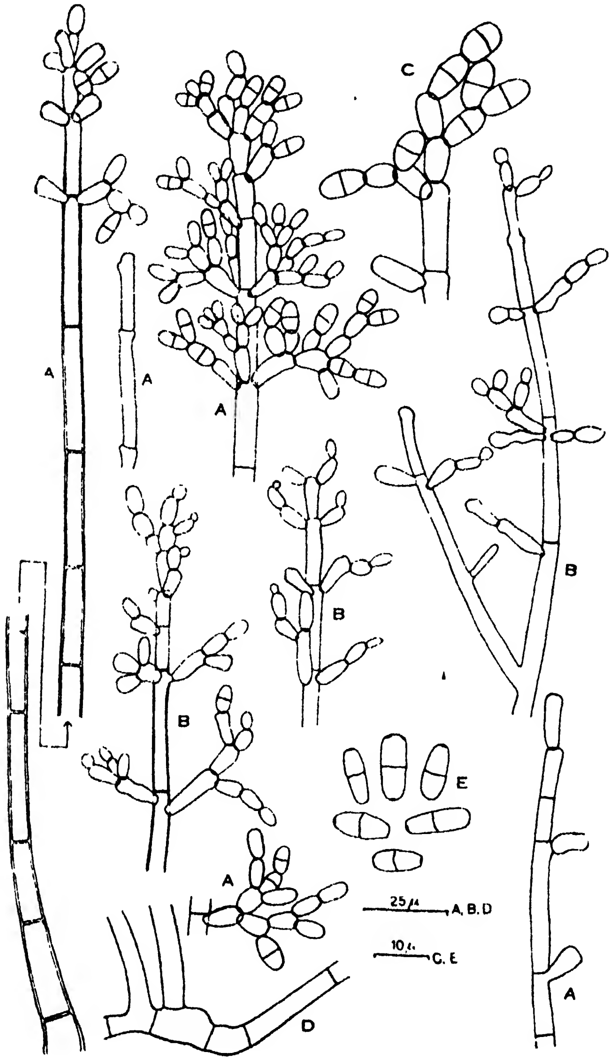

FIG. 14. *Dwayamala prathilomaka*: A, B, conidiophores and conidia; C, formation of conidia; D, vegetative hypha with basal part of conidiophores; E, mature conidia. (A, D and E from Herb. M.U.B.L. 1421; B, C, from type specimen, Herb. M.U.B.L. 1620).

are usually simple, somewhat clavate or cylindrical, with flattened apices, 8·4–12·6 μ long and 4·2–6·3 μ wide. The apices of the main stipe of the conidiophore and of its branches always end in sporogenous cells similar to those borne elsewhere on them; these terminal sporogenous cells are, however, longer, being up to 14·0 μ long, and are up to 4·2 μ wide. The conidia are produced in simple or branched chains from one or more points on the apical part of the sporogenous cells, and these points coincide with the scars left on the sporogenous cells after the conidial chains are shed. The mature conidia are pale to dark brown in colour, ovoid to elongate-ovoid with rounded or somewhat flattened ends, one-septate, thick-walled, finely verrucose, 7–12 μ long and 3·5–5·6 μ wide. They are produced in acropetal, simple or branched chains, but usually mature from the apex downwards in the chains, as in some species of *Periconia* (Mason & Ellis, 1953; Subramanian, 1955 *a*).

The most noteworthy features of the fungus just described are the possession of simple or branched macronematous conidiophores producing conidia on sporogenous cells borne laterally and terminally on the conidiophore and its branches, and the production of phæodidymospores in simple or branched chains developing acropetally but maturing from the apex downwards. Indeed, it is very much like some species of *Periconia*, but differs from them in having didymospores. It obviously belongs to the Hyphomycetes-Dematiaceæ-Didymosporæ, but I know of no genus which combines the characteristics exhibited by my fungus. I. therefore, consider it necessary to establish a new genus for it. The generic and specific names are both derived from Sanskrit: the generic name *Dwayamala* from द्वय (*dwaya*) = pair, in twos, and माला (*mala*) = chain, indicative of the chains of 2-celled conidia; and the specific name *prathilomaka* from प्रतिलोमक = inverted, contrary to the natural or prescribed order, suggestive of the maturation of the conidia in the conidial chains from the apex downwards in contrast to their development in an acropetal manner.

Dwayamala Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Dematiaceas et Didymosporas. Hyphæ repentes brunneæ, septatæ, ramosæ. Conidiophori erecti, simplices vel ramosi, septati, brunnei, producentes conidia e cellulis sporogenis. Cellulæ sporogenæ simplices, brunneæ, lateraliter productæ e cellulis conidiophororum atque ramorum, et ex eisdem etiam terminaliter. Conidia producta in catenulas acropetas, simplices vel ramosas ex una alterave parte ad apicem cellularum sporogenarum, brunnea, semel septata, maturitatem attingentia ex apice deorsum in catenulis.

Fungus imperfectus, Moniliales, Dematiaceæ, Didymosporæ. Repent hyphæ brown, septate, branched. Conidiophores erect, simple or branched, septate, brown, producing conidia on sporogenous cells. Sporogenous cells simple, brown, produced laterally on cells of conidiophore and branches, and terminally on them. Conidia produced in simple or branched acropetal chains from one or more points on the apex of the sporogenous cells, brown, 1-septate, maturing from apex downwards in the chains.

Type species

Dwayamala prathilomaka Subramanian sp. nov.

Coloniæ brunneæ, constantes ex aggregatione conidiophororum. Conidiophori lateraliter surgentes e cellulis hypharum repentium brunnei, erecti, recti vel curvi vel flexi, cylindrici, fusciores ad basim, pallidiores supra, septati (septis inter se 14·4–68·4 μ distantibus), simplices vel ramosi, geniculati, verrucosi ad apicem, producentes conidia e cellulis sporogenis, 300 700 μ longi, 8·4–11·2 μ lati ad basim, usque ad 7 μ lati ad medium, 3·5–6·3 μ lati ad apicem. Conidiophorɔrum rami ex parte quavis conidiophori surgunt, sed sæpissime ex regione sub ipsis septis posita, racemosi. Cellulæ sporogenæ duplicis naturæ; laterales et terminales; laterales quidem insidentes cellulis stipitis principis vel ramorum, ex parte sub ipsis septis posita vel aliunde procedentes, singulæ vel aggregatæ, conidiophoro vel ramis concoloræ, vel hisce pallidiores, simplices, clavatæ vel cylindricæ, apicibus complanatis, 8·4 12·6 μ longæ, 4·2–6·3 μ latæ; terminales vero lateralibus similes, usque ad 14·0 μ longæ, 4·2 μ latæ. Conidia producta in catenulas simplices vel ramosas ex una alterave parte ad apicem cellularum sporogenarum; catenulæ evolvuntur acropete sed conidia maturitatem attingunt ex apice deorsum in catenulis. Conidia matura pallide vel fusce brunnea, ovoidea vel elongato-ovoidea, apicibus rotundatis vel aliquantum complanatis, semel septata, crassis parietibus prædita, minute verrucosa, 7–12 μ longa, 3·5–5·6 μ lata.

Typus lectus in culmo emortuo quodam, in hortu Gubernii, in loco Ootacamund, in districtu Nilgiris, in Statu Madras, die 24 septembris anni 1955 a C. V. S. et positus in herbario M.U.B.L. sub numero 1620; lectus etiam in culmis emortuis *Clitoriæ ternateæ* Linn., in hortu Laboratorii Botanici Universitatis, in urbe Madras, die 10 novembris anni 1955 a C. V. S. et positus in herbario eodem sub numero 1421.

39. **Nalanthamala madreeya** gen. et sp. nov.

An interesting Tuberculariaceous fungus was recently collected from the University Botany Laboratory campus, Madras. It was found growing on dead stems. The sporodochia are somewhat button-like, scattered, separate, superficial, hemispherical to subglobose, sometimes shortly stipitate and pale white in colour. They are mostly 700–980 μ in diameter and 420–700 μ tall. The sporodochia are composed of a conspicuous, somewhat hemispherical, pseudoparenchymatous tissue of variable size which is covered over by conidiophores and conidia. The pseudoparenchymatous tissue is massive and is composed of polygonal, thin-walled hyaline cells up to 28 μ wide. The conidiophores arise from the upper layers of the pseudoparenchymatous tissue. They are of variable length and are hyaline, septate, radiating, repeatedly and verticillately branched and 4·2–7·0 μ wide. Every conidiophore branch terminates ultimately in one or more phialides. The phialides are elongate, widest at the base, narrowed towards the apex, simple, hyaline, 9·8–35·0 μ long, 4·2–8·4 μ wide at the base and 2·1–2·8 μ wide at the apex. The conidia are produced in simple basipetal chains at the tips of the phialides. They are elliptical-oval or lenticular, hyaline, 1-celled, smooth and mostly 7·0×2·8 μ.

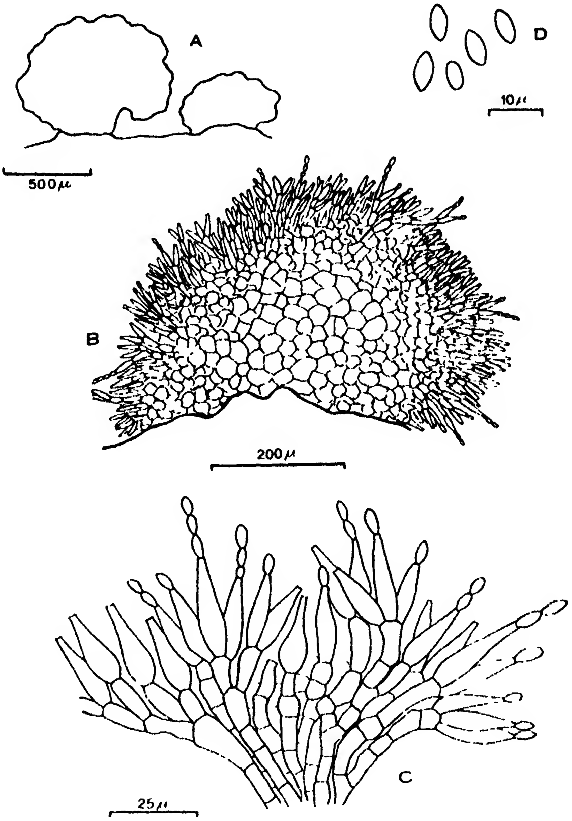

Fig. 15. *Nalanthamala madreeya* from type specimen, Herb. M.U.B L. 1466. A, B, sporodochia ; C, conidiophores and phialides, with conidia and conidial chains; D, conidia.

The fungus is easily placed in the Tuberculariaceæ-Mucedineæ-Hyalosporæ. It comes closest to *Riclaretia* Peyronel (see Saccardo, 1931, pp. 953–54) but differs from it in having conidiophores which are repeatedly and verticillately branched and in having conidia which are oblong and not bacillar. For the same reasons it differs also from *Cylindrocolla* Bon. It resembles *Verticillodochium tubercularioides* (Speg.) Speg. (the type species of the genus *Verticillodochium* Speg.) to some extent (Saccardo, 1931, p. 957), but in this fungus the conidia are produced singly and not in chains. I know of no genus in which it can be placed and I, therefore, propose a new one for it. The generic name *Nalanthamala* is derived from Sanskrit: from नाल (*nala*) = tube, tubular vessel, अन्त (*antha*) = end, and माला (*mala*) = chain, indicative of a chain at the tip of a tube (phialide).

Nalanthamala Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Tuberculariaceas, Hyalosporas. Sporodochia superficialia, sessilia vel stipitata, separata, hemisphærica vel subglobosa, alba, constantia e textibus pseudoparenchymaticis, conspicuis, hemisphæricis, hyalinis, quos operiunt conidiophori et conidia. Conidiophori surgentes e seriebus superioribus textuum pseudoparenchymaticorum, iterum iterumque ramosi, septati, hyalini, ramis, desinentibus in phialides. Phialides simplices, hyalinæ. Conidia producta acrogene, in catenulas simplices, basipetas, unicellulata, hyalina, elliptica vel ovalia vel lenticularia.

Fungus imperfectus, Moniliales, Tuberculariaceæ, Hyalosporæ. Sporodochia superficial, sessile or stipitate, separate, hemispherical to subglobose, white, composed of a conspicuous, hemispherical, hyaline, pseudoparenchymatous mound of tissue covered over by conidiophores and conidia. Conidiophores arising from upper layers of pseudoparenchymatous tissue, repeatedly branched, septate, hyaline, branches terminating in phialides. Phialides simple, hyaline. Conidia produced in acrogenous, simple, basipetal chains, 1-celled, hyaline, elliptical or oval or lenticular.

Type species

Nalanthamala madreeya Subramanian sp. nov.

Sporodochia dispersa, separata, superficialia, hemisphærica vel subglobosa, sessilia vel nonnumquam breviter stipitata, pallide alba, 420–700 μ alta, 700–980 μ diameter, constantia e textibus pseudoparenchymaticis aliquantum hemisphæricis, quos operiunt conidiophori et conidia. Textus pseudoparenchymatici constant e cellulis polygonalibus, tenui pariete præditis, hyalinis, usque ad 28 μ latis. Conidiophori emergunt e seriebus superioribus huius textus, longitudinis variæ, hyalini, septati, radiantes, iterum atque iterum ramosi, 4·2–7·0 μ lati; rami tandem desinunt in phialides. Phialides simplices, hyalinæ, elongatæ, latissimæ ad basim, angustatæ ad apicem, 9·8–35·0 μ longæ, 4·2–8·4 μ latæ ad basim, 2·1–2·8 μ latæ ad apicem. Conidia producta in catenulas simplices acrogenas basipetas ad apices phialidum, elliptico-ovata vel lenticularia, hyalina, unicellulata, levia, 7·0 × 2·8 μ.

Typus lectus in culmis emortuis, in campo Laboratorii Botanici Universitatis, in urbe Madras, die 3 mensis decembris anni 1955, a K. Ramakrishnan, et positus in herbario M.U.B.L. sub numero 1466.

40. **Kutilakesa madreeya** gen. et sp. nov.

This interesting Tuberculariaceous fungus was found growing on dead leaves of *Sansevieria* sp. in a shady moist place amongst litter in the University Botany Laboratory campus, Madras. It forms sporodochia in prolific numbers on the substratum. The sporodochia are discrete, superficial, button-like, mostly stipitate, sometimes sessile, pale green in colour and setose. The stipe may be short or long, up to 182 μ tall and up to 154 μ wide; it is composed of a compact group of hyphæ which are hyaline. The sporodochial elements expand above the stipe into the fertile portion which is up to 420 μ in diameter and up to 280 μ in height. The setæ arise from the base of the stipe as prolongations of some of the hyaline hyphæ. They are erect, deep brown and straight below, paler above, characteristically circinate or coiled towards the upper half, almost hyaline towards the tip, cylindrical and of uniform thickness throughout except at the tip where it is slightly wider and clavate, markedly verrucose in the upper two-thirds of its length, up to 6-septate, simple, thick-walled below and thin-walled above. They are 108–144 μ long, 2·1–3·5 μ wide at the base and 4·9–6·3 μ wide at the tip. The conidia are produced at the tips of phialides which are developed as the ultimate branches or branchlets of erect, hyaline, septate hyphæ. The phialides are produced in pairs or in whorls of 3 or 4; they are long, simple, hyaline, slightly wider towards the base and tapering above, up to 17 μ long and usually 2·1 μ but up to 2·8 μ wide at the base. The conidia are produced acrogenously and singly at the tips of the phialides; they are 1-celled, oval to elliptical, faintly mamillate at the base, hyaline, smooth, guttulate, 4·2–7·0 μ long and 2·8 μ wide.

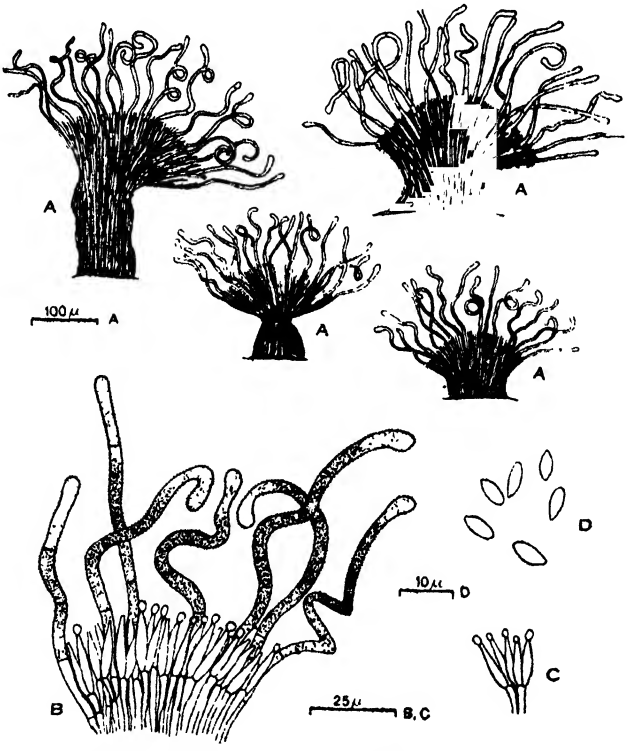

FIG. 16. *Kutilakesa madreeya* from type specimen, Herb. M.U.B.L. 1462. A, sporodochia; B, conidiophores and setæ; C, phialides; D, conidia.

The fungus is easily classified in the Tuberculariaceæ; the presence of dark brown setæ suggests that its position in the Tuberculariaceæ would be under Dematieæ, notwithstanding the hyaline conidiophores and conidia. Amongst the genera of the Tuberculariaceæ, it comes closest to the genus *Periolopsis* Maire (see Saccardo, 1931, p. 956) which was placed in the Tuberculariaceæ-Mucedineæ by its author and by Clements & Shear (1931) and by Ainsworth & Bisby (1954). The type species, *P. helicochæta* Maire, was based on a collection on cladodes of *Ruscus aculeatus* from Greece. My fungus has a close similarity to *P. helicochæta* in having setose sporodochia, and setæ which are brown, circinate or coiled, and verrucose towards their tips. I have not seen a specimen, but *P. helicochæta* was described as having cylindrical conidia which are produced acropleurogenously. Whilst undue emphasis should not be laid on conidial shape alone for generic separation, I think that the method of production of conidia is certainly of importance in delimiting genera. In my fungus the conidia are always produced only acrogenously and it cannot, therefore, be placed in *Periolopsis*. Accordingly, I am proposing a new genus for it. The generic name, *Kutilakesa*, is derived from Sanskrit: कुटिलकेश (*kutilakēśa*) = curly-haired, suggestive of the circinate or curled setæ characteristic of the fungus.

Kutilakesa Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Tuberculariaceas, Hyalosporæ. Sporodochia superficialia, sessilia vel stipitata, setosa. Setæ simplices, brunneæ, septatæ, circinnatæ vel tortuosæ supra. Conidiophori simplices, hyalini, septati, desinentes in unam pluresve phialides. Conidia producta acrogene atque singulariter ad apices phialidum, unicellulata, hyalina.

Fungus imperfectus, Moniliales, Tuberculariaceæ, Hyalosporæ. Sporodochia superficial, sessile or stipitate, setose. Setæ simple, brown, septate, circinate or coiled above. Conidiophores simple, hyaline, septate, terminating in one or more phialides. Conidia produced acrogenously and singly at the tips of phialides, 1-celled, hyaline.

Type species

Kutilakesa madreeya Subramanian sp. nov

Sporodochia discreta, superficialia, hemisphærica vel subglobosa, pallide viridia, setosa, nonnumquam sessilia, ut plurimum stipitata infra, expansa supra. Stipes brevis vel longus, usque ad 182 μ longus, 154 μ latus; portio dilatata usque ad 420 μ diameter, 280 μ alta. Setæ erectæ, simplices, fusce brunneæ atque rectæ infra, pallidiores supra, characteristice circinnatæ ad mediam superiorem partem, fere hyalinæ atque aliquantum clavatæ ad apicem, distincte verrucosæ præter inferiorem trientem, usque sexies septatæ, 108–144 μ longæ, 2·1–3·5 μ latæ ad basim, 4·9–6·3 μ latæ ad apicem. Conidiophori simplices, hyalini, septati, desinentes in unam pluresve phialides vel in verticillum ex eisdem constans. Phialides simplices, hyalinæ, latiores ad basim, fastigatæ supra, usque ad 17 μ longæ, 2·1–2·8 μ latæ ad basim. Conidia producta acrogene atque singulariter ad apices phialidum, unicellulata, ovalia vel elliptica, minutissime mamillata ad basim, hyalina, levia, guttulata, 4·2–7·0×2·8 μ.

Typus lectus in foliis emortuis *Sansevieriæ* sp., in campo Laboratorii Botanici Universitatis, in urbe Madras, die 3 decembris anni 1955 a K. Ramakrishnan et positus in herbario M.U.B.L. sub numero 1462.

41. **Acrostaphylus lignicola** sp. nov.

This fungus was collected from Madras recently and was found growing on moist dead wood. The colonies are brown, velutinous and effuse. The repent hyphæ are dark brown, 3–4 μ wide, septate, intricately branched and form a complex network of mycelium on the substratum. The conidiophores are erect, straight or bent or curved, and arise laterally from cells of the repent hyphæ; they are dark brown below, paler above, septate (septa 8·4–28·0 μ apart) and copiously branched, the branches always arising from immediately below septa. The main stipe of the conidiophore is 140–200 μ long and 2·8–4·9 μ wide; the branches are shorter, but almost of the same width. The conidia are produced singly on denticles on the flat or slightly rounded apex of sporogenous cells. The sporogenous cells have a characteristic shape being somewhat clavate and often curved, narrower at the locus of origin than above, flat or rounded and bearing many denticles at the tip, simple, pale brown in colour and subhyaline at the tip. They are borne laterally and terminally on the main stipe of the conidiophore and its branches. The lateral sporogenous cells always arise from immediately below septa, sometimes singly, but more often in groups

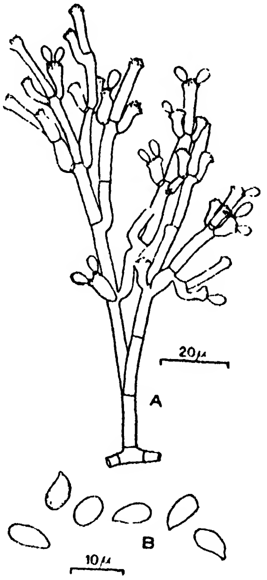

FIG. 17. *Acrostaphylus lignicola* from type specimen, Herb. M.U.B.L. 1485. A, conidiophore with conidia; B, mature conidia.

of more than one and up to four from below a septum; they are 8·4–9·8 μ long and 2·8–4·2 μ wide. The terminal sporogenous cells are usually longer and terminate the growth of the conidiophore; they are 14·0–17·2 μ long and 2·8 μ wide. The conidia are produced singly on denticles on the sporogenous cells, so as to form a head; they are deciduous, subhyaline to golden brown in colour, oval or elliptical with a basal apiculus indicating the point of attachment to the denticle, smooth, 6·3–7·0 μ long and 3·5–4·2 μ wide.

From a study of literature, I find that the fungus just described shows a striking resemblance to conidial *Daldinia concentrica* as described and figured by several workers (Elliott, 1919; Brooks, 1913; Miller, 1930), although Elliott and Brooks stated that the conidia were hyaline. According to Miller (1930) the conidia have a greenish tint. Molliard (1904), in his well-known study of *Daldinia concentrica*, casually suggested *Nodulisporium* (*Botrytis*) *Tulasnei* as a suitable name for the conidial stage. The genus *Nodulisporium* Preuss, as typified by *N. album* Preuss and *N. ochraceum* Preuss, is moniliaceous and, notwithstanding the otherwise striking resemblance to these two species, my fungus, which is distinctly Dematiaceous, has to be classified elsewhere. This applies also to the Dematiaceous moulds which were classified in *Nodulisporium* by Smith (1951, 1954).

I consider that *Nodulisporium*-like Dematiaceous moulds may be suitably classified in the genus *Acrostaphylus* recently described by Arnaud (1953, p. 272), notwithstanding the very brief description which was given. This genus was described as: "Analogue à Trichosporium, mais extrémitiés conidifères condensées en une tête. Formes conidiennes de Xylariées." It is typified by *A. hypoxyli* Arnaud which was briefly described as: "Conidiophores ramifiés de 150–200 μ de haut; conidies ovoïdes-piriformes de 3-4 μ." One can hardly picture what the fungus would be like from these scanty descriptions, but his figure (Arnaud, 1953, Fig. 1 N) shows striking similarity to *Nodulisporium* and, further, he classified his genus in the Dematiaceæ.

Accordingly, I propose to classify my fungus on dead wood in *Acrostaphylus*.* Comparison with some *Nodulisporium*-like Dematiaceous moulds which have received names indicates that my fungus is distinct. Hence, it is described here as a new species.

Acrostaphylus lignicola Subramanian sp. nov.

Coloniæ brunneæ, velutinæ, effusæ. Hyphæ repentes fusce brunneæ, 3–4 μ latæ, septatæ, implicatæ ramosæ, efformantes mycelii reticulum complexum super substratum. Conidiophori erecti, recti vel

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* The following Latin diagnosis for *Acrostaphylus* Arnaud will validate the genus: Pertinet ad Fungos Imperfectos, ad Moniliales, Dematiaceas, Amerosporas. Hyphæ repentes brunneæ, septatæ, ramosæ. Conidiophori erecti, brunnei, ramosi, septati. Cellulæ sporogenæ simplices lateraliter vel terminaliter insidentes stipiti conidiophororum vel ramorum. Conidia producta singulariter insidentia denticulis cellularum sporogenarum, efformantia capitulum deciduum, subhyalinum ad brunneum, unicellulatum.

curvi vel flexi, surgentes lateraliter e cellulis hypharum repentium, fusce brunnei infra, pallidiores supra, septati (septis inter se 8·4–28·0 μ distantibus), ramosi, 140–200 μ longi, 2·8–4·9 μ lati. Ramuli emergentes ex parte sub ipsis septis posita, stipite vel ramo paterno breviores, fere eiusdem latitudinis. Cellulæ sporogenæ forma typica præditæ, aliquantum clavatæ, sæpe curvæ, fastigatæ ad basim, pallide brunneæ, simplices, planæ vel rotundatæ atque plurimis denticulis ornatæ ad apicem subhyalinum, insidentes lateribus et apicibus stipitis principis conidiophororum et ramorum; cellulæ sporogenæ laterales emergentes ex parte sub ipsis septis posita, singulæ vel binæ, ternæ vel quaternæ, 8·4–9·8×2·8–4·2 μ; terminales vero 14·0–17·2×2·8 μ. Conidia singula denticulis cellularum sporogenarum insidentia, in capitulum coacta, decidua, subhyalina vel aureobrunnea, ovata vel elliptica, ad basim apiculata, levia, 6·2–7·0×3·5–4·2 μ.

Typus lectus in ligno emortuo in loco Villiwakkam, in districtu Chingleput, in Statu Madras, die 9 decembris anni 1955 a K. Ramakrishnan et positus in herbario M.U.B.L. sub numero 1485.

It is pertinent to consider here the systematic position of Dematiaceous *Nodulisporium*-like fungi which have received valid names in literature. These include: *Nodulisporium africanum* Smith and *N. thelenum* (Sacc.) Smith (Smith, 1951); *N. verrucosum* (v. Beyma) Smith (Smith, 1954); *Verticicladium pulvereum* (Peck & Cint.) Sacc. (see Saccardo, 1884, p. 328); *Verticicladium cheesmanii* Crossland (see Saccardo, 1913, p. 1361–62) and *Botrytis argillacea* Cooke (see Saccardo, 1884, p. 125). Of these, the first three are already in *Nodulisporium*, but are definitely Dematiaceous and are best classified in *Acrostaphylus*. *Verticicladium pulvereum*, *Verticicladium cheesmanii* and *Botrytis argillacea* are congeneric according to Hughes (1951 *b*). Indeed, Hughes suggested that these species and also the conidial states of *Rosellinia aquila*, *R. thelena*, *R. buxi* and *Daldinia concentrica* may be temporarily disposed in *Nodulisporium*. As I have already pointed out, *Acrostaphylus* appears to be the Dematiaceous counterpart of *Nodulisporium* and therefore a suitable genus in which some of the previously described taxa may be more appropriately classified. Accordingly, I propose the following combinations:—

(*a*) **Acrostaphylus africanus** (Smith) Subramanian comb. nov.

= *Nodulisporium africanum* Smith, 1951, *Trans. Brit. mycol. Soc.*, **34** : 18, *ic.* On cellulose acetate film, W. Africa.

(*b*) **Acrostaphylus thelenus** (Sacc.) Subramanian comb. nov.

= *Stachylidium thelenum* Sacc., 1877, *Michelia*, **1** : 85; Saccardo, 1884, *Sylloge Fungorum*, **4** : 331. On bark of *Quercus* sp., in association with *Rosellinia thelena* (Fr.) Rabenh., 'cujus tatum conidicum sistit', Italy.

= *Nodulisporium thelenum* (Sacc.) Smith, 1951, *Trans. Brit. mycol. Soc.*, **34** : 19.

(*c*) **Acrostaphylus verrucosus** (v. Beyma) Subramanian comb. nov.

Botrytis verrucosa v. Beyma, 1929, *Verh. Akad. Wet., Amst. Afd. Natuurk.* (*Tw. Sect.*), **26** : 13, *ic.* On *Coffea robusta*, Sumatra.

Nodulisporium verrucosum (v. Beyma) Smith, 1954, *Trans. Brit. mycol. Soc.*, **37** : 166.

v. Beyma's (1929) figure shows a few short conidial chains of two each, but this is probably a mistake !

(*d*) **Acrostaphylus pulvereus** (Peck & Clint.) Subramanian comb. nov.

Verticillium pulvereum Peck & Clint. apud Peck, 1876, Rept. of the Botanist, 30*th Rept. of the State Museum, New York*, **1876**, p. 56. On dead wood, Alden, N. Amer.

Verticicladium pulvereum (Peck & Clint.) Sacc., 1884, *Sylloge Fungorum*, **4** : 328.

(*e*) **Acrostaphylus cheesmanii** (Crossland) Subramanian comb. nov.

Verticicladium cheesmanii Crossland, 1907, *The Naturalist*, p. 98, *ic.* On decorticated wood, Stainor Wood, Selby, Britain, Nov. 1906.

(*f*) **Acrostaphylus argillaceus** (Cooke) Subramanian comb. nov.

Botrytis argillacea Cooke, 1875, *Grevillea*, **3**: 183. On dead wood, Britain.

42. **Acrostaphylus hyperparasiticus** sp. nov.

This fungus occurred as a hyperparasite on *Camptomeris cratævæ* on *Cratæva religiosa* collected from Guindy, Madras. The colonies are floccose, pale gray in colour and cover the spots occupied by the *Camptomeris*. The vegetative hyphæ are pale olivaceous, septate, branched and 4-6 μ wide. The conidiophores are decumbent or erect and very long; they are straight or curved or bent, pale olivaceous to golden brown in colour, smooth, septate (septa up to 72 μ apart), septa farther apart in the lower part and closer in the upper part, racemosely branched with primary and sometimes secondary branches, up to 1,400 μ long and 2·8–4·9 μ wide. The branches arise from immediately below septa and are shorter than the main stipe or the parent branch. The conidia are produced on sporogenous cells. The sporogenous cells have a characteristic shape, being widest towards the base, tapering above and terminating in a somewhat globose or flattened apex with many denticles; sometimes they are extremely short and button-like. The sporogenous cells are concolorous with the branches on which they are borne. They may be terminal on the main stipe or branches of the conidiophore or may be produced singly and laterally on them immediately below septa, the terminal sporogenous cells being usually longer than the lateral ones. They are 8·5–15·4 μ long, 2·1–2·8 μ wide below and 2·1–3·5 μ wide at the swollen apex. The conidia are produced singly on the denticles of the sporogenous cells. They are globose, subhyaline to pale olivaceous, apiculate at the base, smooth, and 4·2 (3·5–4·9) μ in diameter.

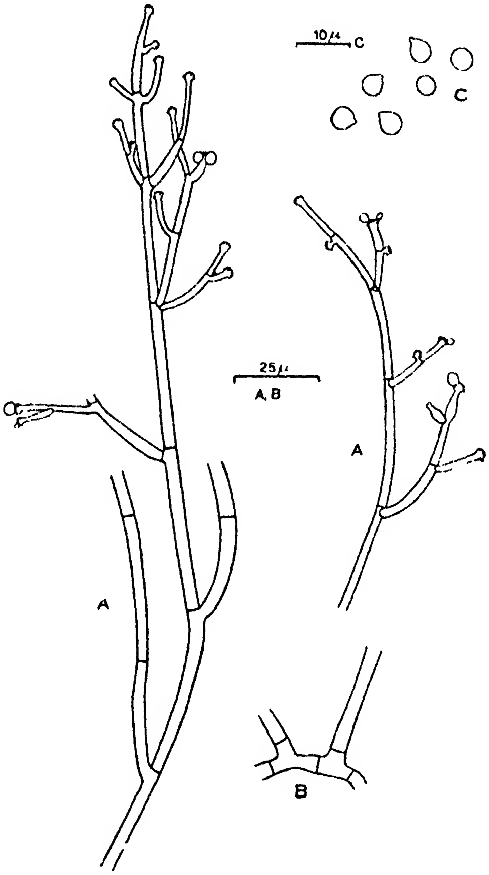

FIG. 18. *Acrostaphylus hyperparasiticus* from type specimen, Herb. M.U.B.L. 1432. A, conidiophores; B, vegetative hypha showing origin of conidiophores; C, conidia.

This fungus has a superficial resemblance to species of the genus *Hansfordia* Hughes; but it is better classified in *Acrostaphylus* since the denticles bearing conidia are closely crowded at the subglobose tip of the sporogenous cell. It appears to differ from species of *Acrostaphylus* already discussed in this paper and is described as a new species.

Acrostaphylus hyperparasiticus Subramanian sp. nov.

Coloniæ flocculosæ, pallide griseæ. Hyphæ pallide olivaceæ, septatæ, ramosæ, 4–6 μ latæ. Conidiophori decumbentes vel erecti, recti vel curvi vel flexi, pallide olivacei ad aureo-brunneos, leves, septati (septis inter se usque ad 72 μ distantibus, longius in parte inferiore, brevius in superiore), racemose furcati in ramos primarios et secundarios, usque ad 1400 μ longi, 2·8–4·9 μ lati. Ramuli emergentes e regione sub ipsis septis posita. Cellulæ sporogenæ forma typica præditæ, latissimæ ad basim, fastigatæ supra. desinentes in apicem globosum vel complanatum plurimis denticulis ornatum; sæpe breves et fibuliformes; concolore ramis conidiophororum, terminales atque etiam laterales et singulæ conidiophoris et ramis insidentes sub ipsis septis, 8·5–15·4 μ longæ, 2·1–2·8 μ latæ infra, 2·1–3·5 μ latæ ad apicem tumescentem. Conidia producta singula denticulis cellularum sporogenarum insidentia, globosa, apiculata ad basim, subhyalina vel pallide olivacea, levia, 4·2 (3·5–4·9) μ diameter.

Typus lectus infectans *Camptomeridem cratævæ* Subram., quæ vicisim *Cratævam religiosam* Forst. inficiebat, in loco Guindy, Madras, die 19 novembris anni 1955 a C. V. S. et positus in herbario M.U.B.L. sub numero 1432.

43. *Hormiactella sacchari* Johnston apud Johnston & Stevenson, 1917, *J. Dept. Agric. Porto Rico*, **1** : 224, *ic.*; Saccardo, 1931, *Sylloge Fungorum*, **25** : 803–804.

Hormiactella sacchari was described as follows: "Soris parvis, nigris, sparsis, 1 mm. circ. diameter, ex hyphis sterilibus erectis et fertilibus commixtis efformatis; sterilibus nigris, septatis plus v. minus erectis 500–900 μ long.; fertilibus brevioribus 200–300 μ altis, sparse ramosis, hinc inde ramulos v. conidiophoros lageniformes gerentibus; conidiis irregulariter catenulatis rugulosis. 6 μ diameter. Hab. in foliis emortuis *Sacchari officinarum* (Graminaceæ), frequens in Porto Rico, Amer. Centra" (from Saccardo, 1931).

I suspected that this fungus may be a *Lacellinopsis* (Subramanian, 1953 *a*) and the following specimens obtained from the National Fungus Collections, U.S.D.A., were examined:

(i) on cane trash, Rio Piedras, P.R., coll. & det. J. R. Johnston, June 5, 1912, Herb. of John A. Stevenson no. 4351 (Herb. M.U.B.L. 1585);

(ii) on cane leaves, Rio Piedras, P.R., Jan. 1914, coll. & det. J. A. Stevenson, Herb. John A. Stevenson no. 456 Jas. (Herb. M.U.B.L. 1586);

(iii) on dead cane leaves, Annaco Valley, R. Pied, May 7, 1916, coll. & det. John A. Stevenson, Herb. J.A.S., no. 5350 (Herb. M.U.B.L. 1587);

(iv) on *Saccharum officinarum*, Miami, Florida, February 1920, coll. & det. J. A. Stevenson (Herb. M.U.B.L. 1588).

Of these, (i) is probably the type (or at least authentic) and it has been collected and determined by the author of the species. My study of the specimens showed that they are all similar and the fungus is not congeneric with *Hormiactella fusca* (Preuss) Sacc.; on the other hand, the fungus is a typical *Lacellina*. Indeed, in a note dated Jan. 3, 1953, credited to Mr. E. W. Mason accompanying specimens (i) and (iii), it is stated: "4351 and 5350, as *Hormiactella sacchari*, make a perfect match with Thwaites' 505 from Ceylon, which is now in the *Spegazzinia essaarthra* folder in R.B.G., Kew, and is the type of *Lacellina graminicolt* (Berk. & Br.) Petch (Ann. R. B. G. Peradeniya, **9**, 2, p. 171). We are already using Mr. Petch's name for four African collections (E. W. Mason)."

Hormiactella sacchari, then, is a synonym of *Lacellina graminicola*, fide Mason.

44. *Arthrobotryum velutinum* Butler apud Chona & Munjal, 1955 (issued May 1956), *Indian Phytopath.*, **8** : 194.

In publishing this name and the diagnosis credited to Butler, Chona & Munjal (1955, p. 194) added: "This species has not been effectively published by Sir Edwin, though the name occurs in the printed list of Mycological specimens at the Agri. Res. Inst., Pusa, May 1921 (published 1922)"; they did not, however, add anything to the description of the fungus either based on Butler's material ["in pagina superiore foliorum Thysanolænæ acariferæ Nees (= *T. procera* Mez.), Dehra Dun, legit Inayat Khan, Oct. 24, 1903"] or the two other collections cited by them, *viz.*, one from Assam and the other from Coonoor, Nilgiris District, Madras State.

From Butler's diagnosis it would appear that the fungus is the same as *Arthrobotryum coonoorense* Subramanian (Subramanian, 1955 *b*)—a name which was effectively published in December 1955 and antedates *A. velutinum* Butler apud Chona & Munjal which was effectively published only in May 1956. *A. velutinum* Butler is a synonym of *A. coonoorense* Subramanian.

45. *Helicosporium guianensis* Linder, 1929, *Ann. Mo. bot. Gdn.*, **16** : 280–81, *ic.*

A collection of this fungus was made in November 1955 on dead moist wood at Madras. The colonies are pale to yellowish green in colour and effuse. The conidiophores are of two types: the macro-conidiophores and the micro-conidiophores. The macro-conidiophores are crowded, arising laterally or terminally from cells of repent hyphæ, erect, straight or bent or curved, simple, stiff and rigid, dark brown below, paler above, often subhyaline towards the tip, thick-walled, many-septate (septa $4 \cdot 2$–$9 \cdot 8\,\mu$ apart below, $9 \cdot 8$–$15 \cdot 4\,\mu$ apart above), sterile at the apex, and producing conidia on short subhyaline sterigma-like outgrowths laterally on any part of the conidiophore, but more often on the lower part. The macro-conidiophores are up to $210\,\mu$ long, with a swollen basal cell $6 \cdot 0$–$7 \cdot 4\,\mu$ tall and $5 \cdot 6$–$9 \cdot 8\,\mu$ wide, $4 \cdot 2$–$6 \cdot 0\,\mu$ wide immediately above the swollen basal cell, $4 \cdot 2$–$5 \cdot 6\,\mu$ wide in the middle and $2 \cdot 8$–$4 \cdot 2\,\mu$ wide towards the apex. The micro-conidiophores are short, simple, subhyaline, erect, straight or bent, sometimes septate, and with conidia produced acropleurogenously on pegs on them; they are up to $28\,\mu$ long and $2 \cdot 8$–$4 \cdot 2\,\mu$ wide. On the macro-conidiophores the conidia are produced on bladder-like, hyaline pleurogenous outgrowths borne on cells of the conidiophore; these outgrowths are widest at the base being up to 4·2 μ wide, narrower and up to 2·8 μ wide at the tip and 7·0–16·8 μ long. They are sometimes 1-septate, but mostly non-septate. Each outgrowth may produce one or more conidia on short pegs borne acrogenously or pleurogenously on them. The conidia are hyaline to subhyaline, typically coiled, filiform and of uniform thickness, thin-walled, 5–7-septate, 1·5 μ thick, and the diameter of the coil is 18·2–29·4 μ.

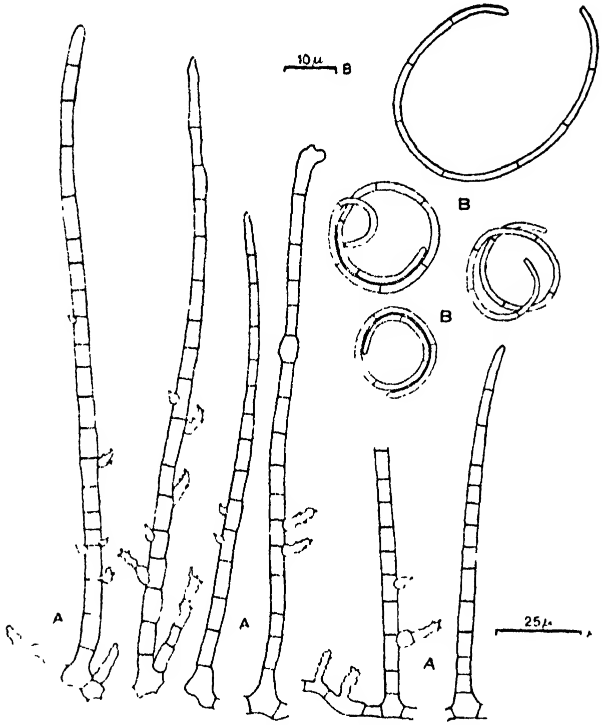

FIG. 19. *Helicosporium guianensis* from Herb. M.U.B.L. 1426. A, conidiophores; B, conidia.

In Herb. M.U.B.L. the following three collections come nearest to *Helicosporium guianensis*, although the macro-conidiophores are shorter in the three M.U.B.L. collections: on dead moist wood, University Botany Laboratory campus, Madras, coll. C. V. S., 11–11–1955 (M.U.B.L. 1426); 23–12–1955 (MUBL 1501); on dead pod of *Cæsalpinia pulcherrima* Sw., University Botany Laboratory campus, Madras, 22–12–1955, coll. K. Ramakrishnan (M.U.B.L. 1500).

This is the first record of this fungus from India.

46. *Sporidesmium hormiscioides* Corda, 1838, *Icon. Fung.*, **2** : 6, Fig. 26; Saccardo, 1884. *Sylloge Fungorum*, **4** : 383 as *Clasterosporium hormiscioides* (Corda) Sacc.

The fungus forms dark brown, velutinous, effuse colonies on deda stems of *Quisqualis malabarica*. The conidiophores arise from repent hyphæ and are erect, straight or bent, short, dark brown in colour, thick-walled, 3–6-septate, cylindrical, sometimes constricted at septa, 32·3–54·4 μ long, 5·9–8·5 μ wide at the base and 3·4–5·1 μ wide at the tip. The conidia are produced acrogenously and singly at the tips of the conidiophores. Successive production of conidia may take place by continued growth of conidiophore by proliferation through scar of fallen conidium. The mature conidia are long-obclavate, widest immediately above the base, with a distinct flat scar 3·4–5·1 μ wide at the base, straight or more often curved or bent, many- (up to 30-) septate, constricted at some septa, thick-walled, brown in colour except at the tip which may be paler in colour and sometimes subhyaline, with smoothly rounded tip, and smooth; they are 46–294 μ long, 10·2–15·3 μ wide where they are widest, and 4·3–6·8 μ wide at the tip.

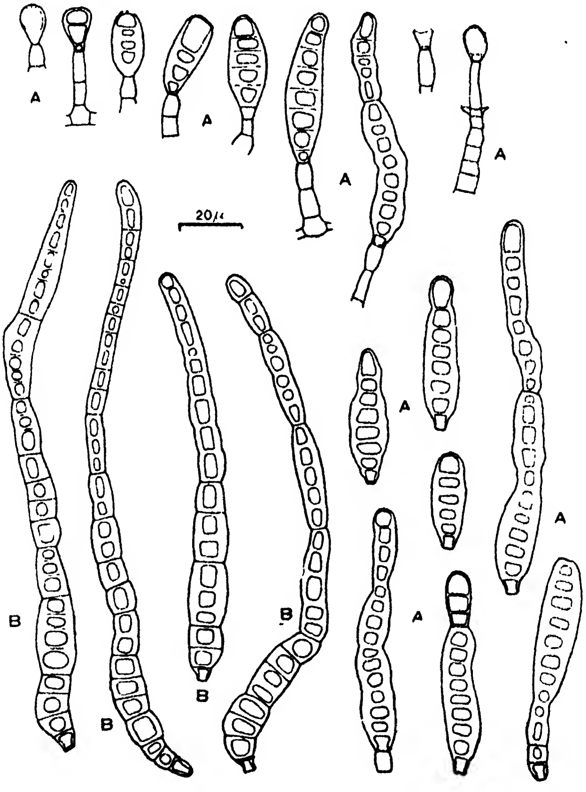

FIG. 20. *Sporidesmium hormiscioides*: conidiophores, development of conidia, and mature conidia. A, from Herb. M.U.B.L. 896; B, from Herb. M.U.B.L. 164.

In Herb. M.U.B.L., the following collections have been assigned to this species: on dead stem of *Quisqualis malabarica*, Bedd., University Botany Laboratory campus, coll. C. V. S., 30–3–1951 (M.U.B.L. 164); 11–10–1953 (M.U.B.L. 896).

This is the first record of this fungus from India.

47. *Virgaria nigra* Nees, 1817, *Syst.*, **2** : 14 (ex Sacc., 1884 ?), Saccardo, 1884, *Sylloge Fungorum*, **4** : 281; Hughes, S. J., 1953, *Canad. J. Bot.*, **31** : 62, Fig. 30.

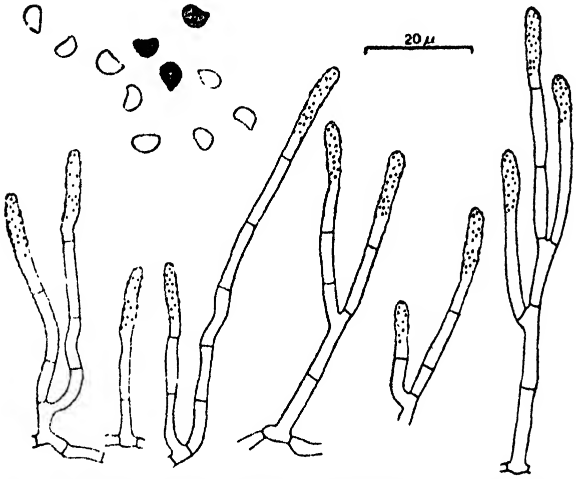

FIG. 21. Conidiophores and conidia of *Virgaria nigra* from Herb. M.U.B.L. 729.

The colonies are olivaceous to brown and effuse. The repent hyphæ are brown, intricately branched and 1·5–3·0 μ wide. The conidiophores arise laterally from cells of repent hyphæ. They are erect or decumbent, straight or bent, septate (septa 8–12 μ apart), simple, or producing 1–4 lateral branches usually arising singly immediately below septa, dark brown below, paler above, often wavy, smooth, 1·5–2·0 μ wide at the base and above, up to 100 μ long and fertile towards the apex of the main conidiophore and its branches. The fertile part is as wide as the rest of the conidiophore or slightly wider, subhyaline, thin-walled, with many prominent scars left over after detachment of conidia which are produced acrogenously and successively, and 5–21 μ long. The conidia are small, dark brown, characteristically lozenge-shaped, somewhat resembling those of *Pseudocamptoum fasciculatum* (Cke. & Mass.) Mason, 1-celled, smooth, apiculate at the base, produced singly and acrogenously at the tips of conidiophores and branches, 4·9–5·6 μ long and 2·8–3·5 μ wide.

Only one collection has been made: on dead stem, Thanthipandal, Kambakkam Hills, Chingleput District, Madras State, 3–2–1953, coll. C. V. S., Herb. M.U.B.L. 729.

This would appear to be the first record of this fungus from India.

SUMMARY

This is a systematic and taxonomic paper dealing with some hyphomycetes, the majority of which are from this country. The new taxa proposed in this paper and the taxonomic revisions and notes made are summarised below. Names of new taxa and new combinations are in Roman.

Acrostaphylus hyperparasiticus sp. nov.
A. lignicola sp. nov.
Acrothecium falcatum Tehon = *Curvularia senegalensis* (Speg.) Subram.
Arthrobotryum velutinum Butler = *Arthrobotryum coonoorense* Subram.
BAHUSANDHIKA gen. nov., Dematiaceæ, Phragmosporæ (see *Polydesmus indicus* and *Septonema intercalare*)
Botrytis argillacea Cke. ≡ Acrostaphylus argillaceus (Cke.) Subram.
B. verrucosa v. Beyma ≡ Acrostaphylus verrucosus (v. Beyma) Subram.
Brachysporium senegalense Speg. ≡ Curvularia senegalensis (Speg.) Subram.
Cladosporium buteacolum Cke. = ? *Cladosporium herbarum* Link ex Fr.
C. congestum Berk. = *Helminthosporium scopæforme* (Berk.) Subram.
C. delicatulum Cke. = ? *Cladosporium herbarum* Link. ex Fr.
C. scopæforme Berk. ≡ Helminthosporium scopæforme (Berk.) Subram.
Cladotrichum glenosporoides Sacc. is based on a Microthyriaceous fungus.
Curvularia falcata (Tehon) Boedijn = *Curvularia senegalensis* (Speg.) Subram.
Dendrographium interseminatum sp. nov.
DWAYAMALA gen. nov. (Dematiaceæ, Didymosporæ).
D. prathilomaka sp. nov.
Glenospora didyma Cke. is based on a Microthyriaceous fungus.
Gliocladium compactum Cke. & Massee is based on an ascomycete (fide Petch).
Helminthosporium bambusæ Cke. ≡ Exosporium bambusæ (Cke.) Subram.
H. cantonense Sacc. ≡ Sporidesmium cantonense (Sacc.) Subram.
H. longirostratum sp. nov.
H. obclavatum Massee ≡ Helminthosporium siwalikum nom. nov.
H. sigmoideum Cavara ≡ Vakrabeeja sigmoidea (Cavara) Subram.
H. stahlii Stevens ≡ Cercospora stahlii (Stevens) Subram.
Hormiactella sacchari Johnston = *Lacellina graminicola* (Berk. & Br.) Petch (fide Mason).
KUTILAKESA gen. nov. (Tuberculariaceæ, Hyalosporæ)
K. madreeya sp. nov.
NALANTHAMALA gen. nov. (Tuberculariaceæ, Hyalosporæ)
N. madreeya sp. nov.
Nodulisporium africanum Smith ≡ Acrostaphylus africanus (Smith) Subram.
N. thelenum (Sacc.) Smith ≡ Acrostaphylus thelenus (Sacc.) Subram.
N. verrucosum (v. Beyma) Smith ≡ Acrostaphylus verrucosus (v. Beyma) Subram.
Polydesmus indicus Subram. ≡ Bahusandhika indica (Subram.) Subram.
Rhinocladium corticolum Massee ≡ Peziotrichum corticolum (Mass.) Subram.
Septonema bombayense sp. nov.
S. intercalare Cash & Watson ≡ Bahusandhika intercalare (Cash & Watson) Subram.
Stachylidium thelenum Sacc. ≡ Acrostaphylus thelenus (Sacc.) Subram.
Trichosporium aterrimum Massee ≡ Phæoscopulariopsis aterrima (Massee) Subram.
T. masseei Sacc. ≡ Phæoscopulariopsis aterrima (Massee) Subram.

VAKRABEEJA gen. nov. (Dematiaceæ, Phragmosporæ); see *Helminthosporium sigmoideum*.

Verticicladium cheesmanii Crossland ≡ Acrostaphylus cheesmanii (Crossland) Subram.

V. pulvereum (P. & C.) Sacc. ≡ Acrostaphylus pulvereus (P. & C.) Subram.

Verticillium pulvereum P. & C. ≡ Acrostaphylus pulvereus (P. & C.) Subram.

Helicosporium guianensis Linder, *Helminthosporium rostratum* Drechsler, *Sporidesmium hormiscioides* Corda and *Virgaria nigra* Nees are recorded from India for the first time.

ACKNOWLEDGEMENTS

I am deeply indebted to Professor T. S. Sadasivan for continued encouragement during the course of these studies, but for which this paper could not have been completed or published. For loan of herbarium material cited in the text of this paper, I am also deeply indebted to Sir E. J. Salisbury, Director, Royal Botanic Gardens, Kew, England; to Mr. John A. Stevenson of the National Fungus Collections, U.S.D.A., Beltsville, Maryland, U.S.A.; to Dr. J. C. Lindquist of the Instituto de Botanica "Spegazzini", University of La Plata, Argentina; and to the Government Mycologist, Agricultural Research Institute, Coimbatore. I am also grateful to the Rev. Fr. H. Santapau for rendering the diagnoses of the new taxa into Latin, and to Sri. C. V. Mahalingam for suggesting the generic names (derived from Sanskrit) proposed in this paper. I thank the Ministry of Education, Government of India, for a grant-in-aid for travel which enabled me to collect some of the fungi reported in this paper.

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ADDENDUM

Since this paper went to press Kandaswamy and Sundaram (*Indian Phytopath.*, **9**: 76, 1956) have described a new species of *Podosporium*, *P. thysanolænæ* on living leaves of *Thysanolæna agrostis* from Coonoor, Nilgiris. Their description and figures clearly indicate that the fungus is an *Arthrobotryum* and is identical with *A. coonoorense* Subram. These observations may be read along with the discussion on *A. velutinum* Butler appearing on p. 487 of this paper.

PLANT ECOLOGY OF BIKANER AND ITS ADJACENT AREAS IN COMPARISON WITH THE REST OF WESTERN RAJASTHAN

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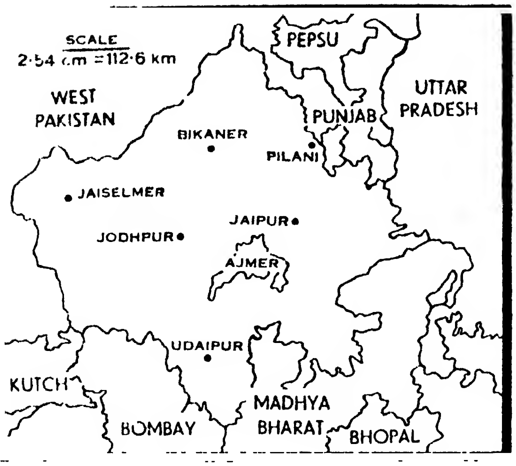
(Received for publication on December 6, 1955)

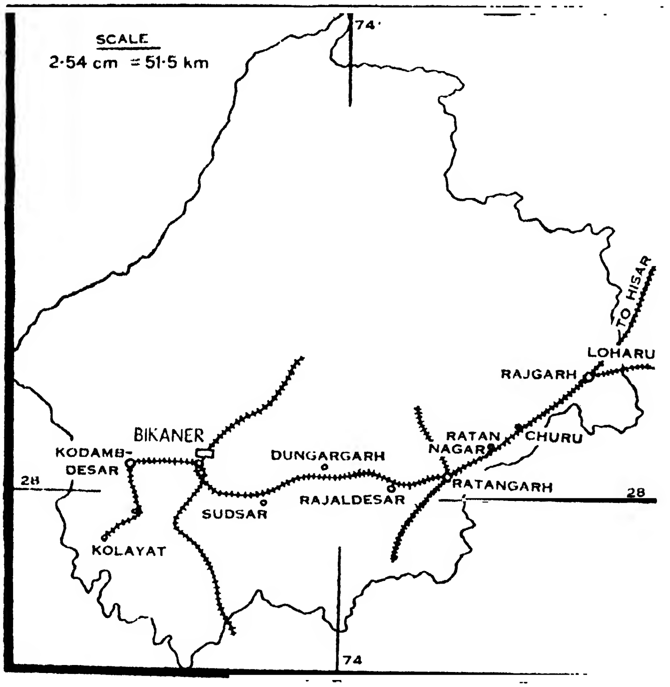
Western Rajasthan comprises a greater part of the Indian desert. The divisions of Jodhpur, Jaisalmer and Bikaner are included in this region. Its vegetation, especially of the western region, had received attention of several earlier workers. Blatter and Hallberg (1918–21) described the vegetation and the ecological formations in Jodhpur and Jaisalmer regions. Macadam described the trees of Jodhpur and its neighbourhood in an undated publication. In recent years Sarup and his colleagues (1951–54) have described the vegetation of Jodhpur and compared the biological spectrum of the area with the African and Egyptian deserts. Sankhala (1951) and Sarup (1951) published a list of plants growing in Western Rajasthan.

In a recent publication on the Rajasthan desert by the National Institute of Sciences of India, several authors have contributed on the ecology and vegetation of Western Rajasthan. Puri (1952) has briefly summarized the present position of plant ecology of the Rajasthan desert. He has described five main plant formations in this area, *viz.*, aquatic, sand, gravel, rock and ruderal. The above classification is mainly based upon the work of Blatter and Hallberg (1918–21). Agharkar (1952) has also recognised the same formations, and regards the flora of Rajasthan as a mixture of the western, the eastern and the general elements. Biswas (1952) has shown that very little work has been done with regard to the desert vegetation of this country. However, these papers do not actually tell us about the plant ecology of the different areas in Rajasthan, but include only a general survey on the basis of previous work.

Sarup (1952) has given a good account of the plant ecology of Jodhpur and its neighbourhood, situated in the North-Western Rajasthan. The area is regarded as arid and he distinguishes plants of two types—*i.e.*, those that depend upon rain; and those that depend upon subterranean water. The former are mostly annuals while the latter are perennials. Sarup and Vyas (1953—unpublished) have studied the ecology of the vegetation in the suburbs of Jodhpur including the Luni river bed. Plant associations growing on different substrata such as rocks, sandy plains, saline river bed and cultivated areas have been studied and their successional stages have been outlined. Sarup and Dutta (1954—unpublished) have studied the vegetation in some parts of Jodhpur division in relation to the soil conditions and have shown



Map showing location of Bikaner in Rajasthan with its neighbouring areas.



Map showing general location of the area surveyed.

(Both maps have been reduced to ½ and therefore 2·54 cm. = 225·2 km. and 103 km. respectively.)

that the type of plant community can be correlated with the soil conditions.

The foregoing account shows that the vegetation of Bikaner division comprising one-third of the Western Rajasthan remains neglected. The present paper, therefore, gives an ecological survey of the vegetation of Bikaner and its neighbourhood. It is interesting to follow the vegetation along the Bikaner State Railway between Loharu and Bikaner for regional zonation in the Bikaner division. A detailed investigation is being pursued.

SITUATION AND TOPOGRAPHY

Bikaner division occupies almost the north-west of Rajasthan between longitudes 72·5° and 75·5° E. and latitudes 27·5° and 30·0° N. Towards the north, north-east and north-west are situated the States of East Punjab and West Punjab respectively. Jodhpur and Jaisalmer are the boundary divisions towards the south and south-west. Thus, except for a few fertile tracts towards the south-east and north-east the whole of Bikaner division is surrounded by arid zones of Rajasthan and West Punjab. A large part of the area in the region consists mostly of sandy plains and dunes at an elevation of 61 to 305 metres above sea-level. There are extensive areas covered by sand dunes of varying heights. Only two natural rivers drain the area. A few hillocks may also be seen.

The following localities have been investigated during the course of the present study: Rajgarh, Churu, Ashiu, Daipalsar, Ratangarh, Rajaldesar, Bigga, Shri Dungargarh, Sudsar, Belasar, Napasar and Bikaner proper with its neighbourhood. In the last-mentioned area a number of places in several directions of Bikaner proper are studied. These include Vallabh Garden, Hindumal Road area in the east; open sandy plains of west, Lallgarh Palace area in the north and Udramsar, Binasahar, Gangasahar villages in the south. In addition, the vegetation of Nal and Kodambdesar on way to Gajner, Gajner Palace, its lake and its hillside regions, were also studied. This area is situated towards the south-west of Bikaner at a distance of 30·5 kilometers (See Map).

CLIMATE

The climate of the area is typical of the dry hot desert. The summer temperatures are high and the annual rainfall is low. This leads evaporation to exceed precipitation. As a consequence there is little moisture in the soil to support much vegetation. The available data (Table I) for the maximum and minimum temperatures and rainfall for the period 1951–55 clearly show the above fact.

The annual rainfall within the area does not exceed 352 mm. and the maximum amount of rainfall is distributed in the months of June to August when the maximum temperatures are also high. Thus, the rain-water made available to the scanty vegetation results in excessive transpiration which adversely affects the growth.

There is considerable variation between the maximum and minimum temperature in different months of the year, which again results in the retardation of the development of the plant species growing in the

TABLE I

Monthly average records for rainfall and temperature of Bikaner (from 1951 *to* 1955)

Locality	Year	Temperature in Degrees C. and rainfall in mm.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bikaner	1951	Maximum	22·0	25·5	31·3	35·2	41·4	41·6	40·3	36·9	38·7	37·7	30·3	25·2
		Minimum	3·4	5·8	13·5	18·5	26·5	28·7	29·4	26·8	24·8	22·6	13·0	6·8
		Rainfall	0·0	0·0	0·0	35·0	7·1	13·5	18·4	94·2	0·0	0·0	44·0	0·0
	1952	Maximum	24·2	27·2	31·6	39·5	42·6	42·1	38·9	35·7	36·3	33·8	30·0	23·9
		Minimum	5·3	10·0	14·1	22·7	27·6	28·2	28·2	26·3	24·8	18·1	9·2	4·4
		Rainfall	0·0	7·1	0·0	0·0	6·3	39·5	47·2	111·8	0·0	0·0	0·0	0·5
	1953	Maximum	21·7	28·3	35·5	38·6	41·4	42·1	38·4	35·0	35·4	35·7	30·8	28·5
		Minimum	6·2	9·7	16·6	21·6	27·9	30·2	28·5	26·1	24·7	17·2	9·4	8·2
		Rainfall	13·7	0·0	0·0	0·0	1·5	0·0	26·6	131·0	9·0	0·0	0·0	0·0
	1954	Maximum	22·6	26·0	31·5	38·0	43·3	42·0	38·7	37·7	36·4	33·7	30·3	25·8
		Minimum	4·1	10·7	14·7	21·1	28·4	30·2	28·5	27·4	26·2	17·4	11·6	5·1
		Rainfall	0·0	42·4	0·0	0·0	1·0	41·1	40·8	10·6	216·0	0·0	0·0	0·0
	1955	Maximum	21·2	27·3	33·6	36·1	39·8	42·1	38·6	35·9	35·3	34·3	29·7	25·3
		Minimum	5·7	8·3	16·1	17·5	24·6	29·7	28·6	26·7	25·0	17·7	8·7	7·0
		Rainfall	3·8	1·5	6·1	0·7	10·9	50·8	1·0	215·9	12·7	0·0	0·0	0·0

area. The seasonal variations during the year are of extreme nature. The rainy months are followed by a severe winter with very little rainfall. Thus, the winter season which extends up to the end of February is dry and cold. It is most unfavourable for the growth of any vegetation. The spring starts early in March and the little vegetation that comes up during this part of the year is soon subjected to dry hot months from April to July.

The wind velocity in the dry hot months is considerably high resulting in desiccation of the atmosphere and also in blowing sand from place to place. The climate thus prevailing in the area is of an arid nature and does not suit the growth and development of vegetation. Hence the vegetation remains very open throughout the year.

SOIL

A survey of the nature of the soil as given in Table II shows:—

1. The soils are sandy and brown to black in colour.
2. In the lake area, the soil is fairly rich in silt and is black in colour.
3. On the hillocks in Gajner the soil is gritty. The colour ranges from black to brown and red. These are probably red sandstone hills.
4. The other characteristics of the soil show a pH value ranging from 7·0 to 8·5, though occasionally in the north and western directions it may be as low as 6·0. The same feature is noted in some parts of Gajner. Except in the north and west of Bikaner proper the soil samples from other directions and also of Gajner area, are fairly rich in carbonates at different depths. In this respect the soils of this area differ from those in the sandy plains of Shekhawati area. This is probably due to the afforestation scheme sponsored by the Bikaner Government, when it was an independent State.

There is little base deficiency in the soils. The nitrate content generally increases from the surface to the deeper layers in the sandy areas. The same feature was noted in the lake soils of Gajner. The Gajner rock soil was, however, deficient in nitrates.

BIOTIC FACTORS

The biotic factors are mostly similar to those of Shekhawati area in Eastern Rajasthan. In the sandy plains and the hill areas the grazing animals, rodents and other mammals such as rabbits, deer, etc., play a considerable role in disturbing the natural development of the vegetation. In the rural areas man disturbs natural plant growth but grows some useful trees. The thorny bushes including the ground vegetation are often scraped for fuel. The pathogenic fungi which attack the herbaceous vegetation in their growing season include species of *Cystopus*

TABLE II

Characters of the soil samples in Bikaner and its neighbouring areas from different directions and at different depths

Locality	Direction	No. of soil samples	Depth in cm. at which soil samples were taken	Colour of soil	Texture	Carbonate content	Nitrate content	Chloride content	Reductivity	pH value
BIKANER .. (On way to Vallabh Gardens)	East	A	7·5	Brown	Sandy	++	+	+	−	8·0
		B	15·0	do	do	+++	+	+	+	8·0
		C	22·5	do	do	++	+	+	+	8·5
		D	30·0	do	do	+++	+	+	+	8·5
BIKANER .. (Vallabh Gardens area)	East	A	7·5	Brownish black	do	+++	++	+	+	8·5
		B	15·0	do	do	+++	+	+	+	8·0
		C	22·5	do	do	+++	++	+	+	8·0
		D	30·0	do	do	++++	++	+	+	7·5
BIKANER ..	West	A	7·5	Brown	do	+	+	+	+	7·5
		B	15·0	do	do	+	+	+	−	6·0
		C	22·5	do	do	++	+	+	−	6·0
		D	30·0	do	do	++	+	+	−	7·5
BIKANER .. (Soil samples collected from the cultivated fields)	West	A	7·5	Blackish-brown	do	+	+	+	+	7·5
		B	15·0	do	do	++	++	+	+	6·5
		C	22·5	do	do	+	+	+	++	6·0
		D	30·0	do	do	++	+++	+	+	6·0
BIKANER .. (Lallgarh Palace area)	North	A	7·5	Brown	do	+	+	+	−	7·5
		B	15·0	do	do	+	+	+	−	6·0
		C	22·5	do	do	+	+	+	−	7·5
		D	30·0	do	do	+	+	+	−	6·0

BIKANER .. (Soil samples were collected from the three villages : (*a*) Udramsar, (*b*) Binasahar & (*c*) Gangasahar)	South	A	Surface soil	do	Sandy	++++	+++	+	+	7·0
		B	7·5	do	do	++	+	+	−	7·5
		C	15·0	do	do	++	+	+	+	8·5
		D	22·5	do	do	++	+	+	−	6·0
		E	30·0	do	do	++	+	+	+	7·0
GAJNER .. (The lake and its surrounding area)	South-West of Bikaner	Sample I	Surface Rocksoil	Blackish-brown	Rocky	++++	+	+	+	8·5
		,, II	7·5 cm. shady area	Brown	Sandy	++++	++	+	+	7·5
		,, III	15·0 cm. shady area	do	do	++++	+++	++	+	6·5
		,, IV	Dried up suface soil of the lake	Red	Sandy smooth	++	+++	+	+	6·0
		,, V	7·5 cm. lake soil	Black	do	++++	+	+	+	7·0
		,, VI	15·0 cm. lake soil	do	do	++++	++	++	−	8·5

on *Bærhaavia*, *Amarantus*, smuts on grasses, and several rusts on species of *Sida* and cultivated plants. The downy mildews are also prevalent on crop plants like Bajra (*Pennisetum typhoideum*). The insect pests include termites, locusts and caterpillars which again cause considerable damage to the developing vegetation.

VEGETATION

In the Rajgarh area the vegetation is dominated by *Gymnosporia montana* while *Calligonum polygonoides* is abundant and *Prosopis spicigera* and *Aerua tomentosa* are common. In the Churu-Ashru area the most dominant tree species is *Prosopis spicigera* while *Leptadenia spartium* forms a dominant shrub association along with *Calligonum polygonoides* and *Crotalaria burhia*. Species of *Tephrosia* are abundant throughout this area. In Daipalsar-Churu area there are dominant associations of *Tephrosia purpurea* while *Prosopis spicigera* constitutes the common tree species.

In Ratangarh area *Prosopis spicigera* is a dominant tree. Along the railway track *Calotropis procera* is seen growing; it forms dominant associations with *Aerua tomentosa*. In this area *Zizyphus* is also quite frequent while *Capparis decidua* is totally absent. In Rajaldesar-Bigga area the vegetation consists of a scrub jungle of *Prosopis spicigera*, *Calligonum polygonoides* and *Zizyphus rotundifolia*. The sand dunes in this area are inhabited by bushes of *Calligonum* and *Aerua tomentosa*. *Tephrosia purpurea* is abundant along the railway track. *Calotropis* is totally absent in this region and along with the shrubby plants, species of *Sida* and *Cenchrus* are common. The Shri Dungargarh area is characterized by *Calligonum polygonoides* mixed with *Prosopis spicigera*. *Zizyphus rotundifolia* and *Calotropis procera* are also common. *Aerua tomentosa* grows frequently on the slopes of sand dunes and in ditches in this area.

In Sudsar area *Calligonum* is dominant while *Prosopis* and *Zizyphus* form rare associations. Mixed with *Calligonum* bushes there are associations of *Calotropis procera* at several places and *Aerua tomentosa* grows over the slopes of the sand dunes.

In Belasar area also *Calligonum* forms the dominant species. *Zizyphus* is rather common in this region while *Aerua* is abundant. *Prosopis* is rare.

In the Napasar area the dominant constituent plants are *Calligonum* and *Prosopis* in different belts.

Towards Bikaner proper, *Zizyphus rotundifolia* forms the dominant species while *Calligonum* is confined to small areas along the railway line. *Prosopis spicigera* which is rare in the previous area again becomes dominant as we approach towards Bikaner. About 6·5 kilometres from Bikaner there are extensive savannah formations of *Zizyphus rotundifolia*.

In Bikaner proper towards the east on the way to Vallabh Gardens *Zizyphus rotundifolia* and *Aerua tomentosa* are the dominant species in the plains, while *Prosopis* is common. On the sand dunes in this area, there are associations of *Aerua* and *Crotalaria burhia*, while *Capparis decidua* occurs as a rare species. In the Vallabh Garden area there are characteristic associations of *Prosopis* and *Tecoma undulata.* A number of ground species also grow in this area along with *Mollugo cerviana* and *Convolvulus* species. There are a number of cultivated species in this area which include *Melia*, *Dodonaea* and others. *Gymnosporia montana* is characteristic of this region.

The Hindumal Road area in the east is all sandy and the vegetation is very scanty. This area is characterized by *Aerua tomentosa* and *Crotalaria burhia* associations. *Euphorbia clarkeana* is also growing in dominant associations with *Crotalaria* and *Aerua.* Amongst the tree species *Prosopis* is rare and *Zizyphus* abundant. *Calotropis procera* is the common shrub species.

Towards west of Bikaner proper are present open sandy plains which constitute the grazing areas for cattle. This area is characterized by associations of *Aerua tomentosa* and *Leptadenia spartium* along with *Euphorbia clarkeana* and a number of grasses. Isolated trees of *Prosopis spicigera* occur here and there. *Capparis decidua* and *Gymnosporia montana* are completely absent from this region.

The Lallgarh Palace area in the north consists of sandy plains characterized by scrub jungle of *Capparis decidua* and *Zizyphus rotundifolia.* In the outskirts of the palace *Zizyphus* constitutes the dominant species at certain places while *Capparis decidua* at other places. Other plants available with the dominant species include *Leptadenia spartium*, *Crotalaria burhia*, *Euphorbia clarkeana*, *Boerhaavia diffusa*, *Polygala erioptera* and a number of *Gramineae. Monsonia heliotropioides* and *Fagonia cretica* are also common in this area. Along the roadsides and ditches there is another interesting association of *Peganum harmala* along with *Crotalaria burhia* and *Aerua tomentosa.*

Towards the south of Bikaner the area is sandy with several sand dunes and a number of villages have been visited in this direction. The village Udramsar is characterized by *Prosopis spicigera* as the dominant tree species. The ground vegetation was rather sparse and is represented by *Crotalaria burhia* and *Leptadenia spartium.* Within the village proper are bushes of *Zizyphus rotundifolia* and association of *Aerua tomentosa* and *Crotalaria burhia. Calotropis procera* also occurs frequently in the village area.

Binasahar and Gangasahar villages in the same direction are characterized by dominant associations of *Capparis decidua* and *Zizyphus rotundifolia* along with *Calotropis procera.* There are some temporary ponds in these villages along the banks of which grows the dominant association of *Salvadora persica* and *Zizyphus rotundifolia.*

The Gajner area situated at a distance of 30·5 km. from Bikaner in the south-west direction was also visited. This area shows typical savannah formation of *Zizyphus* while *Capparia decidua* also forms extensive savannah at some places. In Gajner proper *Capparis* is absent while there are extensive areas covered by the Australian *Acacia* introduced in this area.

In cultivated gardens of Gajner a number of introduced plants are seen growing along with *Zizyphus*, *Ficus* and *Melia*. This area is devoid of any characteristic species of the sandy plains except for occasional growth of *Aerua tomentosa* at isolated places. This area is entirely rocky with a vegetation only on one side. On the banks of the lake when water recedes certain species of *Ficoideæ* grow abundantly.

On the way to Gajner two villages Nal and Kodambdesar were also studied. In the Nal village there are characteristic associations of *Aerua tomentosa* and *Leptadenia spartium* while *Capparis*, *Zizyphus* and *Prosopis* have different frequencies at different zones. *Calotropis procera* is also common in the area. At Kodambdesar village there is extensive savannah of *Zizyphus*. *Capparis decidua* is also present at certain places.

PLANT ASSOCIATIONS

In the course of the present investigation the following plant associations have been recognised:–

I. *Gymnosporia-Calligonum Association*

1.	*Gymnosporia montana*, Benth	*d*
2.	*Calligonum polygonoides*, Linn.	*a*
3.	*Prosopis spicigera*, Linn.	*c*
4.	*Aerua tomentosa*, Forsk.	*a*
5.	*Tephrosia purpurea*, Pers.	*a*
6.	*Blepharis indica*, Stocks.	*a*
7.	*Anticharis linearis*, Hochst.	*a*
8.	*Eragrostis ciliaris*, Link.	*a*
9.	*Cenchrus ciliaris*, Beau. Linn.	*a*
10.	*Cenchrus biflorus*, Roxb.	*a*
11.	*Aristida hystricula*, Edgew.	*c*
12.	*Dactyloctenium ægyptiacum*, Willd.	*c*

II. *Prosopis-Calligonum Association*

1.	*Prosopis spicigera*, L.	*d*
2.	*Calligonum polygonoides*, L.	*a*
3.	*Leptadenia spartium*, Wight.	*a*
4.	*Tephrosia purpurea*, Pers.	*a*
5.	*Abutilon indicum*, G. Don.	*a*
6.	*Sida rhombifolia*, L.	*a*
7.	*Corchorus tridens*, L.	*c*
8.	*Corchorus antichorus*, Rœusch.	*c*
9.	*Tribulus terrestris*, L.	*a*
10.	*Fagonia arabica*, L.	*a*
11.	*Fagonia cretica*, L.	*a*
12.	*Monsonia heliotropioides*. Cav.	*a*

13.	*Boerhaavia repens*, L.	*a*
14.	*Aerua tomentosa*, Forsk.	*a*

III. *Prosopis-Zizyphus Association*

1.	*Prosopis spicigera*, L.	*d*
2.	*Zizyphus rotundifolia*, Lamk.	*a*
3.	*Calotropis procera*. Br.	*a*
4.	*Aerua tomentosa*, Forsk.	*c*
5.	*Boerhaavia diffusa*. L.	*a*
6	*Gisekia pharnaceoides*. L.	*c*
7.	*Trianthema pentandra*, L.	*a*
8.	*Chenopodium album*, L.	*c*
9.	*Euphorbia hirta*, L.	*a*
10.	*Euphorbia thymifolia*, Burm.	*c*
11.	*Corchorus acutangulus*, Lamk.	*a*
12.	*Sida grewioides*, Guill & Perr.	*c*
13.	*Oldenlandia aspera*, DC.	*c*
14.	*Leucas urticæfolia*, Br.	*a*
15.	*Sporobolus coromandelianus*, Kunth.	*a*
16.	*Andropogon javanicus*, Steud.	*c*
17.	*Aristida adscenscionis*, L.	*c*
18.	*Cenchrus biflorus*, Roxb.	*c*
19.	*Eleusine indica*, Gærtn.	*c*
20.	*Eleusine flagellifera*, Nees.	*c*
21.	*Eragrostis tenella*, R. & S.	*c*

IV. *Prosopis-Capparis Association*

1.	*Prosopis spicigera*, L.	*d*
2.	*Capparis decidua*, Pax.	*co.d.*
3.	*Zizyphus rotundifolia*, Lamk.	*a*
4.	*Leptadenia spartium*, Wight.	*a*
5.	*Crotalaria burhia*, Ham.	*a*
6.	*Eragrostis minor*, Host.	*c*
7.	*Eragrostis tenella*, R. & S.	*a*
8.	*Eleusine ægyptiaca*, Desf.	*c*
9.	*Boerhaavia diffusa*, L.	*a*
10.	*Polygala erioptera*, DC.	*a*
11.	*Monsonia heliotropioides*, Cav.	*c*
12.	*Euphorbia clarkeana*, Hk. f.	*c*
13.	*Calotropis procera*, Br.	*r*
14.	*Abutilon indicum*, G. Don.	*c*
15.	*Dicoma tomentosa*, Cass.	*a*

V. *Salvadora-Capparis Association*

1.	*Salvadora persica*, L.	*d*
2.	*Capparis decidua*, Pax.	*co.d.*
3.	*Prosopis spicigera*. L.	*a*
4.	*Calotropis procera*, Br.	*a*
5.	*Abutilon bidentatum*, Hochst.	*a*
6.	*Achyranthes aspera*, L.	*c*

7.	*Pupalia lappacea*, Moq.	*c*
8.	*Phyllanthus niruri*, L.	*c*
9.	*Tephrosia purpurea*, Pers.	*a*
10.	*Urena lobata*, L.	*c*
11.	*Ctenolepis garcini*, Naud.	*a*
12.	*Cucumis trigonus*, Roxb.	*a*
13.	*Dicoma tomentosa*, Cass.	*c*
14.	*Volutarella divaricata*, Benth.	*c*
15.	*Peristrophe bicalyculata*, Nees.	*a*
16.	*Scirpus supinus*, L.	*c*
17.	*Fimbristylis æstivalis*, Vahl.	*c*
18.	*Eragrostis ciliaris*, Link.	*a*
19.	*Eleusine verticillata*, Roxb.	*c*
20.	*Cenchrus ciliaris*, L.	*a*
21.	*Aristida hystricula*, Edgew.	*a*
22.	*Physalis minima*, L.	*c*

VI. *Calligonum-Aerua Association*

1.	*Calligonum polygonoides*, L.	*d*
2.	*Aerua tomentosa*, Forsk.	*a*
3.	*Zizyphus rotundifolia*, Lamk.	*c*
4.	*Calotropis procera*, Br.	*c*
5.	*Cucumis trigonus*, Roxb.	*c*
6.	*Acacia arabica*, Willd.	*c*
7.	*Achyranthes aspera*, L.	*c*
8.	*Pupalia lappacea*, Moq.	*c*
9.	*Heliotropium zeylanicum* Lamk.	*c*
10.	*Fagonia cretica*, L.	*c*
11.	*Euphorbia hirta*, L.	*c*
12.	*Tribulus alatus*, Del.	*c*
13.	*Farsetia hamiltonii*, Royle.	*a*
14.	*Cleome viscosa*, L.	*a*
15.	*Physalis minima*, L.	*c*
16.	*Convolvulus microphyllus*, Sieb.	*a*
17.	*Blepharis sindica*, Stocks.	*a*
18.	*Eragrostis minor*, Host.	*a*
19.	*Eragrostis tenella*, R. & S.	*c*
20.	*Cenchrus ciliaris*, L.	*a*
21.	*Cenchrus biflorus*, Roxb.	*a*
22.	*Dactyloctenium ægyptiacum*, Wills.	*c*

VII. *Aerua-Leptadenia Association*

1.	*Aerua tomentosa*, Forsk.	*d*
2.	*Leptadenia spartium*, Wight.	*co.d.*
3.	*Euphorbia clarkeana*, Hk. f.	*a*
4.	*Cenchrus ciliaris*, L.	*a*
5.	*Convolvulus microphyllus*, Sieb.	*a*
6.	*Tragus racemosus*, Scop.	*a*
7.	*Aristida adscenscionis*, L.	*a*
8.	*Eragrostis pilosa*, Beauv.	*a*
9.	*Sporobolus coromandelianus*, Kunth.	*c*

10.	*Crotalaria burhia*, Ham.	*c*
11.	*Prosopis spicigera*, L.	*r*

VIII. *Leptadenia-Crotalaria Association*

1.	*Crotalaria burhia*, Ham.	*d*
2.	*Leptadenia spartium*, Wight.	*co.d.*
3.	*Aerua tomentosa*, Forsk.	*a*
4.	*Achyranthes aspera*, L.	*c*
5.	*Setaria verticillata*, Beauv.	*c*
6.	*Brachiaria eruciformis*, Griseb.	*c*
7.	*Cyperus iria*, L.	*c*
8.	*Ipomœa rumicifolia*, Chois.	*c*
9.	*Sida grewioides*, Guill. & Perr.	*c*
10.	*Tribulus alatus*, Del.	*c*
11.	*Indigofera trigonelloides*. J. & S.	*c*

IX. *Aerua-Tephrosia Association*

1.	*Aerua tomentosa*, Forsk.	*d*
2.	*Tephrosia purpurea*, Pers.	*a*
3.	*Zizyphus rotundifolia*, Lamk.	*c*
4.	*Calligonum polygonoides*, L.	*c*
5.	*Cenchrus biflorus*, Roxb.	*a*
6.	*Anticharis linearis*, Hochst.	*c*
7.	*Boerhaavia diffusa*, L.	*a*
8.	*Digera arvensis*, Forsk.	*c*
9.	*Euphorbia hypericifolia*, L.	*c*
10.	*Indigofera cordifolia*, Heyne.	*c*
11.	*Crotalaria burhia*, Ham.	*c*
12.	*Trianthema pentandra*, L.	*c*
13.	*Polygala erioptera*, DC.	*a*
14.	*Brachiaria eruciformis*, Griseb.	*c*
15.	*Dactyloctenium ægyptiacum*, Willd.	*c*
16.	*Eleusine aristata*, Ehrenb.	*c*
17.	*Eragrostis tenella*, R. & S.	*a*
18.	*Elionurus hirsutus*, Munro.	*c*

X. *Aerua-Crotalaria Association*

1.	*Aerua tomentosa*, Forsk.	*d*
2.	*Crotalaria burhia*, Ham.	*a*
3.	*Peganum harmala*, L.	*a*
4.	*Leucas urticæfolia*, Br.	*c*
5.	*Ipomœa rumicifolia*, Chois.	*c*
6.	*Trianthema pentandra*, L.	*a*
7.	*Trianthema crystallina*, Vahl.	*c*
8.	*Amarantus blitum*, L.	*c*
9.	*Portulaca oleracea*, L.	*c*
10.	*Polygala erioptera*, DC.	*a*
11.	*Polygonum plebejum*, Br.	*a*
12.	*Phyllanthus niruri*, L.	*c*

Note:—*d*—Dominant species; *co.d.*—Co-dominant species; *a*—Abundant species; *c*—Common species; *r*—Rare species.

DISCUSSION

Bikaner division situated in the north of Rajasthan is a typical sand-dune plain and as compared to other regions in the Indian desert this area is perhaps drier. In this respect the Jaisalmer area also stands in close comparison to Bikaner. The geographical status of Rajasthan as a whole shows that the northern and western regions of the area receive scanty rainfall as compared to the eastern and southern regions. Another fact of geographical importance is the presence of discontinuous chains of Aravali ranges in the eastern and southern regions, though they extend to the western part as seen at Jodhpur. The northern area does not show this mountainous topography.

Natural rivers are also very scarce in the northern area. Some major rivers of Rajasthan are present in the eastern region like the river Chambal while in the west the most important river is Luni with several tributaries but unfortunately its waters are saline and the area covered by this river is practically of no utility for the growth of vegetation.

In a recent Sir Albert Charles Seward Memorial Lecture Wadia (1954) points out that the whole of Asia is undergoing desiccation. The main reasons attributed by him for this is based on climatic changes which lower the rainfall in several areas. Western Rajasthan, according to him, was a fertile basin some 2,500 years ago and the existing arid conditions have developed only since then. The luxuriant growth of vegetation represented by a large number of species in the rainy season definitely supports the hypothesis of Wadia that this scarce vegetation in Western Rajasthan must mainly be attributed to the climate of the region.

The vegetation in Bikaner and its neighbourhood stands in close contrast to other investigated areas of Western Rajasthan and those of east. The area consists of almost sandy plains and sand dunes and there are extensive savannah formations of *Zizyphus*, *Calligonum* and *Capparis* in this area. The above three species no doubt grow in different other parts of Rajasthan but never invade extensive tracts as they grow mixed with other plants. For example, in Eastern Rajasthan they grow mixed with *Gymnosporia montana* and *Balanites roxburghii*. The latter species is totally unrepresented in this region. This is perhaps due to the drier conditions prevalent in the region. In the Western Rajasthan also such extensive savannah formations of *Zizyphus*, *Calligonum* and *Capparis* are reported from Jaisalmer side, but they are absent in the Jodhpur region. The Jodhpur region is characterised by several rock formations and the number of plant species is definitely higher in this region. Giant *Euphorbias* are very frequent in the area and the tree species on the mountains include *Grewia*, *Cordia*, *Anogeissus* and others. The herbaceous vegetation also is richer as compared to the sandy plains which might be seen in the list of species outlined by Sarup and his colleagues (1951). The abundance of flora in this area may partly be attributed to the availability of more water which is stored in a number of artificial water reservoirs in the mountainous valleys of Jodhpur.

The Bikaner area which lacks in all the above features naturally supports very little vegetation. Not only the number of species is less but the variety of species is also very poor. The *Asclepiadaceae*, *Convolvulaceae*, *Malvaceae*, *Compositae*, *Acanthaceae* and *Labiatae* which are very well represented in Jodhpur and Eastern Rajasthan are very poorly represented in this region. There are certain endemic species in this area such as *Peganum harmala*; *Salvadora* and *Tamarix*, characteristic of the saline Luni river bed in Western Rajasthan which are also fairly abundant in this region. The absence of rock and gravel formations of vegetation is another feature of the area. The aquatic formations represented by several species of *Ceratophyllum*, *Hydrilla*, *Vallisneria* and *Potamogeton* in Jodhpur and other areas of Eastern Rajasthan are not represented within this area. The aquatic formations at best are represented by several species of algæ and on the dried up banks of the ponds several *Ficoideae* grow. In this respect the area shows resemblance to the vegetation of temporary ponds in Eastern Rajasthan.

The pioneer species in consolidating the soil in the sand-dunes are *Leptadenia spartium*, *Crotalaria burhia*, *Aerua tomentosa* and a number of herbaceous annuals like *Trianthema pentandra*, *Euphorbia clarkeana* and a number of grasses. The sandy plains in which the soil has been little established by the ground vegetation in the rainy season supports the characteristic savannah formations of *Capparis decidua*, *Calligonum polygonoides* and *Zizyphus rotundifolia*. The climax that could be developed in this part of the Indian desert is an association of *Calligonum-Zizyphus* and *Capparis* due to the extreme conditions of climate available in the area.

A comparison of vegetation of this region with other investigated areas of Rajasthan thus shows that it stands in close comparison to Jaisalmer and Phalodi areas in the west and Shekhawati region in the east. The decreasing rainfall in the Indian desert as we proceed from east to west is the main factor for the poor representation of the plant species in the area under study.

SUMMARY

1. The present paper deals with the vegetation of Bikaner and its neighbourhood.

2. The soil analysis of Bikaner and its neighbourhood was carried out in different regions.

3. A detailed account of the vegetation and plant associations in the area is given.

4. A comparison of the vegetation of Bikaner with neighbourly areas of Rajasthan which have been so far investigated shows that the present area resembles the arid division of Western Rajasthan like Jaisalmar and Phalodi and the sandy plains of Shekhawati in the east.

5. On the basis of the available data the vegetation is ascribed to a definite ecological status and it is shown to be a *Calligonum-Zizyphus-Capparis* association.

ACKNOWLEDGEMENTS

I am thankful to Professor B. V. Ratnam, Department of Botany, Jaswant College, Jodhpur, under whose suggestion the present work was undertaken. My sincere thanks are also due to Dr. B. N. Mulay, Head of the Department of Botany, Birla Science College, for his keen interest in the work and to the Birla Education Trust for facilitating this work by awarding me a scholarship. I am highly obliged to Dr. R. Misra, Head of the Department of Botany, Banaras Hindu University, Banaras, for going through the manuscript and for several useful suggestions. My thanks are also due to the Director, Meteorological Department, New Delhi, for supplying the climatic data.

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THE CLAVARIACEÆ OF THE MUSSOORIE HILLS—V

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(Received for publication on August 8, 1956)

The first four contributions (listed under references) describe 17 known Clavarias (12 species, 3 varieties and 2 forms), mostly new records for India, and 11 new Clavarias (5 new species and 6 new varieties). This fifth contribution deals with 7 more known Clavarias (5 species, 1 variety and 1 form) all of which are new records in India.

The classification of Corner (1950) has been followed throughout this study.

The numbers of the Clavarias are the serial numbers of the Flora.

Type collections have been deposited in the Herbarium of the Panjab University, Duplicate material is at the Botany School, University of Cambridge, England.

29. *Ramaria flavobrunnescens* (Atk.) Corner

Fructifications up to 18 cm. high and up to 23 cm. broad, solitary, scattered, erect large-sized, radial, trunk absent, profusely branched, fleshy, smooth, glabrous, deep golden-yellow, lighter coloured at the base: branching polychotomous below, dichotomous above, up to 6 times branched, compact, unequal, in alternating planes, internodes long: primary branches up to 1 cm. wide, longitudinally rugulose: ultimate branchlets very short, mostly up to 1·5 mm. long, rarely up to 6 mm. long, in pairs: apices blunt or obtuse, concolorous: flesh concolorous (?): taste and smell inparticular.

Hymenium spread all over except the lighter coloured base, slightly thickening, up to 90 μ thick.

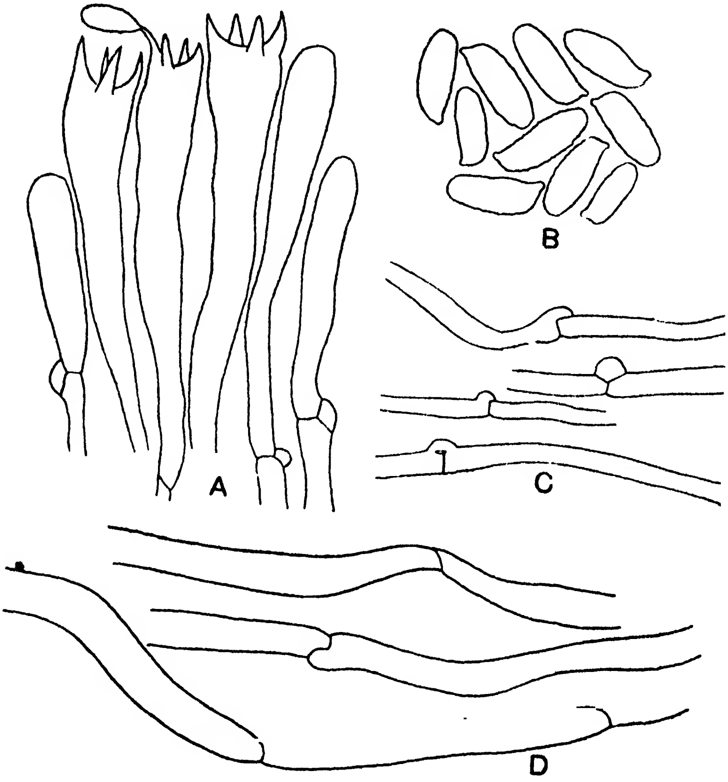
Basidia 30–52 6–8 μ, clavate-elongate, clamped at the base: sterigmata 4, slender, straight or slightly incurved, 1·6–7·4 μ long.

Basidiospores 7·6–11 × 3·6–4 μ, pale brown, wall slightly darker, ellipsoid to ellipsoid-elongate, papillate, papilla small and up to 0·6 μ long, faintly verruculose-rough to almost smooth, aguttate.

Hyphæ monomitic, 3–16 μ wide, hyphal cells up to 202 μ long, hyaline, thin walled, branched, inflated, septate, septa mostly at short intervals, sometimes swollen terminally or on one side of the septum, clamped, clamps common on the subhymenial hyphæ and the basidia but sparse to rare on the medullary hyphæ.

Plate XXIII, Fig. 1; Text-Fig. 1, A-D.

Collected on soil under Oak forest, Chakrata Toll, Mussoorie, August 6, 1953, 61.



TEXT-FIG. 1. *Ramaria flavobrunnescens* (Atk.) Corner. A. Clamped basidia × 1,150. B. Verruculose-rough to almost smooth basidiospores, × 1,150. C. Clamped sub-hymenial hyphæ, × 1,150. D. Medullary hyphæ with a very few or no clamps, × 500.

This collection agrees with *Ramaria flavobrunnescens* (Atk.) Corner in all points except that most of the medullary hyphæ are septate without clamps, though a few septa have them, but the subhymenial hyphæ and basidia are clamped. Such an intermediate hyphal state has not been reported before in the genus *Ramaria.*

30. *Aphelaria tuberosa* (Grev.) Corner

Fructifications 2·1–5 × 0·6–1·2 cm., gregarious, scattered, erect, small sized, radial to flattened, trunk present, sparsely branched, sometimes simple, tough, rough, dirty white, becoming brighter at the top, on drying turning brown: trunk 1·5–3·2 cm. × 0·8–2 mm., cylindrical: branches lax, sparse, 1–3 dichotomous, unequal, mostly in one plane, lower branches flattened and broadly palmately divided, ultimate branchlets long, radial and up to 1·7 cm. long: apices acute and sterile:

flesh white, unchanging on exposure or bruising: smell and taste inparticular.

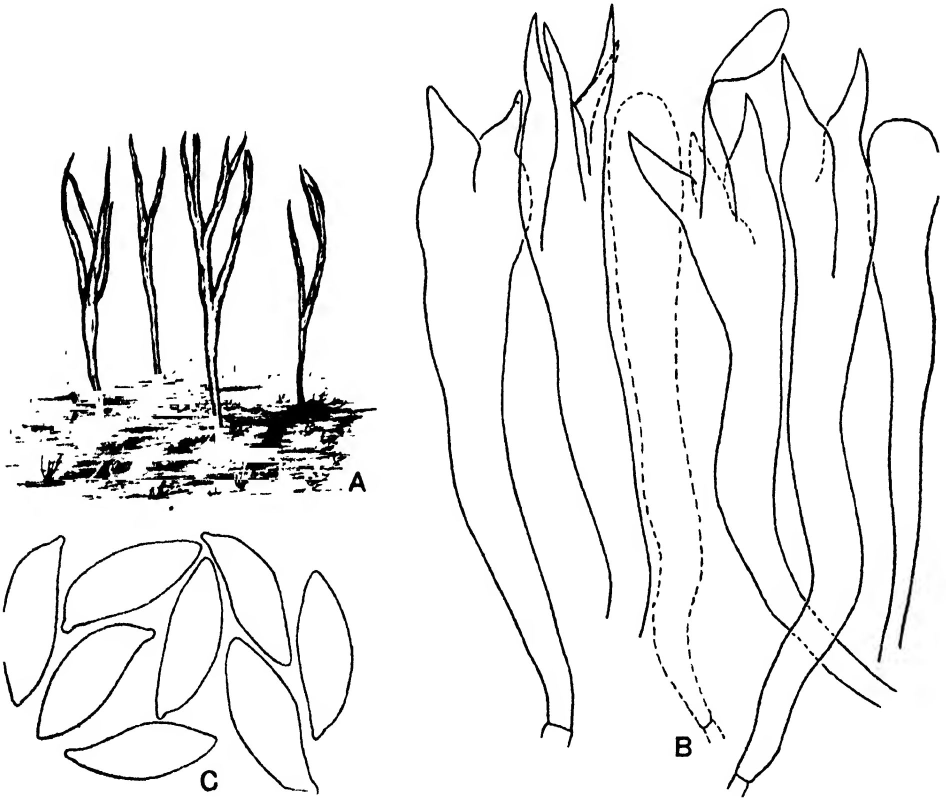
Hymenium spread all over except the sterile apices and the lower sterile part of the trunk, thickening, with numerous embedded spores, up to 315 μ thick.

Basidia 50–90 × 6–12 μ, hyaline, subtremellaceous, clavato-elongate, or clavate with a long tapered base, filled up with abundant irregular guttules: sterigmata 4, sometimes 2, stout, straight or incurved, 4–12 μ long.

Basidiospores 14·4–20 × 4·8–6·4 μ, hyaline, elongato-ellipsoid, subfusoid or subsigmoid, subacute, papillate, attenuating to the papilla, papilla prominent and 1–1·6 μ long, smooth, aguttate.

Hyphæ monomitic, 3–4 μ wide, hyaline, thin-walled to slightly thick-walled, branched, uninflated, septate, septa at long intervals, clamped.

Text-Fig. 2, A-C.



Text-Fig. 2. *Aphelaria tuberosa* (Grev.) Corner. A. Sparsely branched fructifications, × 1. B. Sub-tremellaceous basidia, × 1,150. C. Elongato-ellipsoid and smooth-walled basidiospores, × 1,150.

Collected on soil amid mosses, The Upper Park Road, Mussoorie, August 22, 1955, 62.

This fungus undoubtedly belongs to *Aphelaria tuberosa* (Grev.) Corner. It has only one kind of basidia which appear to be subtremellaceous. The young basidia are clavate with a long tapered base. Later at maturity they become 2–4 lobed, each lobe prolonging above into a stout sterigma up to 12×4 μ. The four lobes divide the basidium imperfectly longitudinally (at the top only, the partition walls always remaining above the middle of the basidium), thus imparting a subtremellaceous appearance to the basidium.

31. *Lentaria byssiseda* Corner

Fructifications lignicolous, 1·5–3·6 cm. tall and 0·5–2·5 cm. broad, densely gregarious or cæspitose, all fructifications in a densely gregarious patch springing from a common white mycelial felt or patch which extends on the dead twigs up to 12 cm., erect, small sized, trunk present, or absent, branched, fleshy, smooth, glabrous, reddish brown, with white apices, turning to light brown on drying: trunk small to inconspicuous, or even absent, 2–5×1–1·5 mm., radial to slightly flattened, arising from the mycelial felt: mycelial patch (or felt) white, extending up to 12 cm., giving out fructifications throughout its surface, composed of hyaline, narrow, thin-walled, branched, uninflated, septate (septa at long intervals) clamped hyphæ, which are 1·8–2·4 μ wide: branches lax, fastigiate, up to 4-dichotomous, radial, unequal, in alternating planes, ultimate branchlets long, up to 2·5 cm. long: apices acute, sometimes rounded, sterile when acute, fertile when rounded: flesh white: taste and smell inparticular.

Hymenium spread all over, trunk fertile, thickening, up to 110 μ thick, with many embedded spores.

Basidia 30–38×5·6–8 μ, clavate: sterigmata 4, straight or slightly incurved, 3·2–9 μ long.

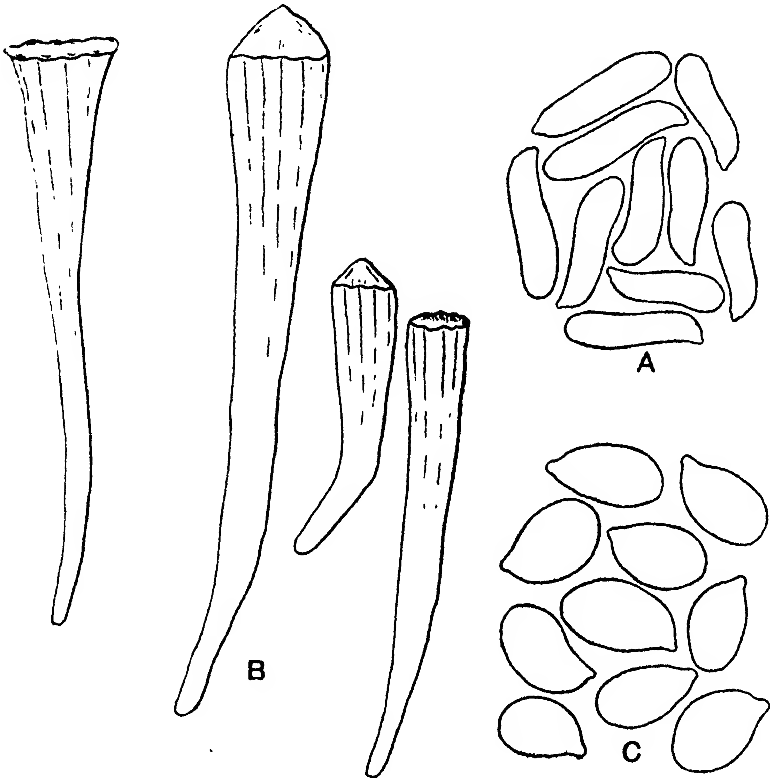
Basidiospores 6·8–15·2×3–4·8 μ, narrowly ellipsoid, mostly sinuous or subsigmoid, blunt or rounded at the apex, subacute at the oblique base, papillate, papilla small, smooth, aguttate.

Hyphæ monomitic, 2–10 μ wide, hyphal cells up to 344 μ long, or even more, hyaline, thin-walled, branched, wavy to convoluted, slightly inflated, septate, septa at short to long intervals, clamped, clamps common.

Plate XXIII, Fig. 2; Text-Fig. 3, A.

Collected on dead twigs of *Picea morinda* Link under *Picea* forest, Sarkunda Temple, Mussoorie, September 2, 1955, 63.

This collection undoubtedly belongs to *Lentaria byssiseda* Corner and is characterized by the lignicolous, small-sized, reddish brown fruit bodies springing from the white mycelial patch, long ultimate branchlets, narrowly ellipsoid, often sinuous to sigmoid spores (6·8–15·2 × 3–4·8 μ), and clamped hyphæ.



Text-Fig. 3. *Lentaria byssiseda* Corner. A. Sinuous or subsigmoid, narrowly ellipsoid and smooth-walled basidiospores, × 1,150. *Clavariadelphus truncatus* (Quél.) Donk. B. Simple clavate fructifications with conical and truncatus apices, × ½. C. Broadly ellipsoid basidiospores, × 1,150.

32. *Clavariadelphus truncatus* (Quél.) Donk

Fructifications 5–16 cm. tall, scattered, large-sized, radial, simple, clavate, trunk present, fleshy, brittle, smooth, glabrous, apical portion first light-yellow then orange-red, lower portion dark-red, while the basal trunk portion is pale yellow, entire clubs turning dark-brown on drying: trunk indistinct, 1–4 × 0·4–0·8 cm., solid, sterile: simple clubs clavate being broadest at the top and gradually narrowing to the base, longitudinally rugose, hollow above and solid below: apex at first conical, 1·5–2·5 cm. wide, later becoming truncate to concave or depressed and eventually perforated, sterile: flesh white, on bruising turning dark-red: taste sweet: smell inparticular: white mycelial threads given out from the base of the clubs are composed of narrow, thin-walled, hyaline, branched, clamped, 2–3 μ wide hyphæ.

Hymenium spread all over except the sterile apex and sterile trunk, not thickening, up to 140 μ thick.

Basidia 80-120×7–10 μ, subhyaline, clavate: sterigmata 4, straight or slightly incurved, 3–11 μ long.

Basidiospores 9·6–12×5·6–6·8 μ, subhyaline, broadly ellipsoid, sometimes ovoid, papillate, papilla up to 0·8 μ long, smooth, aguttate.

Hyphæ monomitic, 2–15 μ wide, hyphal cells up to 166 μ long, hyaline, thin-walled, branched, inflated to uninflated, septate, septa at short intervals in inflated and at long intervals in narrow hyphæ, inflated hyphæ usually constricted in the region of septa, clamped, clamps sparse.

Text-Fig. 3, B-C.

Collected on soil under *Picea* forest, Kadu Khal, Mussoorie, September 2, 1954, 64.

This fungus undoubtedly belongs to *Clavariadelphus truncatus* (Quél.) Donk. The perforated sterile apex is not pervious to the base of the fruit body. This specimen evidently represents the red form of the species as described by Lovejoy (Corner, 1950). It is differentiated from collection n. 15 of *Clavariadelphus mirus* (Pat.) Corner collected from the Mussoorie hills (Thind and Anand, 1956) in the colour of its fruit body and in the sterile conical apex which later becomes truncatus and perforated.

33. *Clavulina cristata* (Fr.) Schroet. var. *fimbriata* Fr.

Fructifications gregarious, scattered, solitary, erect, medium-sized, radial, trunk present, branched, fleshy, glabrous, light-brown, up to 7·5 cm. tall and up to 4·2 cm. broad: trunk long, cylindrical or slightly flattened in some cases, whitish at the base, tomentose, up to 3·3 cm. long and up to 1·1 cm. broad: tomentose hairs hyaline, simple, rarely branched, closely septate, clamped, thin to slightly thick-walled, narrow, up to 210 μ long and 1–4 μ broad: branching lax, sparse to abundant, radial, dichotomous, branches equal or unequal, and in alternating planes, internodes long, primary branches up to 5·5 mm. broad, ultimate branchlets small, cristate due to close and irregular dichotomy: apices acute, lighter coloured, fertile: flesh lighter coloured: taste bitter: smell inparticular: rhizomorphic hyphæ given out from the base of the fructification and they are brown, thick-walled, branched, with numerous antler-like branches, 4–6 μ broad, with hyphal cells up to 240 μ long, wall up to 1 μ thick.

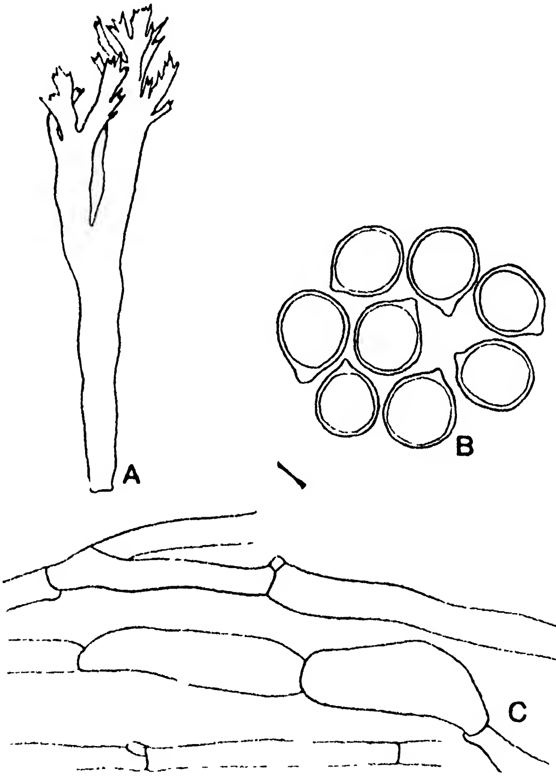
Hymenium spread all over except trunk, also absent in the lower portions of some of the primary branches where the latter are tomentose like the trunk, thickening, up to 68 μ thick.

Basidia 44–48×5·16–6·88 μ, subhyaline, clavate: sterigmata 2, sometimes 1, strongly incurved, up to 7·74 μ long.

Basidiospores hyaline, globose, papillate, papilla small and very fine, smooth, uniguttate, guttule filling almost whole of the spore cavity, 8–9 μ in diameter.

Hyphæ monomitic, 4–17·2 μ wide, hyphal cells up to 138 μ long, or more, in broader hyphæ, and up to 258 μ, or longer, in the narrower ones, hyaline, branched, thin-walled, inflated, septate, septa at long intervals in narrower and at shorter intervals in broader hyphæ, clamped, clamps abundant and appear more prominent on the narrower hyphæ than on broader ones.

Text-Fig. 4, A-C.



TEXT-FIG. 4. *Clavulina cristata* (Fr.) Schroet. var. *fimbriata* Fr. A. A fructification with a long trunk and cristate apices, ×1. B. Globose and uniguttulate basidiospores, ×1,150. C. Clamped hyphæ, ×500.

Collected on moist soil under Oak forest, Dhobi Khud, Mussoorie, August 30, 1954, 65.

The present collection resembles *Clavulina cristata* (Fr.) Schrœt. var. *fimbriata* Fr. in the elongate trunk, lax branching at the top, cristate ultimate branchlets and globose spores of the same size.

34. *Clavulina cinerea* (Fr.) Schrœt. f. *sublilascens* Bourd. et Galz.

Fructifications 2·4–4 × 1·6–3·8 cm., scattered, erect, small-sized, radial, without a trunk, profusely branched, fleshy-tough, smooth, glabrous, dark vinaceous with black tips, on drying turning sooty or dark-brown, the embedded base of the fructifications elongated (up to 2·1 × 0·8 cm.): branches profuse, often slightly irregularly flattened, rugulose, polychotomous below, becoming irregularly-chotomous above giving a bushy appearance to the fruit bodies, internodes short, branches compact, ultimate branchlets short and giving a cristate appearance: apices acute, sometimes obtuse, sterile: flesh lighter concolorous, turning dark-red on bruising: smell and taste inparticular.

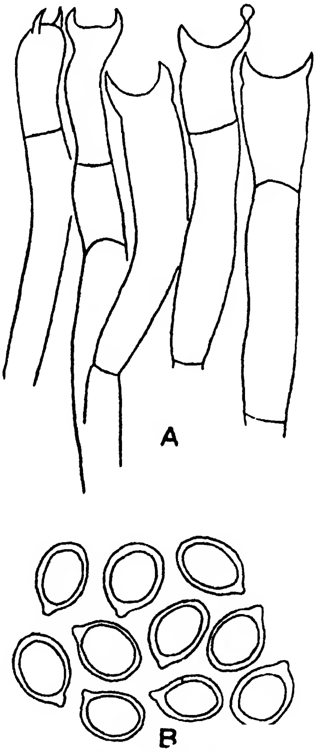
Hymenium spread all over except the sterile apices, thickening, up to 164 μ thick.

Basidia 36–44 × 4–8 μ, cylindrical to subclavate, secondarily septate after spore discharge: sterigmata 2, sometimes 1 or 4, stout, strongly incurved, 3–7 μ long.

Basidiospores 7·2–9·6 × 4·8–6·4 μ, subhyaline to hyaline, ovoid sometimes subglobose to globose, papillate, papilla prominent and up to 0·8 μ long, smooth, uniguttate, guttule large and filling three-fourth to almost whole of the spore cavity.

Hyphæ monomitic, 2–14 μ wide, hyphal cells up to 260 μ long, hyaline, thin-walled, branched, inflated, some uninflated, septate, septa at short intervals in wider and at long intervals in narrower hyphæ, clamped, clamps almost at all septa.

Plate XXIII, Fig. 3; Text-Fig. 5, A-B.



Text-Fig. 5. *Clavulina cinerea* (Fr.) Schrœt. f. *sublilascens* Bourd. et Galz. A. Secondarily septate basidia, × 1,150. B. Uniguttulate spores, × 1,150.

Collected on soil amid mosses under *Cedrus* forest, Kanatal, Mussoorie, September 11, 1955, 66.

Clavulina cinerea (Fr.) Schrœt. often has such stunted forms as this collection n. 66 from the Mussoorie hills. It differs from *Clavulina cristata* (Fr.) Schrœt. in its darker fruit bodies from the beginning.

35. *Clavaria acuta* Fr.

Fructifications up to 6 cm. tall, solitary, scattered, erect, slender, small-sized, radial, trunk present, simple, clavate, fleshy, brittle, smooth, glabrous: head 0·2-4 cm. long and 0·5-1·8 mm. wide, white, elongated, bent or allantoid, cylindrical, usually slightly broader at the top, apex acute in young fruit bodies, becoming obtuse or blunt and swollen in mature ones: trunk 1·1-3 cm. long and 0·5-1 mm. wide, distinctly demarcated, white, narrow, smooth but usually with very fine narrow hyphæ loosened out from its surface and appearing as a fine irregular pubescence which is more pronounced at the base: numerous rhizomorphic myceliel threads given out from the base of the fructifications: flesh white: smell and taste inparticular.

Hymenium spread all over the head, trunk sterile, not thickening, up to 60 μ thick.

Basidia 40-48 × 6·4-7 μ, hyaline, clavate with a long tapered base, provided with a wide loop-like clamp at the base: sterigmata mostly 4, sometimes 2, long, straight, 4-12 μ long.

Basidiospores 7·2-8·8 × 4·8-5·6 μ, hyaline, broadly ellipsoid to oval, papillate, papilla small but distinct and up to 0·8 μ long, smooth, aguttate, filled with dense grannular contents.

Hyphæ monomitic, 2-22 μ wide, hyphal cells up to 414 μ long, or even more, hyaline, thin-walled, branched, inflated, septate, septa at long intervals, also secondarily septate, secondary septa sparse, clamps absent.

Text-Fig. 6, A-D.

Collected on soil, Company Garden, Mussoorie, August 24, 1955, 67.

This collection undoubtedly belongs to *Clavaria acuta* Fr. Its fruit bodies were observed as solitary and scattered. Densely-fasciculate or fruit bodies gregarious in small groups as reported for *C. acuta* (Corner, 1950) were not observed. Also the basidia are mostly 4-spored in contrast to the mostly 2-spored basidia reported for this species. Spore size and shape fall well within the range for the species which is so variable.

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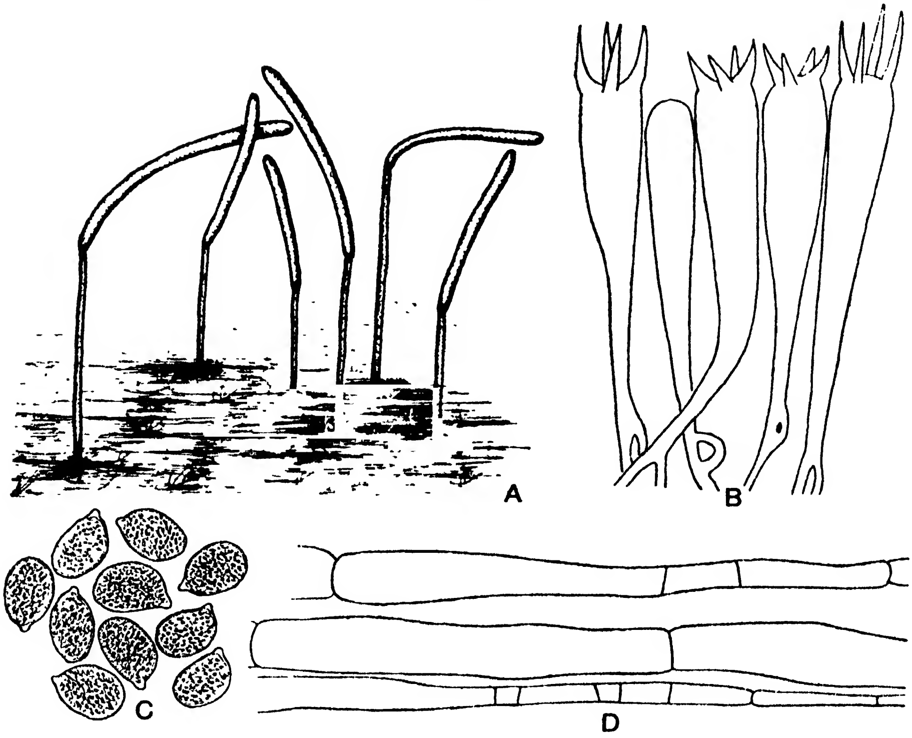

TEXT-FIG. 6. *Clavaria acuta* Fr. A. Clavate simple fructifications with a sharply demarcated trunk, × 1. B. Basidia with a wide loop-like clamp at the base, × 1,150. C. Basidiospores with densely granular contents, × 1,150. D. Secondarily septate hyphæ, × 500.

ACKNOWLEDGMENTS

The authors are deeply indebted to Mr. E. J. H. Corner, F.R.S., of the Botany School, Cambridge, England, for help in the identification of the Clavarias and to Prof. P. N. Mehra, Head of the Panjab University Botany Department, for providing facilities and encouragement.

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EXPLANATION OF PLATE

FIG. 1. *Ramaria flavobrunnescens* (Atk.) Corner, fruit body without a trunk, × ½ (approx.).

FIG. 2. *Lentaria byssiseda* Corner, a dead twig covered over with white mycelial patch bearing numerous fruit bodies with lax and fastigiate branches, × 1 (approx.).

FIG. 3. *Clavulina cinerea* (Fr.) Schrœt. f. *sublilascens* Bourd. et Galz., fruit bodies profusely branched and bushy, × 1 (approx.).

FELIX EUGEN FRITSCH, 1879-1954

FELIX EUGEN FRITSCH was born on the 26th April 1879 at Hampstead in London. He was the only son of H. Fritsch who was a schoolmaster at Hampstead. During his school-life, Felix suffered very much from frequent illness and developed asthma. His father thought that his son would never be strong enough to follow any ordinary profession and so chose botany as a career for him, as it would mean a good amount of outdoor work which was likely to improve his health considerably.

Fritsch was educated at Warwick House School at Hampstead, and graduated at London University. He then went to Germany and worked as an assistant in the Botany Department of the University of Munich from 1899 to 1901, during which period he obtained the Ph.D. Degree of the University and returned to England in 1902 and joined the staff of the Botany Department of the University College, London, where he was an Assistant from 1902-06 and an Assistant Professor from 1906-11. From 1907, he started teaching at Queen Mary College also, which was then called East London College. In 1911, he became the Head of the Department of Botany at Queen Mary College. When he first went there, he found the Botany Department ill-equipped and ill-staffed. Prof. Fritsch built up both with steady perseverance in spite of his ill-health and the heavy demands of teaching and became the first Dean of the College Faculty of Science.

Fritsch took a very active part in the affairs of the University of London. He was University Professor for twenty-four years and served on a number of its Committees, for some of which he was also Chairman.

He was President of the Botany Section of the British Association for the Advancement of Science in 1927. In 1931, he became the President of the British Ecological Society and in 1932 he was elected a Fellow of the Royal Society. In 1948, he retired from the Queen Mary College as Emeritus Professor and settled down in Cambridge, where he spent much of his time at the Botany School. He was responsible for bringing Prof. E. G. Pringsheim to Cambridge and starting cultures of algæ at the Botany School. In 1950, he was awarded the Darwin Medal by the Royal Society and in 1952, the University of London conferred on him the degree of LL.D. *honoris causa.* In 1953 Fritsch became the President of the British Institute of Biology and of the International Association of Limnology.

He was a Fellow of the Linnean Society for fifty-one years. He was elected in 1903, served on its councils from 1922-26 and 1949-53, was Vice-President in 1925-26 and 1952-53 and President of the Society from 1949-52. In 1954 the Council of the Linnean Society nominated Professor Fritsch for the award of the Linnean Gold Medal in apprecia-

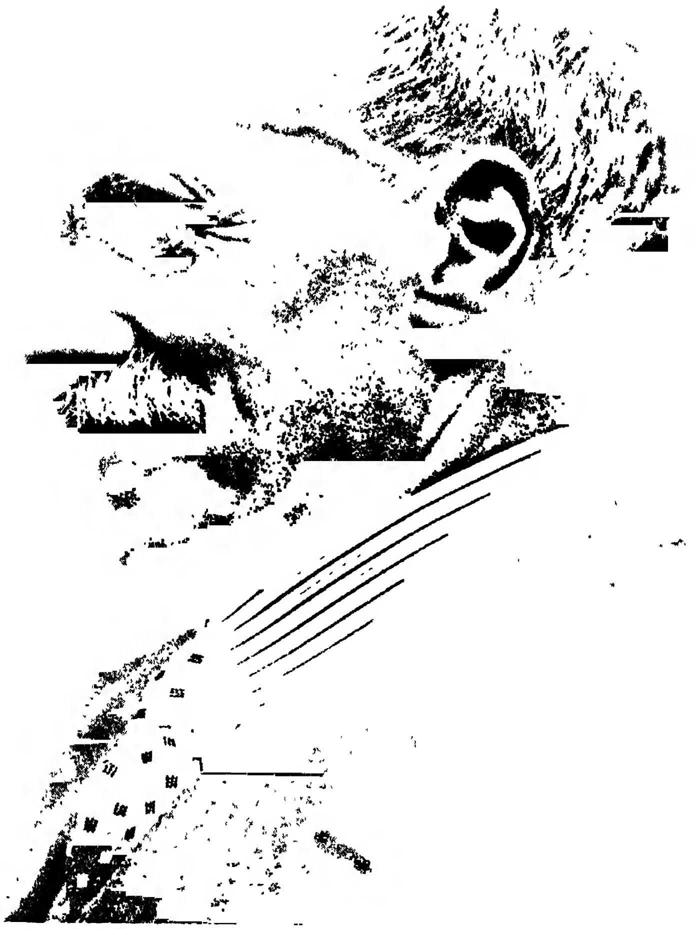

Photo. G. C. Monkhouse, F.R.P.S.

F. E. FRITSCH (1879-1954)

tion of his great contributions to the study of Botany. The Medal was to have been awarded to him at the Anniversary Meeting of the Society on the 24th May 1954. Unfortunately he died on the 23rd May 1954 and the Medal had to be awarded posthumously. The esteem and affection of the members of the Society for him was so great that the President and Councillors of the Society went to Cambridge with the Gold Medal, and formally presented it to Mrs. Fritsch in her own flat with all the usual ceremony.

He was an Honorary Member of the Indian Botanical Society and of a number of foreign Scientific Societies in Austria, Belgium, Norway, Sweden and the U.S.A.

He took part in many International Botanical and Limnological Congresses and in doing so visited most European countries. He visited Ceylon in 1903 and India in 1938. In India, he attended the 25th Annual Meeting of the Indian Science Congress Association at Calcutta, and presided at the Discussion on "the Algal problems peculiar to the tropics" and delivered a course of advanced Lectures on Algæ and Hydrobiology at the University of Madras. He then visited Seven Pagodas, Madura and the Marine Biological Station at Krusadai Island near Pamban, and Ceylon once again on his way back to England.

Fritsch was throughout his life keenly interested in phytoplankton and algal periodicity. He became first interested in this aspect of algology while he was in Germany through the publications of continental algologists on phytoplankton. When he returned to England, he started collecting phytoplankton from the River Thames and published two notes (1902 *d* and 1903 *e*) on the phytoplankton of the river. In 1903 he published a note on the seasonal changes in the algal flora of the artificial waters at Kew. He published in 1905 an account of the phytoplankton of some English rivers and in 1906 a paper on the problems in aquatic biology with special reference to algal periodicity. With Miss Florence Rich, he published in 1909 an account of a five years' study of the fish pond at Abbots Leigh near Bristol, and in 1913 an account of a four years' study of another freshwater pond. In 1920, he published a bibliography of English and American papers on Hydrobiology. He also published a few papers on the algæ of flowing streams (1929 *b*, 1946 *a*, 1949 *b*).

In his memorable Presidential Address to the Botanical Section of the British Association for the Advancement of Science in 1927, he deplored the absence of any institution in England similar to the inland biological stations on the continent and stressed on the great importance and usefulness of the research work that was being done at these stations. As a result of his address, there was a special discussion at the next meeting of the British Association regarding the formation of a biological station in England. And in June 1929, the Freshwater Biological Station was formed at a meeting held in the rooms of the Linnean Society, and Fritsch was made the Chairman of the Association's Council, a post which he held until his death. Thus the British

Freshwater Biological Association owes its origin almost entirely to Fritsch's initiative.

In 1902, when Fritsch was studying the algal flora in the hot houses at Kew, the observations that he made seemed scarcely to support the prevalent view among algologists at the time that there was a close similarity between tropical and temperate algal vegetation. He, therefore, wanted to investigate personally some typical tropical algal flora. And Ceylon was chosen by him for this investigation. Fritsch visited Ceylon in 1903 and stayed on the island for three months (August 21 to November 10, 1903), and studied the ecological and biological aspects of the algal vegetation of the island. His studies fully confirmed his original suspicions and brought to light very considerable differences between the algal flora of the tropics and that of the temperate regions. In 1909 he published a comprehensive paper on the ecology of the sub-aerial and freshwater algal flora of Ceylon incorporating in detail all his valuable observations on the algal flora of the island. This is the first and still the most important contribution to our knowledge of the algal ecology of the tropics. In the same year he published another important paper (1907 *b*) on the sub-aerial and freshwater algal flora of the tropics in general.

Fritsch was interested in the ecology of the higher plants also. He, with A. G. Tansley, published an important paper on the ecology of the littoral phanerogamic flora of Ceylon (1905 *b*). He published three papers on the Heath Association of Hindhead Common, one with W. M. Parker (1913 *a*), another with E. J. Salisbury (1915) and a third independently by himself (1927).

Fritsch collaborated with L. A. Boodle in translating into English Solereder's *Systematische Anatomie der Dicotyledonen* (1906 *b*) for the Clarendon Press, Oxford.

He published three papers on the anatomy of the higher plants with special reference to the relation of the anatomical characters of the plants to their systematic position (1902, 1903 *d* and 1908).

After his return from Ceylon, Miss Florence Rich, who was a retired schoolmistress, came to work in his research laboratory. Fritsch in collaboration with Miss Rich published a number of papers on algæ during a period of over thirty years. They published several papers on the occurrence and reproduction of British Freshwater Algæ (1907 *c*, 1909, 1913, 1927 *c* 1927 *d*) and a number of papers on the Freshwater Algæ of South Africa (1925, 1929 *a*, 1929 *d*, 1937). Three papers had previously been published on the algal flora of South Africa, two independently by Fritsch (1914, 1918), and another in collaboration with Miss E. Stephens (1921 *a*). Previous to these publications practically little was known about the algal flora of South Africa. In these publications a large number of forms were recorded, and the records include some very rare and interesting forms, *e.g.*, *Echallocystis*, *Sphæroplea Wilmani*, *S. tenuis*, *S. africana*. *Pearsoniella* gen. nov., *Raphidiopsis* gen. nov., etc.

In 1927, he revised, and to a large extent rewrote, G. S. West's *A Treatise on British Freshwater Algæ*, which was originally published in 1904.

He contributed an article entitled "Forests of the Sea" in *Endeavour* (1943), a number of articles on algæ in *Chamber's Encyclopædia* (1950 *b*), the article on "Protophyta" in the *Encyclopædia Britannica* (1951), and the chapter on "Chrysophyta" in the *Manual of Phycology* (1951 *b*).

After the publication of Oltmann's *Morphologie und Biologie der Algen* in 1904-05, no authoritative, comprehensive work on algæ was available, either in English or in German, incorporating all the later contributions, until Fritsch filled this gap with the two volumes of his classical work, *The Structure and Reproduction of the Algæ* in 1935 and 1945. These two volumes constitute a monumental piece of work. When one reads these two volumes, one is struck with the thoroughness with which practically every group and every aspect of algæ is dealt with and that so clearly and so succinctly. The results of practically all the important researches on algæ are incorporated and carefully evaluated. The references given are comprehensive and very helpful to the research worker. Fritsch's *Structure and Reproduction of the Algæ* will form a classical reference work to all research workers on algæ for a long time to come.

He was always intrigued by the blue-green algæ. He published a number of papers on their structure, ecology, phylogeny and classification (1904, 1905, 1932, 1942 *d*, 1949 *b*, 1949 *c*, 1950 *a*, 1953 *a*). In 1938 he with P. K. De published a note on the fixation of nitrogen by blue-green algæ. For his Presidential Address to the Linnean Society in 1951, he chose "The Heterocyst: A Botanical Enigma", as the subject of the address, and gave a masterly account of the nature of the heterocyst and the rôle played by it. He comes to the conclusion that the primary function of the heterocyst is concerned with growth and cell-division. And, in the case of those blue-green algæ in which akinetes are formed, he suggests that very probably there is a secretion of a substance or substances by the heterocyst which stimulates the series of changes (enlargement, accumulation of food, modification of the membrane) that lead to the formation of the akinetes. He, however, finally states that the last word on the subject of the heterocyst is not yet spoken and that the heterocyst will remain a botanical enigma for quite a long time.

He published accounts of many interesting British algæ which are new to science, *e.g.*, *Isococcus* gen. nov. (1914 *a*), *Fischerellopsis* gen. nov. (1932), *Ecballocystis fluitans* sp. nov. (1933), *Chrooderma* gen. nov. (1942) and *Cladophoropsis* gen. nov. (1944 *a* and 1944 *b*). In 1929, he published a monographic account of the genus *Sphæroplea*.

He was much interested in terrestrial algæ and pointed out the widespread importance of these algæ in the economy of nature. He published a series of papers on these algæ (1907 *a*, 1916 *a*, 1922, 1922 *a*, 1923, 1936. 1942 *a*).

Various other aspects of algæ were dealt with by him in several important contributions, (1) on the life-cycles of algæ (1942 *c*), (2) on the phylogeny and interrelationships of the Green Algæ (1910–11), (3) on the evolutionary sequence in Desmids (1930, 1933 *a*, 1953), (4) on the interrelations and classification of the Myxophyceæ (1942 *d*), (5) on the evolutionary tendencies and affinities among Phæophyceæ (1943), (6) on the lines of advance in Algæ (1949) and (7) on the classification of Algæ (1944, 1954).

Fritsch considered the Green Algæ as the probable ancestors of the higher plants (1910–11, 1916). In 1919, A. H. Church put forward the view that the origin of the higher plants was not from the Green Algæ but from bulky highly organised seaweeds (Thallassiophyta). Fritsch in 1921 showed that Church's view was not correct and put forward his view once again that the higher plants originated from the green algæ.

Later on he published a number of papers on heterotrichy in algæ (1939, 1942 *b*, 1953 *b*) in which he drew attention to the widespread occurrence of heterotrichy among almost all the groups of algæ. He expressed the view that the heterotrichous filament was most likely to have been the starting point for the evolution of the land plant, and that, among the various groups of algæ, the heterotrichous Chætophoraceæ were the probable ancestors of the higher plants. He considered that a Chætophoraceous terrestrial alga like *Fritschiella*, which the present writer had the privilege of naming after Professor Fritsch, was the most probable ancestor of the higher plants, since this alga possessed all the necessary features for getting established on land.

His publications extended over a period of more than half a century, and covered a wide range of topics on practically almost all aspects of algæ. It is remarkable how, in the face of frequent spells of severe attacks of asthma throughout his life, he was able to achieve such a tremendous lot of work. He had a very orderly mind, and was very methodical and industrious. Painstaking thoroughness characterised all his work.

He had a remarkable capacity for dealing with administrative matters. He was endowed with strong commonsense and sound judgment.

He had a genial and lovable personality, a fund of humour and a merry twinkle in his eye. He was extremely sympathetic with his students whom he always treated as his friends.

He was a lover of the countryside, and was fond of walking and gardening. He was growing a number of alpine plants in his garden at Dorking. While taking his guests through his garden, he would humorously point out to a toad which had made its home in one of the crevices of his rock garden, and say "This is my Zoo"!

Fritsch had a great love for music and could play on the violin extremely well. His performance was of a high order of excellence. The talent for music was clearly hereditary, for not only was his father a good musician but both his grandfather and grandmother had a great talent for music.

He married in 1905 Hedwig Laskar, daughter of Mr. M. Laskar. and his married life was very happy. He owed much to his devoted wife, who, with one son, survives him. Professor and Mrs. Fritsch were charming people and practically kept an open house at which all his friends and students were welcome. His students can never forget their kindnesses and the delightful hospitality they enjoyed during several week-ends at their house.

Fritsch was one of the greatest figures in the botanical world. His passing away leaves a big void which will be hard to fill for a long time to come.

M. O. P. IYENGAR.

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