A REVISION OF <u>STIGEOCLONIUM</u> AND CRITICAL STUDIES IN RELATED GENERA

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

A. K. M. Nurul Islam

1960

This is to certify that the

thesis entitled

A REVISION OF STIGEOCLONIUM
AND CRITICAL STUDIES IN RELATED GENERA

presented by

A. K. M. Nurul Islam

has been accepted towards fulfillment
of the requirements for

Ph. D. degree in BOTANY

G. W. Prescott
Major professor

Date Nov. 15, 1960

O-169

ABSTRACT

A REVISION OF STIGEOCLONIUM AND CRITICAL STUDIES IN RELATED GENERA

by A. K. M. Nurul Islam

The present work is primarily a taxonomic revision of the algal genus Stigeoclonium, a member of the family Chaetophoraceae under Chlorophyceae. It is based primarily upon a large number of herbarium specimens and other preserved and cultured materials obtained from different parts of the world. In all, about five thousand collections have been studied but a good number of them are not listed here because they included young growth-forms or were poorly preserved.

Historical review of taxonomic, physiologic, ecologic and cultural studies were made and summarized and information has been added to them from my personal observations.

General morphology of the habit, cell-types, hairs, chloroplast structures and rhizoids have been critically studied, described and illustrated. Information on zygospore structure has been obtained from the works of others. A suggestion presents itself that species definition may be more precise if chloroplast and zygospore structures are considered. These features have been considered only in part to the present time. It is to be expected that more work on life-histories of all species will give a clearer understanding of the systematics of the genus and its close relatives.

Nurul Islam

The main purpose of this work is to eliminate confusions in the limitations of the genera *Stigeoclonium*, *Cloniophora*, *Chaetophora* and *Draparnaldia*, especially among intergrading species. A tentative key has been written to separate the closely related genera *Stigeoclonium*, *Cloniophora* and *Draparnaldia*, and besides this, a brief discussion has been made on the interrelationships between different species-groups of *Stigeoclonium* and their possible evolutionary trends. Valid species and varieties of *Stigeoclonium* have been designated after critically studying type specimens and other numerous collections. The polymorphic nature of *Stigeoclonium* species, the results of cultural studies and ecological investigations were all kept in mind in evaluating species. The whole treatment here has been made toward a contribution for a monograph of the genus *Stigeoclonium*.

A key has been written to separate the species of *Stigeoclonium*, mostly based on some characters previously not considered by any author. At this time there are about seventy species and forty-seven varieties and formae described in the literature. Here in this work twenty-eight species and fourteen varieties are considered valid and of these four species and four varieties are new to science. Two new combinations and four emended descriptions of *Stigeoclonium* species have been made.

A study of the genus Cloniophora has been made to show the systematic positions of some species of Stigeoclonium which have been transferred to the former genus, This is the first critical study of the genus Cloniophora, based on available materials including both old herbarium as well as recently collected specimens from different parts of the world. In all, three species with one new combination and one new variety have been described and illustrated and their geographic distributions recorded in detail.

In all, thirty-nine plates containing 231 figures, 113 text figures and one table, one map and one chart supplement the written text.

A. K. M. NURUL ISLAM

candidate for the degree of

Doctor of Philosophy

Final Examination: November 11, 1960.

Dissertation: A Revision of Stigeoclonium and Critical Studies in Related Genera.

Outline of Studies:

Major Subjects: Phycology, Plant Morphology, Mycology, Plant Physiology.
Minor Subjects: Limnology, Aquiculture.

Biographical Items: Born on Oct. 11, 1928 at Nator, East Pakistan.
Undergraduate Studies: Ripon College, Calcutta, 1945-46; Rajshahi Govt. College, East Pakistan, 1946-49.

Graduate Studies: University of Dacca, East Pakistan; Michigan State University, East Lansing, Michigan.

Experience: Lecturer in Biology, Kushtia College, East Pakistan, Jan. 1952-Oct. 1952; Lecturer in Botany, University of Dacca, East Pakistan, since Oct. 1952-(now on study leave); Graduate Teaching Assistant, Department of Botany and Plant Pathology, Michigan State University, Sept. 1957-Dec. 1960; Graduate Assistant, Montana State University Biological Station, Flathead Lake, Montana, summer, 1958.

Member: Society of the Sigma Xi; Phycological Society of America; American Microscopical Society; International Phycological Society; The Botanical Society of Bengal.

A REVISION OF *STIGEOCLONIUM* AND CRITICAL STUDIES IN RELATED GENERA

By

A. K. M. Nurul Islam

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Botany and Plant Pathology

1960

ACKNOWLEDGMENTS

It is my privilege here to gratefully acknowledge the valued assistance and criticisms offered by Professor Gerald W. Prescott, under whose guidance this work has been carried out. It is equally a great pleasure to thank him for the use of his library and bibliographic files. Numerous field trips to different places in Michigan and Montana with him will be long remembered as the most pleasant experience during the tenure of this work.

It is also my pleasure to thank the members of the Guidance Committee who have taken the time and trouble to concern themselves with the present problem. The classes taught by Dr. G. P. Steinbauer, Dr. E. S. Beneke, Dr. J. E. Cantlon and Dr. Henry Imshaug shall be long remembered.

My studies have been aided by a Michigan State University Graduate Teaching Assistantship for more than three academic years and for this I am especially indebted to Dr. William B. Drew, Head of the Department of Botany and Plant Pathology, without whose assistance it would not have been possible to come here and carry out the work. Grateful appreciations are also extended to Montana State University for providing me with a Graduate Assistantship during the summer, 1958 at the Flathead Lake Biological Station, Montana. I also wish to thank Dr. Ruth Patrick, Chairman of the Jessup Scholarships Fund and Head of the Department of Limnology, The Academy of Natural Sciences, Philadelphia, for granting me financial aid which permitted my study at the Academy and at the herbarium of the University of Pennsylvania, where I was able to examine a large number of collections in December, 1959.

I extend my special thanks to those who have generously supplied preserved and cultured materials, particularly to Dr. L. A. Whitford, North Carolina State College, Raleigh, N.C., who sent me numerous fresh and preserved materials with many ecological notes; to Dr. Jules Brunel, University of Montreal, Canada; Dr. S. A. Guarrera, Director, La Plata University Museum and Museo Argentino de Ciencias Naturales, Buenos Aires; Dr. M. Hirano, Kyoto University, and Dr. M. Akiyama, Shimane University, Japan; Dr. M. R. Suxena, Osmania University, India; Dr. Miss E.C.M. Segar, Auckland University College, New Zealand; Dr. Janet Stein, Berkeley, California; Dr. Mme. Gauthier-Lievre, Alger University, Algier; Dr. Mme. P. Gayral, Institut Scient. Chérifien Lab. de Phan. et de Crypt, Rabat, Morocco; Dr. E. Kol, Botany Department, Hungary Natural History Museum, Budapest; Dr. H.S. Forest, Knoxville, Tennessee; Dr. W. B. Daily, Butler University Museum, Indiana; Mr. S. Aziz, Dacca, Pakistan;

Dr. G. W. Prescott, Michigan State University; Dr. W. Vinyard, California; Mr. John Schindler, Mr. D. C. Jackson, Botany Department, Michigan State University; Dr. T. Christensen, Botanical Museum and Herbarium, Gothersgade, Copenhagen, Denmark; Dr. Richard C. Starr, Indiana University; Dr. W. E. Wade, Department of Natural Science, Michigan State University, all for sending collections and supplying informations on ecological notes. Sincere thanks are due Dr. H. C. Bold, The University of Texas, for sending information on _Stigeoclonium_; to Mr. P. J. Halicki, Central Michigan University, Mt. Pleasant for his collections and cooperations; to Dr. N. Reynolds, Ministry of Agriculture, Conway, England, for kindly lending his Doctoral Thesis and other works; to Mr. J. H. Graffius of this laboratory for his collections and observations on _Stigeoclonium subsecundum_ Kg. in a Michigan bog. I should also like to extend my thanks and appreciations to all of my friends in the Phycological Laboratory who by their cooperation and nice company made my stay pleasant during the time of this work. Lastly, it is my most important wish to acknowledge the generosity of the Directors and Curators of the several Herbaria and Museums throughout the world who have cooperated with us in supplying their materials without which it would have been impossible to realize and fulfill the objectives of this work. The names of these herbaria and museums are mentioned on page 16.

TABLE OF CONTENTS

Page

LIST OF ILLUSTRATIONS

Page

Text Figs.

LIST OF TABLE

Page

LIST OF MAP AND CHART

Chapter I

INTRODUCTION

Any monographic study of a group of organisms or of taxa is a time-consuming task, because in most instances one is called upon to examine a large number of specimens. Also, one is faced with a great challenge, particularly if the genus is a polymorphic one, to identify precisely these specimens. The challenge is two-fold: first, one must become familiar with "TYPE" specimens and must judge their validity by comparisons with other specimens and their interpretations. The main purpose of this is fundamental, namely, to determine what constitutes a "good species" in the genus. Second, to learn what are the constant characters of species by which one may differentiate them. This is not easy, especially, in an instance where it is necessary to depend mostly, if not entirely, upon vegetative morphology which may be extremely variable under the influence of environmental factors. Stigeoclonium Kütz. is such a genus with at least 116 described species and varieties. Such a list offers a challenge to determine some 'true' features of a species from among its diversified forms of expressions. One needs to become familiar with these plants as they grow, both in nature and in culture. Thus, one may come to know the range and direction of variation within a particular species and

from these variations to learn some 'constant characters'. It is assumed in this work that when a plant occurs in "optimum or favorable conditions" it grows to its full size and in a mature stage all the essential characters of the species will be expressed that may be peculiar to that species. Again, the mature status is not easy to evaluate, for, regular observations in the field throughout the year are required to determine when the plant has attained its full size. In culture medium also one may not see the 'optimum' growth, since it is difficult to adjust the chemical proportions of the medium as well as the physical features of the environment. Natural (ecological) factors may be imitated but difficult to duplicate. Recently, however, there has been some effort to study and grow these plants either in the natural habitat (Butcher, 1932, Reynolds, 1948, etc.) or, in a culture solution prepared after analyzing the chemical constituents of the water in which the plant was growing (Godward, 1942). The latter method produces better results than a general formula of algal culture media. In this work it was not possible to obtain all the known species in culture from the entire world. But the knowledge and experience gained from limited culture and field experience was used here in studying and evaluating the herbaria specimens both in dry and in liquid preserved conditions. Identification was based mostly on vegetative morphology, although the separation of Stigeoclonium from related genera such as Draparnaldia and Cloniophora was made on basis of both vegetative and reproductive structures.

The types of filaments in Stigeoclonium show great variations and possibly they remain throughout most of the year in nature as reduced, or incompletely developed forms. Some exhibited reduced thalli also in culture. Only at a particular time of the year and under certain conditions does a plant reach its full size or "peak" development. This fact has been supported by many workers, and the term 'summer-form', 'spring-form', 'winter-form' etc. have been used to designate certain species that mature in various seasons. Thus Klebs (1896), Godward (1942), Blum (1956) and others in their year-around investigations found that a particular species grows luxuriantly at a particular place at one time of the year, whereas in other seasons it exists in a reduced growth-form, or disappears from the habitat. Godward (l.c.) further points out that the zygospores of Stig. amoenum Kg. germinate only in spring, both in nature and in the laboratory, in spite of favorable conditions having been maintained for the cultures. Blum (1956) on the other hand, found that Stig. tenue (Ag.) Kg. in Michigan shows luxuriant growth in summer, otherwise, remaining as reduced in form or disappearing. Klebs

(1896) found that Stig. tenue is a spring-form in Brun where it grew luxuriantly although at the same time it had disappeared from the running spring water of the city of Basel. Personal observations and those of colleagues also support the periodic 'high peak' growth of Stig. subsecundum Kg. during the winter season in a Michigan bog. Here the plant grew profusely under ice, gradually disappearing from the habitat in Spring.

This suggests two aspects: 1) the same species may be either perennial or annual and 2) some species may be only annual, in a particular area. Our major problem or confusion arises when we ignore these two modes and try to identify each single collection which possibly may show a reduced state of growth. It may be only a chance that the date of collection by some seasonal collectors would coincide with the time of 'highpeak' growth of the plant which is rather short. For, if specimens are found in a young or reduced form, a confirmed identification cannot be made. During the investigations of herbaria specimens it was found that not all specimens with same taxa names are equally well-developed. Occassionally, well-developed forms were found which were even better than "Type" specimens.

Another point worth mentioning here, is that Stigeoclonium plants are able to live as epiphytes or as

endophytes or parasites(?). These epiphytes have created much confusions and as a result several new species and varieties were established by Szymanski (1878), Hansgirg (1889), Iwanoff (1899), Franke (1883), Heering (1914) and Skvortzov (1946). Several species were reported alone from Lemna species. Some of these forms were originally placed under the genus Endoclonium by Szymanski (l.c.), but Hansgirg (l.c.), Heering (l.c.) and also Klebs (1896) preferred to retain them under Stigeoclonium and such a disposition has been followed by many modern workers. In this present study these species are not considered as 'good species', although they might all belong to the genus Stigeoclonium. Complete and more extended ecological and physiological investigations are needed to solve the species problem of this complex and reduced group of plants.

In this connection it should also be mentioned that Stigeoclonium plants in turn, also can be parasitized by some aquatic fungi, especially chytrids, and it is not uncommon to find inflated, modified cells of the filaments which may appear bulbuous, spherical or elliptical reminding one of the oogonium of Oedogonium (some of these cells could be akinetes or hypnocysts). Wolle's Stig. tenue var. bulbiferum Wolle may represent such a condition. This type of cell was found also in

other species by me, e.g., in Stig. flagelliferum Kg. and Stig. amoenum Kg. Special studies must be made also to learn the symbiotic (?) relationships between Stigeoclonium filaments and the aquatic fungi and insects.

At the close of the discussions on Stigeoclonium the genus Cloniophora has also been considered, since this is the most closely related genus and moreover, recently several species of Stigeoclonium have been transferred to it by Bourrelly (1952). Thus, the discussions on Cloniophora will show the fates of those discarded Stigeoclonium species as well as permitting one to compare these two genera. For the first time a detail description of the history, world-wide distributions and characters of the species of Cloniophora are presented here after a critical and comparative investigation of the herbaria and freshly collected specimens.

SCOPE OF THE WORK

The genus *Stigeoclonium* was established by Kuetzing in 1843 with five species which were originally described under *Conferva* and *Draparnaldia*. Later, Kuetzing (1845, 1847, 1849) transferred more species from *Draparnaldia*, added several new species and varieties, and again in 1853, he added, transferred and rearranged different species and varieties, some of which might be regarded now as simply ecological (and some genetical ?) variations. More than one hundred years have passed since Kuetzing's original publications. During this time many other new species have been described and others have been transferred to the genus from *Draparnaldia* (cf. Schmidle, 1900), from *Endoclonium* (cf. Hansgirg, 1889, Heering, 1914), and from *Pseudochaete* (Tiffany, 1937). On the other hand, some *Stigeoclonium* species have been transferred to another genus *Cloniophora* by Bourrelly (1952). This indicates that there must be some confusions and uncertainties in respect to the delimitations of these genera. The present work was undertaken to:

1) Critically investigate this matter as much as possible with the help of originally described specimens as well as other collections.

2) To determine and delimit the generic level of the above genera which are closely related, especially Stigeoclonium, Cloniophora and Draparnaldia.

3) To understand the polymorphic nature and range of variations of the species and to separate them on comparative basis. For this purpose large numbers of herbarium specimens and living plants have been studied.

4) To bring together in one place all the relevant informations about the genus from the works on taxonomy, ecology and culture studies which are directly or indirectly related to our better understanding of the species concept and probably a first venture to study a large number of collections from different parts of the world with a view to revise and make a contribution towards the monograph of the genus Stigeoclonium.

5) To show the range of chloroplast structure, rhizoids, hairs, cell walls, life-cycles, zygospore structures and other vegetative and reproductive characters with a view of showing whether it is possible to combine some previously recognized taxa together and place them in some small groups. This comparative study on vegetative and reproductive structures may be elaborated further by future investigations to add to our knowledge of the affinities and differences between the species. This may also help to understand the general trend of morphological variations from simple to complex

or advanced forms and to arrange them in a hypothetically phylogenetic series.

6) To evaluate the true nature of the species of Stigeoclonium not in a traditional, orthodox and typological sense but in a liberal, non-conservative way in which values of ecological and cultural works have been considered in order to determine with unbiased and unprejudiced mind "good species' from among manifold variations. In a monographic work, the student becomes a "lumper" or "splitter" or both, according to his definition of species. Some workers may be prejudiced beforehand as to the course of the work to be followed. Here, no preconceived idea was allowed to interfere with the decision taken afterwards. The facts were determined first, then the conclusion was derived. In some considerations I had to differentiate several varieties. Again, in some instances it was judged necessary to combine several species according to the facts exhibited by the type specimens and other collections. A limited number of drawings are included herein to maintain this principle and to show the range of variations. Illustrations of those species which are deemed invalid or doubtful have been included, for example, Stig. pygmaeum, Stig. polymorphum, Stig. autumnale,&

Stig. weissianum. These specimens show striking similarities to one another and all of them show young stages of growth and could be assigned to a valid species if their full growth-form and life-histories were known from comparative cultural studies.

Although some cultures have been studied no attempts have been made to follow the entire life-cycle of any species, nor was it possible to get all species in living form from any source. It was impossible to collect and culture all the species from different parts of the world in the time available. It is assumed, however, that in the future, studies on life-history, cytology and morphological features mentioned above may reveal more about the 'true' nature of 'species' in this highly polymorphic group of plants.

MATERIALS AND METHODS

The present work on Stigeoclonium was based mainly upon large numbers of herbaria specimens, both dry and preserved, borrowed from different herbaria of different countries of the world as well as on living materials -- fresh and in culture, collected and supplied by many colleagues.

Before identifications were attempted all the original descriptions of the species were collected and an iconograph of the whole genus was made, so that both descriptions and illustrations might provide an over-all concept of a particular taxa. (As the taxonomist well knows sometimes the same type of plants may bear two names, the reason being that the later author who makes the new species may not know or may not have seen the works of earlier authors who might have already published on similar plants and given name or names to them. This may happen, especially when the papers are published in different languages. It is unavoidable though regrettable.) Then with actual specimens attention was first given to the Holo- or Lecto-type specimens whereever it was possible to get them. Unfortunately, it was not possible to obtain several Type specimens in spite of our great efforts, especially, from China ,

Manchuria, and other places. All the Type specimens of five new species made by Hazen also were not available from the New York Botanical Garden where he supposedly deposited them (Hazen, 1902, p.139). Dr. Clark T. Rogerson, Curator, Cryptogamic Herbarium, writes, March 7, 1960........"Your letter asking about the TYPE specimens of Hazen arrived some time ago. I regret to say that a careful and thorough search has failed to reveal a single one of the specimens of the several new species which Hazen described in 1902. It appears that Hazen must have intended to deposit specimens at The New York Botanical Garden, but apparently failed to do so. I have written to my curatorial predecessors in regard to the matter. Perhaps they may recall some bit of information about Hazen collections".

Besides this, several Types made by Kuetzing also were not received, although most of them were obtained from Rijksherbarium, Leiden, Holland. But, in this case many 'iso-types' and others used by Kuetzing were found. It is assumed that the above Type specimens were either lost, damaged or misplaced. Here, again, personal iconograph with all the published illustrations aided in understanding them when compared with their original descriptions. In some instances, however, authors did not illustrate certain species and several new varieties or formae, for example, Stig.

amoenum beta pulchellum Kg., Stig. longipilum beta majus Kg., Stig. subtile Reinch, Stig. lubricum var. salina Dixit. In this connection, I believe that good illustrations, especially, camera lucida drawings, may be taken as a satisfactory representative of the described species, if the material is not available for study, although all illustrations are not equally well executed. I do not fully agree with those who prefer to publish photomicrographs rather than camera lucida drawings. The reason is that not all parts of the plants, especially when the branches are in different planes, come to the same focus. Ruskin rightly says (quoted from Smith, 1919) "Learn drawing.... that you may set down clearly and usefully, records of such things as cannot be described in words, either to assist your own memory of them or, to convey distinct ideas of them to other people". In my study all the drawings of the species were made under camera lucida and sometimes, more than one figure has been prepared for each species to show the range of variations. Some figures have been borrowed for this purpose, especially when suitable material was not available for study.

The dry herbaria specimens were examined with much care and patience. Materials were mostly soaked in distilled water with a little glycerine or sometimes, soap-water was used. Materials mounted on mica or

glass slides were in better conditions than those on the paper. The latter specimens which were many in number posed a great difficulty in separating them from the paper. It was found necessary to study herbarium specimens several times before identification could be made with assurance. This is because in removing dried specimens from the mounting paper it was usually impossible to obtain all parts of the plant, basal-distally, at a time. In a few instances, some rare collections were troublesome because of scanty material mounted on the herbarium sheet, for example, Stig. rangoonicum Zell. appeared in only two collections (same material). These contained a few soil particles and dust. These particles were soaked and carefully spread and after several trials a few filaments were found, although mixed with mud. Sometimes, it was found that the main-axis, especially where it is more prominent than the branches, was completely covered by profuse branches and as a result it exhibited the appearance of other species. It is assumed that this was one of the reasons why the identifications, even of better collections and made by well-known workers were not always correct. Apparently it seems that they overlooked or failed to see some parts of the plants possibly because of faulty mounts. Small or younger plants or fragments were not seriously considered, because they presented no convincing features.

Camera lucida drawings, as mentioned above, were made from holotypes, lectotypes or from any other living or cultured specimens which in some cases appeared more suitable than type specimens. Art. 7, Note 1 of International Code of Botanical Nomenclature, 1956 was followed to choose the specimens for illustrations. Several holotypes were found to be comparatively younger plants than in other collections.

A few cultures were made and studied to verify certain characters in some species, especially small, sparsely-branched ones.

Numerous field trips were made to collect *Stigeoclonium* in natural habitats and to study the habit of growth.

List of Herbaria where the dried specimens obtained from: Abbreviations according to Lanjouw and Stafleu (1956):

AKU --- Dept. of Botany, Auckland University College, Auckland, New Zealand.

AL --- Laboratoire de Botanique, Fac. d. Sc. Université d'Alger, Algeria.

B --- Botanisches Museum, Berlin-Dahlem, Germany.

BA --- Museo Argentino de Ciencias Naturales, Dept. de Botánica, B.A. Argentina.

BP --- Museum of Natural History, Dept. of Botany, Budapest, Hungary.

BUT --- Butler University, Indianapolis, Indiana, U.S.A.

C --- Universitetets botaniske Museum, Gothersgade, Copenhagen, Denmark.

DUKE -- Duke University, Durham, North Carolina, U.S.A.

F --- Chicago Natural History Museum, Chicago, Illinois, U.S.A.

FH --- Farlow Library and Herbarium of Cryptogamic Botany, Cambridge, Mass.

G --- Conservatoire et Jardin Botaniques, Geneva, Switzerland.

GRO --- Botanische Laboratorium der Rijksuniversiteit te Groningen, Holland.

H --- Botanical Museum, University of Helsinki, Finland.

HUJ --- Dept. of Botany, Hebrew University, Jerusalem, Israel.

HY --- Hydrobiological Lab., Osmania University, Hyderabad, India.

IA --- Botany Dept., State University of Iowa, Iowa City, Iowa, U.S.A.

K --- Royal Botanic Garden, Kew, Richmond, Surrey, England.

L --- Rijksherbarium, Leiden, Holland.

LAU --- Musée Botanique Cantonal, Lausanne, Switzerland.

LD --- The Botanical Museum and Herbarium, The Univ. of Lund, Sweden.

LE --- Instituti Botanici Academiae Sc. Leningrad, USSR.

LP --- Museo de La Plata, División Botánica, Provincia de Buenos Aires, Argentina.

MICH -- Univ. Herbarium, University of Michigan, Ann Arbor, U.S.A.

MO --- Missouri Botanical Garden, St. Louis, Missouri, U.S.A.

MT --- Cryptogamic Herbarium, Univ. of Montreal, Montreal, Canada.

NSW --- National Herbarium of New South Wales, Sydney, Australia.

NY --- The New York Botanical Garden, New York, U.S.A.

PC --- Muséum d'Histoire Naturelle, Laboratoire de Cryptogamie, Paris, France.

PH --- The Academy of Natural Sciences, Philadelphia, U.S.A.

RAB --- Institut Scientifique Chérifien, Rabat, Maroc, Morocco.

U --- Botanical Museum and Herbarium, Utrecht, Netherlands.

US --- Smithsonian Institution, National Museum of United States, Washington, D.C.

W --- Naturhistorisches Museum, Wien, Austria.

Z --- Botanischer Garten und Museum der Universität Zürich, Switzerland

Abbreviations used for individual collectors:

Brun -- Herb. of Dr. Jules Brunel

Graf -- " " Mr. J. H. Graffius

Is --- Personal herbarium

Jack -- Herb. of Mr. D. C. Jackson

Pres -- " " Dr. G. W. Prescott

Schd -- " " Mr. J. Schindler

Whit -- " " Dr. L. A. Whitford

Exsiccatae:

P.B.A. -- Phycotheca Borealis Americana

Tilden -- American Algae Century

HISTORICAL REVIEW

Taxonomy:

The genus Stigeoclonium (original spelling Stygeoclonium, now discarded) was first established by Kuetzing in 1843, and according to International Code of Botanical Nomenclature, 1956, Stig. tenue (Ag.) Kg. is the lectotype species. Stigeoclonium has been kept as nomina conservanda over the earlier name Myxonema Fries (1825) by the International Botanical Congress in 1910. Fries (l.c.) used Myxonema lubrica (Dillw.) Fries as the lectotype species, a system also followed by Hazen (1902). Fries' Myxonema is obviously a heterogeneous genus, placed under Batrachospermeae, including besides the branched form Myxonema lubrica other unbranched forms, now referred to other genera. The following species he put under Myxonema, such as Conferva lubrica, Conf. zonata, Conf. compacta, Conf. oscillatorioides, Conf. dissiliens and Diatoma, Draparnaldia Bory, Draparnaldia Ag. Hazen (l.c.) further mentioned two other names, Naematrix Fries and Myxotrix Fries which Fries and other authors quoted as synonyms of Myxonema, although Hazen could not give any information on these two genera. Recently Silva (1959) was

able to locate these original published papers and discussed them in detail. One should not confuse with the same name *Myxonema* made by Corda (1837), however, for a fungus plant. It seems quite clear that Kuetzing had established this genus to include the branched forms (also part of *Myxonema*) which were different from typical *Draparnaldia* or other genera.

A taxonomic monograph on the world-wide basis has not been undertaken since Kuetzing's publications (1843, '45, '47, '49, '53) in Europe. Most valuable works, although localized, on a monographic level, were done by Hazen (1902) in United States, and by Heering (1914) in Europe and still today these works are widely used for species identification.

Kuetzing (1843) first described five species with *Stig. stellare* as the lectotype, which has been rejected by International Botanical Congress and considered as a young growth-form of *Stig. tenue* (Silva, 1952). Rabenhorst (1868) also earlier considered it as a young form of *Stig. tenue* (Ag.) Kg. The other four species mentioned by Kuetzing are in order *Stig. uniforme* (Ag.) Kg., *Stig. tenue* (Ag.) Kg., *Stig. Biasolettianum* Kg., *Stig. subsecundum* Kg. These were all transferred from *Conferva* and *Draparnaldia* made earlier by C. A. Agardh and Kuetzing himself. In 1845 Kuetzing added nine new species. Then, in his classical work in 1849 (Species Algarum) he described in all 24 species with several varieties. Some of them were transferred from Draparnaldia then recently made by Hassall in England (1843). In 1853 he transferred several varieties to species rank, transferred Draparnaldia nudiuscula Kg. to Stig. nudiusculum Kg., added another new species, Stig. debile Kg. and illustrated all of them. During this period C. Naegeli, A. Braun, L. Rabenhorst were actively working on these and other algae in general. Naegeli mostly studied algal physiology including Stigeoclonium. Rabenhorst, in the early development of his Algal Exsiccatae used the name Myxonema in 1850's, then later in 1860's used the name Stigeoclonium. His major contribution was an algal exsiccata and probably is the first to treat algal distribution for the whole of Europe. He added a new species Stig. Grunowii, described Stig. weissianum Grun. in litt. and rearranged some of the earlier species of Stigeoclonium. In some instances these transfers created more confusion than order. For example, he placed Stig. subuligerum Kg. under Stig. protensum (Dillw.) Kg. as a variety; Stig. lubricum Ktz.(not referring to Stig. lubricum (Dillw.) Kg. syn. Conferva lubrica Dillw., he mentioned Conferva lubrica Lyngb., p.377) as a variety of Stig. tenue.

Also, in some places instead of retaining correct author's names he placed his own name as authority, mostly in his exsiccatae, for example, Stig. tenue Rab., Stig. uniforme Rab. His system was followed by De Toni in his compilation, Sylloge Algarum (1889). Grunow's large number of collections were included under Rabenhorst's Flora Europa Algar. Sachsens.

During the latter part of the 19th century there were greater activities, especially in Europe and in U.S.A. in respect to collecting and reporting new species of algae. Similar to Rabenhorst in Europe, Gardner, Holden, Setchell and Collins prepared their exsiccatae in U.S.A. during latter quarter of the 19th century under the name Phycotheca-Borealis-Americana. Tilden also made her American Algae Exsiccatae including algae from Hawaii Islands at the same time. Wittrock, Nordstedt, and Lagerheim were also making exsiccatae from different parts of the world, mostly from New Zealand, Australia, South America, Africa, etc., some under the name Phycotheca Universalis. Hansgirg in 1880's collected algae extensively from Böhmen (Czechoslovakia) and besides reporting several species, he added several new taxa from the area to Stigeoclonium. He was the first to divide Stigeoclonium into the sections: I. Eustigeoclonium and II. Endoclonium (Szym) Hansg. - in which he included the endophytic and parasitic forms. This was later followed by Heering (1914) in Pascher's Süsswasserflora. Contemporary with Hansgirg was Wolle in U.S.A. who reported (1887) several Stigeoclonium species from Pennsylvania including one new variety. Earlier Wood (1872) published the history of freshwater algae of North America. Tilden (1894-96) in a series of papers reported several Stigeoclonium species from Minnesota. Schmidle in a series of publications (1895, 1896, 1900) described several new species of Stigeoclonium from widely different regions of the world, from Southern India, Ceylon, Sumatra to Australia. Reinsch (1877) reported two new species (parasitic forms) from Kerguelen Island, in S. Indian Ocean near Madagascar. Later Bourrelly (1954) also reported some species from this Island. Cooke (1882-84, 1902) reported several species of Stigeoclonium from British freshwaters. At the beginning of the 20th century Hazen (1902) made an excellent contribution on the genus (he actually used the name Myxonema) treating it monographically for the United States, mostly covering the Eastern parts. Collins (1907, 1909, 1912, 1918) compiled the known green algal flora of North America adding some new species of Stigeoclonium. Setchell and others collected many algal specimens from Tahiti, Bahama-Islands etc. Wille collected extensively from Puerto Rico in 1914-15. These and other numerous individual collections, such as Herbarium of Suringar, Lebel, van den Bossch etc. contributed much toward the herbarium lists and established the foundation of taxonomic work. This list is increasing day by day and correspondingly it is becoming more and more difficult to review all publications. However, a brief list of major taxonomic works reporting Stigeoclonium species is given below under the heading of each country.

EUROPE

Europe is perhaps the most intensively and extensively studied area in respect to algal floras and has been so for more than a century. Dillwyn in early 1800's reported several species under Conferva from England some of which are now regarded as Stigeoclonium species, for example, Conferva lubrica, Conferva nana, and Conferva protensa. C. A. Agardh also in early 19th century reported several species under Draparnaldia, for example, Drap. tenuis Ag. now as Stig. tenue. Kuetzing himself made several species first under Conferva and Draparnaldia as mentioned before, mostly from Germany and adjacent countries. Hassall (1843, 52) reported several new species and varieties from England under Draparnaldia, as Drap. elongata, Drap. tenuis var. elongata, Drap. condensata. Naegeli reported two new species, Stig. variabile and Stig. insigne, the latter from Zürich; Fiorini-Mazanti (1861) one new species from Italy, Stig. hydrosulphureum, now discarded by me; Rabenhorst (1868) reported one new species Stig. grunowii from Austria, redescribed Stig. Weissianum Grun. from Zante; Kirchner (1878) from Breslau; Berthold (1878) with a new species, Stig. farctum from Germany; Cooke from England; Lagerheim from Sweden; Hansgirg (1884, 86, 87, 88) from Böhmen with a new species, Stig. pygmaeum and new varieties, e.g. Stig. variabile var. minus, and Stig. falklandicum var. longearticulatum, also Stig. tenue var. lyngbyaecolum, and var. epiphyticum (from India); Wildeman (1896) from Belgium; Wille (1897) in general; West and West (1897, 1901, 1906) from Great Britain; Fritsch (1903) with one new variety, Stig. farctum var. simplex from England; G. S. West (1904) published the British Freshwater Algae from England; Teodoresco (1907) with one new variety, Stig. subsecundum var. ulotrichoides from Roumania; Migula (1907) from Germany, German-Austria and Sweden; Iwanoff (1899) reported a new species from Puerto Rico, Stig. terrestre; Coupin (1907?)

published an algal catalog of the whole world; Heering (1914) from Germany, Austria and Switzerland reported several species with several new combinations as, Stig. longearticulatum (Hansg.), Stig. Huberi, Stig. polymorphum (Franke), Stig. chroolepiforme (Szym); Kufferath (1919) two new spp., Stig. salinum and Stig. submarinum from Belgium; Printz (1927) in general from Europe; West and Fritsch (1927) revised British Freshwater Algae; Vischer (1933) with a new species, Stig. helveticum with two varieties from Switzerland; Butcher (1932) reported two new varieties, Stig. farctum var. rivulare, and Stig. falklandicum var. anglicum; Godward (1942), Reynolds (1948) reported several species from some mawr and lakes in England and mostly studied Stig. spp. in culture; Campion (1956) also from England reported several species of Stigeoclonium from the shells of molluscs and bivalves; Llotsky and Rosa (1955) reported several Stig. spp. from Czechoslovakia; Prof. Kukk of Tartu State University, Estonia, writes in a personal letter to Prof. G. W. Prescott (Dec. 18, 1958) that there are three species so far found from Estonia Territory: Stig. longipilum Kg., Stig. subsecundum Kg. and Stig. tenue (Ag.) Kg. of which the former two have been found only in the middle of Estonia and the last one was found

sporadically in the middle and south of Estonia.

U.S.A. and North America plus Adjacent Islands

Besides the publications by Harvey (1852), Wood (1872), Woole (1887) with a new variety Stig. tenue var. bulbiferum, Tilden (1894-96) etc. Hazen's work (l.c.) may be regarded as the taxonomic starting point of this genus in U.S.A., although he covered mostly the eastern parts of the United States. He reported in all 13 species, five of which were new taxa, viz. Stig. glomeratum, Stig. aestivale, Stig. attenuatum, Stig. ventricosum, and Stig. stagnatile. Since Hazen many papers have reported several European species from different States in U.S.A. The important of those are mentioned as follows: Ackley (1930-31) preliminary reports of ten spp. from Michigan; Andrews (1910) from Indiana; Borge (1909) in general; Britton (1944) cataloged seven spp. from Illinois, later on described with Tiffany (1952); Bradley (1929) from Colorado, reported the fossil Stigeoclonium lubricum (Dillw.) Kg. (although highly doubtful) from middle of Eocene epoch of early Tertiary (about 40 million years); Buchanan (1907) from Iowa; Chapman (1934) from Ohio; Collins (l.c.) several with three new species and one new forma from U.S.A. viz. Stig. autumnale, Stig. subsimplex,

Stig. minus, and Stig. amoenum forma biforme; Croasdale (1935, 48) from Mass. (New England); Davidson (1932) from Ohio; Fink (1905) from Iowa; Forest (1954) from Tennessee Valley and S-E U.S.A.; Hayden (1910) from Missouri; Hobby (1880) from Iowa; Holden (1899) in general, also in P.B.A.; Hopman (1893) from Nebraska; Hylander (1928) from Connecticut; Kellerman (1902) from Ohio; Lewis et al (1933) S. Carolina; Lillick and Lee (1934) from Ohio; Love and Rogers (1933) from Indiana; McInteer (1939) from Kentucky; McNaught (1920) from Kansas; McNeill (1948) from W. Virginia; Moore and Carter (1923) from N. Dakota; Palmer (1929) from Indiana; Phinney (1951) from Michigan; Prescott (1931) from Iowa; (1944) from Wisconsin with a new species, Stig. pachydermum, (1951) from Western Great Lakes Area, (1955) a new species from Montana, Stig. Nelsonii; Smith (1931) from Indiana; Smith (1933, 1950) in general; Snow (1932) from Utah; Stone (1900) from Mass; Thompson (1938) from Kansas; Tiffany (1926, 1937) from Iowa and West Lake Erie with a new combination Stig. gracile (West & West) Tiff.; Transeau (1913) from Illinois, (1917) from Michigan; Vinyard (1956) from Oklahoma; Webber (1892) from Nebraska; Whitford (1943) from N. Carolina; Woodson (1957) from Virginia; Hughes (1943) from Maritime Provinces, Canada.

CENTRAL AND SOUTH AMERICA

Borge (1918) from Brazil; Britton (1937) from Puerto Rico; Bourrelly and Manguin (1952) from Guadeloupe Island; Prescott (1951) from Panama Canal Zone; West (1914) from Colombia; West and West (1894) from West Indies; Guarrera and Kühnemann (1949) gave a list of references of four species for Argentina Republic including Falkland Island.

ASIA

Comparatively much less is known from this larger and diversified continent. Following are some papers reporting *Stigeoclonium*: Dixit (1937) from S. India with a new variety, *Stig. lubricum* var. *salina*; Iwanoff (1899) from central Russia; Jao (1940, 1947) from China with two new species, *Stig. prolixum* and *Stig. polyrhizum*; Li (1932) from China; Richter (19?) from Java with one new variety, *Stig. subsecundum* var. *javanicum*; Schmidle (1895, 1900) from Sumatra, India, Ceylon, with one new species and a new variety, *Stig. spicatum* from Sumatra and *Stig. nudiusculum* var. *tomentosum* from S. India; Singh (1954) on life-history of *Stig. amoenum* and *Stig. farctum*; Skvortzow (1926) from Ceylon, (1946) Manchuria and other areas, with two new species, *Stig.*

najadeanum and Stig. gracile; Skuja (1949) from Burma with a new species, Stig. curvirostrum; Venkataraman (1957) from India; West (1904) from West India; West and West (1907) from Burma, Bengal and Madras; Wildemann (1900) from Java; Zeller (1873) with a new species from Burma, Stig. rangoonicum.

AFRICA

Bourrelly and Manguin (1954) from Kerguelen Island; Fritsch (1918) from Cape Peninsula with a new species, Stig. prostratum Fritsch.; Fritsch and Rich (1924) from Natal, (1930) from Griqualand and south-west Africa, (1937) from Belfast Pan, Transvaal; Gayral (1954) from Maroc; Hodgetts (1926) from Stellenbosch, Cape of Good Hope; Nayal (1935, 1937, 1939) from Egypt with a new variety, Stig. macrocladium var. Egyptiacae; Reinsch (1877) from Kerguelen Island with new parasitic type of species, Stig. Hookeri, and Stig. subtile; Rich (1932) from S. Africa Pans and Vleis; West (1912) from S. West Africa; West and West (1895) from Madagascar.

AUSTRALIA AND NEW ZEALAND AND ADJACENT ISLANDS

Still less is known from these countries and their surrounding islands. Pertinent publications include:

Moebius (1892) with a new species, Stig. australense from Australia; Moewus (1953) from semi-desert round Broken Hill, New South Wales; Nordstedt (1887, 1888) from New Zealand and Australia, with two new varieties both from New Zealand, Stig. subsecundum var. tenuis, and Stig. amoenum var. novi-zelandicum; Schmidle (1896) with a new species from Queensland, Stig. Askenasyi; Setchell (1926) from Tahiti.

Although the above list of references given for each country may be incomplete it presents the relative extent of field-work done in these areas. More materials are to be studied in Asia, Africa, S. America, Australia and New Zealand. Very little is known also from the inland waters of China and Russia.

Although species distributions do not follow the political boundaries between adjacent countries, still for the purpose of locating them a table (see Table I) is given below which shows the total number of species so far reported from each country of the world, at least the major continents. This species list does not necessarily correspond to the valid species accepted in this work.

Table 1 Showing the distributions of known species & varieties of *Stigeoclonium*

Species & varieties	U.S.A. Hawaii	N.& S. Amer.	Europe	Asia	Africa	Australia	N.Zealand
St. *aestivale* (Haz.) Col.	X			X	X		
St. *amoenum* Kg.	X		X	X	X		X
f. *biforme* Collins	X						
var. *novizelandicum* Nordst.	X	X					X
var. *pulchellum* Kg.			X				
var. *simplex* Tilden?	X						
St. *Askenaysi* Schmidle						X	
St. *attenuatum* (Haz.) Col.	X	X		X		X	
St. *australense* Koeb.						X	
St. *autumnale* Collins	X						
St. *Biasolettianum* Kg.			X				
St. *chroolepiforme* Heering			X				
St. *condensatum* (Hass.) Kg.			X				
St. *crassiusculum* Kg.	X		X				
St. *curvirostrum* Skuja				X			

Species & varieties	U.S.A. Hawaii	N.& S. Amer.	Europe	Asia	Africa	Australia	N.Zealand
St. debile Kg.			X				
St. elongatum (Hass.) Kg.			X				
St. falklandicum Kg.	X	X	X	X	X	?	
St. farctum Berth.	X		X	X			
var. pygmaeum Hansg.			X				
var. rivulare Butcher			X				
var. simplex Fritsch			X				
St. fasciculare Kg.	X	X			X		
St. fastigiatum (Ralfs.) Kg.	X		X				
St. flagelliferum Kg.	X	X	X				
var. irregulare Rab.			X				
St. glomeratum (Haz.) Col.	X		X	X	X		

Species & varieties	U.S.A. Hawaii	N.& S. Amer.	Europe	Asia	Africa	Australia	N.Zealand
St. gracile Kg.		X	X	X			
St. gracile (West & West) Tiffany	X						
St. gracile Skvort.				X			
St. Grunowii Rab.			X				
St. helveticum Vischer			X				
var. majus Vischer			X				
var. minor Vischer			X				
St. Hookeri Reinsch			X		X		
St. Huberi Heering			X				
St. hydrosulphureum Fior.			X				
St. insigne Naeg.			X				
St. irregulare Kg.			X				
St. longearticulatum (Hansg.) Heering	X		X				

Species & varieties	U.S.A. Hawaii	N.& S. Amer.	Europe	Asia	Africa	Australia	N.Zealand
St. longipilum Kg.	X		X				
var. *lacustre* Chodat			X				
var. *majus* Kg.			X				
var. *minus* Hansg.	X		X				
St. lubricum (Dillw.) Kg.	X	X	X	X			
var. *salina* Dixit				X			
var. *varians* (Haz.) Col.	X			X			
St. macrocladium (Nord.) Schmidle	X	X					
var. *Egyptiacae* Nayal					X		
St. minus (Hansg.) Collins	X		X				
St. Najadeanum Skvort.				X			
St. nanum (Dillw.) Kg.	X	X	X	X			
St. natans Kg.			X				
St. Nelsonii Prescott	X						

Species & varieties	U.S.A. Hawaii	N. & S. Amer.	Europe	Asia	Africa	Australia	N.Zealand
St. nudiusculum Kg.	X	X	X				
var. tomentosum Schm.				X			
St. pachydermum Presc.	X						
St. plumosum Kg.		X					
St. polymorphum (Franke) Heering	X		X				
St. polyrhizum Jao				X			
St. prolixum Jao				X			
St. prostratum Fritsch					X		
St. protensum (Dillw.) Kg.	X		X				
St. pusillum (Lyng.) Kg.			X				
var. irregulare Rab.			X				
St. pygmaeum Hansg.			X				
St. radians Kg.	X		X				
St. rangoonicum Zell.				X			

Species & varieties	U.S.A. Hawaii	N.& S. Amer.	Europe	Asia	Africa	Australia	N.Zealand
St. salinum Kufferath			X				
St. setigerum Kg.			X				
St. spicatum Schmidle				X			
St. stagnatile (Haz.) Col.	X	X		X			
St. stellare Kg.			X				
St. submarinum Kuff.			X				
St. subsecundum Kg.	X	X	X	X			
var. javanicum Richter				X			
var. tenuis Nordst.			X				X
var. ulotrichoides Teod.			X				
St. subsimplex Collins	X						
St. subspinosum Kg.	X		X				
St. subtile Reinsch					X		
St. subuliferum Kg.	X		X				

Species & varieties	U.S.A. Hawaii	N.& S. Amer.	Europe	Asia	Africa	Australia	N.Zealand
St. tenue (Ag.) Kg.	X	X	X	X	X	X	X
var. bulbiferum Wolle	X						
var. genuinum Kirch.	X		X				
var. epiphyticum Hansg.				X			
var. lyngbyaecolum Hansg.			X				
var. minus De Toni			X				
St. terrestre Iwanoff		X					
St. thermale A. Br.	X		X				
St. uniforme Kg.	X		X				
var. gracile (Kg.) Rab.			X				
St. variabile Naeg.	X		X				
var. minus Hansg.			X				
St. ventricosum (Hux.) Collins	X						
St. weissianum Grun.			X				

Physiology, Culture and Life History Study of Stigeoclonium

Although not all the species of Stigeoclonium have been studied in culture and their life-history and physiology learned, a considerable knowledge has been accumulated so far. Many studies have been made on zoospore-formation, liberation and germination; few on the life-cycle, branch-formation and other physiological responses exhibited by certain species. Informations on these aspects have been obtained from the important works of Kuetzing (1844), Braun (1853), Naegeli (1855), Famintzin (1871), Cienkowski (1878), Berthold (1878), Gay (1891), Huber (1892), Klebs (1896), Tilden (1896), Livingston (1900, 1903, 1905), Chodat (1902), Fritsch (1903), Pascher (1905, 1906, 1907 ?), Cholnoky (1929), Butcher (1932), Vischer (1933), Uspenskaia (1936), Godward (1942), Reynolds (1948, 1950), Chang (1952) and several others. Detail discussion of the results of these works is not in order here but for the sake of better understanding of Stigeoclonium, a brief review is presented below together with certain remarks based on my own observations.

CULTURE STUDY:- Various methods and media have been used for culturing Stigeoclonium species by different investigators. Such cultures have been made in the laboratory on artificial media and by 'culture' in the field under natural conditions (both controlled and uncontrolled).

In laboratury culture either the ordinary pond or lake water or different chemical solutions have been used, such as 1) Benecke's solution, 2) Knop's solution, sometimes with modifications, 3) Bristol solution, 4) Chu's solution, 5) Godward's solution etc.; sometimes soil extracts are mixed up for better results. In many cases agar is added to solidify the medium in culture plate or slant. The principle of making Godward's solution seems to be quite satisfactory. Godward (l.c.) made the culture media (as modified Chu's solution) after analyzing the detailed chemical constituents of the lake (where the plant was growing) for several months. This type of solution gives fairly exact chemical constituents required by the plant. Godward found almost identical growth both in culture as well as in nature.

Culture plates and slants can be placed both in natural light or under continuous artificial light of various Watts, either from ordinary bulb, or fluorescent tube.

'Culture' in natural habitat was practiced by several workers due to the fact that these filamentous plants are extremely sensitive and variable in culture media where they are not subjected to all the physical and chemical conditions of natural habitat. Hazen (1902) however, tried to culture these filamentous algae by putting fresh specimens in glass cylinders (large bottles with bottoms knocked out), covering both ends with muslin and anchoring them near the surface in a running brook. Not all plants, however, grew satisfactorily in this controlled experiment.

Butcher (1932) used glass slides which he kept directly in natural habitat water on which attached plants might grow thus permitting examination from time to time. This method was also followed by Reynold (1943) who also cultured the same plants artificially to compare the growth in nature as well as under laboratory conditions.

The main purpose of the culture study, however, I believe, should be to learn the complete life-history from zygospore to zygospore and to find out the maximum vegetative expressions of a thallus and not merely to show the variations. It is obvious that in different media these plants will grow differently but one should determine where the 'normal' growth takes place and what it is like so that all the characters of the species may be seen.

ZOOSPORES-FORMATION, LIBERATION AND GERMINATION

It is very common to see zoospore-formation and liberation in any species as soon as the plant is brought to the laboratory from the field, or, when transferred from one culture to another fresh one. Zoospores also may be seen by simply mounting specimens on a microscope slide. It may be that change of light to that of an ordinary to microscope lamp may induce zoospore-formation. Zoospore-formation like this, however, was observed by many workers since the time of Kuetzing.. Braun (1853) in his article "Rejuvenescence in Nature" mentioned the quadriflagellate 'germ-cells' one in each cell in several species that he examined at different times, e.g. in Stig. thermale A. Br., 1847, Stig. subspinosum Kg., 1847, Stig. protensum (Dillw.) Kg., 1848, Stig. tenue (Ag.) Kg., 1849, In Stigeoclonium protensum (?) however, he found two to four smaller, more roundish swarmers. He did not observe the further fate of these swarmers, but noticed that they were naked, with one 'eye' in each and that they emerged through a lateral pore in the wall, within a vesicle before swimming away. He observed also their liberation in Stig. protensum (?) between 6-10 a.m. in May. In Stig. subspinosum Kg. he found that the zoospores were liberated through a very narrow orifice

as a result of internal constriction which sometimes divided the contents into an inner and outer part. The outer part provided with flagella becomes a free swarmer. Similar liberation of biflagellate zoospores through a narrow opening has been shown by Juller (1937) for the same species, (Text Fig. 46). Naegeli (1855) and Godward (1942) showed narrow pore and constricted protoplasm at the time of zoospore-liberation in Stig. insigne Näg. and Stig. amoenum Kg. respectively (Text Fig. 57).

Swarmers (both zoospore and gamete) are formed in any cell but mostly of the erect part, both in the main axis and its branches. Prostrate cells may also produce swarmers, especially when they form akinetes or Palmella-like cells. Usually the cells producing swarmers in nature are not much modified but when induced to do so in the laboratory they become irregularly inflated and produce one to several swarmers in each cell. This was observed in a culture study by Tilden (1896), Chodat (1902), Madge (1940) and others. Similar swelling of the vegetative cells which produce zoospores has been observed by me in Stig. tenue when the plant was kept for some days after collecting in the same lake water in which it was growing (Text Fig. 64). This type of swelling and zoospores-production took place usually

3 or 4 days after the plant was brought to laboratory. Similar to Pascher's (l.c.) observation, I also found larger macrozoospore-formation in Stig. tenue as soon as it was brought to the laboratory, and after 3 or 4 days smaller microzoospores were formed in swollen cells.

Madge (l.c.) noticed that certain filaments and occassionally whole plants, however, did not form zoospores at all, even after induction. Instead, cell-divisions usually occurred and each new cell proceeded to grow out to form a branch. Those cells producing motile zoospores were much larger and longer than the other cells in the filaments.

The liberation of swarmers is mostly through a lateral pore in the cell-wall, a ulotrichoid character. When the cells become empty after zoospore liberation these pores or ruptures are clearly visible. Two different conditions, however, can be noticed in the manner by which cells produce swarmers. First the cell contents form one or few zoospores without any partition wall-formation; most commonly found in Stig. tenue (Ag.) Kg., Stig. stagnatile (Haz.) Col., Stig. subsecundum Kg. (Text Figs.57, 59).

Secondly, the cell contents undergo cleavage to form many zoospores after partitioning by wall-formation,

--in transverse, diagonal and vertical planes. This is visible after the liberation of the zoospores, especially in such forms as *Stig. variabile* Näg., *Stig. amoenum* Kg. (Text Fig. 60). I have observed both of these types in freshly collected specimens.

GERMINATION OF SWARMERS

Asexual zoospores, after liberation, usually swim for some time and then rest on some substratum with the anterior end down, withdraw their flagella, increase in size and begin germination with the division of their cell contents in a transverse or a longitudinal plane, or both. Certain zoospores, especially biflagellate ones, do not germinate immediately but form a resting stage --an aplanospore (Pascher, 1905), a hypnospore or cyst (Chang, 1952). It is interesting to note that the mode of germination or at least the young germling stage is not uniform in all the species but varies within the same species according to the kind of zoospore structure (see below), each behaving in a different way. Fritsch (1903) has observed and discussed three types of zoospore-germinations two of which Berthold (l.c.) had described earlier. These are: The zoospore germinates to form an upright filament from the lowermost cell of which an irregularly branching filament forms which creeps over the substratum, from the cells of these latter other vertical branches subsequently arise, e.g. Stig. variabile Näg., Stig. flagelliferum Kg.

The germinating zoospore grows out on both sides to form a creeping filament which branches several times on the substratum; from the prostrate, basal portion thus formed all the vertical branches arise; e.g. Stig. lubricum (Dillw.) Kg.

Fritsch (l.c.) pointed out that in certain species Kuetzing had shown the basal cell of young plants to appear like Oedogonium (club-shaped); for example, Stig. stellare, pl. 4, f. 2; Stig. radians, pl. 7, f. 2 (Kuetzing 1853).

The third type of development from zoospores is found in Stig. amoenum Kg. where, on germination, an upright filament with a basal cell especially modified for attachment is formed. A similar type is also shown in *Stig. insigne* by Naegeli, (l.c.) in *Stig. Nelsonii* by Prescott (1955), in *Stig. subspinosum* Kg. by Juller (l.c.) in *Stig. subsecundum* Kg. (?) by Chang, (1952).

In *Stig. tenue* (Ag.) Kg. I have found the second type of zoospore-germination. Zoospores usually clump together and each one of them begins to divide after a short rest and forms a creeping filament from which erect filaments develop (Text Fig. 53). Text Fig.52 illustrates the kind of germination where several zoospores are arranged in a row (but usually are curved with an arch-like appearance), each one sending out an erect filament first. At this stage it appears as *Stig. nanum* (Dillw.) Kg. as shown by Fritsch (1903). This latter type may be found in more than one species and thus making species identification difficult at this stage.

As mentioned before the same species may produce different kinds of zoospores which germinate in different ways. Thus, Juller (l.c.) showed in *Stig. subspinosum* that 4-ciliate macrozoospores may germinate like *Stig. amoenum* -- the third type (Text Figs. 56 , 51), and 2 or 4-ciliate microzoospores which may germinate like the second type (Text Figs.50 , 54).

Sometimes the zoospores under unfavorable conditions may not germinate but may become aplanospores, hypnospores or arrested zoospores either outside or inside the filament and later on germinate on the arrival of favorable condition.

It should be mentioned that a plant may produce a pseudoparenchymatous or disc-like basal part which may not develop from the germination of a single zoospore but from a number of zoospores clumped together. This was observed also by Cienkowski (l.c.). It is unknown whether the prostrate part in *Stigeoclonium farctum* shown by Berthold, or in two new varieties *Stig.* *farctum* var. *rivulare* and *Stig.* *falklandicum* var. *anglicum* shown by Butcher (1932), is formed from a single zoospore or several.

TYPES OF SWARMERS

It is now fairly well-known that there are 3 different types of zoospores or swarmers formed by *Stigeoclonium* species, and in this respect Pascher (l.c.) states that *Stigeoclonium* shows intermediate behavior between *Ulothrix* and *Draparnaldia*. The different zoospores are: Large, quadriflagellate, asexual macrozoospores; Intermediate-sized, asexual quadriflagellate microzoospores (Pascher 1906); Smaller quadriflagellate or biflagellate microzoospores, usually gametic in nature; may be parthenogenetic; Besides these, Pascher (1906, 1907) reported the occurrence of amoeboid gametes which may copulate to form an amoeboid zygote.

The macrozoospores are formed universally in all species so far studied; usually they produce new plants directly.

Quadriflagellate microzoospores, quite common, are either asexual or sexual in nature. When gametic, but fail to fuse, they form thick-walled resting spores (hypnospores) within the mother cell without showing any swarming (see Pringsheim, 1860, however) or they may grow directly into a new plant if conditions are favorable. Godward (l.c.) however, noted that in Stig. amoenum Kg. the gametes are always quadriflagellate microzoospores and that without copulation they die. Usually, however, gametes are biflagellate swarmers, although Pascher (1906, p.400) did not observe copulation between biflagellate (zoospores) gametes in Stig. fasciculare Kg. (?) (or in other species) which produce peculiar or characteristic (eigentüliche) resting cells. In other papers (l.c.) he also expressed a doubt as to the gametic nature of these biflagellate zoospores. Biflagellate gametes have been observed, however, in several species, e.g. in Stig. flagelliferum Kg. by Tilden (1896), in Stig. subspinosum Kg. by Juller, in Stig. subsecundum Kg. by Chang and in one form of Stig. tenue (Ag.) Kg. by West (1904) (also by Heering 1914). Without copulation these biflagellate gametes may germinate parthenogenetically. Therefore, as mentioned before, both micro- and macro-zoospores may become resting or cyst cells with thick gelatinous wall in which they may further divide. Chang (l.c.) noted that 6-7 small microzoospores may develop from these cyst cells in Stig. subsecundum Kg. (?) which may fuse or develop directly.

Pascher (1915, 1918) however, mentioned about the formation and development of amoeboid macrozoospores (and gametes ?) in Stigeoclonium species (see detail in Pascher 1915 and 1918, p.352, f, 1, a, b, c,; p. 434-435).

Uspenskaia (1936, p.321) states that "both zoospores and gametes are more readily formed in the absence of an excess of nitrogen. The zoospores are formed in presence of excess CO_2 and acidulation, while the gametes in that of a lack of CO_2 and alcalinization, and should not experience any deficiency in iron."

A few words may be added about the periodic zoospore-formation in culture. Braun (1853) as mentioned before, observed quadriciliate 'germ-cells' in Stig. protensum Kg.(?) in Europe, in May, between 6-10 a.m. Madge (1940) studied zoospore-formation in a species of Stigeoclonium and remarked that specimen in culture in general does not form zoospores unless induced to do so, usually by transferring to new medium and even, sometimes several filaments or whole plant could not be induced. Madge observed also that mostly in summer zoospores are formed in early morning if kept for long times in dark. Zoospore-formation may occur in dark but they do not escape from the filament, instead they germinate in situ. Klebs (1896, p.12) similarly observed zoospore-formation in the dark and remarked that this formation can take place when the nutrition is reduced or on the whole cut off for some time. Madge (l.c.) further noted that before zoospore-formation in experimental plants, transverse and occassionally longitudinal cell-divisions occur giving the filament more than one-cell thickness. These walls are comparatively thinner than the vegetative cell wall and are clearly visible after the liberation of zoospores. During zoospore formation and discharge the filament shows elongation and a coiling appearance and cells become more barrel-shaped or irregularly spherical due to the fact that walls do not stretch evenly all over their surface but begin to bulge. Motility of zoospores starts during the expansion of the cell and before their liberation. The formation and liberation may take about a minute.

Chang (l.c.) similarly observed that macrozoospores are mostly formed in summer and microzoospores throughout the year but less in June and July. Godward (l.c.) also found that in Stig. amoenum Kg. gametes are formed only in Spring and he failed to induce gamete-production and zygote germination out of season, i.e. at times other than Spring, by adjusting high and low temperatures, illumination, aeration, variation of culture solution, increase or decrease of pH, auxin, soil extracts and vitamin C. (Does it suggest any "after-ripening" phenomenon that the zygote must pass certain time for maturity before germination ?).

ZYGOSPORE OR ZYGOTE: Zygotes are formed by the fusion of bi- or quadri-flagellate microzoospores at their anterior ends (Planogamy). During the fusion of two gametes motility is retained for sometime, then they withdraw their flagella, form a thick wall and become spherical. (However, see Pascher, 1915, 1918, for aplanogamy). The zygote represents the diploid stage, since the gametes are formed directly from the haploid plants. The zygotes are not visible on plants collected from nature as they are formed outside the thallus body, and therefore, our knowledge of zygospore structure is extremely meagre. Our present knowledge about zygospore-structures is based upon the life-cycle studies of only a few species in cultures. Whether the zygospore structure in Stigeoclonium is taxonomically important as it is in Oedogoniales or Conjugales is impossible to state at the moment but a significant indication has been made by Godward (l.c.) on this point (also see West & Fritsch, 1927). Godward's method of studying the life-history of Stigeoclonium deserves further attention. Godward in his study of Stig. amoenum Kg. developed the plant from zygospore to zygospore in culture medium which was more or less identical with that of the natural habitat. In two generations he found the zygospores (the only diploid generation) with stellate or wavy cell wall. He remarked that this type of zygote was found only in Stig. insigne Nag. as shown by Trebaux in 1899. He therefore, compared and classified several species of Stigeoclonium on the basis of zygote structure into two main groups: (see Godward's Table I):

Species with smooth-walled, spherical zygote; (Text Fig. 72).

Species with wavy, stellate-walled, spherical zygote. (Text Figs. 77-79).

In the first group the following species are included: Stig. tenue (Ag.), Stig. nudiusculum Kg., Stig. subspinosum Kg., Stig. subsecundum Kg. (?), Stig. fasciculare Kg., and Stig. flagelliferum Kg.

In the second group, so far only Stig. insigne Näg. and Stig. amoenum Kg. are known.

Mature zygotes are mostly orange or bright red in color.

It is interesting to note that in most of the species in group I the zygotes are formed from biflagellate gametes. In Stig. fasciculare ? (where Pascher was doubtful about the species) the zygote comes from quadriflagellate gametes. In the second group with stellate wall the zygotes are formed from quadriflagellate gametes in both the species.

The analyses above cast some doubt as to whether in each group above 1) the species studied by different workers are correctly identified or 2) they belong to the same species.

This doubt is justified for the following reasons:
1) In certain instances when the life-history was studied the authors expressed their doubts in respect to their identification of the species and sometimes, they put a question mark after the name of the species, for example, Pascher (1906, p.399), Braun (1853, p.139), etc. Both Klebs and Pascher had shown quadriflagellate microzoospores (or gametes) in Stig. tenue; but West (l.c.) had shown biflagellate gametes to form zygotes in that species. (Heering, 1914, on this character and size classified Stig. tenue as Stig. tenue Klebsii, Pascheri and Westi).
2) The species identified in studying the life-history of Stig. subsecundum Kg. by Chang (l.c., same under

the name Kuo, 1958) is highly doubtful. The measurements of the cells given as 1:2 diameter to length ratio in matured plants does not characterize *Stig. subsecundum* Kg., where the cell length is 3-10(-12) times the diam. (mostly 6-8 times) in main axis. Moreover, the life-cycle shown in this plant is quite identical with that shown by Juller (l.c.) in *Stig. subspinosum* Kg., For this, one may compare all the illustrations given by these two workers.

Juller mentions that the filament developing from a zygospore represents the diploid stage so that a regular alternation of generation exists between haploid and diploid plants in that species. (This has not been confirmed by any worker). On the other hand, Kuo (Chang) states that her species did not show any alterration of generation in spite of the fact that she shows a 4-celled filament (f.23) developing from zygospore without reduction division. Again, in a life-cycle diagram she showed that zygote could either produce the filament without reduction division or after reduction division it might produce 4-ciliate macrozoospores which on germination produced a branched filament. This and the presence of 3-kinds of filaments that she observed in the life-cycle all suggest that her plant in question might have also two alternating phases which the author seems to have failed to observe. In all essential features and illustrations this plant bears a close resemblance to Jullers' specimen which he thinks agrees well with Kuetzing's description and illustration.

Tilden's (1896) identification of Stig. flagelliferum Kg. was also doubted by Hazen (1902) and by Pascher (1905, 1906).

If it is taken for granted that those species all with smooth-walled round zygospores are different, however, it needs to be determined whether there exists any difference in the morphology of the wall-structure such as is present in Oedogonium, for example.

Similar doubt can be expressed also in the case of the second group with stellate-shaped zygospores. In both species the same quadriflagellate gametes produce the same type of zygospores. This gives the impression that either the two workers dealt with similar plants, or, there is at least not much difference present in the original descriptions of the two species. This latter view has been more or less confirmed by my study of herbaria specimens and I am convinced that essentially there exists no difference between these two species except in size and therefore, I put

Stig. insigne Näg. under Stig. amoenum Kg. as a variety due to latter's priority. Further, if one examines the illustrations given by Naegeli (1855) and Gay (1891) on the zoospore-formation, liberation and germination in Stig. insigne Näg., he will be amazed to see the similarity with those given by Godward for Stig. amoenum Kg. Thus, it could be deduced that these two entities are the same and this is supported by their physiology and general morphology including zygote structure.

LIFE-CYCLE AND CYTOLOGY

In general, as indicated above (p. 57) *Stigeoclonium* species show two types of life-cycle, although these need confirmations:

There are those without alternation of generations and also species possessing an alternation of generations. (Isomorphic type).

In the first group haploid plants produce bi or quadri-flagellate gametes (usually isogametes) which fuse to form zygotes or resting spores, which represent the diploid phase. During germination each zygote divides meiotically to produce four macro- or micro-zoospores which on germination produce haploid plants. Sometimes the haploid plant completes its life-cycle asexually through macro- and/or micro-zoospores and also parthenogenetically.

In second type, only known in *Stig. subspinosum* Kg. (Juller, l.c.) (which needs confirmation) however, the haploid plant produced gametes (and also asexual zoospores) which fuse and give rise to zygotes, which on germination form diploid plant directly. This latter plant produces through meiosis haploid quadri-flagellate swarmers which on germination produce the haploid plant directly, or, after a resting period. It may be possible that this type of life-cycle is also present in other species of *Stigeoclonium*. In a brief note Singh (1954) states that in *Stig. amoenum* Kg. there exists an isomorphic alternation of generation which is entirely contradictory to Godward's (1942) observations on the life-cycle of the same species. Latter author similarly did not observe any biflagellate gamete as the former author has mentioned.

PALMELLA-STAGE

One important feature, however, in the life-cycle of *Stigeoclonium* has been brought to light by Cienkowski (l.c.), although Kuetzing (l.c.) and

Famintzin (1871) noticed it earlier. This is the Palmella- or protococcoid-stage assumed under unfavorable conditions. At this stage the filaments of both erect and prostrate portions may break down and the cells round off, develop a thick wall and may remain singly or in groups very much like protococcoid plants. In general however, as Cienkowski (l.c.), Klebs (l.c.), Tilden (l.c.), Livingston (l.c.), Juller (l.c.), Chang (l.c.) and others showed the characteristics of palmella-stage lies in the disintegration of the cell membrane, division of cells in all directions and separation of the individual cells so that a large palmella-mass results. Klebs (l.c., p.405) had cultivated Stig. tenue (Ag.) Kg. for months in water, nutrient salts and sugar solutions on moist agar-agar with low and high temperature and under various illuminations. In all instances he found similar results, that is, after a period of (vegetative) growth the cells were filled with reserve materials, starch and oils, and swelled to form barrel-shaped to spherical (globular) structures. He also stated (l.c.) that in nutrient solution with high concentrations a decomposition of a plant could also occur in which the spherical cells separate from each other. Similar results were also obtained by Livingston (l.c.) who used Stig. tenue (Vischer doubted it as Stigeoclonium sp.) to study the polymorphism of these lower plants. He obtained Palmella-cells in solution of high osmotic pressure, in solution of low osmotic pressure with stimulating metallic salts, poisonous cations, in lower temperature and sea water. The effects of all these factors on the plant were, according to Livingston, to 1) decrease vegetative activity, 2) inhibit zoospore-production, 3) cause cylindrical cells to become spherical and to separate, 4) to free the plant from certain limitations as to the orientation of planes of divisions.

Tilden (1896) earlier in her study of the life-history of Pilinia diluta Wood found that this plant actually represented a growth stage of Stig. flagelliferum Kg. which might also remain as a Palmella-form in nature (and in culture too). According to her, the Stigeoclonium plant in question may remain in one of three growth forms throughout its life-cycle depending upon the environmental conditions, such as, the Pilinia stage, represented by a Coleochaete-like plate of cells giving rise to Chaetophora-like filaments (related to certain factors in the habitat); the true Stigeoclonium-stage, represented by well-developed, branched and erect filaments and thirdly Palmella-stage, represented by thick-walled, spherical, solitary, or small groups of *Protococcus*-like cells surrounded by mucilage and capable of division, (related to extreme unfavorable conditions). This latter stage may develop either from the *Pilinia*-stage or *Stigeoclonium*-stage. The *Pilinia*-stage, according to her, was induced by the lime-boring and calcareous secretions by these plants when growing on the rocks; but upon being transferred to freshwater without $CaCO_3$ the plant gave rise to *Stigeoclonium* stage which in turn, after aging, produced *Palmella*-stage. Further, she noted that "megazoospores" are commonly formed from *Pilinia* and *Stigeoclonium* stages, whereas "microzoospores" are commonly formed from the *Palmella*-stage and are gametic in nature (pl. 34, f. 5,6). Uspenskaja (1936, p.30) also states that "*Stig. tenue Kuetz* passes into a *Palmella*-like condition, if the medium is strongly alkalified and is kept under conditions of nitrogen starvation (the material for the experiment must be taken underfed)".

Whether the plant studied by Tilden, however, was a true or "an abnormal" form (Hazen, p.200) of *Stigeoclonium flagelliferum* Kg., her observations on the above 3-growth-stages (viz. *Pilinia*, *Stigeoclonium* and *Palmella*) are quite in accordance with later ecological and cultural investigations with true *Stigeoclonium* plants. Under ecological discussions I have mentioned 'stunted' or reduced growth-form and 'peak' growth-form, which may correspond with the *Pilinia* and *Stigeoclonium* stages of Tilden respectively. (The *Palmella*-stage is the result of extreme unfavorable conditions).

Oltmann (1922, p.311) states that these *Palmella*-cells may be also called akinetes. In some cases these thick-walled, round cells may not break apart but maintain the filamentous nature of the plant. It seems that *Palmella*-cells, hypnospores, akinetes etc. are more or less similar, the only difference being the cell-wall thickening and they either produce new plants directly or through the formation of zoospores. Oltmann (p. 310) reviewed the works of Pringsheim, Kirchner, Wille, Gay, Klebs and others relative to the formation of another kind of resting stage known as a cyst. These arise mostly singly, occassionally 2-4 in a cell as a result of withdrawal of plasmatic contents from the cell wall and then surround themselves with new individual membranes. Later, they accumulate yellow oil and form a thick wall to become cysts. These cells mostly germinate directly after a short or long dormant period.

Aplanospores may form in the cells from arrested zoospores which may show some motility (Pringsheim, l.c.) within the mother cells before being converted to aplanospores. Klebs (l.c.) demonstrated an eye-spot in young stages of the same.

Yatsu (1905), while studying Stigeoclonium, compared the cytological differences between the filamentous form and Palmella-cells and found that the latter occur in dry situations whereas the filamentous stage occurs in the water. In Palmella cells are characterized by having no vacuoles, chlorophyll more green, large pyrenoids, and thicker walls. Whereas in the filamentous form, there occurred large vacuoles, smaller pyrenoids and thinner walls. The nucleus size was the same in both stages. Palmella-cells in weaker solution usually produced biflagellate zoospores 2-4 or 8 in each cell.

So far only in a few species has the chromosome number been studied. Results of observations on them are conflicting and need confirmation. Thus, for example, Godward (l.c.) tentatively determined the chromosome number (2n?) in Stig. amoenum Kg. to be between 11 and 16, whereas Singh (1954) found the diploid number to be 10 and haploid number five in Stig. amoenum Kg. and in Stig. farctum Berth. (the haploid number recorded only as five).

More cytological information in respect to nuclear divisions, flagella-formation, gamete-formation and copulation, pyrenoid-structure and its division, caryosome structure, contractile vacuoles, stigma or 'eye' in zoospores etc. may be found in the works of Reich (1926), Cholnoky (1929), Vischer(1933), Reinhardt (1876), Cienkowski (l.c.), Klebs (l.c.), Juller (l.c.) and several others already mentioned above.

Meneghini (1833) stated long ago that germ-cells of <u>Stigeoclonium</u> are similar to animals because they possess motility with terminal cilia and have a red spot similar to the 'eyes' of Infusoria and sometimes a transparent space or an aperture by which they fix themselves to vegetate. He mentions that Kuetzing was the first to show that "<u>Chlamydomonas</u> <u>Pulvisculus</u>" was nothing more than the germ-cell of <u>Stigeoclonium</u> <u>stellare</u> Kg.

VEGETATIVE CELL DIVISION AND BRANCH FORMATION

In general, vegetative cell division in *Stigeoclonium* is intercalary and diffuse and mostly takes place in a transverse plane. Occassionally, at the point of branching diagonal or angular divisions may also occur (Text Figs. 39-41). More irregular cell divisions are found toward tips of branches, especially, in actively growing plants. In this latter instance the dividing cells at the tips may produce zoospores but usually they become arrested and germinate directly as aplanospores. It is quite common to see in fresh material that the cells at the branch tips are smaller, dividing in different planes and sending out lateral branches in every direction (Text Fig. 67). The cells of the main axis often divide and produce four or more daughter cells with slightly thicker walls and are wider than vegetative cells. These cells can produce directly filamentous branches (Text Fig. 39). In another type of irregular cell-division, which may be found in any species, several cells in a row divide in more than one series in both vertical and horizontal planes and median splitting may occur thus ultimately separating the cells in two parts (Text Fig. 40). Kuetzing (1853) has shown this

type of division in Stigeoclonium stellare and Stig. irregulare Kg. Vegetative cells may divide in different planes at the time of zoospore-production.

Cholnoky (l.c.) has shown branch-formation in Stig. tenue (Ag.) Kg. It is a well-recognized fact that branching habit in Stigeoclonium (formation, orientation, etc.) is one of the most important features for species identification, although branching is extremely variable in response to several environmental factors. The effects of these factors such as, nutrients, light, and temperature on branching are briefly described below:

CONCENTRATION OF CHEMICAL NUTRIENTS IN THE MEDIUM:

It has been shown in several species of Stigeoclonium by Klebs (l.c.), Vischer (l.c.), Uspenskaia (1936), Reynolds (1948, 1950) and others that concentration of nutrients and other chemical constituents may favor or retard the growth or growth-rate of the erect filaments to a great extent. Klebs (l.c.,p.401) showed that in different concentrations of agar nutrients, light and moisture he got different results of branch-formation. He found that almost every cell of very sparsely-branched filaments, if kept in a

drop of 1 percent nutrient salts in a moist chamber, gives rise to a branch. If the plant is kept submerged in a large amount of the same salt, then a thickly glomerated (or coiled) branch system results. Similar results have been shown by Reynolds (1948) who cultivated some Stigeoclonium plants in different nutrient media and found different branching growths. Interesting results were shown by him in Text Figs. 26 ,28 ,29 , and 30 , where comparatively better branch growth took place in both pond water in laboratory (Text Fig. 26) as well as in Godward's solution (Text Fig.28); but in one-half strength Benecke's solution (29e) and in Chu's solution (30 e.g.) the branch growth was greatly retarded. He observed, however, that in ponds the erect system tends to be reduced to colorless hairs whereas in the laboratory a green, fully erect system is usually produced. The cause of this difference he thinks, lies in the chemical constituents of the culture solution, especially KNO_3 plays a large part in this but the amounts of other salts, such as $CaCO_3$ and KH_2PO_4 are also important. Increasing the amount of $MgSO_4$ seems to encourage the formation of colorless hairs (nitrogen has the opposite effect, Uspenskaia, l.c.).

Uspenskaia (l.c., p.320) has further pointed out

that in Stig. tenue Klebsi "the breadth of the cells is hardly affected by lighting or by nitrogenous nutrition, while their length varies greatly in dependence on these factors". Generally speaking, these cells are more elongated under favorable growth conditions. This increase in cell-length was also observed by me in a culture of Stig. tenue (Ag.) Kg., obtained from Indiana University, Bloomington, which does not look at all like Stig. tenue.

Thus it seems that branching habit or growth is significantly dominated by chemical nutrients in the environment. Therefore, for a taxonomic evaluation of a species, in culture at least, one has to determine the proper concentration of the medium in which the plant may fully express itself. In nature, also, it seems that these plants express themselves fully only when a 'proper' concentration of chemical nutrients is available.

b). LIGHT: Usually Stigeoclonium plants grow better in medium to bright light. They may grow even under ice where light can penetrate up to a certain optimum depth. Similarly, they can grow several inches below the water surface if the water is quite transparent and clear. Klebs (l.c., p.402) long ago remarked that light has a strong influence on the growth, arrangement, and orientation of the branches. One-sided strong incident light will cause unilateral branch formation and when the light comes from all sides then branches will grow in several directions. I found this to be true both in nature as well as under laboratory conditions (Text Figs. 43-45). Here, after keeping the plants in fingerbowls with natural water or on agar slant for several days the orientation of branches changed greatly, mostly towards the light sources placed directly above the material. Early growth of the branches from zoospores shows also positive phototropism and the branches arise mostly from the upper convex sides of germinating zoospores rather than lower sides.

c) TEMPERATURE: Temperature has less influence on the growth and orientation of branches than do light and nutrients. Generally, *Stigeoclonium* plants grow well between 10 and 30 degrees C. Extreme temperature tolerance has been recorded in certain species, i.e. plants growing under ice at about 1 degree C. as well as in hot spring water. Seasonal growth of certain species might be to some extent influenced by temperature. Livingston (l.c.) however, found that under lower temperature his experimental plant (he called _Stig. tenue_) produced palmelloid cells. (It might be that _Stig. tenue_ is a summer form which favors only warm water).

Thus, it seems that it is equally risky to identify each and every collection from nature and also to rely on any culture where concentration of chemical nutrients, light, temperature, etc. could be a regulating factor on the growth of the plant. Therefore, one must use his personal judgment to decide which plant-collection should be taken as reliable for species identification.

ECOLOGY AND DISTRIBUTION

Stigeoclonium is strictly a freshwater genus, although some species have been found incidentally in brackish water. It has a world-wide distribution, occurring in the Arctic and Antarctic, in temperate and tropical countries of both hemispheres and have shown tolerance to extreme temperatures. Thus, some species, for example, *Stigeoclonium lubricum* (Dillw.) Kg., *Stig. subsecundum* Kg., can grow well under ice, whereas *Stig. thermale* A. Br. occurs in hot spring water where temperatures may reach 40 degrees C. or more.

Stigeoclonium species are found in streams, rivers, lakes, ponds, bogs, rice fields, road-side ditches, fish-ponds etc. wherever they can attach to a suitable substrate such as stones, pebbles, floating or fixed sticks and logs, dead leaves, on boats and pilings, on wooden turbine-conduit, horse-troughs (Ström, 1926), and on living aquatic higher plants as epiphytic, and as endophytic or parasitic(?) forms in small plants like *Lemna* spp; they grow also as epizoic or histozoic forms on aquatic animals, such as among the scales and nares of fishes like kissing gourami (Tilden, 1937); Nigrelli et al, 1958); on the shells of snails

(Prescott, 1955); of various molluscs and bivalves (Campion, 1956); on the toad body abundantly in early spring (Wang, 1935), and also found to survive satisfactorily in the alimentary canal of the fat-head minnow in the Ohio River drainage (Coyle, 1930). *Stig. tenue* (Ag.) Kg. is the most common species occurring epizoically and in widely distributed areas, reported from Australia, China, Japan, Europe, and U.S.A. Campion (l.c.) also reported *Stig. farctum* and 30 other different unidentified forms of *Stigeoclonium* from the shells of molluscs and bivalves. Some of the herbaria specimens collected from the fish body were examined by me and found to be beautiful *Stig. tenue* (Ag.) Kg. Moewus (1953) reported one *Stigeoclonium* sp. from a semi-desert of Australia (see detail habitat lists under each species). Bradley (1929) reported one fossil *Stig. lubricum* (Dillw.) Kg. (although doubtful) from lower Eocene period in Colorado, U.S.A.

Sometimes, these benthic forms may be detached from the substratum at any stage in the life-cycle, however, and are found floating. Rarely, they grow directly on soil (as for example, *Stig. terrestre* Iwan., *Stig. rangoonicum* Zell.)

Some species show a selectivity for either alkaline, hardwater or acidic water media. **The detailed** ecological information in this respect for all the species is not yet available and therefore, no general inference can be drawn now in respect to the significance of the pH factor, whether there are any strictly 'acidophilic' or 'basiphilic' species of Stigeoclonium. Lowe (1945[illegible]) found Stigeoclonium amoenum Kütz. growing luxuriantly in alkaline water, with pH 8.0 at 17.5 degrees C. in spring (April). The same species was observed by me to grow in basic water in Round Lake, Lake Lansing, both in Michigan, in early spring (April, 1950). Whitford (1956) also reported some species of Stigeoclonium growing in hard freshwater of Florida Springs. On the contrary, some other species of Stigeoclonium were found to grow in soft, or acid water of streams and bogs. Stigeoclonium subsecundum Kg. was found in an acid bog, Michigan, in winter. Some Stigeoclonium species(?) were reported to grow in acidic water, however, at pH as low as 4.0 or below ([illegible], 19[illegible]). Silva (1951) reported Stig. lubricum (Dillw.) Kg. to grow in a water, pH 4.5-5.0 in a road side drain, Tennessee. Dr. Whitford sent me large number of collections from North Carolina streams where the pH value was mostly between 5.0-6.5. Dr. Whitford, who is mainly working on the ecology of the freshwater filamentous Algae in the streams of North Carolina and adjacent areas, for several years, however, has supplied me with (personal communication) some valuable information about the ecology of *Stigeoclonium* in those areas of the South -East United States and I take this opportunity to mention here some of the ecological conditions there where *Stigeoclonium* was found to grow. Dr. Whitford states that all the waters (except for fertilized farm ponds and a few rivers high in salts from sewage) are soft and oligotrophic. Minerals, especially calcium, are very low. The pH varies from near neutral (slightly above in streams) to as low as 4.5. The actual range is 4.5-7.4. Coastal plain streams and ponds are often brownish and mostly below pH 6.0. Mountain streams and ponds are clear and have a pH from 6.0 to 6.[illegible]. Piedmont streams and ponds always have considerable colloidal clay and range in general from 6.5 to 7.2. He further states that *Stigeoclonium* in those areas is distributed mostly in cool water and may be regarded as a winter and spring genus. *Stigeoclonium* seems to belong to a group of algae having a medium temperature requirement (1[illegible]-[illegible] degrees C.) and probably a medium to high light requirement. In open winters, it is common to abundant in the coastal plain from December on. It probably becomes common in late autumn and persists if the winter is sunny and not too cold. In the lower coastal plain water temperatures exceed 10 degrees C. often enough for it to grow throughout the winter. At temperatures below 15 degrees C. it is found in the littoral zone of ponds and in streams of all sizes. <u>Stigeoclonium</u> <u>lubricum</u> (Dillw.) Kg., according to Dr. Whitford, seems to be the most common species in those areas. He collected it in all seasons in streams; also in pond shallows mostly in winter and spring (until about April 1). <u>Stig.</u> <u>tenue</u> (Ag.) Kg. was also present but not so common. He believes that the commonest species in Florida springs is <u>Stig.</u> <u>lubricum</u> (Dillw.) Kg. The genus is rare in the brownest and most acid waters. The lowest pH recorded for it to grow consistently is about 5.2.

A few species including some new ones have been collected from brackish water of rather high salinity (Dixit, 1937; Kufferath, 1919). Unfortunately, I did not secure these specimens for study and therefore, cannot determine whether these are good <u>Stigeoclonium</u> species.

<u>Stigeoclonium</u> species may tolerate a high degree

of pollution, especially, when growing in streams and rivers carrying sewage and mill wastes. Occasionally, toxic ions may be present in sufficient concentration to kill or inhibit other green filamentous algae like *Cladophora*, *Oedogonium* etc., whereas *Stigeoclonium* may survive and tolerate the toxicity fairly well. Thus, Blum (1957) found *Stig.* *tenue* (Ag.) Kz., the largest alga in the polluted course of the river Saline, Michigan in summer to be markedly resistant to chromium and other polluting ions. Palmer (1959) in his survey of the algae in water supplies found *Stig.* *tenue* (Ag.) Kz. dominant in organically enriched polluted areas, such as on sludge or in retention basins of sewage treatment plants. This species, he states, is used as an indicator of industrial wastes, such as copper, chromium, etc. polluting the rivers and streams. Patrick (1949, 1950) also in her study of the biological measure of stream conditions used several algal genera as indicator of stream conditions and referred to *Stigeoclonium* as one indicating "semi-health, polluted and heavy polluted conditions of the streams". Lade (1942) also collected and reported *Stig.* *tenue* from a rock at storm sewer entrance. In herbarium specimens I found several collections obtained from sewage disposal areas (see under each species).

Stigeoclonium has a preference for iron as sometimes shown by direct attachment on iron surfaces (Whitford, 1956). Uspenskaia (1936, p.29) also states that "under natural conditions Stig. tenue Klebsi was found in waters, which cannot be considered poor in iron. In stream No. 2 Fe_2O_3-content was as high as 1 mg. (p.p.m.?) at low oxidability of water. In other places, Stig. tenue grew in the presence of obvious supply of iron from the ground".

Dr. Whitford (personal communication) mentions that at least some species of Stigeoclonium respond to current and are able to absorb oxygen(?) enough to persist in rapids even in summer (also Whitford, 1960). Uspenskaia (l.c. p.29) states that "Stig. tenue does not need an excess of free CO_2 as this was the case with Draparnaldia glomerata".

Few works have been done exclusively on the ecology of Stigeoclonium and much less is known about the correlation between the ecological factors and growth periodicity and distributions of species. Some general ecological observations have already been mentioned above. In addition to those papers the works and reports on the river surveys in several states in U.S.A. and Canada from the standpoint of limnology and ecology, made by the Limnology Department, Academy of Natural Sciences of Philadelphia may be mentioned (see Appendix for Reference). It is out of scope here to discuss in detail all the above works made by different authors, but a few points will be discussed briefly below, involving my own and the observations of others. In all their studies authors have observed <u>Stigeoclonium</u> as a member of algal communities which prefer to grow in cool, clear, well-lighted, well-aerated running water and to grow at comparatively shallow depth. Those species growing on molluscs shells and fishes favor growth in clear water where light can penetrate to a greater depth. In this latter instance, it cannot be stated how far below the surface these aquatic animals go and how long they remain without interferring with the growth of <u>Stigeoclonium.</u> Some species grow well in swift currents and can withstand the force of tremendous wave actions. Blum (1957) determined that <u>Stig. tenue</u> can resist the pull of the water current up to 1.35 m. per sec. He did not find this species in quiet water. Similarly, I observed the same species on pine logs on the eastern shore of Flathead Lake (near Biology Station, Montana State Univ.) where all day and night it was completely washed by big waves at frequent intervals. Blum (l.c.) however, also found difference in growth rate of this species at different time of the year which, he thinks, depends upon suitable riffles of the habitat. At certain stations he found that *Stig. tenue* was luxuriant in spring, at others in summer; at other situations less abundant and sporadic. He generally referred *Stig. tenue* to summer communities among other benthic algae of the polluted portion of the river. Small plants of this species forming a layer over the riffles were found abundant only in winter at certain stations, although at other stations it was completely missing throughout much of the winter, whereas spring-growth was luxuriant. I also found this species in Flathead Lake, Montana but not before fourth week of June, 19[illegible].

Blum (l.c.) suggested that the appearance and disappearance of *Stig. tenue* did not occur at corresponding times each year. During most of the year, rocks in riffles at a particular station remained covered with a dwarf form without the usual erect system. Then, suddenly, rapid widespread growth of the erect system took place in August, 19[illegible] and again in May and June but not in August, 19[illegible].

Klebs (1896), as mentioned before, had also observed *Stig. tenue* growing in running water and showing luxuriant growth in spring in Europe. Leake (1945) found *Stigeoclonium amoenum* Kg. growing luxuriantly in spring time in Oklahoma, U.S.A. Likewise, Godward (1942) noticed the same species growing luxuriantly in spring in nature as well as in culture, in England. I, too, found this spring development in Lake Lansing and Round Lake, Michigan, U.S.A., in 1960. *Stigeoclonium subsecundum* Kg. on the otherhand, was found to begin growth in the fall, reaching its maximum in winter under ice in a Michigan acid bog, and gradually disappearing from the place in early spring. This was observed in year around collections from the bog by Mr. J. H. Graffius (Personal communication).

All these observations suggest that (although data are not abundant) different species of *Stigeoclonium* show periodic growth 'peak' at different seasons and, accordingly, they may be classified as "summer form" like *Stig. tenue* (Ag.) Kg. (cf. Klebs, l.c.); "winter-form" like *Stig. lubricum* (Dillw.) (cf. Transeau, 1917, 1913), *Stig. subsecundum* Kg.; and "spring form" like *Stig. amoenum* Kg. (Godward, l.c., Leake, l.c., etc.). Other species may fall in any of the above categories or may be intermediate or may show transitional periodicities between all three. It may be, however, as pointed out before, that some species are 1) perennial or, both perennial, and annual and 2) always annual. More data and field observations are needed to support this statement.

ASSOCIATION

A brief discussion only is possible on ecological associations of this genus *Utricularia* with others in the same environments. Not all species were collected enough times from different habitats and countries to indicate any ecological significance. In several instances, however, it has been found that

Stigeoclonium species are most commonly associated with freshwater diatoms, especially, with the genus Cocconeis. Whitford (19[illegible]) recognized three algal communities in springs and spring streams of Florida of which the first one is the "Cocconeis-Stigeoclonium-Community" of hard, freshwater springs. Butcher (1932) also showed (1932, Text Figs.4B , 5B) from a study of algae in the bed of a shallow river that at times the development of Stigeoclonium plants was checked by the profuse overgrowth of Cocconeis colonies. Presence of Stigeoclonium sp. in a body of water, especially in a river, is taken as an indicator of the type of water conditions and other organisms present in it ([illegible], 19[illegible]; also see Appendix). Blum (1957) recorded that "Ulothrix spp., Stig. tenue and Diatoma vulgare are all characteristic of riffles and regularly drop out as massive components of the vegetation wherever 'pool' conditions obtain". In my study of numerous herbarium materials from different countries I have found other diatoms abundantly present, mostly Navicula and Melosira. Among the filamentous algae Cladophora and Oedogonium spp. were found to be frequently associated with Stigeoclonium, and less frequently [illegible], Audouinella and Draparnaldia. Dr. Whitford (l.c.)

from N. Carolina states that *Stigeoclonium* is always attached and frequently is the attached part of an 'aufwuchs' in which *[illegible]*, *Tabellaria*, *Bulbochaete*, *Microspora*, *Oedogonium* and few desmids such as *Staurastrum* and *Cosmarium* are common. As the water warms *Stigeoclonium* becomes confined to springs (where it may persist all summer at a temperature of 11-13 degrees C.) or the rapids of the streams. In the coastal plain it is often associated with *Eunotia pectinalis* and *Audouinella violacea* and is abundantly attached to leaves, sticks and pebbles. It seems to disappear from slow or still waters at pH above 6.5 earlier than at a lower pH. In warm weather at least one species can still be found attached to rocks in very swift water at a temperature of 27 degrees C. (pH about 7.2). In the mountains it is present all summer in streams with a temperature of 20 degrees C. or lower.

The association of *Stigeoclonium* with fish, snails, toad, molluscs, bivalves (and possibly other aquatic animals like turtles) has already been mentioned. In a majority of instances *Stig. tenue* was found to be involved. [illegible] (l.c.) pointed out, however, that *Stig. tenue* and *Stig. farctum* grow mostly on the larger bivalve shells and are practically, absent from the smaller ones. Laboratory experiments showed that these two species of Stigeoclonium, especially the latter, is more sensitive to "silting up and being covered", and so developing poorly.

It seems therefore, that different species of Stigeoclonium have varying chemical requirements, some for more acid conditions than others and vice versa, although some may be facultative in their adjustments. The periodic appearance of different species in a particular habitat besides being related to temperature could be due to chemical differences, and in respect to epizoic forms to the age and periodic appearance of the host.

The growth of most species in running water or in water frequently agitated by waves, or, as epizoophytes, all suggest greater oxygen requirement by these plants. Running water or drifting substrates may provide the needed conditions of aeration.

GENERAL MORPHOLOGY

HABIT: In general, *Stigeoclonium* species are well-branched filamentous green algae, having erect and prostrate systems. In some species, both the systems are equally developed, in others, either the erect part is well-developed and the prostrate part is greatly reduced, or vice versa. The relative proportion between erect and prostrate systems however, is extremely variable and is influenced by many environmental factors. If the conditions are not "optimum", then a 'stunted' growth with more prostrate system usually develops. Under favorable 'optimum' conditions this prostrate system may give rise to profuse erect filaments. Again, the same species may, under extremely unfavorable condition, break down into individual pieces and remain as a *Palmella*-protococcoid stage.

A distinct prostrate thallus, however, is not at all developed in some *Stigeoclonium* species as found both in nature and in culture. On the whole, the erect filaments are the most conspicuous expression in the life-cycle of the plants and are important for species identifications. On the other hand, because the prostrate system often is not so conspicuous and because the cells are more variable this portion of the thallus is not considered much for taxonomic differentiation. The disc-like prostrate part of *Stig. farctum* Berthold (1878) was not found to occur in the culture that we obtained from Indiana University culture collection, but was composed of linear row of cells (pl. 26 f. 6,7). Thus, the same species may produce different types of prostrate system depending upon various environmental factors in addition probably to the nature of substratum. Contrary to this, many species may have developed similar type of prostrate system. A few types of prostrate systems from which the erect filaments develop are shown by Text Figures 23 , 24 , 31 , 32 , 33 ,; (also pl . 27 f. 1-8).

CELL TYPES: Usually the cells of the prostrate system are shorter, globular, elliptical, angular or isodiametric, thick-walled, compact, filled with dense foods and plastids; the filaments creeping on the substratum irregularly; rhizoids also develop from them.

Cells of the erect filaments vary in shape and size but usually they are longer than those of prostrate part and are more cylindric. They show greater morphological range in different species, especially, between the main axis and its branches. Thus, according to size and variations of these the species of *Stigeoclonium* can be classified into two groups.

First, there is the primitive type -- where no marked size difference exists between vegetative cells of main axis and its primary and secondary branches. Cells of the axis which bear branches are not much different, if at all, from those not producing branches. The other group, advanced, includes those species in which vegetative cells of the main axis and its branches are differentiated into long cells and short cells, although irregularly arranged; usually the short cells produce the lateral branches. This character, however, is not strictly followed in the branches.

HAIRS: The tips of erect branches are variable and may be pointed, attenuate, setiferous, flagelliform, blunt, acute or ending into long colorless uni- or multicellular hairs (Text Figs. 15 - 21). The hair-formation, in many instances depends upon the nature of habitat; whether the plant is growing in quiet or running water. Klebs (1896), Fischer (1905, 1906), Reynolds (1950) and others have pointed out that hair-formation usually occurs in the [illegible] rather than in flowing water. Further, Reynolds (l.c.) pointed out that hair-production can be controlled by adjusting the concentration of KNO_3 in the culture medium, low concentration favoring the reduction of the erect system to colorless hairs and that similar variations in the amount of KH_2PO_4 do not have a similar effect. Change from green filaments to colorless hairs is one of reduction as the plant adapts itself to poorer nutrient condition. A similar conclusion was also made earlier by Uspenskaja (19[illegible], p.300) who states that weak light favors hair-formation in Stig. tenue Klebsi, whereas more [illegible] suppresses the development of hairs.

It is my general opinion, however, that the nature of the tip of any fully-developed plant is fairly uniform and not the same in all species. In some forms the tips are gradually attenuate, or sharply pointed, for example, in Stig. tenue, Stig. [illegible], Stig. stagnatile etc.; in some, long, setiferous or flagelliform, for example, in Stig. flagelliferum, Stig. setigerum etc.; in some, blunt, e.g. in Stig. [illegible] Jr.; in still others, mostly with long colorless hairs, e.g. in Stig. longipilum, Stig. [illegible] etc. A well-developed plant always tends to produce tips characteristic of that species-group mentioned above.

This character, that is nature of the tip, may help to a limited extent in separating closely similar species.

[illegible] (1[illegible], p.[illegible]4) states that according to Berthold *Chaetophora* and *Draparnaldia* species show trichothallic growth from few definite cells, like *Ectocarpus*. In many *Stigeoclonium* species, e.g. *Stig. lubricum*, Berthold found hairless conditions which, however, grow more in culture; in *Stig. variabile* the old hair-formation he has to appear in autumn. In *[illegible]* (which may be a reduced form of *Stigeoclonium*) the hair is not so well-developed.

MUCILAGE: *Stigeoclonium* filaments are commonly surrounded by a thin layer of mucilage, but in some species there is a thick sheath. The mucilage continues, covers the entire basal part, especially under poor light, as for example in *Stig. variabile* Näg. (Fritsch, 1935). It is difficult to determine the limit of mucilage sheath around the filaments. In some species, for example, *Stig. lubricum* (Dillw.) Kg., *Stig. longipilum* Kg., *Stig. fasciculare* Kg., *Stig. subsecundum* Kg., *Stig. pachydermum* Prescott the mucilage layer is comparatively thicker than in others. It has been observed and remarked upon, however, by several workers, e.g. Wood (1[illegible]), Wolle (1[illegible]), Harvey (1[illegible]), Cooke (1[illegible], 1[illegible]) and others that some *Stigeoclonium* species such as those mentioned above, appear like *Chaetophora* in their earlier stages of growth, being surrounded by heavy gelatinous sheath, but later, as the plant grows, the filaments break through the mucilaginous matrices. I also observed this condition in the instance of *Stigeoclonium subsecundum* Kg. growing under ice in winter where the thin gelatinous layer covered the plant most of the time. At such a stage it may be confused with *Chaetophora* but can be separated from the latter by its branching habit and by the fact that it does not develop into the *Chaetophora*-like mucilaginous colony or ball. It may be said that low temperature (also high temperature?) is responsible for the production of abundant mucilage, especially found more in winter-forms or in plants growing in cooler (stagnant?) water and in less bright light. Sometimes, brownish-red matter may be secreted by the plant which may surround the basal cells as observed by Fritsch (1[illegible]), in *Stig. variabile* Näg. Similar brown-red pigment was also observed by Cheng (1952).

CHLOROPLAST:

Generally the chloroplast in *Stigeoclonium* is ulotrichaceous, each cell having a single, parietal, band-shaped chloroplast containing one to several pyrenoids. If we examine the general morphology of chloroplast, however, in different genera of Ulotrichales and Chaetophorales, for example, *Ulothrix*, *Stigeoclonium*, *Cloniophora* and *Draparnaldia*, we find an interestingly significant range of chloroplast structure and its transition from *Ulothrix*- to the *Draparnaldia*-type. This transition is quite remarkable and pronounced in several *Stigeoclonium* species. The chloroplast in *Ulothrix* is either a parietal band occupying most of the cell or a complete or incomplete ring occupying the mid portion of the cell. In *Draparnaldia* the chloroplast is also a parietal band or ring-like structure but occupying only smaller area in the mid-region of the cell. It differs, however, from the *Ulothrix*-type by its characteristic reticulate nature with wavy, lobed, laciniate or fimbriate margins. Thus, we can state that the former one is *ulotrichoid* type and the latter is the *draparnaldioid* type of chloroplast. *Stigeoclonium*, interestingly enough, stands between these two extremes, with various transitional forms, although in the younger cells of the main axis and in cells of the smaller branches the chloroplasts mostly retain the ulotrichoid habit. Therefore, here I shall refer only to the chloroplast of the main filaments and of larger cells of primary branches.

Forest (1955) states "in Stigeoclonium itself there are so many intermediate forms that the genus would appear to contain few separable entities."

It is not the purpose here to classify all the species of Stigeoclonium on the basis of the chloroplast structure but at least an approach may be made so that a more critical study on chloroplast structure of all Stigeoclonium species can be undertaken in the future. Thus, it may become possible that the related species can be brought closer together. In lower unicellular algae, for example, in the order Chlorococcales, recently several new genera have been established, mainly based on the chloroplast structure, e.g. Spongiochloris, Neochloris, by Starr (1955). Gojdics (1953) attempted to separate Euglena species on the basis of chloroplast morphology. How far this practice of separating species and genera based on chloroplast morphology is tenable is difficult to state but at least a few types of chloroplast can be mentioned which are characteristics of certain well-known Stigeoclonium species.

The ulotrichoid type of chloroplast: The ulotrichoid chloroplast is usually found in forms in which the cells of the main axis are relatively small. Here, the parietal chloroplast occupies most of the cell. Gradually, as the cell becomes more cylindrical, the main chloroplast-body shifts towards the center leaving projected ends in two corners of both sides of the median region. Examples are Stig. variabile Kg., Stig. subsecundum Kg., Stig. stagnatile (Hazen) Collins, Stig. tenue (Ag.) Kg. (Text Figs.1 -4).

[illegible] type: This shows a transition between the ulotrichoid type and draparnaldioid type. The chloroplast in all big cells here occupies a median position like narrow ribbon or band (Text Fig. 8) after the reduction of the side projections (Text Figs.4, 9). In some instances this central band becomes dissected and produces a fimbriate appearance on both sides (Text Fig. 6) giving rise to draparnaldioid type of structure; for example, in Stig. flagelliferum Kg., Stig. nudiusculum Kg., Stig. amoenum Kg. and its varieties.

Draparnaldioid type: This Draparnaldia-like chloroplast is found in few species of Stigeoclonium where the central parietal band appears reticulate with more pyrenoids and the margins towards the polar sides are wavy, fimbriate or lobed. For example, in Stig. lubricum (Dillw.) Kg., Stig. Lebolii. (Text Figs. 6-7).

Subsecundum type: This type of chloroplast is found most consistently in species like Stig. subsecundum Kg. The difference from the above types is striking. For example, it may be mentioned that cells of both Stig. amoenum Kg. and of Stig. subsecundum Kg. are more or less equally long, about 3-10(-12) times the diameter, but in the latter species the chloroplast is massive, almost cylindrical and occupies almost the entire cell-length. In general, it appears as a longer and cylindrical form of the ulotrichoid type. Here, as opposed to draparnaldioid type the chloroplast margins towards the center show some variations-- from smooth, straight margin or little wavy to lobed margins (Text Figs. 11-14); example Stig. subsecundum Kg., Stig. longipilum Kg.

Sometimes the chloroplast may show as diffused due to poor fixation in slide preparation or because of some factors such as high or low temperature, and these forms then cannot be assigned to any particular type. Such an abnormal condition is illustrated in Text Fig. 5.

In almost all species there are several pyrenoids present in each chloroplast. In [illegible] and [illegible] the chloroplast is usually cup-shaped.

RHIZOID:

There is no regularity in the arrangement of the rhizoids and it is my conviction that any species may form rhizoids under certain conditions. Although rhizoids and their characters are not mainly used here to separate any species, a few remarks about them are pertinent.

It has been observed during my investigations that in certain species rhizoids are invariably developed, even at young stages of thallus development and that in the mature plant they become profuse. In other species they may or may not develop but when present they are not very profuse. The former condition is present in those species in which the prostrate part is usually reduced or absent, when the prostrate part is totally absent the entire fixation of the plant to the substratum is produced by profuse downward growth of rhizoids from the erect filament, e.g. in *Stig.* *amoenum* Kg., *Stig.* *longipilum* Kg. etc. (Text Figs. 22, 25, 29). In plants like *Stig.* *aestivale* (Has.) Collins., *Stig.* *thermale* A. Br. etc. a small creeping base is found from which the rhizoids grow downward to form a loose interwoven mat. (Pl.31 Fig. 1 ; Text Figs.23 , 24). Sometimes, this creeping base may be partly reduced when the rhizoidal growth renders *Stig.* *amoenum*-like appearance (Text Fig. 22). The positions of the rhizoids, although variable, are mentioned below.

In many instances the rhizoids grow from lower sides of prostrate cells and when these prostrate cells are reduced or absent the rhizoids grow from any side and from either lower, middle or upper parts of a few basal cells in the erect filament. In *Stig.* *longipilum* Kg. however, an exception has been found. Here, the rhizoidal growth is profuse and forms almost throughout the plant, at least in the lower two thirds of its entire length. The rhizoids mostly develop at the lower end of each cell or cells at the place of branching which is mostly dichotomous type. The growth of rhizoids here is so profuse that they can obscure the lower part of the thallus. [illegible] ([illegible]), however, either ignored or overlooked these rhizoids, for none are shown for *Stig. longipilum* Kg., *Stig.* *[illegible]* Kg. and *Stig. fastigiatum* Kg. In the type specimens and other collections of these species used by Kutzing and by others these rhizoids are clearly seen, although the quantity of rhizoids may be variable (Text Figs. 30,106). Based on profuse rhizoidal growth at the basal part Chodat (1902) made a new variety *Stig. longipilum* var. *lacustre* Chodat and Jao (1947) made a new species *Stig. polyrhizum* Jao, although in all essential features this latter species agrees to be *Stig. longipilum* Kg.

Rhizoids may be unbranched or branched, very long, or short, simple, or crooked. (Text Figs. 22-30). In most instances the rhizoids are multicellular and colorless but sometimes a few cells may contain pigments especially, in the branches which grow downward to become rhizoids (Text Fig.24). It is not uncommon to find that felt-like or protonema-like rhizoids, occasionally give rise to new upright erect filaments (Text Fig.24). In such instances the plant appears as bushy tufts. In plants like *Stig.* *[illegible]* Kg. the rhizoids are very long and loosely arranged, coming down from many cells above the basal ones.

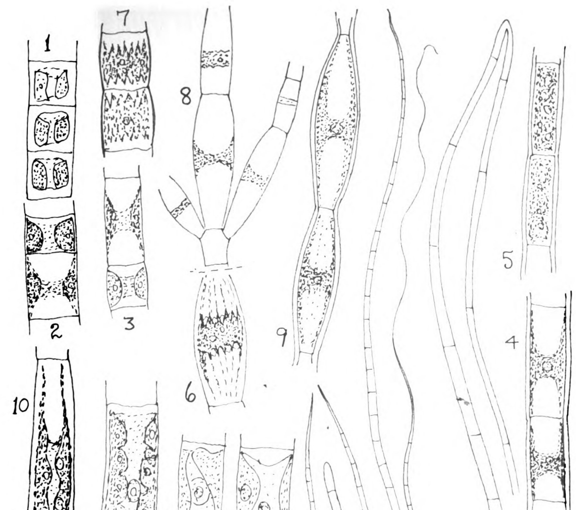
Briefly therefore, we may summarise a few general patterns of rhizoid-formation in _Rhizoclonium_.

Acorn-like, in which no prostrate part exists and rhizoids are profuse; _[illegible]-like_, in which the rhizoids are associated with a slightly developed prostrate part; _[illegible]-like_, rhizoids develop irregularly, may or may not occur; _[illegible]-like_, rhizoids mostly from more or less localised places along the filament; _[illegible]-like_, the rhizoids are short and crooked, usually when the cell walls are very thick.

These generalisations are of course only broad but give an idea as to the range of variations in the style of rhizoid-formation and their conditions. It cannot be said with certainty whether more rhizoids are formed in running or in stagnant water. It appears that plants growing in stagnant water bear longer rhizoids than those growing in running water or where disturbed by wave action. But in the latter case the number of rhizoids may be greater although they are short. This statement needs confirmation.

EXPLANATION OF THE TEXT FIGURES

Text-figs.	1-14.	Types of Chloroplast
" "	1-4.	[illegible]-type of chloroplast
" "	5.	[illegible] chloroplast
" "	6-7.	[illegible] - Stig. [illegible] -- type of chloroplast
" "	8-10.	Stig. [illegible]-type of chloroplast
" "	11-14.	Stig. [illegible]-type of chloroplast
" "	15-21.	[illegible]
" "	15.	[illegible]-like branch with [illegible] and [illegible] (as in Stig. [illegible])
" "	16.	[illegible]-like branch with [illegible] and [illegible] pointed end (as in Stig. [illegible])
" "	17.	[illegible] on point of branch tip (as in Stig. [illegible])
" "	18.	Flagelliform type of branch (as in Stig. flagelliferum)
" "	19.	Flagelliform or [illegible] branch (as in Stig. flagelliferum)
" "	20.	Branch with long colorless, multi-cellular hair or simply with hair (as in Stig. [illegible], Stig. [illegible])
" "	21.	Stig. [illegible]-type of branch tip.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

[illegible]. [illegible]. [illegible]

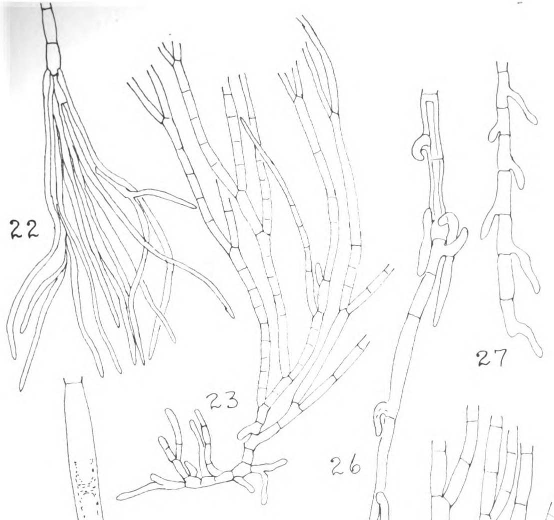
" " [illegible]. [illegible]. [illegible]

" " [illegible]. [illegible]. [illegible]

" " [illegible]. " " -[illegible]-

[illegible]

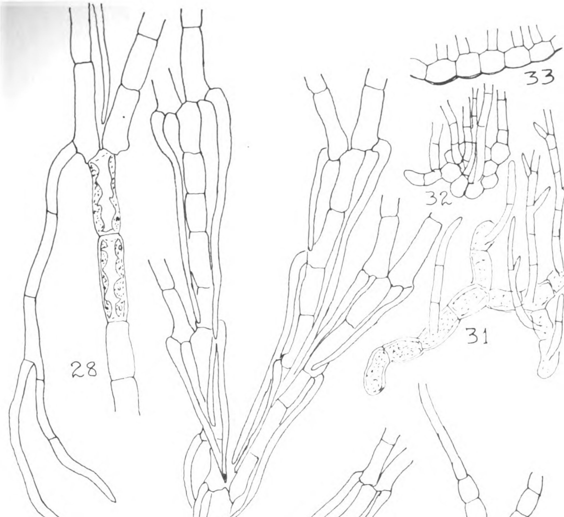
" " [illegible]. [illegible]. [illegible] type


22
23
27
26
25
24
N.I.

[illegible] (Continued)

[illegible] [illegible]. [illegible]-[illegible]. [illegible]. [illegible]-[illegible]

" " [illegible]-[illegible]. [illegible]

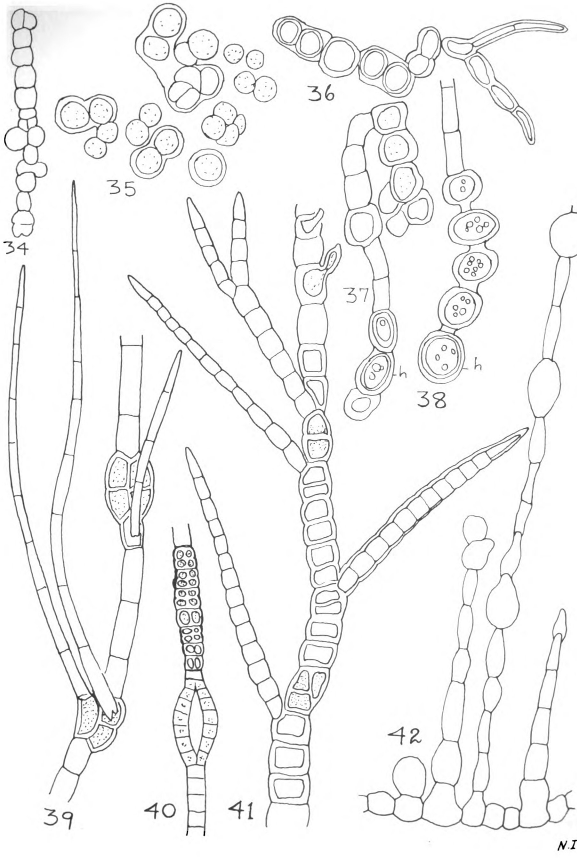

28
29
30
31
32
33
N.I.

[illegible] Fi[illegible]. [illegible]. [illegible] -
[illegible] ([illegible])

" [illegible]. [illegible]-[illegible]. [illegible]-[illegible]ts(h)
([illegible], [illegible])

" " [illegible]-[illegible]. [illegible] -
[illegible] ([illegible]. [illegible]. [illegible]- [illegible])

" [illegible]. [illegible]. [illegible]. [illegible] [illegible]
[illegible] ([illegible]
[illegible])



N.I

EXPLANATION OF TEXT FIGURES

Text figs. 1-14. [illegible] of [illegible]

" " 1-4. [illegible]-type of [illegible]

" " 5. [illegible]

" " 6-7. [illegible] -- [illegible] of [illegible]

" " 8-10. Stig. [illegible]-type of [illegible]

" " 11-14. Stig. [illegible]-type of [illegible]

" " 15-21. [illegible]

" " 15. [illegible]-like branch with [illegible] and sharply pointed end (as in Stig. [illegible])

" " 16. [illegible]-like branch with [illegible] and slightly pointed end (as in Stig. [illegible])

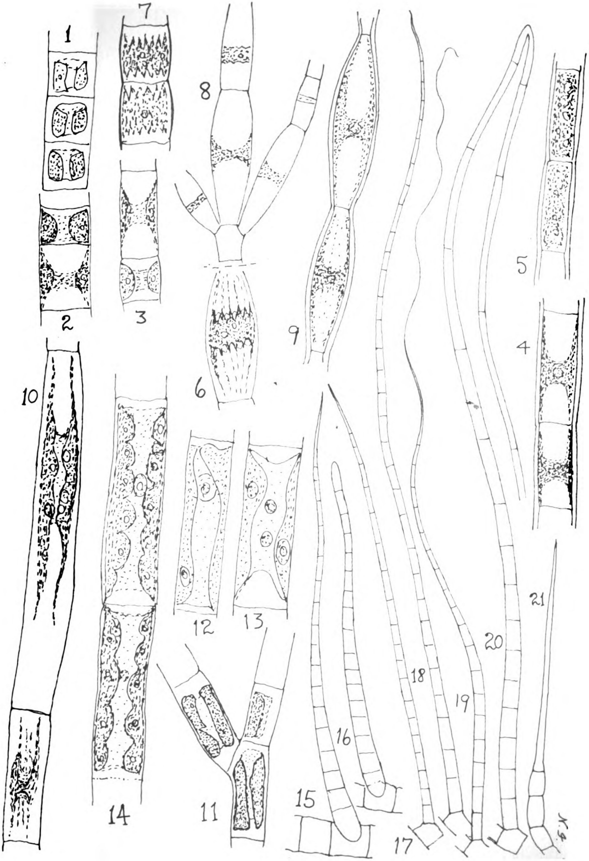
" " 17. Simply attenuated or pointed branch tip (as in Stig. [illegible])

" " 18. Flagelliform type of branch (as in Stig. flagelliferum)

" " 19. Flagelliform or [illegible] branch (as in Stig. flagelliferum)

" " 20. Branch with long colorless, multicellular hair or simply with hair (as in Stig. [illegible], Stig. pedicellatum)

" " 21. Stig. protonema-type of branch tip.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

[illegible]. [illegible]-[illegible]. [illegible]

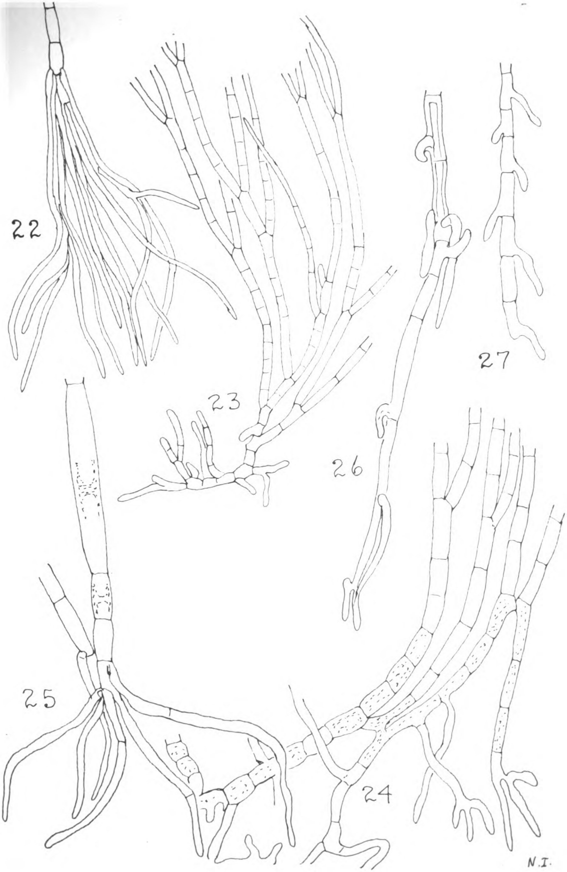
" " [illegible]-[illegible]. [illegible]. [illegible]-[illegible]-[illegible]

" " [illegible]. [illegible]. [illegible]-[illegible]

" " [illegible]. " " -[illegible]-[illegible]-

[illegible]-[illegible]

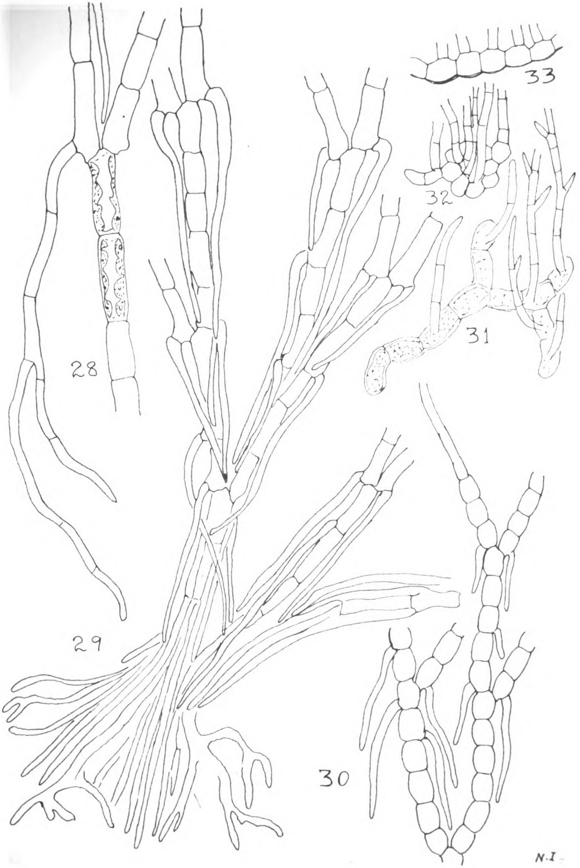
" " [illegible]. [illegible]. [illegible]-[illegible] type


22
23
27
26
25
24
N.I.

[illegible] (Co[illegible])

[illegible]. [illegible]-[illegible]. [illegible]. [illegible]-[illegible]

" " [illegible]-[illegible]. [illegible] of [illegible]-[illegible]- [illegible]



33
32
31
28
29
30
N.I

[illegible] Fi[illegible]. [illegible]. Cell division [illegible]-

[illegible] ([illegible])

" [illegible]. [illegible]-[illegible]. [illegible]-[illegible]ts(h)

([illegible], [illegible])

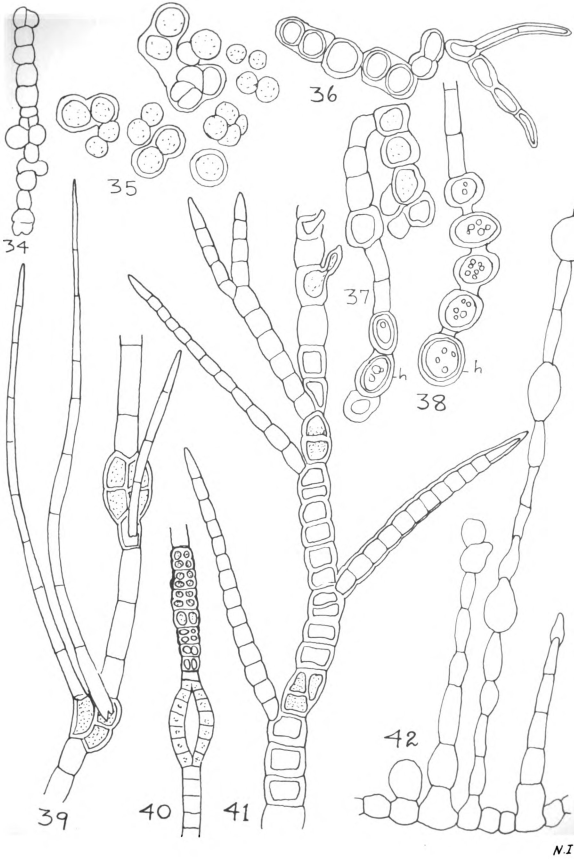
" " [illegible]-[illegible]. [illegible] cell [illegible]-

[illegible] ([illegible]. [illegible]. [illegible]-[illegible])

" [illegible]. [illegible]. [illegible]. [illegible] [illegible]

[illegible] ([illegible]

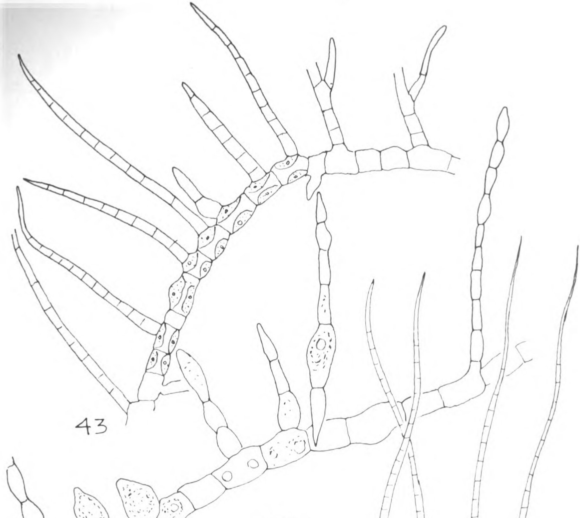
[illegible] University)



N.I

Text Fig. [illegible]. Influence of light on the orientation of branching; [illegible] towards the light.

" Fig. [illegible]. Old plants in the [illegible] [illegible] [illegible]. ([illegible])


43
44
45
46
N.I

Text Figs. 47-57. Zoospore-formation, liberation and germination.

" " 47-5[illegible]. Types of zoospore germination: (47. after [illegible]; 48. after [illegible]; 49. after Prescott; 50-51. after Fuller)

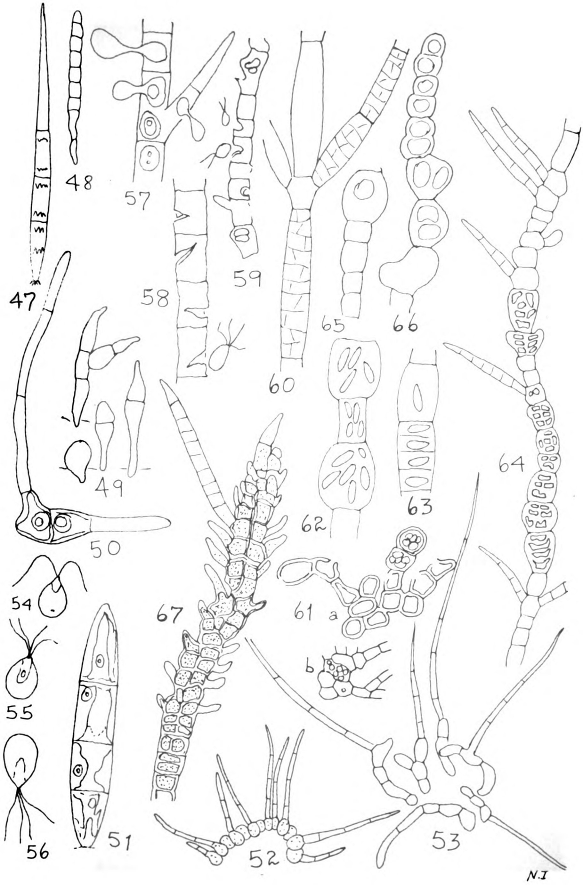
" " [illegible]. Bi- and quadri-flagellate zoospores.

" " [illegible]. Zoospore-liberation through lateral pores.

" " 60. Cell divisions and wall-formation in different planes during zoospore-formation and liberation.

" " [illegible]. Zoospore-formation in palmelloid cells and zygotes ([illegible]. after [illegible], b. after [illegible]; [illegible] after [illegible])

" " 67. Cell divisions in different planes at the branch-tip forming [illegible] zoospores which later producing lateral branches.


47
48
57
58
59
60
65
66
49
50
62
63
64
67
61 a
b
54
55
56
51
52
53
N.I

Text Fig. 68. Cells parasitised by [illegible] fungi (h--fungal hyphae)

" " 69. Stig. tubes growing on the fila-ments below [illegible]

" Figs. 70-71. [illegible] cells [illegible] their fusion

" Fig. 72. Round [illegible], producing haploid [illegible] (h) ([illegible] from [illegible])

" Figs. 73-74. Direct germination of the [illegible] to a diploid filament

" " 75-76. [illegible] cells [illegible] and their fusion

" " 77-78. Stellate [illegible] ([illegible] from Go[illegible])

" Fig. 79. Haploid [illegible] (h) from the [illegible]-[illegible] after r/d.

Text Figs. 91-114. Types of cells of the cell axis producing branches; and branching habit.

" Fig. 91. 1st. [illegible]-type.

" " 92. 2nd. [illegible] type. [illegible] type

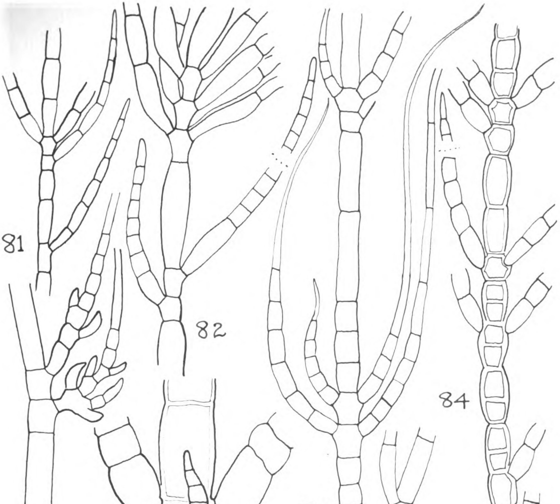
" " 93. 3rd. [illegible]-type

" " 94. 4th. [illegible]-type.

" " 95. 5th. [illegible]-type

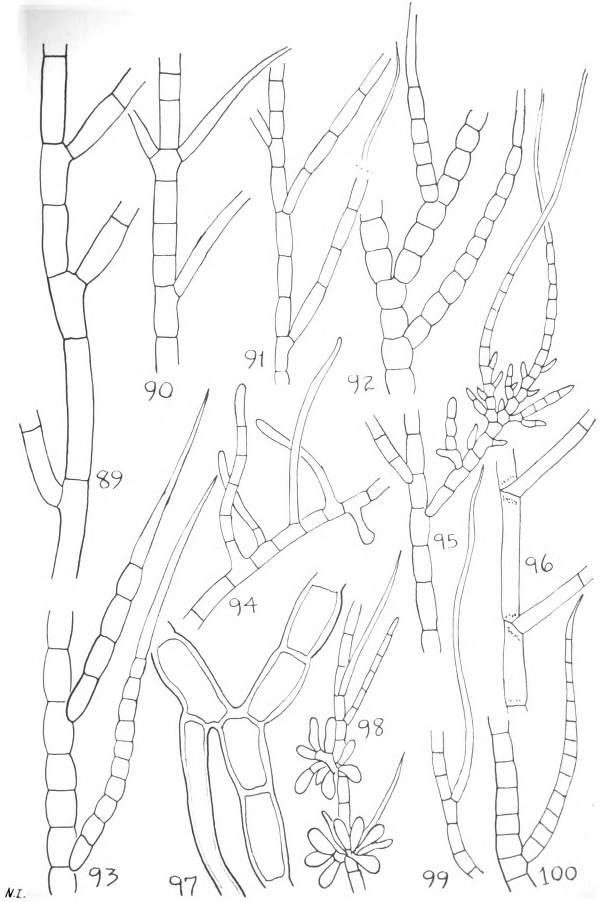
" " 96. 6th. [illegible] -type

" Figs. 97-[illegible]. 7th. [illegible]- type


81
82
83
84
85
86
87
88
N.I.

[illegible] (Continued)

Text Fig.	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	[illegible].	[illegible].	[illegible] -type
" "	100.	[illegible].	[illegible] -type


89
90
91
92
93
94
95
96
97
98
99
100
N.I.

[illegible] (Continued)

Text Fig. 101. Cladophora [illegible] -type

" " 102. Clad. [illegible] var. [illegible]-type

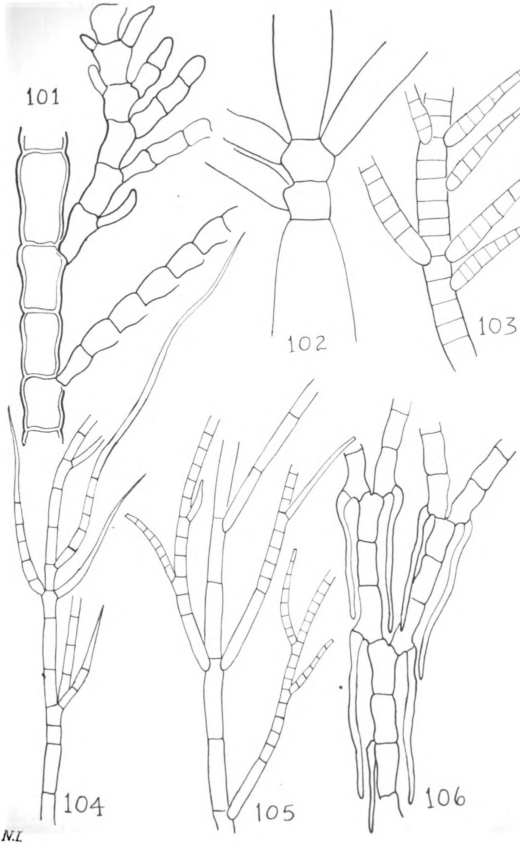
" " 103. Clad. [illegible] -type

" " 104. Clad. glomerata -type

" " 105. Clad. [illegible] -type

" " 106. Clad. [illegible] var. [illegible]-

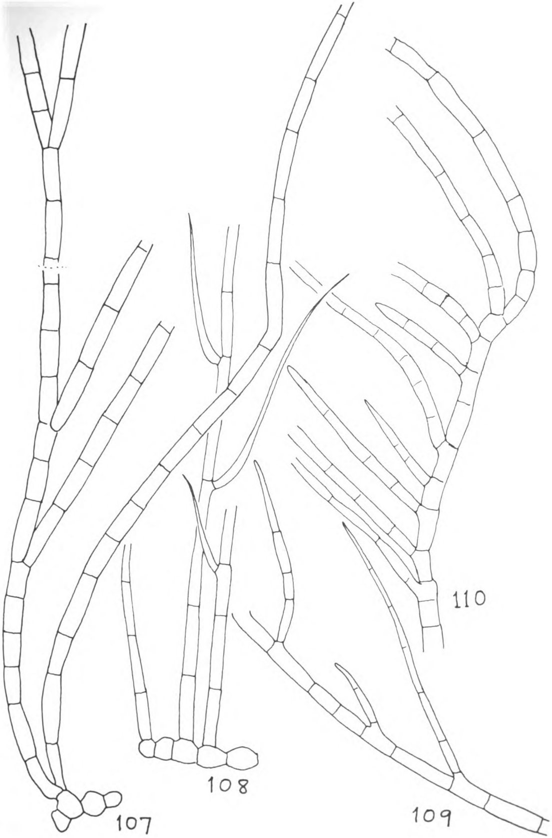
type.



N.I.

[illegible] (Continued)

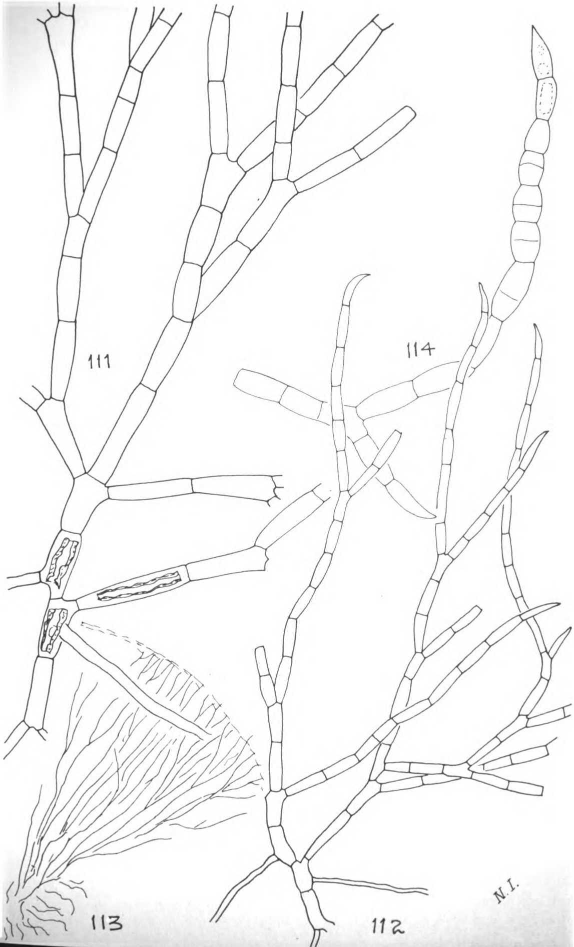
[illegible] 107-11[illegible]. [illegible]



107 108 109 110

(Continued)

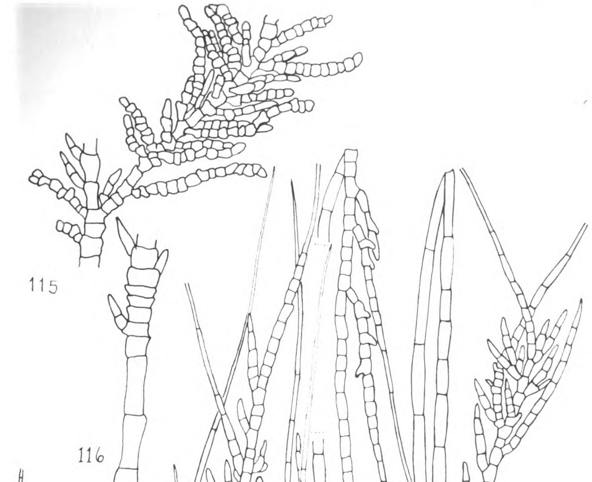
Text Figs. 111-114. [illegible] [illegible]--type
(From pencil sketch by [illegible]
[illegible]-11 cm.)


111
114
113
112
N.I.

[illegible] 111-117. [illegible] (after [illegible]; non, [illegible] (Coll.) comb. nov.).

" [illegible] 117. [illegible] (after [illegible]; non [illegible])

" " 11[illegible]. [illegible] ([illegible]) [illegible] (after [illegible]; non, [illegible]).


115
116
117
118
N.T.

Chapter II

SPECIES AND VARIETY CONCEPTS

A short and brief explanation should be given concerning the concepts which have been followed here in describing the species and varieties of *Stigeoclonium* and *Cloniophora*. The definition of species is extremely debatable and no satisfactory definition is there which can suit all the groups of plants. Several definitions have been given alone for the flowering plants which may be also applied broadly to lower plants, for according to International Code of Botanical Nomenclatures, 1956, the same epithet genus, species, subspecies, variety, form etc., are common to all groups of plants.

There are different conceptions at present in respect to higher plant species problems which are different and modified from that of Linnaeus' (1957, reprint) who defined species 'as a descrete, constant, natural unit that had been created independently by God, while varieties are the results of environmental influence.' There are several species concepts, such as, biological, applied, philosophical, typological, morphological, nondimensional, multidimensional etc. which have been advanced from time to time in a more broader sense than before. Of these the typological or morphological species concept has been followed [illegible] non-crossing until [illegible] inclined to [illegible] individual plants as the standard unit ([illegible] other plants [illegible]) rather than the whole population. Therefore the standard taxonomists have seen that the concept of [illegible]species, coenospecies, ecotypes, ecoclines, etc. where the entire population of a particular kind of plant is considered as a standard unit rather than the individual plant. Although the taxonomy of these filamentous [illegible] plants is based on 'type specimen study' (morphological); nevertheless, it can be said that a single collection of these plants may consist of hundreds of individual plants and a Type specimen may actually be called a micropopulation and a question may be raised whether they be called by any of the terms such as coenospecies, ecospecies, ecotypes or ecoclines etc. But here, contrary to the flowering plants, one is faced with the problem of deciding whether the plants in the collection are natural or not. In flowering plants usually the flowering stage is considered during the study, either taxonomic or ecological. But in the case of these filamentous algae mentioned above no such structure, nor even the spore-bearing structure, is available in nature to help understand the stage of growth. It is assumed that in a particular habitat two fully-grown, but different kinds of plants may exist side by side and in that event they should be regarded as separate species, or in other words, a particular species at a particular time at a particular place will look uniform and not show extreme variations except young-adult growth forms. It may be possible that two separate species may produce hybrid forms in the populations if they exist side by side for a long time.

Geographical variation is not so pronounced in aquatic plants as it is in higher land plants. No new species or variety has been made based alone on geographical isolation and minor variations, unless they are quite pronounced and sufficiently distinct morphologically. Species are considered "dynamic and continuously, though slowly changing rather than static and unchangeable and speciation may proceed in different directions. Although species may rarely hybridize, they are usually separated by internal barriers of a genetic-physiological nature" (Clausen, Keck and Hiesey, 1940). Stebbins' (1950) definition is "species are separated from each other by gaps of genetic discontinuity in morphological and physiological characters which are maintained by the absence or rarity of gene interchange between members of different species, especially in sexually reproducing organisms". Likewise, a variety may be a population of one or several biotypes, for instance a more or less distinct local form of a species (Du Rietz, 1930) or a distinguished variety may be a discontinuous variation in more or less conspicuous morphological features ([illegible], 19[illegible]).

Without going further into numerous definitions, however, I may conclude by stating that a species maintains its genetical internal barrier and produces its like and shows at least certain constant features wherever it has opportunity to grow 'normally'. Sometimes, these constant characters may not be expressed due to unfavourable environment and then, it is better not to put it under any species by force. Variety of a species here is considered only in those cases where the plant population in all essential features maintains the 'look' of the species but differs by one or two remarkable characters, not by the influence of the environment. It is assumed that these variations of a variety are maintained by the variety over a wide range of habitats. In a border line example, however, it is up to one's judgement whether the particular plant population should be called a species or a variety, and to judge that one has to have experience with the herbarium specimens, plants in nature and in laboratory culture.

Interrelationships between the species of *Stigeoclonium* and their possible evolutionary trends:

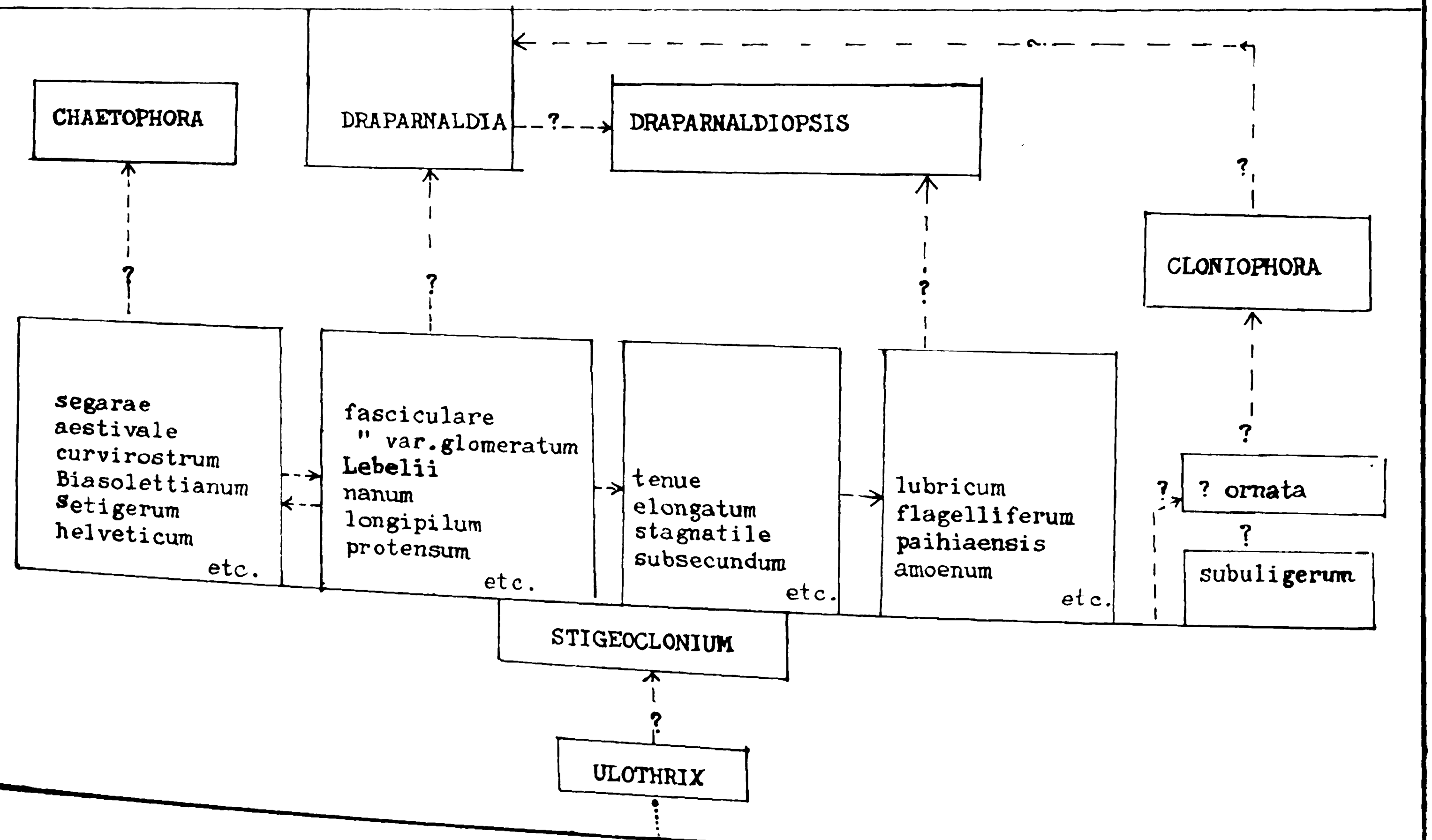
If we take it for granted that morphology or general habit of the plants is one of several important features to be considered in evaluating what is 'primitive' and what is an 'advanced' evolutionary form of *Stigeoclonium*, then we may discuss in brief the possible evolutionary trends presented by the species. When we compare and arrange species of *Stigeoclonium* in some sequence in respect to their general habits, we find gradual transitions or degrees of specializations in different characteristics. Chloroplast structure, branching habit and probably, the most important character specialization and differentiation of the cells of the "main filament" or axis (see Forest, 1956, p.144) of the erect thallus may be considered. It is presumed that from the unbranched *Ulothrix*-like plant branched filaments have been derived. At this stage, and initially, practically all the cells of the main axis and to a limited extent cells of the branches (except apical cells) would be uniform in shape and size and similar in habit and function. For instance, we may cite plants such as *Stig. variabile*, *Stig. nanum*, *Stig. longipilum* and several others. In this group of plants (let us call it a "primitive" group) no differentiation occurs in the cells of the main axis (i.e. cells which produce branches are not appreciably different from other cells not producing branches) and the branching habit is usually irregular, scattered and solitary, alternate or dichotomous. Then, with further development of thallus structure, we may suppose that greater specialization and division of labor developed among the cells of main axis with the branches opposite or whorled arising from specialized cells. This expression we find in plants like _Stig. lubricum_, _Stig. amoenum_, _Stig. flagelliferum_, _Stig. nudiusculum_, _Stig. Nelsonii_ and several others. This latter group of plants (call it an "advanced" group) may be considered derived from the "primitive" group. In between these two groups gradual transitional forms occur (an "intermediate" group), for example, _Stig. subsecundum_, _Stig. stagnatile_, _Stig. elongatum_, _Stig. tenue_ and so on. But this last group is not sharply defined and transition is gradual.

Now, it may be a step further from the "advanced" group indicated above that by gradual increase in diameter of the main axis and corresponding reduction in the number of cells between node-like cells (i.e. cells producing opposite or whorled or fascicled branches) and by reduction in size of lateral branches that the prototype of *Draparnaldiopsis*-like plants evolved. In these the reproductive function had been transferred entirely to the lateral branches. The loss of prostrate thallus, development of profuse rhizoids at the base and a characteristic *Draparnaldia*-type chloroplast structure have been already developed in several species of the "[illegible]" group. It may be visualised that *Draparnaldia*-like plants might have been derived from the "primitive" group mentioned above through *Stig.* *fasciculare*, *Stig.* *[illegible]*, *Stig.* *[illegible]*-like plants. Hence, in this "primitive" group as well as in *Draparnaldia* species we do not find any specialisation of the cells of main axis into [illegible] bearing branches. Later on *Draparnaldia* might have given rise to *Draparnaldiopsis*, so that we get two possible types of origin for the latter genus. Fritsch (1935 p.), however, does not regard *Draparnaldiopsis* as a valid genus and thinks that the culmination of morphological development is reached by *Draparnaldia* (l.c., p.[illegible]) which includes *Draparnaldiopsis*. Probably, it is better to assume that these latter two genera have been derived from *Stigeoclonium* independently. In this connection it may be mentioned that *Cladophora* might have been also derived from *Stigeoclonium* and possibly gave rise to Draparnaldia. It is difficult to state at present which species of Stigeoclonium might be precursor or prototype of Cloniophora, and thus there seems to be a gap left between them. Stig. subuligerum might be showing some initial tendency toward the formation of irregular branching habit like Cloniophora. In this connection further, it might be proposed that two Draparnaldia species, namely, Drap. ornata Kg. and Drap. comosa Kg. (1853, Pl. 16, Figs. 2 and 3 respectively) seem to belong to Cloniophora, especially, the former species. About these two species Forest (1956a, p.9 and 16) states however, that both of them are quite young plants and may belong to either Stigeoclonium or juvenile Draparnaldia. It thus gives me an impression that they might belong to Cloniophora but in the absence of authentic material they are omitted from this study. In case these two species should belong to Stigeoclonium then we get some form which can bridge up the gap between the latter genus and Cloniophora. Clon. plumosa (Kg.) might be related to Stigeoclonium on the one hand, whereas Clon. macrocladia is close to Draparnaldia on the other with Clon. spicata representing a separate form of habit. These three species of Cloniophora, although previously described under Stigeoclonium and Draparnaldia and although they possess characteristics of the latter two genera, they differ considerably and form a distinctive group of plants. It might be speculated that some species of *Draparnaldia* were probably derived through some *Cloniophora* species such as, *Clon. draparnaldioides* or *Clon. spicata*.

Meyer (19[illegible]0) states that his new genus *Draparnaldiopsis* with a single species *[illegible]* stands between *Stigeoclonium* and *Draparnaldia* and suggests that three species of *Draparnaldia* as illustrated by [illegible] (19[illegible]) namely, *D. lubrica*, *D. [illegible]*, and *D. [illegible]* should be transferred to his *Draparnaldiopsis* (p.177) with which Fritsch tentatively agrees (19[illegible]7). I do not see any justification for this radical separation which would seem to be not only confusing but unrealistic. There is some doubt that *Draparnaldiopsis* should be considered a member of the *Chaetophoraceae* because of its reticulate chloroplast and very wide filaments and thick-walled cells.

A schematic representation showing the interrelationships between *Stigeoclonium* species and their possible evolutionary trends is given in Chart 1.

Chart 1. Showing Interrelationships between *Stigeoclonium* spp. and their possible Evolutionary trends.



KEY TO THE GENERA STIGEOCLONIUM, CLONIOPHORA AND DRAPARNALDIA

Below a tentative key is given to separate the closely related genera, namely, Stigeoclonium, Cloniophora and Draparnaldia with notes on Draparnaldiopsis and Chaetophora:

I.a.) Plants with less difference between main axis and branches; in many species branches arise from modified cells and differently shaped from others in the main axis; where this difference is not sharp all the cells of main axis and branches look alike, branches are simple, mostly setiferous, with hairs; usually prostrate and erect parts of the thallus are present; zoospores and gametes produced mostly in the main axis but may arise also from the branches; intercalary and diffuse growth present; vegetative cells mostly between 10-25 μ in diameter.

--------Stigeoclonium

I. b.) Plants big, with remarkable size difference between main axis and branches; branches setiferous or nonsetiferous and blunt; branches are not developed from any specialized cells (or cells producing branches are not different from those not producing branches); prostrate part always lacking; basal cells or erect part producing profuse rhizoids; zoo-spores and gametes always from lateral branches; growth intercalary, diffuse or trichothallic.

-------- 2

2. a.) Plants with irregularly-arranged or scattered short branches which are solitary, crowded or loosely aggregate, not in true whorls or fascicles; vegetative cells of main filament and branches capitellate, inflated, tumid, infundibulliform, almost cylindrical, with or without constriction; branch tips not seti-ferous, hairs absent; apical cells of branches conically rounded or blunt; vegetative cells of main axis mostly between 20-50 μ in diameter; growth intercalary or diffuse.

--------<u>Cloniophora</u>

6.b.) Plants with regularly organized short branches in whorls or fascicles on the main axis or primary branches; apical cells of branches setiferous, with long colorless hair; vegetative cells cylindric, barrel-shaped or [illegible]; growth usually trichothallic; vegetative cells of main axis mostly between [illegible] µ in diameter.

-------- *Draparnaldia*

Chaetophora differs from all these genera by the fact that its filaments are radiated or divergent from a center and usually enclosed, even at maturity, within a copious, firm, usually smooth matrix, and the branches developing at the periphery more than at the central part of the colony, and it shows intercalary growth. *Draparnaldiopsis* has the same features as *Draparnaldia*, differing only by the presence of two types of cells in the main axis, long and short, the latter usually producing lateral branches (see however, Forest, [illegible] p.) and by intercalary growth. In the former respect *Draparnaldiopsis* bears a resemblance to certain "advanced forms" of *Stigeoclonium* (for example, *Stig. amoenum*, *Stig. nudiusculum* Kg. etc.).

KEY TO THE SPECIES OF STIGEOCLONIUM

It is customary to use a working key with which one can identify taxa, species and varieties. This key, as given by any author, depends entirely on how the author defines the species and varieties. It is always a great task for any author to select some 'good, constant' characters of any species and arrange them in some natural sequence. This problem is still more difficult in such a genus as *Stigeoclonium* where one has to depend on the vegetative morphology which is extremely variable. Several authors, however, have given some working keys for *Stigeoclonium* species mainly based on the alternate-opposite branching habit together with cell size, length and breadth. Separation of the species, based upon sexual reproduction, zygospore structures, chloroplast structure etc. may be possible, but until now not enough data have been accumulated along these lines and any attempt to use these characters will be far from satisfactory and complete. Here, in this work, however, a combination of several characters has been used to separate the species. First, an attempt has been made to classify the species into several groups based on a particular character, especially in respect to the cells of the main axis of the erect filaments as to whether there is any difference between the cells producing branches and those not producing branches. Then, in each group, further separation of the species is made on their branching habit (alternate, opposite or whorled), cell size and shape and other minor characters where-ever found applicable. The present author is fully aware of the shortcomings of this type of working key which may not be a perfect one, but it is given with the hope that these _Ptilothamnion_ species mostly show tendencies to express the characters used here to separate them, although variations and modifications will be found. Following is a group classification:

Group one: Species with main axis and primary branches similar; usually no specialized or any modified cells on the main axis producing the branches.

Group two: Species showing transitions between Group I and Group III in which there is some differentiation between the cells of the main axis starts; some cells gradually becoming long and some short, the latter commonly producing branches.

Group three: Species with main axis usually including two types of cells: 1) long, usually not producing branches, and 2) small and short, usually producing lateral primary branches.

KEY TO SPECIES IN GROUP ONE:

I. Cells of the main axis mostly barrel-shaped, constricted at the partition-wall:

a. Branching predominantly alternate or pseudo-dichotomous:

Cells of main axis 10-23 μ in diameter, 1-3 times as long as broad, branching mostly alternate ------Stig. protensum

Cells of main axis 6-9.5 μ in diameter, subequal -1-2 (rarely -3) times as long as broad ------Stig. nanum

Cells mostly inflated; but cells of main axis usually slightly cylindrical below, branching mostly dichotomous-type; cells 11-15(-19) μ in diameter, $\frac{1}{2}$-1-3 (rarely -5 times) times as long as broad

------Stig. longipilum

b. Branching mostly opposite or whorled:
Cells of main axis 15-25 μ in diameter, 2-5 times as long. ------Stig. Lebelii

II. Cells of main axis mostly cylindrical:

A. Cells of main axis but slightly inflated and constricted at the partition wall; branching alternate or pseudodichotomous:

a. <u>Erect filaments well-developed with short creeping base</u>:

// Plants growing in warm water up to 37 degrees Centigrade and sometimes incrusted; cells of main filaments 8-12 μ (rarely -15 μ) in diameter, 2-4 times as long

------<u>Stig.</u> <u>thermale</u>

// Plants growing in cold, or average temperature water; cells of main axis 7-12 μ (15 μ) in diameter, 2-6 times as long

------<u>Stig.</u> <u>aestivale</u>

b. <u>Erect filaments not profusely branched, developing from prostrate thallus composed of pallmelloid or isodiametric, or globular cells</u>:

// Branching of erect thallus more near the base, almost dichotomous type; cells of prostrate thallus 15-20 μ in diameter, of erect filaments 6-11 μ in diameter, 1-2 times (rarely -3 times) as long

------<u>Stig.</u> <u>variabile</u>

// Branching simple, prostrate thallus more elaborate, cushion-like; cells of main axis 6-8 μ in diameter, 1-2 times as long

------<u>Stig.</u> <u>farctum</u>

Branching mostly dichotomous type; apical cells bent, crooked or flame-shaped; cells of main axis 4-[illegible] μ in diameter, 10-50 μ long ------*Stig.* *[illegible]*

c. *Erect filaments well-developed, prostrate part slightly developed or lacking* :

i. Clusters of globular, oblong cells at certain intervals on the main filaments; cells of main axis 7-15 μ in diameter, 2-3 times as long ------*Stig.* *[illegible]*

ii. Characteristic branching habit; no globular cells :

Branching alternate, irregular, origin internal to the partition wall; cells of main filament 12.5-15 μ in diameter, 2-3 (-[illegible]) times as long. ------*Stig.* *Biasolettianum*

Branching very long, extended, slender, setiferous, thin thread-like, cells of main axis 7-12 (-15) μ in diameter, 1-3 times as long. ------*Stig.* *setigerum*

Filaments thread-like, branching by erection, sometimes appears like *Lepto-nema*; cells [illegible]-12.5 μ in diameter, 1-3 times as long. ------*Stig.* *helveticum*

B. <u>Cells of main axis slightly inflated; branching alternate-opposite, whorled or fascicled:</u>

// Primary branches dichotomous below, above opposite or 3-4 branches from same area (whorled); secondary branches form loose fascicles at the tip of the primary branches, cells 10-16 (-18) µ in diameter, 2-7 times as long. ------<u>Stig.</u> <u>fasciculare</u>

// Primary branches mostly opposite or whorled, <u>Chaetophora-like</u> habit, laxly branched; cells of main axis cylindrical, slightly or not constricted, 8-11 µ in diameter, 4-10 (-12) times as long.

------<u>Stig.</u> <u>sparsae</u>

[illegible]:

Slight differentiation into long and short cells in the main axis in the following species with a tendency for the short cells to produce the branches:

I. Alternate, dichotomous branching predominating, cells mostly cylindrical:

Cells of main axis with little or no constrictions below, may be inflated, and constricted above; cells producing branches may or may not be different from other cells, 7-10 μ in diameter, 7-10 (-12) times as long. ------Stig. [illegible]

Cells producing branches usually shorter but not sharply defined from other similar cells not producing branches; secondary branches in short fascicles on the main axis; branches not ending in colorless hair; cells 1[illegible]-20 μ in diameter, ½-7 times as long.

------Stig. [illegible]

II. Branching usually opposite-alternate, or whorled or irregular.

a. Cells mostly cylindrical:

Branching usually alternate-opposite, sometimes several branches from same point;

cells usually nonconstricted, 8-11 µ in diameter, 1-3 times as long

------*Stig.* *stagnatile*

Branches scattered irregularly, thorn-like with broad base and sharp setiferous end; cells producing branches somewhat modified; cells of main axis 11-16 (-18) µ in diameter, equal or slightly longer or shorter as long

------*Stig.* *subuligerum*

b. *Cells mostly barrel-shaped, inflated*:

Branches opposite, whorled or solitary, ending usually in long colorless hair; cells of main axis 15-20 (-25) µ in diameter, 1-2 times as long.. ------*Stig.* *pusillum*

KEY TO SPECIES IN [illegible]:

Species with erect portion of the thallus well-developed; branches alternate, opposite or pseudo-whorled usually arising from specialized short cells:

I. Alternate branching predominating; cells of main axis usually cylindrical; rhizoidal base present, prostrate thallus lacking:

Filaments simple, dichotomously branched below, above alternate and fascicled, the fascicles arising from short rectangular cells of the main axis; br. branches ending in long colorless hairs; cells 1[illegible]-2[illegible] μ in diameter, 4-[illegible] times as long, thick-walled. ------Stig. [illegible]

Filaments simple, alternately branched from rectangular or globular cells; cells usually cylindrical, slightly inflated below and thick-walled; sometimes crooked branches growing downwards irregularly; 1[illegible]-[illegible] (-[illegible]) μ in diameter, 2-[illegible] times as long.

------Stig. pachydermum

II. Branching equally alternate and opposite:

Filaments simple, cells of main axis cylindrical, slightly inflated with little constrictions

at the partition wall, [illegible]-15 μ in diameter, 2-5 times as long; branching simple from short angular or rectangular cells, gracefully attenuating or tapering into a pointed tip; prostrate thallus [illegible] or rhizoidal

------[illegible]. [illegible]

// Filaments simple, cells mostly cylindrical, with little or no constriction; branching alternate, opposite, or 2-[illegible] from same cell arising from short-cylindrical cells; apical cell usually sharply pointed or flagelliform; cells of main axis [illegible]-11 μ in diameter, [illegible]-[illegible] times or more as long. ------[illegible]. [illegible]

III. Opposite-paired branching predominating;

a. Cells of main axis mostly cylindrical, some-times inflated:

// Filaments simple; branching usually from short but cylindrically angular cells, [illegible]- or more in a row between long cells; branch tips usually bluntly pointed; cells of main axis cylindrical, usually inflated in different degrees, (12-)-1[illegible]-3[illegible] μ diameter, [illegible]-10 (rarely 15) times as long; prostrate thallus usually lacking

------[illegible]. [illegible]

Filaments simple; branching mostly opposite or whorled around short, rectangular, or broadly angular cells which arise in series, gradually becoming shorter from the lower cells; branches ending in long, flagelliform or setiferous end or colorless hair; long cells of main axis mostly cylindrical, usually not inflated, short cells may be inflated; cells 14-[illegible] μ in diameter, 4-[illegible]-10 times as long. ------<u>Stig</u>. <u>flagelliforme</u>

b. <u>Cells of main axis mostly inflated, or either cylindrical</u>:

Filaments well-branched; cells [illegible] branches usually globular, [illegible] or short [illegible] cells [illegible], inflated or [illegible] cylindrical cells not producing branches, [illegible] cells 10-[illegible]-(-[illegible]) μ in diameter, ½-[illegible]-(-[illegible]) times as long; [illegible] or [illegible] pointed [illegible] tips.

------<u>[illegible]</u>. <u>[illegible]</u>

Filaments well-branched; cells of main axis [illegible] inflated, [illegible] or [illegible] cylindrical, 10-[illegible] μ in diameter, 1-[illegible] times

as long; cells producing whorls of branches usually much greater in diameter than other cells, mostly globular up to 60-62 μ in diameter, 2/3-1¼ times as long.

------*Stig. paihiaensis*

Stigeoclonium farctum Berth.

Pl. 19, Figs. 3-4; Pl. 26, Figs. 6-7.

Berthold, in Nova Acta Leopold. Carol. XL: 201, t.2.f. 1-5, 1878; De Toni, Syll. Alg. I: 204, 1889; Hansgirg, Prodrom. II: 217, 1893; Heering, in Pascher's Süsswasser. 6: 84-85, 1914.

Synonyms (probably):

Stig. Huberi Heering (Stig. tenue Huber) in Pascher's Süsswasser. 6: 85, f. 125a, 1914.

Stig. sp. Moebius, in Hedwigia, 27: 239, t.9, f.3, 1888.

Endoclonium ? Moebiusianum De Toni, Syll. Alg. I: 208, 1889.

Stig. najadeanum Skvort. in Proc. Harbin. No. 2, f.9-14, 1946.

Thallus epiphytic or endophytic (or sometimes free-floating), forming a cushion-like prostrate part from which erect filaments develop; cells of prostrate thallus more or less angular, compact, nearly iso-diametric, forming a pseudoparenchymatous or monostromatic base, almost every cell producing an erect filament, unbranched for considerable distance, then alternately branched; cells of erect filaments cylindrical, may be slightly inflated; branch tips usually blunt, rarely ending in a multicellular colorless hair; cells of main filament 6-7 µ (-8 µ or little more) in diameter, 1-2 times as long, seldom more, especially at the branch tip or in culture media.

This species is highly variable in habit. The exact nature of this species is still to be determined. Whether the compact *Coleochaete*-like base shown by Berthold develops from a single zoospore or from many has to be verified. In culture (from Indiana) I have seen only the monostromatic filamentous, prostrate type of thallus without the formation of a disc.

The type specimens of *Stig. Huberi*, *Stig. najadeanum*, or *Endoclonium Moebiusianum* have not been seen by me, but from the descriptions and illustrations it appears that these species are identical and possibly may be related to *Stig. farctum*.

Fritsch established variety *simplex* or *Stig. farctum* (Fritsch, Beih. Bot. Centralbl. 13: 368, 1903; also 1906, p.200) based on the absence of branching in the upright filaments. That one should assign such a small plant to any species, not to mention the making of a new **taxon,** raises a question. *Pseudochaete gracilis* W. & G.S. West (Jour. Bot. 41: [illegible]-41, 190[illegible]) which Tiffany transferred to *Stigeoclonium* as *Stig. gracile* (West & West) Tiffany (Amer. Mid. Natur. 1[illegible] ([illegible]): 911-[illegible]1, Pl.[illegible], f.6[illegible], 1937; non *Stig. gracile* [illegible]., 1849 and non *Stig. gracile* [illegible]. 194[illegible]) is probably similar to *Stig. farctum* var. *[illegible]* Fritsch. Neither West and West (see Fig. 75, in Brit. Fr.W.Alg. by West and Fritsch, p.1[illegible], 1927; also Heering, in Pascher's Susswasser[illegible], p.15[illegible], 1914) nor Tiffany (1937) has shown any branched erect filament, but only multicellular hairs and an elaborate prostrate thallus. Whether this is a well-developed *Stigeoclonium* plant or belongs to another genus is one's personal interpretation. At the early stage of zoospore germination in *Stig. [illegible]* I have observed similar structure (text Fig. 53) also see Heering, l.c. fig. 111c after Klebs). Similar multicellular hairs from prostrate filament was shown by Huber for *Stig. [illegible]* which Heering (l.c.) called *Stig. Huberi* Heering (f. 1[illegible] b.). It may be that all these species are the same and show only a prolonged growth condition. To this group may be added *Stig. prostratum* Fritsch (in Ann. S. Afric. Mus. 9: [illegible], f.1[illegible], 191[illegible]; also *[illegible] prostratum* Fritsch (in New

Phytolog. III. [illegible], f.1, c. 1[illegible]) which is also epi-phytic and closely adherent to other aquatic plants and has extensive prostrate, branched filaments which bear multicellular hairs as well as unbranched erect filaments.

Because type specimens and illustrations are lacking it is difficult to determine the systematic positions of Stig. [illegible] Reinsch (in Linn. Soc. Jour. 15: 21[illegible], 1877; Endoclonium ? [illegible] (Reinsch) De Toni, Syll. Alg. I: 207, 18[illegible]) and Stig. subtile Reinsch, loc. cit. 217, 1877 (Endoclonium ? subtile (Reinsch) De Toni, loc. cit. 207, 18[illegible]). Reinsch (l.c.) originally described both Stig. [illegible] and Stig. subtile as parasitic (De Toni, however, referred them to endophytic forms) in Nitella sp. and [illegible]. He had further noted that Stig. [illegible]eri appeared like Stig. debile Kg., and that Stig. subtile was similar to Stig. [illegible] Kg.

[illegible] (19[illegible]) described two new varieties, namely Stig. [illegible] var. [illegible] [illegible] and Stig. [illegible] var. [illegible] from the bed of the shallow river [illegible] and from some other rivers in England, where the water is highly calcareous. [illegible] (19[illegible]) showed, however, in Stig. flagelliferum that this plant was growing in highly calcareous water exhibited a reduced growth all around the pore and appeared like *Pilinia dilute* [illegible]. It is also possible that these two varieties made by [illegible] might be also the reduced growth state of some other well-branched species. Just the [illegible] of variations in branching habit and size of [illegible] thallus are not sufficient characters to justify the creation of new varieties. [illegible]'s illustrations of *Stig*. [illegible] [illegible] of *Stig*. [illegible].

[illegible]:

EUROPE

[illegible]: [illegible]: [illegible], [illegible], [illegible] [illegible] über zichen[illegible], [illegible] [illegible]"[illegible], [illegible]. [illegible], No. [illegible], [illegible], [illegible] ([illegible]); [illegible] No. [illegible], [illegible], H. Harsson, S[illegible]. [illegible], [illegible]. [illegible] ([illegible]); [illegible] [illegible]on, [illegible], [illegible] ([illegible].)

[illegible]

[illegible]: [illegible] Univ. Culture Coll. No. [illegible] 4[illegible] & [illegible] ([illegible]); [illegible]: [illegible], Col. J. [illegible] No. [illegible], [illegible], [illegible], [illegible] [illegible], 19[illegible]: [illegible]: [illegible]'s Co. Col. [illegible], ([illegible]) No. [illegible]([illegible]), [illegible] 19[illegible] ([illegible]); [illegible]: [illegible] Co. [illegible],

L. B. Savannah River, Col. Reimer, Aug. 30, 1955 (PH).

Stigeoclonium variabile Naeg. in Kg. (Emend.)
Pl. 5, Fig. 6; Pl. 7, Figs. 5-6; Pl. 19, Figs. 1-2, 6-8; Pl. 23, Fig. 1; Pl. 25, Figs. 8-9; Pl. 27, Figs. 1-8; Pl. 28, Figs. 3-4; Text Fig. 100.

Kuetzing, Spec. Alg. 352, 1849; Tab. Phyc. 3:t.2, f.1, 1853; Rabenhorst, Flor. Eur. Alg. 3:380, 1868; Berthold, in Nova Acta Leopold. t.15, f.10, 1878; Hansgirg, Prodrom. 65, 1886; De Toni, Syll. Alg. I: 196, 1889; Fritsch, in Beih. Bot. Centralbl. 13: 368; 1903; Heering, in Pascher's Süsswasser.6: 72-74, 1914 (including *Bertholdianum*, *Gayanum* and *Fritschianum*).

Stigeoclonium varisbile var. minus Hansg. Loc. cit., 65, 1886; De Toni, Loc. cit. 196, 1889 (TYPE: Boehmen (W).) (De Toni, l.c. 198, as Stig. tenue var. minus Hansg.)

Stigeoclonium subspinosum Kg. Spec. Alg. 352, 1849; Tab. Phyc. 3: t.2, f.2, 1853; (TYPE: from Hanau (L).) Stig. protensum var. subspinosum (Kg.) Rab. Flor. Eur. Alg. 378, 1868; De Toni, Syll. Alg. I: 199, 1889. Stig. subuligerum subspinosum (Kg.) in Heering, loc. cit. 81, 1914.

Stig. weissianum Grunow, (TYPE: Zante(W): in litt. in Rabenh. Flor. Eur. Alg. 3: 380, 1868; De Toni, Syll. Alg. I: 204, 1889.

Stig. subsimplex Collins (TYPE: Mass.): Gr. Alg. N.Am. Supplem. 22, f.6, 1912; (P.B.A. No. 1791).

Stig. pygmaeum Hansg.(under section Endoclonium) (TYPE: Boehmen(W): Prodrom. I: 69, f.28, 1886; Heering, in Pascher's Süsswasser. 6: 85, 1914.

Stig. farctum beta pygmaeum Hansg. Prodrom. II: 217, 1893. Endoclonium pygmaeum Hansg. in De Toni, Syll. Alg. I: 207, 1889.

PROBABLY ALSO THE FOLLOWING SPECIES MAY BE PUT AS SYNONYMS:

Stig. ? grunowii Rab. loc. cit. 378, 1868; (original specimens, A. Grunow 20/3/1856 (W).)

Stig. *subsecundum* var. *ulotrichoides* Tied. (in Beih. z. Bot. Centralbl. 21:148, 1907), Col. No. 1[illegible], from Chitila in rivulo parvo, [illegible], [illegible]; Heering in Pascher's Süsswasserfl. 6: 71, 1914.

Stig. *polymorphum* (Franke) Heering, in Pascher's Süsswasserfl. 6: 97, f.136, 1914; Prescott, Alg. W.G.L. 116, Pl. 9, f.3, 1951 a.

Endoclonium *polymorphum* Franke, Cohn. Beitr. Biol. Pflanzen, III.t.12, 1883 (in De Toni, Syll. Alg. I: 201, 1889).

This is one of the most extremely polymorphic *Stigeoclonium* species, the true nature of which must be determined by cultural and comparative studies. In my review of this genus the type specimens of several species mentioned above as synonyms, most of which have been described as endophytes, parasites, or reduced epiphytes, have been studied. Camera lucida drawings have been made from them and incorporated herein for morphological comparisons. I have observed in the type specimens that the measurements given by the original authors were not always correct. Sometimes, I found greater diameter and length of the cells than described. All these comparative studies have revealed that these endophytic-epiphytic species are quite identical and in many instances may belong to the same species. Some culture collections have been secured from Indiana University, Bloomington, U.S.A. to verify some species' variations. *Stig. variabile* Indiana Culture No. 4[illegible] showed very interesting results in culture media. Various growth forms expressed all the different stages represented by different species given above as synonyms. For comparison see all the figures labelled under *Stig. variabile*-complex drawn from different sources.

I now believe that all these different species, namely, *Stig.* [illegible], *Stig.* [illegible], *Stig.* [illegible], *Stig.* [illegible] and others mentioned above are the different growth forms of *Stig. variabile* and should be assigned to the latter species *Stig. variabile*. [illegible] (19[illegible], 19[illegible]) noticed very little branching in this species, but it can produce profuse branches in culture as shown by [illegible], [illegible] and others. This suggests that in nature at certain conditions it may be also profusely branched.

Below, for the sake of comparison the individual descriptions of several species are given to show that essentially very little differences exist between them. The main characters are:

Stig. variabile [illegible]: cells of main filament 5.[illegible]-5.5 µ in diameter, (I found in the type specimen 6-8 µ in diameter), 1-2 times as long or rarely longer; alternately and sparsely branched, branch tips sharply pointed (found in culture; also shown by Berthold, t.1[illegible], f.10, 18[illegible]); no hairs; cell divisions occur before and during zoospore-formations.

Stig. variabile var. [illegible]: Cells of the main filaments 4.5-[illegible] µ in diameter, (in some branches may be greater [illegible] in the type); it may be a young stage.

Stig. [illegible]: Type [illegible] the same habit as Stig. variabile, especially [illegible]: 9.7 µ (-10-11 µ) in diameter, 1-[illegible] times as long; branch alternate (rarely opposite) [illegible], sharply pointed [illegible] tip, not piliferum.

Stig. [illegible]: [illegible], [illegible] (?), filaments [illegible]-7 µ in diameter. (I found in type [illegible]-11 µ), 1-2 times as long or little longer; branch tip [illegible], not piliferum.

[illegible] (Stig. [illegible]) [illegible] ful species [illegible] "[illegible]" [illegible] "original specimen" (Type ?) [illegible]. [illegible] filaments [illegible] specimen's cells [illegible]

[illegible] like [illegible] Collins, or [illegible]. Prostrate cells of [illegible] in the Isotype specimens (Pl.27, Figs. 7-8; Pl.28, Fig.4).

[illegible] (1 [illegible]): small plant, [illegible], erect filaments 100-[illegible] μ long, [illegible] near the base, [illegible] μ [illegible], [illegible] shorter or longer, tip [illegible], [illegible]; prostrate thallus similar to [illegible]: [illegible] or pseudo-coccoid cells present, [illegible] μ broad, [illegible] or ellip-tical, [illegible].

In the type material I found: erect filaments [illegible]-7.[illegible] μ (-[illegible] μ) in diameter, 1-[illegible] ([illegible] -[illegible]) times [illegible] long, at the tip little longer; prostrate cells [illegible] μ broad, 1-1½ times [illegible] long, [illegible]-[illegible] μ in diameter, [illegible].

[illegible] Collins: [illegible] layer of prostrate filaments, cells [illegible] μ in diameter, [illegible] length, rounded or polygonal; erect filaments [illegible], [illegible] μ in diameter, ½-1-[illegible] times (near the [illegible]) as long; [illegible] 1 [illegible]. long; [illegible] gradually [illegible] to acute tip without terminal hair; cells cylindrical or slightly constricted at the dissepiments in the stouter part of the filaments; cells sometimes divided longitudinally, the cell usually more or less

oblique; erect filaments once or twice dichotomously branched in the basal part, otherwise simple.

Collins' above descriptions are quite similar to the features I have found in Stig. weissianum in respect to the prostrate thallus, round cells, more branching of erect filaments near the base (also like Stig. pygmaeum), constrictions in case of wider cells, etc. Like Stig. variabile the cells divide longitudinally or diagonally as shown by Berthold (1878). The acute or sharply pointed apex without a long hair seems to be a common character of all these species described.

Stig. Grunowii Rab.: Type specimens very poor. Described as -- very small epiphyte, 3.5-5 µ in diameter, 1-2 times as long.

Similarly, Stig. chroolepiforme (Szym.) Heering, 88, 1914 (Endoclonium chroolepiforme Szymanski, in De Toni, I: 206, 1889) may be regarded as a very young stage of either Stig. variabile or of some other species.

Stig. polymorphum (Franke) Heering, 87, 1914 (Endoclonium polymorphum Franke, in De Toni, 206, 1889); Described as endo- or epi-phytic in Lemna and other aquatics; having a prostrate, pseudoparenchymatous disc, monostromatic and radiating, marginal cells bear the branches; cells of erect filaments on average 4 µ diameter, [illegible] μ long (Prescott (1951 a) gives [illegible]-10 μ diameter, [illegible]-12 μ long); the [illegible] or [illegible] [illegible] form by [illegible] ([illegible], 1914).

The type specimens of *Pith.* [illegible] and *Pith.* [illegible] also show similar thallus and branching habit (see Pl.27, Figs. 1-5 and 7-8).

Pith. [illegible] var. [illegible] [illegible].: Filaments not profusely branched, cells of main filaments about 11 μ in diameter, 1-[illegible] times as long; cells of branches [illegible] μ in diameter, 1½-[illegible] times as long, rarely longer.

As pointed out before, the illustrations given by [illegible] (1907) [illegible] similar filaments of *Pith.* [illegible] and also *Pith. variabilis*.

[illegible] (1914) described three forms of *Pith. variabilis* [illegible] by [illegible], [illegible] and [illegible] and named them for these authors. These descriptions fall within the above-mentioned species and merely show the range of structure and growth forms.

Below an emended description of *Pith. variabilis* is given:

Plants bright green, usually small, sparsely branched, mostly alternate, at the base somewhat dichotomously branched, very rarely opposite, sometimes profusely branched (especially in culture); branches may be long and slender or short and spine-like, branch apex usually sharply pointed or acute, rarely slightly setiferous, but without long terminal hair; thallus developing pseudoparenchymatous or monostromatic prostrate part of round or angular cells, about 15-20 µ in diameter, cells of erect filaments rectangular, cylindrical, or slightly inflated, 6-11 µ in diameter, usually 1-2 times (rarely 3 times) as long (in the cells of the branches especially near the tip, somewhat longer); cell wall usually thin but under unfavorable conditions may be greatly thickened; cell may divide diagonally or longitudinally in old filaments to produce swarmers.

Specimens studied:

EUROPE

Switzerland: Zürich: Col. Naegeli, No. 3 and 72, Herb. Kuetzing, TYPE(L); Kummen (Trogen) bei Neudamm. Rab. Alg. Sachsen. Col. ? and Rothe, No. 296, May, 1853 (B.W. G.NY.K.L.FH.) (as *Stig. subspinosum*): Czechoslovakia: Boehmen: in einem Teichen Pisck, Col. A. Hansgirg, No. 5793 as TYPE of *Stig. variabile* var. *minus* Hansg. (W.US. F.). ?? Leg. Fr. Brand, Col. No. 9495 (33.473), 10.2, 1896 and 15.6.97 (W); Leg. Dr. Poetsch, 3/5, 865 (W);

Brunn. Moravia, Herb. Lenormand. (G.PC.L.); Algae Moravicae, Herb. Reinhardt. Leg. J. Nave (L.US.MO.W.FH.); Neusohl. Marker, Gustav, Jermy Herb. 1897, (MO) (all as Stig. subspinosum Kg.); Boehmen: auf Wasserpflanzen in einem Teiche bei der Chlumcaner Zuckerfabrik nachst Laun, Col. A. Hansgirg, Juli 1884, (TYPE of Stig. pygmaeum, (W); Isotype from F.); France: Melodunum, in rivulis fontis, Herb. Roussel, 20 Sept. 1860, and 26 April 1892 ? (PC.L.); Havre: algues de France. Dupray S 98 (as Stig. protensum f. subuligerum), 1884 (L); and Dupray S 99 (as Stig. protensum f. subspinosum), 1884 (L); Caen. Herb. Lenormand. Ex Col. No. 40, (GRO.F.HIJ.L.W.NY.FH.C.); Germany: Freiburg: Leg. A. Braun, April, ?(L); Leg. A. Braun, No. 145, April, 1848 (L); Hanau. Herb. Kuetzing, Leg. A. Braun, No. 4, May 1847, (L.G.); Leg. A. Braun No. 169 (G); A. Braun, 1850, No. 175, 1849 (PC.NY.); Hanau, Forsburg ?. Th. No. 87 as TYPE OF STIG. SUBSPINOSUM Kg. (also as Conf. tenerrima Kg.) Col. Reichenbach 19/9, 1847 (L); Leg. ? Bulnheim, Acqu. 1889 No. 363007 (W); Sweden: Boden. Rab. Alg. Sach. resp. Mitteleuropa. Col. D. Bulnheim, No. 592, May 1855 (NY.LD.G.K.L.W.FH.); Zante: In Cladophora puteali insulae Zante, Leg. A.

Weiss, TYPE of *Stig. weissianum* Grun. (W); also from (FH); *Romania*: J. Ilfov ? Chitila in rivulo parvo, 2 Feb. 1903, Leg. Dr. E. C. Teodoresco, Col. No. 1247, (as *Stig. subsecundum* var. *ulotrichoides* Teod.); ? Doubtful as *Stigeoclonium* in the type specimen of *Stig.* ? *Grunowii* Rab., (W).

NORTH AMERICA

Ohio: Ottawa River, on rocks, Col. Hohn, No. 4(3), O.R.S. #2, March 7, 1956 (PH); *Maryland*: In shallow running water of outlet of ice plant, Princess Anne, Somerset Co. R. White and F. Drouet, No. 2295, Aug. 24, 1938 (PH); *Massachusetts*: Eastham: Leg. F. S. Collins, TYPE of *Stig. subsimplex* P.B.A. No. 1791, 1909, (K.MICH.NY.PC.C.US.F.W.L.); TYPE from (FH).

NORTH AMERICA

Canada: Quebéc: Low (comte de Gatineau) barrage Pagan sur la riviére Gatineau, Col. J. Brunel and R. Payer. No. 395. July 7, 1933 (MT).

Stigeoclonium nanum (Dillw.) Kg.

Pl. 6, Fig. 2; Pl. 10, Figs. 4-5; Pl. 16, Figs. 6-7; Pl. 17, Fig. 4.

Kuetzing, Spec. Alg. 352, 1849; Raben. Flor. Eur. Alg. 3: 380, 1868; Cooke, Brit. F.W. Alg. 190, t.74, f. 2, 1882-84; Wolle, F.W. Alg. U.S. 112, t.95, f.10, 1887; De Toni, Syll. Alg. I:203, 1889; Fritsch, in Beih. Bot. Centralbl. 13: 368-87, 1903; Collins, Gr. Alg. N. Am. 220, 1909; Heering, in Pascher's Süsswasser.

74, 1914; Prescott, Alg. [illegible] 116, Pl.[illegible].f.[illegible], [illegible]. 1951 [illegible]; Bourrelly, Alg. [illegible] de la [illegible]. 200, Pl.[illegible], f.414-415, 1950; Tiffany & Britton Alg. Ill. 74, Pl.10.f.71, 1952.

[illegible] (Dillw.) [illegible], in [illegible] Bot. Club. Bull.11(2): 1902. [illegible] Dillw. Brit. Conf. Pl.[illegible]0, 1802 (Lectotype, in Herb. Dillwyn, Nov.[illegible], 1[illegible], from [illegible], leg. L. [illegible] Dillwyn ([illegible]).)

[illegible] Hassall, Brit. [illegible] I: 1[illegible], 1845; II. Pl.10.f.4.1845. S[illegible]. [illegible] form [illegible] Collins, (Type [illegible] 1[illegible] ([illegible]), leg. N.L. Gardner, [illegible] Berkeley, California). [illegible] Alg. [illegible] [illegible]0, 1[illegible] (reprint. 19[illegible]).

Thallus small, [illegible], tufted; erect filaments developing from prostrate part, the latter [illegible] loose, pseudoparenchymatous disc composed of angular or isodiametric cells, or of monosiphonous creeping filaments, almost every cell producing an erect filament; erect filaments when well-developed are profusely branched, primary branches are [illegible] and upwardly directed and further bearing many short secondary branches; branching mostly alternate, very rarely opposite, frequently unilateral ones; apical cell mostly bluntly pointed or rarely [illegible] but without any hair; cells of primary and secondary branches more or less similar and scarcely smaller than those of main axis, usually inflated, barrel-shaped, and constricted near partition wall, 3-5.5 µ median diameter, subequal -1-[illegible] (rarely -1½-[illegible] times) times as long; cells of prostrate part somewhat longer than in the erect filaments.

Isotype: [illegible] [illegible] Dillw., [illegible] Dillwyn, Nov.[illegible], 1[illegible], from [illegible] ([illegible]).

Several authors (cf. [illegible], Collins, [illegible], Prescott etc.) have expressed doubt about the validity of this species and considered it to be a young stage of some other species. But, the cell-shape, the characteristic branching habit at short intervals of the erect filaments all directed [illegible] bushy, tufted and fuzzy [illegible] are probably unique for this species. Although, the plant is short, it appears as a miniature bushy shrub.

Probably, the illustrations of this species given by Fritsch ([illegible]) and also by [illegible] ([illegible]) are misleading, since this appearance can be found in other species, especially, under cultural conditions. Young [illegible]. [illegible] may also appear like this species.

Dillwyn (1809) states that branches are all finely attenuated, which however, I did not observe in his collections (see Pl.10, Fig.4).

Collins' (1909) new form *subsimplex* of *Rhiz.* *[illegible]* is definitely a reduced form, probably related to environmental conditions. His statement that "Dr. W. L. Farlow had observed the same condition of this plant for more than a month" does not necessarily justify the creation of new form. The growth condition may remain the same for a [illegible] for several months or more than a year if the ecological conditions are constant. Under changed favorable conditions [illegible]. Moreover, Collins used the [illegible] *subsimplex* [illegible] for a [illegible] (Phycol. [illegible], 19[illegible]) as well as for another form under the [illegible] *[illegible]*, which may cause confusion, [illegible] to be an acceptable form.

[illegible] specimens of *Rhiz.* *[illegible]* [illegible] and Collins's collection seem to show [illegible] the branched plants described by Dillwyn, [illegible], Cooke, and others.

Specimens studied:

[illegible]

[illegible]: [illegible] Dillwyn ([illegible] *Conferva* *[illegible]* Dillw.)

In the [illegible], [illegible] of ? (type locality), [illegible] L. [illegible], [illegible] ([illegible]); [illegible]: ? [illegible] (?), [illegible] C. [illegible] ([illegible]); ? [illegible], [illegible] ([illegible]); col. [illegible] ([illegible]); ? ([illegible]) [illegible] ([illegible]); ([illegible]) [illegible] ? [illegible] ([illegible]); ([illegible] n [illegible] ([illegible].) [illegible].?) [illegible] ([illegible]).

[illegible]

[illegible]: [illegible] Co. [illegible], [illegible], Col. [illegible], [illegible] No. [illegible] ([illegible]); [illegible]: [illegible], [illegible] ([illegible]), Col. [illegible], No. [illegible], [illegible] ([illegible]); [illegible]: [illegible] (?) [illegible], [illegible](?), [illegible], [illegible] ([illegible]); [illegible]: [illegible], [illegible] ([illegible]); [illegible]: [illegible]: [illegible], [illegible] ([illegible]); [illegible]: [illegible]: [illegible], [illegible], [illegible], [illegible], [illegible], col. [illegible], No. [illegible] ([illegible]);

[illegible]: [illegible], [illegible],
Oct. 24, [illegible] ([illegible].); [illegible]: [illegible],
[illegible], [illegible] EHC [illegible],
[illegible], Oct. 3, [illegible] ([illegible]); [illegible]: [illegible].
[illegible], [illegible]. [illegible], [illegible].
[illegible] ([illegible].); [illegible]: [illegible]:
[illegible] to [illegible] in [illegible]. [illegible],
[illegible], [illegible], 1894 ([illegible].): [illegible], [illegible].
[illegible]. [illegible]. [illegible] ([illegible].)

Stigeoclonium longipilum Kg. (Emend.)

Pl. 6, Fig. 4; Pl. 28, Fig. 5; Pl. 32, Fig. 1; Text Fig. 97.

Kuetzing, Phyc. Germ. 198, 1845; Spec. Alg. 354, 1849; Tab. Phyc. 3: Pl. 7, F. 1, 1853; Rabenh. Fl. Eur. Alg. 3: 379, 1868; Krypt. Flor. 68, 1878; Hansg. Prodr. 67, 1886; Wolle, F. W. Alg. U.S. 115, pl. 100, f.2, 3, & pl. 102, f.1-3, 1887; De Toni, Syll. Alg. I: 198, 1889; Hazen, Mem. Tor. Bot. Club 11(2): 209, 1902; Heering, in Pascher's Süsswasser.6: 76, 1914; Tiffany and Britton, Alg. Ill. 36, 1952.

Chaetophora draparnaldioides Kuetz. Alg. Dec. No. 104 (Isotype for Stig. longipilum) Herb. Kuetzing, (L).
Myxonema draparnaldioides Rab. Handb. II(2): 99.
Stig. longipilus var. majus Kg. Spec. Alg. 354, 1849; (Schwarzwald Neushadl. h. 13. April 1847, Herb. Kuetzing. (L).)
Stig. longipilus var. minus Hansg. Prodrom. II: 227, 1888; in Notarisia, 526, 1888; De Toni, Syll. Alg. I: 199, 1889; (Type; also P.B.A. No. 865)
Stig. minus (Hansg.) Collins Gr. Alg. N. Am. 222, 1909
Stig. fastigatum (Ralfs.) Kg. (Chaetophora fastigatum Ralfs. Iso-type; Leg. M. Ralfs. No. 23, Dolgelly,

H. [illegible], Herb. [illegible] (L)); [illegible] 1[illegible]; [illegible] Phyc. [illegible]:t.11.f.1.1[illegible]; [illegible] Flor. [illegible] [illegible]: [illegible], 1[illegible]; [illegible], [illegible] III: 111,t. [illegible] - [illegible]; [illegible], [illegible] 11[illegible],Pl.1[illegible].f.1, 1[illegible]; De Toni, Syll.Alg.I: [illegible], 1[illegible]; [illegible], Flor. [illegible].I:[illegible], Pl.1[illegible].1[illegible]; [illegible], in [illegible] [illegible](?): [illegible],1[illegible]; [illegible], in [illegible] [illegible]: [illegible],1[illegible].

Stig. [illegible] [illegible], [illegible] [illegible], 1[illegible]; [illegible] I:t.7.f.[illegible].1[illegible]; [illegible] Flor. [illegible]: [illegible], 1[illegible]; [illegible], [illegible] 11[illegible], Pl.1[illegible], f.[illegible], 1[illegible]; De Toni, Syll.Alg. I:[illegible], 1[illegible]: Stone, in [illegible] [illegible]. Soc. 1[illegible]; [illegible], loc.cit. [illegible], 1[illegible]; [illegible], in Proc. Ind. Ac. Sc. [illegible]:10[illegible], 1[illegible]; [illegible], [illegible] [illegible]. 1[illegible]([illegible]): 7[illegible], 1[illegible].

Stig. [illegible] [illegible], in [illegible]. [illegible].I: [illegible], f.1.a.[illegible]., 19[illegible]; (Type not [illegible]).

Stig. [illegible] [illegible]. Wittrock et [illegible], [illegible] [illegible] [illegible] (1[illegible]). 1[illegible]/[illegible]/1[illegible], [illegible] [illegible], [illegible].

Thallus [illegible], 1[illegible], [illegible], [illegible]-1[illegible] [illegible]. or more [illegible]; [illegible] [illegible] in every direction from a [illegible]; [illegible] not well-developed and consisting of profuse dense rhizoidal filaments; thallus when young may be

surrounded by mucilage matrix as with Chaetophora; branching more or less dichotomous, or alternate, rarely opposite above; less branching below; more and repeated branching above giving a bushy or tufted appearance (i.e. each main filament remains unbranched up to some distance from the base and then branches repeatedly and dichotomously or alternately to give a radiating or spreading appearance; almost every branch terminating in a long, colorless, multicellular hair; rhizoids profuse below from basal cells, above, they arise usually from the base of the cells at the place of branching; cells of main filaments and chief branches more or less similar in size and shape, subcylindrical below, short and inflated above, subglobose to barrel-shaped, heavily or deeply constricted at the partition wall; cells producing branches not modified or different from others; cells of main filament mostly 11-15 μ(-19 μ) in diameter, $\frac{1}{2}$-1-3 (rarely -5) times as long, in young plants 7-10 μ diameter, $\frac{1}{2}$-1-1$\frac{1}{2}$ times as long; chloroplast broad, parietal.

The isotype of Chaetophora draparnaldioides Kg. No. 104 from which Stig. longipilum had been described by Kuetzing seems to be not a well-developed plant and may be a young stage. I could not find the

whorled or fascicled branching as shown by Kuetzing or in the sense that the branches are fascicled in Stig. fasciculare or Stig. nudiusculum. The whorled arrangement shown by Kuetzing may be due to crowded or overlapping branches which were not, it seems to me, properly while mounted from dry specimens. It is assumed here, however, that Stig. radians and Stig. fastigatum both represent the further developmental stages of Stig. longipilum. The common characteristic features of these three species as described by Kuetzing (1849) are: 1) radiating branches (mostly alternately or dichotomously branched) terminating into long colorless hair; 2) at young stage thallus surrounded by mucous sheath as with Chaetophora (but not when matured); 3) cells with main axis and branches mostly moniliforme type, swollen, and heavily constricted; and 4) in Stig. longipilum cells, 11-12 μ in diameter, equal in length; (De Toni gave 11-14 μ diameter, 1-2 times as long); in Stig. fastigatum cells, 12-13.6μ in diameter, 1-3 times as long; (De Toni gave 10-15 μ diameter, 1-3 times as long; I found cells up to 18.7 μ in diameter, ½-2 times as long); in Stig. radians: cells 15 μ in diameter; (De Toni gave 11-14 μ in diameter, ½-2 times as long; I found cells up to 15-16 μ in diameter, and up to 3 times as long in the type specimens).

It seems to me that in young stages the cells of the main filament are short, moniliform, as long as broad, but as the filaments increase in size the cells, especially the lower ones become more and more cylindrical. Kuetzing failed, however, to show any rhizoid in any of these species which are quite characteristic in respect to their formation and position. These rhizoids are present in large numbers in all the type and isotype specimens mentioned above, i.e. Stig. longipilum, Stig. radians, and Stig. fastigatum. Based on this single rhizoidal character Jao (1947 a), however, made a new species Stig. polyrhizum Jao, which in my opinion, does not differ in any way from Stig. longipilum-group. One can compare Jao's illustration of his above species, Fig. 1. a,b, with any of the three species shown by Kuetzing (Tab. Phyc. Pl.7, and Pl. 11.f.1). The descriptions of this new species given by Jao also agree exactly with that of Stig. longipilum given by De Toni (1889) and for better clarification, I should quote these two descriptions below:

Stig. longipilum Kg. in De Toni, Syll. Alg. I: p. 198:-

"Caespitosum, subpulvinatum, plerumque 2, rarius ad 10mm. altum, laete viride, gelatinoso-molle; filis ramisque primariis radiatim dispositis, 11-14 μ latis, spicem versus plerumque fasciculate-ramulosis, omnibus in pilum achroum longissime productis; cellulis subcylindricis, diametro aequalibus vel subduplo longioribus; geniculis manifesto constrictis; chlorophoris plerumque subeffusis, latis." (underline mine)

Stig. polyrhizum Jao (l.c.) 1947 a, p.258:

"S. parvum, 4-10 mm, altum, laete viride caespitosum; filamentis ramisque primariis radiatim dispositis, 12-18 μ latis, articulis inferioribus cylindricis, plerumque diametro 2-vel 3-plo longioribus, ad genicula leviter constrictis, superioribus diametro aequalibus vel brevioribus, ad genicula manifeste constrictis ramis parcis, elongatis, plerumque alternis, apicem versus plerumque fasciculato-ramulosis; ramis rhizoideis numerosis, ramulis plus minusve elongatis, erectis, secundis vel alternis, numquam oppositis, 7-10 μ latis, articulis inferioribus diam. aequalibus, superioribus, 1- vel 3-plo longioribus, modo non pilliferis, modo in apicem pilliferum, achroum, articulatum longe productis". (underline mine).

As a matter of fact Jao's above complete description for his species very well characterize Kuetsing's

Stig. longipilum and other related species mentioned above.

Wolle (1887), Hazen (1902) and others have already pointed out the close affinities between *Stig. longipilum*, *Stig. radians* and *Stig. fastigatum* which are similar to *Chaetophora* in young stages.

Hansgirg's new variety *Stig. longipilum* var. *minus* to which Collins (1909) gave a species rank, seems to be, as Hazen remarked, a young stage of the species.

Chodat (1902) inadequately described another new variety, *Stig. longipilum* var. *lacustre* from Lac de Geneve, primarily based on the abundant rhizoid-formation from the more elongated, cylindrical basal cells. The figures as shown by Chodat strongly suggest the affinity of his variety with *Stig. aestivale*, although the latter species was published little later in the same year. Provisionally, I have put Chodat's variety as a synonym under *Stig. aestivale* until the type specimen of the above variety is seen.

The specimens collected from East Pakistan look much like the branching habit of *Stig. longipilum* but the cells are comparatively and uniformly long and cylindrical. It does not agree well with any known

species or variety, but think that it could be regarded as a variety of _Stig._ _longipilum_ Kg., and named _Stig._ _longipilum_ var. _cylindricum_ var. nov.: cells of main axis 9.6-16 μ in diameter, 2-5 times as long; basal part corticated with profuse rhizoids; main axis dichotomously and alternately branched; cells cylindrical, slightly inflated; branches gracefully tapering into long hair. (Pl. 32, Figs. 2-4; Text Fig. 106). This variety may at first appear to be like _Stig._ _longipilum_ var. _lacustre_ due to its cylindrical, elongated cells and profuse rhizoids. It differs from the latter variety, however, by its bigger size and branching habit more like other plants of _Stig._ _longipilum_--group.

Specimens studied:

EUROPE

Germany: (Prussia): Eilenburg: as (104. _Chaetophora draparnaldioides_ and 13. _Stig._ _longipilum_ Kutz. 44 Ex.) Herb. Kuetzing XI. and Herb. Suringar (35), (L.W.); Eerbeek (?), Sept. 1906 (L); Schwarzwald: Neushall: Herb. Kuetzing (as h.13 _Stig._ _longipilus_ beta _majus_ Kg.) ex. April, 1847 (L); Titioce (?) Titisan (?), Herb. Kuetzing, No. 14 (as _Stig._ _radians_ Kg. TYPE) 3 Ex.(L); Freiburg: on _Batrachospermum_

(as 147. Stig. radians Kg.), A. Braun 1847 (L); A. Braun No. 172 (Stig. radians Kg.) Aug. 1847 and No. 173 Mai, 1848 (PC); Leipzig: Col. M. Marsson, Feb. 1897 (B); Titisee (?): A. Braun No. 169 (Stig. radians Kg.), sylo Nigr. 1847 (G); ? Alg. ? Bel Elros (?), April, 1888 (FH); England: N. Wales: Dolgelly: Mr. Ralfs. Col. A de Brébisson (L); Herb. Suringar (L) I. Ralfs, No. 23, Herb. Kuetzing (all as Stig. fastigatum Kg.) (L. PC.): ? Herb. Hookerianum (as Drap. tenuis: Conf. discors) Car. H.A. (K); Czeckoslovakia: Böhmen: bei Carhenic nächst Kolin, A Hansgirg (as Stig. longipilum var. minus Hansg. TYPE) Herb. Hansgirg. Acqu. 1903, 5597. (W); Finland: Herb. Plantarum Aquatilium, Helsingfors: Nylandia: Helsingfors: Leg. E. Häyren, 26/10/1919 (H); Sweden: Suecia: Hãllan Dalia: Dr. V. Wittrock (as Stig. tenue Ag.), Col. Grun. No. 11689. 14/7/1866 (W); France: A. Braun (A 1/1 No. 10, No. 12, No. 17) No. 490, 1848. Herb. Lenormand (CN); Env. I, Paris, Leg. Thuret, No. 75 (Stig. irregulare Kg.), May 4, 1850 (L); as (Stig. tenue (Ag.) Rab. var. irregulare (Kg.) Rab. (L); ? in fonte frigido- Fontibelleymo (?) (Le Tare), 29.6, 1869, Herb. Dr. Roussel (PC).

NORTH AMERICA

Massachusetts: Midford: on stems of plants in clay pit (as Stig. longipilus var. minus Hansg.); Collins, Holden, Setchell, P.B.A. No. 865, Col. F. S. Collins. June 4, 1900 (L.NY.C.F.MICH.K.PC.U.S.W.): California: Sacramento Co.: San Joaquin River, On Potamogeton, right bank island, Aug. 17, 1955, Col.Reimer, No. 14(3), S.R.J. II.(PH): Michigan: on old stem of Sagittaria, "Three Lakes", Ann Arbor, Washtenaw Co. Sept. 27, 1892, Col. L. N. Johnson, No. 183 (F); Arkansas: Drew Co.: in ditch, col. D. Demaree, No. 25347 (as Stig. lubricum), alt. 250 m. March, 28, 1945 (F);

SOUTH AMERICA

Brazil: ad Sao Paulo: as (514. Stig. gracile Kg.), Wittrock and Nordstedt, Alg. Ex. Leg. A. Lőfgren (No. 139), 14/7/1882 (F.G.NY.W.US.L.B.);

AFRICA

Algeria: Oved-Bel-Elzar: Herb. Genéral University D'Alger, Leg. F. Debzay, Avril, 15, 1883 (NY);

ASIA

Java:(?): Verslag, Brug, Luchte, Authent, Additam. ad. Flor. Bat. LHB. Dr. Th. Sprée, April 12, 1860 (L);

Stig. longipilum var. cylindricum var. nov.

ASIA

Pakistan: Dacca: attached to aquatic plants, Col. S. Aziz, No. 153, 1957 (Is.).

Stigeoclonium protensum (Dillw.) Kg.

Pl. 5, Fig. 5; Pl. 7, Fig. 1; Pl. 21, Figs. 1-3; Pl. 23, Figs. 2-4; Pl. 28, Fig. 1; Text Fig. 93.

Kuetzing, Phyc. Germ. 198, 1845; Spec. Alg. 355, 1849; Tab. Phyc. 3: Pl. 8, f.2, 1853; Raben. Flor. Eur. Alg. 3:378, 1868; Cooke, Fr. W. Alg. 84, Pl. 74, f.1, 1882; Wolle, F.W. Alg. U.S. 112, t.101, f.1-4, 1887; De Toni, Syll. Alg. I: 199, 1889; Heering, in Pascher's Süsswasser, 74, 1914.

Conferva protensa Dillw., Brit. Conferva. Pl. 67, 1809.

Draparnaldia condensata Hassall, Brit. F. W. Alg. t. 11, f.1, 1843.

Stig. condensata (Hass.) Kg., ?, Spec. Alg. 355, 1849.

Plants growing on stones, sticks, grasses and other aquatic plants, pale green, slender; filaments and branches long drawn out; branches mostly alternate, remote, somewhat scattered, occasionally, 2-3 branches may arise from a place, very rarely opposite; terminal cell of the branches extended into somewhat colorless tapering bristle or sharp point; cells of matured filaments mostly barrel-shaped, of young branches somewhat cylindrical with slight constrictions; cells of main filaments 10-16 (-23) μ in

diameter, 1-3 time as long, in branches 6-7 times as long.

Lectotype: Conferva protensa Dillw. Ex Herb Dillwyn, Hopton, England: April 23, 1807 (K), also July 1804 (K) and 1809 (K).

This species is quite polymorphic and its growth forms may cover several other species of Stigeoclonium. The most nearly related species is Stig. stagnatile, which might represent a certain stage in the life-cycle of Stig. protensum. Rabenhorst (1868) put Stig. subspinosum and Stig. subuligerum as the varieties under Stig. protensum, none of which characterize the latter species well. Whether Stig. stagnatile is the young stage of Stig. protensum is yet to be confirmed, but Dillwyn's illustration (pl.67.f.C.) and also my observations, strongly suggest that these two species might be the same.

This species is characterized by its broad, cylindrical and barrel-shaped cells, and long-drawn, bristle-like or sharp, colorless terminal cell (Text Figs. 21, 93).

Specimens studied:

EUROPE

England: Hopton ? Ex Herb. Dillwyn (as Conferva protensa Dillw.) April, 1807 (K); Herb.Hookerianum 1867 (Conf. protensa Dillw.) July, 1804, 1809) Col. Dillwyn (K); Hopton, Herb. Hookerianum, April, 23, 1807 (K); (as Draparnaldia tenuis: Conf. protensa Dillw.) No. 285 (K); (as Conf. protensa Dillw.) in fossis No. 4 (C); Kingston: Royal Comm. Disposal of Sewage, ? March, 1908 (K). France: Calvados, Herb.A.Brébisson (F); Plouenl Plouenan (?), J. de Rusunan, June, 1928. No. 178 (BUT); Fontaine, Gall, Herb. Kuetzing, No. 16 (288) St. Goseph, 1862 (L); Germany: V.D.B. Herb. Kuetzing, No. 370 and 372 (as Stig. subuligerum Kg.) also, Herb. Suringar (L); Leiden. Herb. Suringar, No. 86 (as Stig. subspinosum Kg.) (L); as No. 5. Conferva protensa Dillw.) Herb. Suringar, (W.L.),? Herb. Hass. Karl, S.276, 1859 (L); Spree. Mueggelsee, (B); Sweden: Flora suecica: Scania, Ystad, Säby Säterbo, Col. O. Fr. Andersson (LD);

NORTH AMERICA

Arkansas: fountain at entrance of Fountain Lake Park, Garland Co., Col. N.E. Gray, No. 114 (as Stig. stagnatile (Haz.) Col.), Aug. 15, 1939 (F); Georgia: Screven Co. S.R.P. #7, Savannah River, on trailing twig, rt. bank, Col. Reimer, No. 9(0), May 15, 1956 (PH);

S.R.P.#5, Col. J. Wallace, No. 2(6), Aug. 21, 1954 (PH); Massachusetts: Melrose: floating in stagnant water, Col. F. S. Collins, P.B.A. No. 1329, April 23, 1903 (K.F.MICH.NY.W.PC.); Mexico: Orizaba, Herb. Kuetzing, No. 21, 24, 55 (as Conf. ansonii and Stig. with epithet tenellum Kg. n. sp.), June 27, 1853 (L); New Jersey: New Brunswick: floating in spring, col. J. Small, Feb. 2, 1941, Herb. H.C. Bold (F); Ohio: Putnam Co.: Ottawa River, attached to branch, Ohio River Survey #2, Col. Hohn, No.4(4), July 4, 1956, also scrapping from rock in quiet water, col. Hohn, no. 5(4), July 4, 1956, No. 2(2-B) & 7(2-B), tufts on rock, July 3, 1956, Hohn, (PH); Allen Co. Ottawa River: on rock, Col. Hohn, No. 1(2), July 8, 1955; South Carolina: Kershaw Co. Wateree River, Du Pont Plant, Camden, Sta. 1-B, Col. R. Patrick (as Stig. stagnatile), April 1950 (BUT).

AFRICA

Soudan: Mopti, mare. col. Mme . Gauthier-Lievre (AL).

Stigeoclonium aestivale (Hazen) Collins

Pl. 13, Figs. 7-8; Pl. 30, Fig. 4; Text Fig. 91.

Collins, Gr. Alg. N. Am. 220, 1909; Fritsch & Rich, in Tran. Roy.Soc. S. Africa 17: 1930; Jao, in Bot. Bull. Acad. Sinica I: 73, 1947;

Myxonema aestivale Hazen, in Mem. Tor. Bot. Club. 11(2); 205, Pl. 33, f.1-3, 1902; Stigeoclonium autumnale Collins, P.B.A. No. 1789, TYPE (FH), Gr. Alg. N. Am. Supplem., 25, 1912 (reprint, 1928).

Plants in dense tufts on stones, aquatic plants, 2-5(-15) mm. long, light-green; erect filaments radiating from a palmelloid base or creeping filaments composed of isodiametric cells, or from interwoven mass of narrow, downward growing filaments and rhizoids, the latter may be profuse from basal cells; erect filaments dichotomously or alternately branched, simple, straight, branchlets few below, more above, erect, slender with attenuated tips, often ending in fine setae; cells thin-walled, slightly inflated and constricted, 7-12 μ (rarely -15 μ) in diameter, 2-6 times as long, above as long as broad and little more inflated.

NEOTYPE: P.B.A. 1074b. Mass.: Col. F.S. Collins, Aug. 13, 1903.

About this species Hazen (1902) states that it appears to be similar to Stig. longipilum in general habit, with radiating filaments and profuse rhizoidal growth, but it is smaller than the latter species and the branches do not terminate in a long hair. The cells here are long and narrow compared to Stig. longipilum. Sometimes, this species comes closer to Stig. subsecundum, especially, to younger forms. But constant presence of small, slightly inflated cells, more setiferous branch tips, tufted and radiating filaments may be characteristics of this species and can be easily separated from Stig. subsecundum.

The type and isotype specimens of Stig. autumnale Collins under the P.B.A. No. 1789 showed the presence of two kinds of filaments, the dominating one seems to be closer to Stig. aestivale, Collins mentioned "strongly swollen cells", thick-walled and short, 12-15 μ in diameter, 1-2 times as long, and again referred to slender branches. It might be that he took these few thick-walled filaments and many slender filaments to be the same plant, which in my opinion does not seem to be correct. The swollen, thick-walled cells may be a growth form of Stig. lubricum or any other species; thin-walled, cylindrical, slightly inflated cells, 2-5(-6) times longer than broad with setiferous branch tips appear more like Stig. aestivale and until more is known I am at present obliged to place Stig. autumnale as a synonym for Stig. aestivale.

Although Stig. aestivale shows its world-wide distribution in cool, fresh water habitats,nevertheless, it is strikingly similar to Stig. thermale A. Br. in every respect except that the latter species grows in hot spring or mill water. Whether this adaptation in hot water is a specific character or not, is yet to be judged. We do not know what should be the limit of the temperature for the growth of Stig. thermale. In our present study we have recorded Stig. tenue, collected from water where the temperature was 25 degrees to 30 degrees Centigrade or more. In tropical and subtropical countries the water temperature at the edge of shallow pool or pond becomes quite high, especially, the temperature of the substrates, such as pebbles, stones etc. on which these plants grow, is higher than surrounding water. If, however, it is proved that Stig. thermale always grows in hot water within a certain temperature range and not in cold water or below the critical minimum temperature (if any), then it can be separated from *Stig. aestivale*, otherwise, they are very close to each other and may be the same species.

Stigeoclonium longipilum Kg. var. *lacustre* Chodat (in Beitz. Krypt. Fl. Schwe. 1(3): 320, 235, f. 30, 1902) although not fully described, appears very much like *Stig. aestivale*, at least from the figures, and in my opinion this variety should be considered as a synonym for the latter species, until more is known about the above variety.

Specimens studied:

NORTH AMERICA

Massachusetts: P.B.A. No. 1074 b. on pebbles wet by spray of small water fall, Spot Pond Brook, Middlesex Falls. F. S. Collins, Aug. 18, 1903 (F.K.MICH.NY.) Medford: P.B.A. 1739, Setchell, Collins and Holden, Alg. Ex. (as *Stigeoclonium autumnale* Collins, TYPE AND ISOTYPES), Lower Mystic Pond, Col. F. S. Collins, Oct. 1, 1910, (F.K. NY.US.C.FH.PC.W.); *California*: San Francisco: Golden Gate Park, Mar. 1, 1914, Col. N. L. Gardner, No. 1326 (NY); *Missouri*: In spray of an artesian "iron and sulphur spring", Halratonka, Camden, Co. Herb. and Col. Fr. Drouet, No. 148, Aug. 9, 1928 (MO. 1035879); Ohio: In moving water bottom of trough of silt sampler and in water below N.A.E.W. Coshocton Co. Col. L. J. King, No. 842, Nov. 15, 1942 (F); New York: In the fountain, front of Museum, N.Y.Bot. Gard. Col. Dr. N. Wille, Nov. 17, 1914 (US.NY.); Herb. F. S. Collins, Jamaica (?), Humply (?), No. 360 (NY); Florida: Philips Lake picnic area. St. Marks Refuge, Wakulla Co. Col. C. S. Nielsen No. 19, March 1948 (as *Stig. lubricum*), (F); Canada: Quebéc: Lac Superieur (comte de Terrebonne), sur plantes aquatiques. Col. Jules Brunel, No. 936 (as *Stig. stagnatile*) (MT);

SOUTH AMERICA

Ecuador: Rio Pelaton. mases of green jelly on wet rocks, Col. Dr. G. W. Prescott, No. T. 101, Feb. 5, 1958 (Pres.);

EUROPE

Hungary: from a well. Mt. Sátor; Nyiri, Col. E. Kol, No. 134, April 21, 1954; from a well with a lever, Borzas farm, Hortobágy, Col. E. Kol. No. 145, July 31, 1951; Balf, from an aerated carbonic acid spring, Col. E. Kol, No. 513, Aug. 21, 1954;

Hortobágy, Szásztelek, from a trough of the well with lever, Col. E. Kol. No. 152, July 31, 1951; Kis. Sárret, Mág. orok, from the trough, a well with lever. Col. E. Kol, No. 151, Oct. 6, 1955; Vácrátót from the bucket of a well with lever #1, Col. E. Kol. Nos. 703, 705, Aug. 10, 1950, also on lever #XI, Col. Nos. 762, 764, Aug. 8, 1950 and Lever No. I. Col. E. Kol. No. 695, May 19, 1950 (All from Dr. E. Kol, BP);

ASIA

Pakistan: Dacca: attached to aquatic plants, Col. S. Aziz. No. 153, Dec. 16, 1956; S. Aziz, Nos. 131, 137, 1957 (Is.): TIPERRA: Col. S. Aziz, on aquatic plants, 1959 (Is.);

AFRICA

Guineé, 448-449, Youkoun Koun and Haute-Volta, prés de Tiogo, Col. M. Gauthier-Lievre (AL).

Stigeoclonium thermale A. Br. in Kg.

Pl. 31, Figs. 1-3.

Kuetzing, Spec. Alg. 353, 1849; Tab. Phyc. 3:t,2. f.4, 1853; Rabenh. Flor. Eur. Alg. 3:376, 1868; Cooke, Brit. F. W. Alg. 189, pl. 73, f.2, 1883; Wolle, F. W. Alg. Ill, pl. 96, f.1, 1887; De Toni, Syll. Alg. I: 201, 1889; Collins, Gr. Alg. N. Am. 220, 1909; Heering, in Pascher's Süsswasser. 74, 1914.

Myxonema thermale (A. Br.) Hazen, in Mem. Tor. Bot. Club. 11(2): 203, 1902.

Stigeoclonium Bormianum Anzi, Erb. Critt. Ital. No. 34 (1034), Oct. 1862, Anzi.

Draparnaldia thermale A. Br. ? No. 902, Guadeloupe, Maze (K).

Stigeoclonium rangoonicum Zell., in Hedwigia, 191, 1873 (No. 3249. Pequ. Rangoon, Burma (L.FH.); De Toni, Syll. Alg. I: 204, 1889.

Tufts bright-green, 2-5 cms. long,profuse erect filaments developing from creeping prostrate base with rhizoids; filaments dichotomously or alternately branched, branchlets remote, alternate or somewhat departed from each other, erect, spreading, extremely rarely opposite; branch tips attenuated upward to an acute point, or flagelliform, somewhat setiferous, hair absent; cells of main filaments cylindrical, often slightly inflated, 8-12 μ (rarely -15 μ) in diameter, 2-4 times as long, in branchlets 2-5 times as long. Collected from hot water, 25-37 degrees Centigrade and sometimes incrustated.

TYPE: Stig. thermale A. Br. No. 5. Badenweiler, June, 1847 (L). Lectotype: Leg. A. Braun No. 146, Jan. 1847 (L).

This species, as the name indicates, grows in thermal water where temperatures, so far recorded, may be up to 37 degrees Centrigrade. As mentioned before, whether this species is strictly restricted to warm water is doubtful. Cooke (1882-84) put Draparnaldia elongata Hassall, a cold water species, as a synonym for Stig. thermale Br. and mentioned also that "Hassall found this (Drap. elongata) species on one occassion growing in a horse trough and sometimes mixed with other algae in ditches"! This species has a strong resemblance to Stig. aestivale and somewhat superficially to Stig. attenuatum as illustrated by Hazen. As discussed under Stig. aestivale if the Stig. thermale can grow equally well in cold or ordinary water temperature other than that of hot springs, the systematic positions of Stig. aestivale and some other species may have to be rearranged.

Hazen (1902) has assigned Draparnaldia uniformis as a synonym for Stig. thermale, which is wholly unwarranted and apparently without having made any basic study of these two species.

Stigeoclonium rangoonicum Zell. under Col. No. 3249 from Leiden and Farlow Herbaria was examined by me. The collection is very poor and only few pieces of dry soil particles are present. These were first dissolved in water on the slide and few filaments were recovered. The branching and other features seem to agree well with Stig. thermale as illustrated by Kuetzing and Wolle.

Specimens studied:

EUROPE

Germany: Badenweiler: Col. A. Braun, No. 5, (Herb. Kuetzing), June, 1847 (TYPE specimen) (L); Col. A. Braun, No. 146 in aqua thermale, Jan. 1847, Herb. Suringar (L); Col. A. Braun, No. 169, July, 1847 (G); Herb. Lenormand, No. 490/3, A. Braun, 1847 (CN); Badenweiler, A. Br. No. 174, 1847 (NY. PC.).

St. Helena: Whitehead, 5/78, (K); Italy: Rouisseaux thermany, Norwean Bains de Bormio (Haute Valteline Italie), Aug. 1871, Leg. E. Levier (L); Erb. Critt. Ital. ser. II. Bagni nuovi in Bormio, in thermale water, Col. E. Levier, No. 660, Aug. 1871 (syn. Stig. Bormianum Anzi) (L.G.F.NY.Z.).
In rivulis aquae thermalis calidissimae et tepescentis infra Balnea Bormiensia vetera et nova, M. Anzi, No. 1664 (Rab. Alg. Eur.), Aug. & Sept., 1863 (L.G.K.C.F. W.NY.Z.); Bormio: Su pietre calcari nell' acqua termale di rapido corso sotto i bagni vecchi e nuovi di Bormio. Col. M. Anzi, No. 34(1034) as Stig. Bormianum Anzi, Erb. Crittog. Ital. Oct. 1862 (G.W.B.); Rhätische Alpen, in water 25-30 degrees -- 37.4 degrees Centigrade temp. Col. Dr. C. Brügger v. Curwalden, No. 244, Aug. 27-Sept. 20, 1862 (G.LAU.Z.); Cyprus: Guelle von Calaloca bei Dali auf Cynern, Col. Pr. Unger, No. 234(W). ?? Col. A. Grunow, No. 401, Mai, 1858 (W); Leg. A. Grunow, 390, ofner Thermen (B).; France: Algac Gall et N. Am. No. 194, R. Brébisson, 7/86 (K); Franconia. P. F. Reinsch 46, 1874 (K).

CENTRAL AMERICA

Guadeloupe: Soufriere: Bassin Reauvalloz, Mazé, No. 902 (as Stig. thermale A. Br. f. and Draparnaldia thermale A. Br.) Purchased, 1890 (K).

NORTH AMERICA

Pennsylvania: Bethlehem: Streamlet of warm water, Ex Herb. Fr. Wolle, March, 1897 (L. FH.) Fr. Wolle, No. 81, May, 1887 and No. 124.7, 126.7, 1875 (FH. F.), also, Oct. 10, 1877 and April, 1878 (NY); Steel-works, Bethlehem, Wolle, April 1879 (F); Hot water from Rolling Mill, Fr. Wolle, July 20, 1879 (NY).; South Carolina: Charleston: from wooden trough into which the warm water from the artesian well flows, Col. H. W. Ravenel, No. 329, July, 1879 (FH. NY.); Aiken: on board in still water, Leg. H. W. Ravenel, 263, Herb. F. Wolle (F).; Arizona: attached to rocks in a small warm stream, 2 miles above Metcalf, Greenlee Co. Col. G. Piranian, June 6, 1935 (F).

ASIA

Pamir: Central Asia: 1898-99, Expn. of Olufsens, Leg. O. Paulsen, No. 1192, 29-IIX-'98 in fonte tepido at temp. 23 degrees Centigrade, Prope lacu Tashilkul (C).

AFRICA

Algerie: Hammam Melouan, 1921 (AL); Leg. C. Sauvageau, April, 1892, Herb. Crypt. Mus. Paris. (F).

<u>Stigeoclonium curvirostrum</u> Skuja

Pl. 31, Figs. 6-8; Text Figs. 111-114.

Skuja, H., in Nova Acta Reg. Soc. Sc. Ups. ser. IV. 14(5): 73, t.12, f.4-8, 1949.

Thallus hemispherical cushion or turf, .5-1 mm. high, somewhat flaccid, green, both prostrate and erect parts well-developed, attached to substratum by rhizoids, cells of prostrate part round or globular, 8-15 μ diameter, 11-17 μ long; erect filaments dichotomously or pseudo-dichotomously (rarely opposite ?) branched from below, monopodial branching above; cells cylindrical, slightly inflated, more or less constricted at the septa, especially at the upper part of the filament, 4-8 μ diameter, 19-50 μ long, apical cells curved or flame-shaped, tip accuminate, rarely a multicellular colorless hair develops; chloroplast single, parietal, ring-shaped with many pyrenoids.

Reported only once from type locality Kamayut and Prome Rd., Burma. (Type specimen not seen).

This species was based on only two preserved samples collected in 1935 and has not been verified by anyone. The plant is extremely minute, so most likely it could be a young stage. How this small, young plant could be considered as a full-grown one as a new species, has yet to be investigated. Skuja (1949) states that because the thallus does not form firm jelly-like structure and has relatively strongly developed branches and creeping base, and because not much difference exists between main axis and branches, this species comes closer to the genus Stigeoclonium than Chaetophora and therefore is probably related to the forms with well-developed prostrate part, such as Stig. farctum Berth. The larger cells and crooked end cells are characteristics of this species.

It is worth mentioning here, however, that in the study of the life-history of Stig. subspinosum Kg. and Stig. subsecundum Kg. Juller (1933) and Kuo (1958) both have illustrated such crooked, bent apical cells, especially, the latter (Kuo, l.c.f.5,8). I have also seen such apical cells in several collections where the branching habit was not like the present species. Moreover, the presence of rarely colorless multicellular hairs, as shown by Skuja, casts some doubt whether this curved apical cell is the constant character of the adult plants and whether only this one character should be considered to make a new species.

It may be noted here that one of several pencil drawings sent to me by Mme. Gauthier-Lievre from Algeria, which she sketched in 1944 from a specimen commonly found at Ivory Coast, Africa, appears more or less similar to Skuja's figures (see Text Figs. 111-114). Here, some opposite branching of the erect filaments has been shown as well as a prominent mucilage matrix surrounding the filaments which can be traced in her drawings (Text Fig. 113). The exact measurements of the thallus in this drawing are not mentioned. This latter drawing of similar filaments from a different place suggests that the present species could be a good one, but as no specimens have been seen by me it is considered here as a doubtful one until further collections and investigations are made.

Stigeoclonium setigerum Kg.

Pl. 17, Fig. 5; Pl. 26, Fig. 8; Text Fig. 99.

Kuetzing, Phyc. Germ. 199, 1845; Spec. Alg. 354, 1849; Tab. Phyc. 3: t.5, f.2, 1853; Rabenh. Krypt. Fl. v. Sachs. 267, 1863; Flor. Eur. Alg. 3: 379, 1868; De Toni, Syll. Alg. I: 204, 1889; Heering, in Pascher's Süsswasser. 6: 71-72, 1914.

Filaments up to 1 cm. or so long, very slimy, slightly yellowish-green; the primary and secondary branches mostly alternate, rarely opposite; cells of the main axis and branches mostly cylindrical, often slightly inflated and constricted; branches, especially secondary branches above, are extremely prolonged without rebranching, somewhat like a thin thread, flagelliform, without ending into colorless hair; cells of main axis 7-10 (-12) μ in diameter, 1-2 (2½-3) times as long, in branches 4-6 μ in diameter (may be more), 2-4 times as long, chloroplast broad.

The isotypes of this species from different herbaria have been examined. The general features of these plants look like Stig. tenue (Ag.) Kg. The only characteristic feature here is the very long, slender branches (the reproduction and life-cycle of this species are not known). Rabenhorst's descriptions of this plant, which have been followed by De Toni and Heering, state that the cells are not constricted and that branches are alternate. In the isotype specimens, however, I found two types of filaments, both with very long, extended, thread-like branches but in one type of filament cells are a little greater in dimension and slightly inflated than the other type. Whether all these filaments belong to the same species is a question. Rarely opposite branching habit, somewhat like Stig. tenue, was observed in the isotype collection.

It is still doubtful whether this species is a well-developed one or whether it belongs to some other species, possibly a variety of Stig. tenue. More collections and life history studies are needed to clarify our understanding of this species.

Specimens studied:

EUROPE

Germany: Eisleben: in aqua limpida fluente. Leg.

Herb. Kuetzing, dat. 1832. Communicata ex Herb. Lugduno-Batavo (F.L.W.); Dresden and Leipzig: L. Rabenhorst, No. 187 (as Myxonema oscillatorioides Fr.)--Highly doubtful for Stigeoclonium, May, 1852 (G.B.); (as Conf. oscillatorioides (Ag.), Herb. Suringar, No. 54 (L); bei Berndorf, Leg. A. Grunow, No. 397 (B.FH.W.); bei Schmillnis, Kaldebrennen ? (as 67 Conf. punctalis Kg.), Col. Grunow, No. 11720 (W); bei Beneslong ?, Ex Herb. Schledermyr (as Stig. setigerum var. epithet brevius-articulatum), 12/3/1862 (W); Frankfurt Bot. Gardens, Col. A. Bary No. 358 (as Stig. subsecundum Kg.); France: algues de France (as 600. Conferva subsecundum Kg., Stig. thermale Br.) Ch. Tourcadel, Oct.-Nov. 1884 (K); Yugoslavia: Sistiana bei Duireo nächst Triest, Leg. Pr. Unger (W); as No. 976, Stig. setigerum*

NORTH AMERICA

Ohio: Coshocton Co. In road side ditch, N.A.E.W. Col. L. J. King, Nos. 1044, 1045, June 5, 1943 (F).

* and 490 Herb. Lenormand, Al/1, 26 (CN).

Stigeoclonium Biasolettianum (Kg.) Kg.

Pl. 29, Fig. 1; Text Fig. 96.

Kuetzing, Phyc. Gener. 253, 1843; Spec. Alg. 352, 1849; Tab. Phyc. 3: Pl. 1, f.3, 1853; De Toni, Syll. Alg. I: 202, 1889.

Draparnaldia Biasolettianum Kg. Alg. Aq. dulc. Dec. No. 142; Forest, in Castanea, 21(1): 9, 1956.

Plants bright green to yellowish-green, mucilaginous; main filaments and branches ribbon-like; branches alternate, remote, often several from the same side of the filaments; primary branches more or less the same diameter as the main filament, very long, slender; apical cells of the branches sharply pointed, hair absent; branches originate mostly from either below or above the septa or from the middle part of the cells; cells of main filament and branches cylindrical, without (or with very little) constriction at the partition wall, 12.5 - 15 μ in diameter, 2-5 (-8) times as long; chloroplast band-like.

Isotype: Draparnaldia Biasolettianum Kg. Dec. in rivulis ad Saxa (al Boschetto) prope Tergestum, April, 1835, Leg. Kuetzing, No. 142, (W).

This species has been reported so far only two or three times from Europe. The exact nature of the thallus and life-cycle are not well-known due to lack of enough specimens. The isotype material, although quite old, appears similar to Kuetzing's illustrations, but the diameter of the cells was found to be less and the length more than the dimensions given by Kuetzing. Often, this plant appears as a young Stigeoclonium subsecundum Kg. The only characteristic feature here seems to be the origin of branches, which arise deeply from the partition wall (see Pl. 29, Figs. 1), and the long, sharply-pointed end cells. The dark bands near the septa as shown by Kuetzing seem to be the shrunken chloroplasts as I observed in the isotype specimens.

Specimens studied:

EUROPE

Trieste: In rivulis ad saxa (al Boschetto) prope Tergestum (Type locality), Leg. Kuetzing, (ISOTYPE), No. 142 (as Draparnaldia Biasolettiana Kg.), April, 1835 (C.W.); Col. Grunow No. Acq. 1889, No. 11615, Leg. Kuetzing, Astien: Herb·Dessav. (W); Col. Grunow 11616, ? prope Capodistria in torrentibus, 6/1859 (PC.W.); ? Berndorf: as (1665 Stig. tenue var. irregulare Grun. ?), Leg. A. Grunow, No. 1665, Nov. 1863 (W.G.L.K.F.NY.); Berndorf ?: (as Stig.

lubricum Kg. var.), A. Grunow, Col. No. 11573, 1860 (W); Triest: Herb. Kuetzing, No. 490, 1849, A 1/1 (CH).

Stigeoclonium helveticum Vischer

Pl. 25, Figs. 1-4; Pl. 29, Figs. 2-6; Text Fig. 94.

Vischer, W., in Beih. z. Bot. Centralbl. 51(1); 36, 1933.

Stig. helveticum var. majus Vischer, loc. cit. f. 13-15, 18, 1933.

Stig. helveticum var. minus Vischer, loc. cit. f. 16-17, 19-20, 1933.

Thallus turf-like, cushion-forming, 1-5 cms.; filaments simple, long, thread-like, branches remote, or sometimes several branches from adjacent cells;

mostly alternate, rarely opposite, or 2-3 from same point, developed by evection from any place of the cell; branches long, bluntly attenuating or ending in a colorless hair; cells of the main filament and branches cylindrical, at the septum usually not constricted or slightly so. 6-12.5 μ in diameter, 1-8 times as long.

Type locality: Birsig near Basileam Rosenau (Switzerland).

Only two culture materials have been studied, one originally obtained from Cambridge Botany School, Col. No. 477/2 and the other from Indiana Culture Collection, Bloomington. Both of them are Stig. helveticum var. minus. The two varieties were separated by Vischer only by their cell size but in cultures of the above var. minus we have observed the size of the filaments greater than recorded by Vischer, and it may be same as the var. majus. The branching habit is somewhat like Stig. setigerum Kg. but the cells are longer here. Sometimes, the filaments appear as young Stig. subsecundum Kg. The branching habit is the only characteristic feature; sometimes the young branches appear like the branching habit of the blue-green alga Scytonema. Whether this is a growth-form in the culture medium or results from particular environmental conditions or whether it is a specific character, must yet be determined. The branching habit as I have shown (Pl. 29, Figs.2-5) was drawn from the culture materials. Similar branching habit, drawn by Mme. Gauthier-Lievre who sent me her pencil drawings made from the field collections, is shown in Pl. 25, Figs. 1-4.

I see scarcely any difference between the two varieties based on the size only. Still, the species itself has been considered here a doubtful one, until more collections and studies are made.

Specimens studied:

NORTH AMERICA

Chio: Culture of Algae (No. 477/2 in the collection of the Botany School, Cambridge) in the Physics Lab., Univ. of Cincinnati. Col. W. M. Diller, April 1, 1933 (F); Indiana: Culture Col. No. 341 (12-10) recd. 22/2/50 (IND);

SOUTH AMERICA

Ecuador: Baños: attached to rocks and moss in run-off from hot springs: April 12, 1950, Col. G. W. Prescott, No. T 573 (may belong to this species) (Pres.)

AFRICA

Rapides du Congo, ? Col. Mme. Gauthier-Lievre (AL).

Stigeoclonium segurae sp. nov.

Pl. 34, Figs. 1-5; Text Fig. 105.

Plants small tufts growing on sticks, woods or aquatic plants; erect filaments very slender, laxly branched; cells of main axis and primary branches of same diameter, cylindrical, 8.5-11 μ (mostly 9.5 μ) in diameter, (4-)-8-10 (-12) times as long, practically nonconstricted; branches having smaller cells, cylindrical, usually the lowermost cell of the branches is longer than the rest; branches whorled, somewhat trichotomous, also alternate above, ending in a colorless hair; chloroplast parietal median band with several pyrenoids in the cells of main axis, of the branches filling up the entire cells.

Type: New Zealand: Auckland, in running water, Remuers, from a roadside ditch off Abbott's Way; Col. E. C. M. Segar, Nov. 1, 1953 (AKU).

Here the branching habit is quite characteristic, somewhat like *Chaetophora*, but does not form thick mucilage matrix like the latter genus. It does not agree with any known species at present and, therefore, it is placed under a separate and new species. The name of the species is made in honor of the phycologist, Miss E. C. M. Segar of Auckland University College, New Zealand, who collected and sent the specimen to us.

Stigeoclonium carolinianum sp. nov.

Pl. 26, Figs. 1-5; Text Fig. 98

Plant bright green, 1 cm. or so high; prostrate part apparently lacking, attached to substratum by rhizoids; erect filaments profusely branched, primary branches mostly alternate or pseudo-dichotomous, often forming pseudo-whorls, branches attenuated, or slightly setiferous, but not ending in a long colorless hair; main filaments and primary branches forming nodes formed by clusters of short oblong or globular cells at certain intervals, these cells look like sporangia, formed directly on the filament or on short stalks, about 3-9 μ wide and 22-29 u long; cells of main filaments cylindrical or slightly inflated, 7.8-13 μ diameter, (mostly 9.6 μ), 16-45 μ long; in branches cells 4.8-6.4 μ in diameter, 4-7 times as long; chloroplast long, parietal.

Type: Schumacher and Whitford Col. No. Bt.8, North Carolina, Roquist Crk. Bertie Co., July 24, 1958 (Whit. Is.)

This species was collected only once from North Carolina in the month of July 1958, but subsequent efforts have failed to get more materials from the same locality.

The filament, in general, appears like _Stig. aestivale_ in branching habit, cell-shape etc., but here, the clusters of short cells grouped together at regular intervals on the main axis and primary branches are quite characteristic. These cells are oblong or globular on abbreviated branches. At first glance it looks like _Audouinella_ sp. but starch test proves it to be a green alga. Superficially, it bears resemblance to _Stig. fasciculare_ Kg. but careful examinations have failed to identify it as such. Whether this plant represents a particular stage in the life-cycle of some species cannot be stated now, but it is hoped that more living material will make it possible to study the life-history in culture and to confirm its identity. At present, it does not agree with any species - description and hence is regarded as a new one.

Stigeoclonium fasciculare Kg. (Emend.)

Kuetzing, in Bot. Zeit. 177, 1847; Spec. Alg. 355, 1849; Tab. Phyc. 3:t.8, f.1, 1853; Rabenhorst, Fl. Eur. Alg. 3:380, 1868; Wolle, F. W. Alg. U.S. 114, t.9, f.1(?), 1887; De Toni, Syll. Alg. I: 203, 1889; Pascher, in Flora, or Bot. Zeit. I: 95-107, 1905; Heering, in Pascher's Süsswasser.6: 76.f.105, 108, 1914; Fritsch, and Rich in Trans. Roy. Soc. S. Africa, 17, 1930.

Thallus tufted, filaments radiating from palmelloid or rhizoidal base, 1-5 cms. long (may be longer), bright green and slimy; erect filaments dichotomously or alternately branched below, primary branches often opposite above, rarely 2-4 primary branches form a whorl on main axis; secondary branches mostly alternate and short and arise close to each other forming a fasciculate appearance (penicillate-fasciculate) on the primary branches (usually near the apex); the primary branches usually terminating in very long colorless, multicellular hairs, occasionally in acute, flagelliforme tips beyond the fascicles; cells of the main axis usually cylindrical but may be slightly inflated, cells producing branches not different from the others, 10-16 µ (rarely 18.5 µ) in diameter, 1-4 -7 times as long; cells of branches less in diameter, 1-2 times as long, little or more inflated than cells of main axis; chloroplast a dense band.

Type: 180 (19), Stig. fasciculare Kg. Holland, in fossis prope Goes. Leg. V. D. Bosch. May, 1845 (L).

Stigeoclonium fasciculare Kg. var. fasciculare

Pl. 24, Fig. 1; Pl. 33, Figs. 1-5; Text Fig. 95.

Kuetzing, in Bot. Zeit. 177, 1847; Spec. Alg. 355, 1849; Tab. Phyc. 3:t.8, f.1, 1853; Rabenhorst, Fl. Eur. Alg. 3:380, 1868; Wolle, F. W. Alg. U.S. 114, t.9, f.1(?), 1887; De Toni, Syll. Alg. I: 203, 1889; Pascher, in Flora, or Bot. Zeit. I: 95-107, 1905; Heering, in Pascher's Süsswasser.6: 76, f.105, 108, 1914; Fritsch and Rich, in Trans. Roy. Soc. S. Africa, 17, 1930.

Primary branches alternate or dichotomous below, often more opposite above or 2-4 primary branches may arise from the same cell of main axis, primary branches ending in long colorless, multicellular hairs beyond the fascicles; cells of main axis 10-16- (-18) µ (mostly 15-16 µ) in diameter, 1-4 times as long.

Type same as the species.

Specimens studied:

EUROPE

Germany: Ellerforst bei Düsseldorf, Rheinland, Col. H. Royers, April 17, 1898; Schleswig, Gallia, No. 371, 392 (as *Stig. flagelliferum* Kg.) Herb. Kuetzing (L); France: Herb. du Dr. Lebel donné au Museum par ses enfants, en 1878; St. Zoseph, prie dele Cham ? Herb. Dr. Lebel, Avril, 1863; Angers, F. Hy. mars, 1888 (PC); Valognes: as (739. *Stig.* with an epithet *glomeruliferum* ?), Herb. Kuetzing, Leg. Dr. Lebel (L); Calvados: Vire: (as 490. *Stig. tenue* var. *lubricum* Rab.), R. Lenormand (MT); Melodunum: on silicious soil; L. H. Buse (L); Calvados: Talaice: Alg. de France No. 390, Brebilloy, 1886 purchased (K); West Ukraine: (formerly under Poland): Lemberg: Galligien: Weiss, Herb. Kuetzing, No. 363 (L); Holland: V. D. Bosch No. 180 (19) (as *Stig. fasciculare* Kg. TYPE)

May 1845 (L); Leg. V. D. Bosch, 180, April 1845, Alg. indigenae, Herb. Suringar; Goes: Herb. V. D. V(L); B. Ex. Herb. Kuetzing (L); ? Quelle (?), bei Berndorf: A. Grunow, 651 (Col. No. 11725) April, 1861 (W); ? Leiden: Herb. No. 130 (No.A) (L); Italy: Monfalco: Col. Grunow, No. 11606 (W); ? Gall: Hubeville: Herb. Kuetzing, Leg. Dr. Lebel, No. 361 (as *Stig.* with an epithet *nidificum* Lebel ?) Mai 8, 1860 (L).

NORTH AMERICA

Connecticut: N. Bridgeport: (as 26. *Stig. tenue*) Col. H. A. Green, 18.7, 1895 (PH); Bridgeport, Leg. I. Holden No. 811 (as *Stig. longipilus* Kg.) May 14, 1893 (FH.NY.); Bridgeport, Fairfield Co. I. Holden, 811 (as *Stig. glomeratum*) Boston Soc. Nat. Hist. (FH); P.B.A. No. 660 (as *Stig. tenue* var. *lubricum*) May 14, on submerged plant in still water (NY); New Jersey: Outlet of swamp, Hudson Heights, Leg. T. E. Hazen, No. 299 April 16, 1900 (F); Somerset Co. Chrysler Herb. Rutgers University (as *Stig. glomeratum*) Littoral, Delaware and Raritan Canal on vegetation, Griggstown Lock, R. Renlund and E. T. Moul, No. 6653, Mar. 18, 1950 (F); Ohio: Clarmont Co. (as *Stig. glomeratum*) Lillick, Fall, 1932 (NY); Michigan: Lake Lansing: on snails and rocks; Sept. 1958 (Is.)

SOUTH AMERICA

Brazil: on stones in swift current, Lagõa., Itapeva, Rio Grande do sul. Herm. Kleerekoper, No. 535 a. (as Stig. glomeratum (Haz.) Collins) Nov. 1941 (F).

AFRICA

Soudan: marais d'inondation du Niger à Gao, Col. Mme. Gauthier-Lievre, 27.12, 1945 (AL).

Stigeoclonium fasciculare Kg. var. glomeratum (Hazen) comb. nov.

Text Fig. 118.

Stigeoclonium glomeratum (Hazen) Collins, Gr. Alg. N. Am. 221, 1909; Hylander, Alg. Conn., 129, 1928; Fritsch and Rich (as Stig. glomeratum (Hazen) Fritsch), in Trans. Roy. Soc. S. Africa, 18: 41, 1930; Prescott, Iowa Alg. 86, 1931; Taft, in Proc. Oklah. Acad. Sc. 20: 49, 1940; Tiffany and Britton, Alg. Ill. 34-36, 1952; Moshkova, in Ukrain. Bot. Zhurn. 15(2): 84-87, Figs. a,b, 1958.

<u>Myxonema</u> <u>glomeratum</u> Hazen, in Mem. Tor. Bot. Club, 11(2): 205, Pl. 34, 1902.

Primary branching more alternating; cells of main axis cylindrical, elongated, 11-14 μ in diameter, 2-7 times as long (mostly 4-6 times); primary branches ending in long, colorless, setiferous or flagelliform hairs beyond the fascicles.

This species <u>Stig</u>. <u>fasciculare</u> Kg., when young, is quite lubricous and may appear as <u>Chaetophora</u> or <u>Stig</u>. <u>longipilum</u> Kg. In the well-developed form, it is quite distinct than any other species. Hazen, however, made a new species <u>Stig</u>. (<u>Myxonema</u>) <u>glomeratum</u> (Hazen) Collins chiefly on the basis of cell-size of the main axis about which he says (p. 206) that "this species is very similar to <u>Stig</u>. <u>fasciculare</u> Kg. (not Wolle), but it differs so much from that form in the long cells of the main branches that it must be considered as distinct, at least until further evidence as to Kuetzing's species is obtained". I have examined the type specimen of <u>Stig</u>. <u>fasciculare</u> Kg. (but could not obtain the type of <u>Stig</u>. <u>glomeratum</u>) and found that measurements given by Kuetzing are not fully correct. He had described less diameter and less length of the cells of the main axis. I have recorded cell diameters of the type specimen as 10-16 μ, and 1-4 times as long. Besides this, there are other collections I obtained from Rijksherbarium, Leiden, which were in Kuetzing's Herbarium and identified as Stig. fascicu-lare by Kuetzing. These plants are much more well-developed and larger in size than his type specimen. It may be mentioned that the type specimen consists of comparatively young plants or at least the growth of the plants might be stunted. Pascher's (1905, 1906) illustration of Stig. fasciculare shows longer cells of the main axis than given by Kuetzing. Pascher (l.c.) even regarded Tilden's (1896) Stig. flagelli-ferum as Stig. fasciculare. Hazen's species no doubt, however, belongs to Stig. fasciculare which can attain a greater size, but at least due to the constant presence of longer cells in the main axis and slightly less diameter and flagelliform or setiferous branch tip, Stig. glomeratum might be considered a distinct variety of Stig. fasciculare and here described as such, i.e. Stig. fasciculare Kg. var. glomeratum (Hazen) comb. nov. Recently, Moshkova (1958) report-ed Stig. glomeratum similar to Hazen's form from Ukrain SSR.

Kuetzing (1849) did not mention whether the primary branches are alternate or opposite except that "ramis erectis, subtorulosis, flagelliformibus; ramulis penicillatim fasciculatis, densis erectis, ----apice in pilum hyalinum longissimum productis". Hazen similarly described his species Stig. glomeratum as "filaments radiating, bearing few, alternate branches below, ----above alternate, or rarely opposite, more or less densely penicillate-fasciculate, particularly at the summit, tapering into an acute or long setiferous point".

In respect to primary branching habit, probably De Toni's (l.c. 203) description "filis ramisque opposito-dichotomis" comes very close to that which we have observed in the type and other specimens where primary branches in the middle or upper part of the thallus are opposite, sometimes 2-4 primary branches arising around the same cell. Secondary branches which make "penicillatim fasciculatis" appearance are mostly alternate, often with several branches arising from the same side.

Wolle's collection of Stig. fasciculare Kg. from Northampton Co., Pennsylvania, seems to be more like Stig. amoenum Kg. So also P.B.A. No. 67. Stig. fasciculare Kg. from Bridgeport, Conn. May 28, 1893, Col. I. Holden (also No. 828 from the same place) agree very well with Stig. amoenum Kg. rather than with Stig. fasciculare.

P.B.A. No. 660 as Stig. tenue var. lubricum and I. Holden No. 811 as Stig. longipilus are found to be Stig. fasciculare and accordingly transferred to the latter species.

It has been noticed that the reduced or growth-form of Stig. lubricum and Stig. flagelliferum may appear as Stig. fasciculare. Similarly, Stig. nudiusculum and Stig. Nelsonii seem to be very close to it. But in all these species the branches develop from the distinct modified cells of the main axis whereas in Stig. fasciculare no such modified cells are formed. In Stig. Nelsonii and Stig. nudiusculum the fascicled branches are formed directly on the main axis and more or less spreading from a short stalk-like branch, more like Draparnaldia, whereas in Stig. fasciculare the long and loose fascicles appear as a result of short secondary branches arising at short intervals from the upper part of the primary branches. Sometimes, on the same plant this secondary branches may be irregularly, scattered or solitary. This was found in the type and other specimens.

For reproduction and zoospore-formation, see Pascher (1905, 1906, 1907).

Moebius (1892) described a new species from Australia, Stigeoclonium autralense Moeb., which he thought to be quite well-developed plant, but his illustration of this species (Fig. 12, p. 435) appears to be a miniature Stig. fasciculare, strongly suggesting that it could be a young stage of the latter species. I have shown (Pl. 21, Fig. 5) a young plant of Stig. fasciculare, collected from a lake in Michigan, which almost looks like Stig. australense. If however, the specimen described by Moebius is really an adult, full-grown plant, then at least it could be considered a form of Stig. fasciculare due to its smaller size. Because no specimens including type were available it was not possible to determine its exact systematic position. Thus, until now, it is placed under Stig. faciculare as a form; the description of this form according to Moebius is as follows: Plants small, fully grown, profusely branched, about 2 mm. high tufts; the cells are cylindric, above slightly thinner than below, in general 6-7 µ broad, 2-5 times as long; chromatophore almost fills the cell; the main filaments or branches mostly solitary, seldom opposite, above branches are small, sometimes bifurcated, branches are all arising upright, ending in long multicellular hairs; cells producing swarmers are swollen and divided in small segments; rhizoids absent. (Text Fig. 117).

<u>Stigeoclonium</u> <u>Lebelii</u> sp. nov.

Pl. 20, Figs. 1-2

Thallus bright green, lubricous, 10-20 mm. high, profusely and irregularly branched; main axis consisting of broad, barrel-shaped, moniliform cells, 15-25 μ in diameter, 2-5 times as long, constricted at the partition wall; branches scattered, alternate, opposite or in pseudo-whorls, several from same place; primary branches producing numerous thorn-like secondary branches; branches with broad basal cells gradually tapering into a colorless hair or becoming setiferous; cells of branches short, inflated, constricted, 9-13 μ in diameter, 1-3 times as long.

Type: Herb. Kuetzing, Fontaine & St. Joseph, 10 June, 1853 (specimen No. 286, bearing the label Stigeoclonium with an epithet pulchellum Lebel nov. sp.) in the Rijksherbarium, Leiden. (L).

This plant superficially looks like [illegible] Meyer (1930), but the latter genus was described as relatively large plant with great dimension of the main axis and with a reticulate chloroplast. The main axis also appears somewhat like Draparnaldia, but the branching habit is definitely Stigeoclonium-like. In the figures (Pl. 20, Figs. 1-2) I have shown only a portion of the thallus; the branching is so profuse and scattered in different planes that it is difficult to represent them. Sometimes, branches appear as those of Stigeoclonium subuligerum with broad base and narrow apex. Until now there seems to be no species known where this plant could be placed.

As the new name given to this plant by Lebel on the herbarium specimen (Stigeoclonium with an epithet pulchellum Lebel sp. nov.) was never published and as this epithet pulchellum was already used by Kuetzing for a variety of Stig. amoenum Kg. (1849, p. 355), a new name Stig. Lebelii sp. nov. is therefore, given to it in honor of Dr. Lebel who collected this specimen and also contributed much to the herbarium of algal collections at the time of Kuetzing during mid-nineteenth century.

Stigeoclonium subsecundum (Kg.) Kg.

Kuetzing, Phyc. Germ. 253, 1843; Spec. Alg. 352, 1849; Tab. Phyc. 3:t.1, f.2, 1853; Rabenh. Flor. Eur. Alg. 376, 1863; Wolle, F. W. Alg. U.S. 112, t.99, f.2, 1887; Collins, Gr. Alg. N. Am. 221, 1909; Heering, in Pascher's Süsswasser 69-71, 1914; Prescott, Alg. G. W. L. A. 117, Pl.10, f.3, 4, 1951a; Tiffany and Britton, Alg. Ill. 34-36, Pl. 8, f.68, 1952.

Myxonema subsecundum (Kg.) Hazen, in Mem. Tor. Bot. Club. 11(2): 207, Pl. 36, f.3, 1902.

Conferva subsecunda Kg. Alg. Dec. XVI. No. 146, 1836.

Plants very delicate, bright green to yellowish-green in color, forming slimy flakes or entangled with aquatic plants, on sticks, etc., mostly found in stagnant water; main filaments very sparsely branched below, rather long rhizoids develop from many cells above the base; branches more or less dichotomous or alternate, never opposite, often several branches developing from successive cells on the same side of the filaments, gracefully tapering to attenuated tips, rarely short-setiferous; some branches with the cells of the same character as the main axis, other branches may be small; cells of main axis long, cylindrical, with little or no constrictions at the transverse wall; some cells of the main axis may be small and barrel-shaped above, followed by long, cylindrical cells; cells producing branches may be different from other cells, if so, they are slightly shorter and little inflated; cells of main filament 7-20 μ in diameter, 3-10 (-12) as long; chloroplast single, cylindrical incomplete parietal plate.

Stigeoclonium subsecundum Kg. var. subsecundum
Pl. 6, Fig. 5; Pl. 21, Fig. 4; Pl. 22, Fig. 3; Pl. 24, Fig. 5; Text Figs. 89, 107-110.

Filaments large; deep green, lubricous; cells of main filaments 12-20 µ in diameter, 3-12 times as long; branches dichotomous, alternate, sometimes several branches from same side; secondary branches sometimes short, with attenuated tips, somewhat curved; branch-producing cells of main axis usually similar to others, may be somewhat shorter, and slightly inflated; sometimes, the prostrate part of thallus is lacking or may consist of short, inflated, more or less isodiametric cells.

Lectotype: 146. Conferva subsecunda Kg. Leg. Com. Kuetzing in fonte Sulfurea "Aarziel" prope Bern. Switzerland (L.W.C.).

Specimens studied:

EUROPE

France: Calvados: (as 385. Draparnaldia tenuis Ag.) Leg. et Sẽryint, Roberge, No. 385, 1847 (PC);
Switzerland: in fonte sulfurea "Aarziel prope Bern in Helvetia, Col. Alg. C. M. Diesing, Leg. Kuetzing (as 146. Conferva subsecunda, Isotype) Ann. 1841 (W.L.);

Helvet. Grunow Ac. 1889 No. 325862 (W); ? Acq. 1939, No. 9496 (as Stig. falklandicum Kg.) Leg. Fr. Brand, 11.5, 1896 (W); Bern. (as Conferva subsecunda Kg.) No. 146 (C.L.).

NORTH AMERICA

Florida: Wakulla Co. Phillips Lake, St. Marks Refuge, Leg. C. S. Nielsen, No. 34, April, 1948 (F); Escambia River survey #3, Santa Rosa Co. on saw grass roots and attached to sticks, Col. Hohn, No. 9(2), and 5(2), May 12, 1955 (PH); E. River Survey #2, left bank on saw grass, Col. J. Wallace, No. 18(4), April 1953 (PH); Connecticut: Bridgeport: April 13, 1890 (as Stig. longipilus), F. S. Collins (FH); New Jersey: Pleasantville. Col. F. S. Collins, No. 2053, May, 1891 (BUT.HUJ.NY.FH.); Princeton. In a ditch at Galway Reservoir, Col. J. E. Peters and S. R. Morse (doubtful) (as Stig. longipilus), April 30, 1891, (F.PH.NY.); Louisiana: La Fourche parrish: In a freshwater marsh between Golden Meadow and LeeVille, Col. F. Drouet and P. Viosca Jr. No. 9423 (as Stig. lubricum Kg.) Nov. 26, 1949 (F.NY.); Michigan: Purdy bog. Col. J. H. Graffius, No. P16-7, Sept. 27, 1959 (Graf.); Cheboygan Co. attached to vegetation in running water, Maple river below the power dam.

Col. H. K. Phinney, No. 31 M-41/4, Aug. 18, 1941 (F); attached to grass at margin of bog lake, Nichol's bog, Mich. University. Biol. Station, Douglas Lake, Col. H. K. Phinney, No. 46, July 12, 1942 (F): Wisconsin: Inlet to trout lake, Sphagnum bog near Carrol Lake, Col. G. W. Prescott, No. W345, W7, W-19, 3W-105, 3W223-2, 3W-266, W-361-5, 2W66-2, 2W335 (Pres.) N. Carolina: L. A. Whitford Col. No. Et. 10 (Whit.)

CENTRAL AMERICA

Honduras: Dept. Morazán; vicinity El Zamorano. Col. P. C. Standley, No. 181, Nov. 26, 1946 - Jan. 9, 1947, attached to rocks in swift cool brook, very gelatinous (F).

AFRICA

Algérie: petite source prés de L'Oued Réghaia, 8-5, 1952, Col. Mme. Gauthier-Lievre (AL).

SOUTH AMERICA

East Andes: Prescott Col. No. 234, Gelatinous and filamentous masses on stones in stream. Puyo. swiftly flowing water, small brook. Col. G. W. Prescott, No. 234, Feb. 17, 1953 (Pres.);

<u>Stigeoclonium</u> <u>subsecundum</u> var. <u>tenuis</u> Nordstedt (Emend.)

Pl. 19, Fig. 5; Pl. 23, Fig. 3.

Nordstedt, in Bot. Not., 116, 1880; <u>Ibid</u>. 153-154, 1887; Notarisia, 459, 1888; Kg. Sv. Vet. Akad. Handl. 14, 1888; De Toni, Syll. Alg. I: 202, 1889; Teodoresco, in Beih. Bot. Centralbl. 21: 103-219, 1907; Heering, in Pascher's Süsswasser. 6: 71, 1914. <u>Stig</u>. <u>falklandicum</u> Kg. var. <u>longearticulatum</u> Hansg. Prodrom. 65, 1886; (Wittrock et Nordstedt Alg. aq. dulc. Ex. No. 110 <u>Stig</u>. <u>falklandicum</u> Kg.); De Toni, Syll. Alg. I: 196, 1889.

<u>Stig</u>. <u>longearticulatum</u> (Hansg.) Heering, loc. cit. 6: 71, f.95, 1914; Collins, Gr. Alg. N. Am. 2nd Suppl. Tuft College J. Sc. 4: 75, 1918a.

Plants small, delicate, light green, filaments rarely branched, especially below; branches long, gracefully tapering; cells of main filaments cylindrical; with very little or no constrictions, 7-10-12 µ in diameter, 4-9(-12) times as long; some cells may be short, rarely only 2-3 times as long; cells producing branches may be similar to other cells or may be slightly smaller.

<u>Lectotype</u>: 315. Wittrock and Nordstedt, Alg. Exs; Col. S. Berggren, No. 293, <u>New Zealand</u>:

in rivulis ad Coromandel, 1874;
also Type of Stig. falklandicum
beta longearticulatum Hansg.
Boehmen, bei Lobosotz, July 1884 (W).

Stig. subsecundum seems to be a well-known and well-distributed species, usually growing in cool stagnant water. In winter it has been found under the ice in temperate areas, when the filaments are more mucilaginous. The species is characterized by its scattered branches, dichotomous, alternate, also uniseriate arrangement, and by the absence of opposite branching habit. The chloroplast is also characteristic.

Stig. subsecundum var. tenuis may be regarded as a young stage of the species. Stig. longearticulatum (Hansg.) Heering in all respects agreeing well with this variety and therefore, has been considered here as synonym of the former variety.

The two other varieties, namely, Stig. subsecundum var. javanicum Richter (in Heering, l.c. and in Skuja, Zur Süsswasser. Fl. Burmas, 74, 1949) and Stig. subsecundum var. ulotrichoides Teod. (in Beih. Bot. Centralbl. 21: 103-219, 1907; Heering, l.c. 71, 1914) have been reported. The descriptions of these two varieties are almost identical: in var. *javanicum* cells of main axis 8-12 μ in diameter, usually equal, rarely 2-3 times as long; cells of branches 7 μ wide, 1-2 times, rarely 5 times as long; in var. *ulotrichoides*: diameter of main filaments about 11 μ; cells of the branches 6.6-8.8 μ in diameter, 1½-2½ times (rarely up to 5 times) as long. The above desdriptions gave me the impression that these two varieties may belong to *Stig. variabile*--complex rather than to *Stig. subsecundum*. Sometimes, the young stages of *Stig. subsecundum* may look like *Stig. aestivale* (Hazen) Collins.

Specimens studied:

NEW ZEALAND

In rivulis ad Coromandel; Wittrock and Nordstedt Alg. Ex. No. 315, Leg. Dr. S. Berggren (No. 293), 1874 (L. LD. W. F. G. K. NY.);

ANTARCTIC

Small freshwater pool against snowbank, point No. 13, island, Knox coast, Lat. 66 degrees 31 S. Long. 110 degrees, 26 E. Col. Dr. Apfel, No. 119 (as *Stig. falklandicum* Kg.), Jan. 19, 1948 (F);

ASIA

Japan: Chichibu. Saitama. Col. J. Yamagishi, No. 7, Jan. 1956 (Akiy.); Matsue, Shimane, Col. Akiyama, No. 1., March 1960 (Akiy.);

NORTH AMERICA

Maryland: Somerset Co. Princess Anne, in shallow running water of outlet of ice plant, Col. R. White and F. R. Drouet, No. 2295 (as Stig. attenuatum), Aug. 24, 1930 (F); South Carolina: Darlington Co. on sides of drums through which artesian water flows near Coker College boat house, Hartsville, Col. R. Patrick, Oct. 2, 1946 (PH). Hawaii: Wittr. et Nordstedt Alg. Exs. No. 110. as Stig. falklandicum Kg. In insulis Sandvicensibus, in Conralle Nuanu insulae Oahu. July & August, 1875, deg. Dr. S. Berggren (F.G.W.L.NY.FH .K.).

EUROPE

Roumania: Apud Cotroceni (Bucuresti) in fossis horti botanici; Caepites conferviformis formans, Herb. Alg. Gr. Teodoresco, No. 1074, Feb. 16, 1902 (W.F.); also No. 665, Debrgea, Mangalia, April 6, 1900 (W). Hungary: Vácrátót. from the trough of well with lever No. I. Col. E. Kol, No. 705, 1950, (BP). Czechoslovakia: Böhmen: bei Lobositz. Col. A. Hansgirg, July 1884 TYPE (Stig. falklandicum beta longearticulatum) (W) Lectotype from (F.US.)

<u>Stigeoclonium</u> <u>subuligerum</u> Kg.

Pl. 1, Fig. 5; Pl. 8, Fig. 1; Text Fig.103.

Kuetzing, Spec. Alg. 354, 1849; Tab. Phyc. 3:t.5, f.1, 1853; Collins, Gr. Alg. N. Am. 219, 1909; Heering, in Pascher's Süsswasser. 6:79-81, 1914.

<u>Stig.</u> <u>protensum</u> (Dillw.) Kg. <u>var</u>. <u>subuligerum</u> (Kg.) Rab. Flor. Eur. Alg. 3:378, 1868; De Toni, Syll. Alg. I:200, 1889.

<u>Myxonema</u> <u>subuligerum</u> (Kuetz.) Hazen in Mem. Tor. Bot. Club. 11(2): 200-201, Pl. 30, 1902.

Plant bright green, tufted, 5 cms. or more in length, filaments profusely and irregularly branched, the branches scattered, erect, vertical or at right angles to the filaments; primary branches opposite, alternate or 2-3 approximate and densely set with mostly secondary branchlets; the latter are thorn-like with broad basal cells, gradually tapering to a sharp, acute tip, often attenuate to a short seta; cells mostly cylindrical, may be slightly inflated, short, 11-16 μ (-18 μ) broad, about as long as broad or somewhat longer, or shorter than diameter, cells filled with dense chloroplast.

Type locality: In stagnis Hercyniae, prope Hanau, Col. Theobold. (not seen); New Lectotype (until TYPE is found): 10. Stig. subuligerum Kg., Clausthal; Hanau, Holland, Herb. Kuetzing (L) or, (No. 30. Stig. subuligerum Kg., O. Nordstedt, Norway & Finshoe -- montium Dovrensium, 20/8/1868).

This species, as Hazen (1902) mentioned, should not be confused with Stig. protensum (Dillw.) Kg. as Rabenhorst did who placed it as a variety of the latter species. This species is not so common and apparently looks like Stig. lubricum. The branches are quite characteristic here in this species. A caution may be necessary because sometimes the upper parts of Stig. amoenum may appear exactly like Hazen's illustration of Stig. subuligerum and great care should be taken to identify this species.

Specimens studied:

AFRICA

Algerie: massif de l"Akfadou mare (agoulmine Temfout ?), Tehad Ain Galaka (AL).

ASIA

Nicobar Island: ad sexa in rivulis secus pratos irriguos prope Papiam: Leg. Montemartini et Cavara, No. 629, April 1894. Phyk. Universalis (K.NY.L.W.PC.U.C.).

NORTH AMERICA

Kansas: On U.S. 75 Hwy. a small Cr., near Coffey Co. Burlington, on stone, Col. Dr. Vinyard No. 4, April 11, 1958; (Is.). Canada: Quebec: Longueuil, comte de Chambly; Col. J. Brunel, No. 218, May 26, 1931 (MT).

EUROPE

Norway and Finshöe: Wittrock & Nordst. Alg. Ex. montium Dovrensium, O. Nordstedt No. 30, 20.8, 1868 (C.W.LD.F.L.G.K.NY.F.). Germany: Hanau, Clausthal, Herb. Kuzing, No. 10 & 399 (L.PC.); Sweden: Algae Hallandicae, Varberg: Djupädraktsbäcken, Col. D. E. Hylmö (as *St. protensum*) 20.4, 1928 (C.LD.) "Kyrkogardsbacken" (as *St. protensum*) Col. D. E. Hylmö 16,4. 1928 (C.LD.)

Stigeoclonium pusilium (Lyngb.) Kg.

Pl. 24, Figs.2-4; Pl. 25, Figs. 5-7

Kuetzing, Phyc. Germ. 198, 1845; Spec. Alg. 355, 1849; Tab. Phyc. 3: t.9, f.1, 1853; Rabenhorst, Krypt. Flor. v. Sachs. 267, 1863; Flor. Eur. Alg. III: 379, 1868; Hansgirg, Prodr. I: 67,1886 (not Drap. pusilla Hook. et Harv.); De Toni, Syll. Alg. 199, 1889.

Conferva pusilla Lyngb. Tent Hydr. Dan. t.51, 1819.

Plants bright green, about 1 cm. or more high, filaments stout, cells of main axis and branches gracefully inflated and constricted at the partition wall; branches mostly alternate, scattered, sometimes opposite or 2-3 branches forming a little whorl; basal cells of the branches mostly broader than upper cells which terminate in long colorless hairs; small branches bluntly tapering; cells producing branches may or may not be different from others; cells of main axis 15-20 μ (-25 μ) in diameter, mostly 1-2 times as long, in branches sometimes a little longer.

Lectotype: 18. Stig. pusillum, Herb. Kuetzing, Schleswig. (L).

The cell size and shape of the main axis are similar to Stig. lubricum; the branching habit is more like Stig. subuligerum Kg. but unlike the latter species here the branches are usually terminating in a long colorless hair. It also may appear somewhat like Stig. longipilum because of the inflated cells and long hairs but branching is not so dichotomous or radiating type like the latter species. Sometimes, the barrel-shaped cells of this species may resemble Stig. protensum but the latter species has rather elongated cells and characteristic apical cells with sharply pointed tips.

Stig. pusillum var. irregulare Rab. Flor. Eur. Alg. 3: 379, 1868; De Toni, Syll. Alg. I: 199, 1889.

This variety is not adequately described and illustrated, and thus, it is not possible to designate its systematic position properly.

Specimens studied:

EUROPE

Germany: Leipzig: A. Rab. Alg. Sach. resp. Mittel, Col. Bulnheim, No. 974, April 1859 (NY.K.F.FH.G.W.); Ehrenbergs Teich (?) No. 117, 1859 (NY); Schleswig. Herb. Kuetzing, No. 18 (L); Liesing ?. Col. Grunow. No. 11613 (as Stig. pusillum forma), Leg. A. Grunow (W); Switzerland: Schleswig-Tessen, Col. Grunow No. 11679(W).

AFRICA

Algerie: massif de L'Akfadou, Temjout, Col. Mme. Gauthier-Lievre (AL).

Stigeoclonium stagnatile (Hazen) Collins

Pl. 16, Figs. 1-3; Text Fig. 90.

Collins, Gr. Alg. N. Am. 221, 1909 (reprint, 1928); Prescott, Alg. W. G. L. A. 117, Pl. 11, f.3, 1951a. Myxonema stagnatile Hazen, in Mem. Tor. Bot. Club, 11(2): 207, Pl. 36, f.1, 2, 1902.

Tufts attached to floating leaf margins or other substrates, sometimes becoming free-floating; filaments elongate, delicate, bearing branches at widely separated intervals; branches solitary, opposite or sometimes 2-3 arising from the same place, long-drawn ending in a sharp point, rarely setiferous; branchlets may be short, thorn-like and curved; cells of the main filaments cylindrical without constriction, 7.5--11 μ (mostly 9.5 μ) in diameter, 1-2 times as long, sometimes 3-6 (specially near branching) times as long as broad.

This is one of the doubtful species whose exact nature still has to be investigated and determined. No type specimens were available for our study. Hazen and others have mentioned that they always found this species floating on the water surface, which however, should not be taken as a specific character. Hazen further mentions that this species resembles Stig. protensum which I found to be true. The branching habit of the species is more or less like Stig. protensum and very much like Dillwyn's Fig. C, Pl. 67, 1809. Dillwyn, however, mentioned that in older filaments the cells frequently become inflated (shown in Pl.67, f.C. 1809). Here in this work Stig. stagnatile is provisionally accepted on two points, namely, first, that the cells of the filaments are cylindrical without being inflated and no constrictions at the partition wall, whereas in Stig. protensum cells of the main filaments and branches become inflated and barrel-shaped;

and second, that the branches are equally alternate and opposite in arrangement and are tapering to a fine point or setiferous, whereas in Stig. protensum branches are rarely opposite, and the long, sharply-pointed colorless tips of the branches are quite characteristic.

Several collections under the name Stig. stagnatile from different herbaria on examinations were found to be Stig. protensum, in which the cells are mostly barrel-shaped; only in young branches are they cylindrical. This casts strong doubt as to whether Stig. stagnatile could be a certain stage in the life-cycle of Stig. protensum. Prescott's (1951) illustration of Stig. stagnatile appears to be more like Stig. subsecundum Kg.

The growth form of Stig. stagnatile was found to appear like what Kuetzing had shown for Stig. irregulare Kg. Stig. stellare Kg. Sometimes, it also appears like Stig. elongatum when several irregular branches arise from same area. Comparative cultural studies are needed to determine the distinct limits of these species.

Specimens studied:

NORTH AMERICA

North Carolina: Wayne Co. Sleepy Cr.; attached to floating leaves margin; Col. L. A. Whitford. July 3, 1958 (Whit.)

Stigeoclonium tenue (Ag.) Kg.

Kuetzing, Phyc. Gener. 253, 1843; Phyc. Germ. 197, 1845; Spec. Alg. 353, 1849; Tab. Phyc. 3: Pl. 3, f.1, 1853; Rabenh. Flor. Eur. Alg. 3: 377, 1868; Kirchner, Krypt. Flor. Schles. 2: 68, 1878; Hansgirg, Prodr. Alg. Boehmen, I: 66, 1886; Wolle, F. W. Alg. U.S. 3: Pl. 96, f.11, 1887; Cooke, Brit. F. W. Alg. 189, Pl. 73, f.3, 1883; Ibid, 271, 1902; De Toni, Syll. Alg. I: 197, 1889; Wildemann, Flor. Alg. Belg. 44, 1896; Collins, Gr. Alg. N. Am. 217, 1909; Heering, in Pascher's Süsswasser.6: 111-112, 1914; Prescott, Alg. W. Gr. L. Area, 117, 1951a; Tiffany & Britton, Alg. Ill. 34, Pl. 70, 1952.

Draparnaldia tenuis Ag. Alg. Dec. 40, 1814; Syst. Alg. 57, 1824; Icon. Alg. Eur. Pl. 38, 1828-35; Hassall, Brit. F. W. Alg. 123, Pl.11, f.2, 1845 and 1852.

Myxonema tenue (Ag.) Rab. Deutsch. Krypt. Flor. 2(2): 100, 1847; Hazen, Mem. Tor. Bot. Club. 11(2): 202, Pl. 32, f.1-2, 1902.

Myxothrix tenuis Trevis, Alg. Ten. Udin., 16, 1844.

Stigeoclonium tenue var. geniunum Kirch. Alg. Sachles. 68, 1878; Hansgirg, I:66, 1886; De Toni, Syll. Alg. I: 197, 1889.

Stigeoclonium irregulare Kg. Phyc. Germ. 197, 1845; Spec. Alg. 353, 1849; Tab. Phyc. 3: Pl. 4, f.3, 1853.

Stigeoclonium tenue (Ag.) var. irregulare (Kg.) Rab. (non Alg. Exs. No. 1665 !); Flor. Eur. Alg. 377, 1868; Wolle, F. W. Alg. U.S. 111, 1886; Hansgirg, I: 66, 1886; De Toni, Syll. Alg. I: 197, 1889.

Stigeoclonium tenue Klebsi, Pascheri and Westi, Heering in Pascher's Süsswasser, 1914, 78-81.

Stigeoclonium tenue (Ag.) var. bulbiferum Wolle, F.W. Alg. U.S. 111, Pl. 96, f.12, 1887; De Toni, Syll. Alg. I: 198, 1889.

Stigeoclonium stellare Kg. Phyc. Gener. 253, 1843; Phyc. Germ. 198, 1845; Spec. Alg. 353, 1849; Tab. Phyc. 3: t.4, f.2, 1853; Rabenhorst, Flor. Eur. Alg.

3: 381, 1868; (*Conferva stellaris* Ag., *Conferva stellaris* Roth.).

Stigeoclonium irregulare Kg. beta *natans* Kg. Spec. Alg. 353, 1849.

Conferva exigua Dillw. Brit. Conf. 1809. ?

Doubtful synonyms:

Stigeoclonium tenue var. *epirhyticum* Hansg. Prodr. I: 56, 1886.

Stig. tenue var. *lyngbyaecolum* Hansg. Prodr. II: 227, 1886.

Stigeoclonium gracile Skvort., Pr. Harb. Soc. Nat. Hist. Ethn. N.2: 7, Pl. 10, f.8-14, 1946.

Well-developed plants forming cushion, turf of tuft, lubricous, few mm. to 5-10 cms. (sometimes more) high; bright green; profuse erect filaments developed from prostrate parts; branches simple, attenuate and opposite, usually developed from angular cells smaller than others; cells of main axis cylindrical, little constricted, 6-15 (rarely 18 ?) μ diameter, 2-5(-6) times longer than broad (usually 10-12 μ diameter, and 2-3(-4) times longer; branches gracefully attenuated or tapering into thin, colorless tips, rarely finely setiferous and usually without long hairs; at the upper part the secondary branches may be short, scattered, or alternate, or long, slender and crowded to form bushy long-drawn tufts (appearing as a horse tail); chloroplast filling the smaller cells, in long cells occupying the middle portion; sometimes, prostrate part may be palmelloid or with profuse rhizoids.

Stigeoclonium tenue (Ag.) Kg. var. *tenue*

Pl. 1, Figs. 2-4; Pl. 6, Fig. 1; Pl. 8, Fig. 5; Text Figs. 42, 69, 81.

Syn: Same as species.

Thallus bright green, filaments delicate, lubricous simple, branches both alternate and opposite, mostly from short angular cells, not forming remarkably long-drawn tufts at the end of the branches; cells of main filaments mostly 8-12 μ diameter (rarely -15 μ), 2-4 times longer than broad, little-constricted under cultural conditions cells may be quite long and narrow; sometimes become short and *Palmella*-like.

Specimens studied:

NORTH AMERICA

Alabama: Baldwin Co.: in a road side pool, between Fairhope and Grand Hotel, Point Clear, Col. Louderback and Drouet, No. 10165, Dec. 20, 1948 (F); California: Marin Co.: Tomales Bay, N. L. Gardner, P.B.A. No. 2235, June 1914, (C.NY.); Guadeloupe Island (near W. California) Algae Californica: Col. Dr. E. Palmer, 1875 (Pres. FH.); Santa Clara Co.: on small rocks in rapids of Coyote Cr., San José, Col. J. Fr. Macbride, No. 7806, Sept. 1944 (Pres. FH.); San Barnardino Co.: S. California on dripping-water-fiber, Col. S. B. Parish, No. 2636, April 4, 1893 (FH); San Francisco: Col. N. L. Gardner, No. 82 (3257) March, 1916 (K); Herb. Ger. J. Hollenberg: attached to roots, stones, in slow streams at lower end of spillway leading into Puddington Lake, near La Verne, Col. G. J. H. No. 2613, 3.29, 1939 (F): Yuba Co. from mouth of race flowing out Yuba River opposite mouth of Dry Creek, 10-15 miles east of Marysville, Col. G. H. Giles, No. 35, Aug. 18, 1933 (F); Eldorado Co.; on rocks at mouth of Canyon Cr. on Middle Fork of American River, G. H. Giles No. 10, July 8, 1933 (F); Santa Clara Co.: Lake in Los Trancos Woods near Stanford University, Col. Fr. Drouet, D. Richards and O. A. Johansen, No. 4328, Sept. 29, 1941 (F); Nevada Co.: mouth of south fork, Yuba, 1 mile west of Bridgeport, Col. G. H. Giles, No. 45, Sept. 1, 1938 (F); Contra Costa Co.: San Joaquin River, on Scirpus, Col. Reimer, No. 5(1), May 1955, S. J. River Survey (PH); San Francisco: Lake Merced on stones and grass (P.B.A. No. 1731, Col. W. J. V. Osterhout, and N. L. Gardner, June, 1903 (L.K.MICH.C.NY.W.); Lake Merced, N. L. Gardner, No. 1013, June, 1903 (L.MO.G.NY.FH.).

Canada: Québec: Saint-Hyacinthe (comte de St. Hyacinthe) terrain du seminaire, Dans source d'eau minerale, Col. O. Rournier, No. 287, Mai 15, 1931 (MT); Grenville: (comte d'Angenteuil), fixé aux pierres, au bord des rapides de la riviére Ottawa, Col. J. Brunel, No. 120, Sept. 23, 1930 (MT); Lac Jacques-Cartier (comte de Montmorency), fossé le long du Chemin sur cailloux, brindilles etc. Alt. 2600 pieds, Juin, 1938, Col. J. Brunel No. 514 (MT); Baie Johann-Beetz. (comte de Saguenay),,dans la riviére, (doubtful) Col. J. Brunel, No. 636, Aug. 1, 1939 (MT); Lac Jacques-Cartier (comte de Montmorency), fixe aux pierres dans un ruisseau rapide, en arriére du camp. Col. C. Lanouette, No. 547, July 11, 1938 (MT); Riviére Archambault, prés du lac Superieur, (comte de Terrebonne), su pied de la Chute Archambault, Col. J. Brunel, No. 1113, Oct. 12, 1952 (MT); Sainte-Marguerite (comte de Terrebonne) dans la riviére du Nord, sur les pierres des rapides, July 12, 1953, Col. J. Brunel No. 1220, (MT); Ontario: Pelee Point: on concrete blocks in water (Lake Erie); Col. C. M. Wetmore, Oct. 10, 1959 (Is.); La Vase River Survey #1, West Ferries Township near Nipissing Junction, Col. Hohn, Sept. 24, 1957 (F); Grenville Co.: St. Lawrence River, on dock, Col. R. Patrick, (6(3A) (PH), Col. J. Wallace, No. 15(2), 16(2), Aug. 1952 (PH). Colorado: In a drinking fountain at Rio Grande railroad station, Canyon City, Col. H. B. Louderback (as Stig. lubricum) Aug. 24, 1946 (F); Connecticut: near Ridgefield, Col. R. Weikert, May 26, 1935, (NY); Fairfield Co.: in running water sluice below Moody's dam, Bridgeport, Col. L. N. Johnson, No. 160, and 160a. July 11, 1892 and June 17, 1892 (NY); Bridgeport, Holden Collection, 1892 (MICH), No. 517, Dec. 12, 1891 (FH); Below factory pond, Feb. 2, 1890, Herb. I. Holden, (FH); Lower Mystic pond, 11 April, 1909 (FH); Florida: Leon Co.: rapidly flowing water in culvert from road side pond into Crane Lake, Col. S. Nielsen, No. 8, Mar. 1948 (F); St. Marks River at Little Natural Bridge, Col. C. S. Nielsen, G. C. Madsen, and D. Crowson No. 564, Oct. 1948 (F); Wakulla Co.: in an outlet of a large sulphur spring bathing pool about 1 mile north of Newport, Col. F. Drouet, D. Crowson, and R. Thornton, No. 11388, Jan. 25, 1949 (F); Bay Co.: in seepage along the sea wall, St. Andrews Bay, Cove Hotel, Panama City (doubtful form), Col. F. Drouet, and C. S. Nielsen, No. 11616, Jan. 30, 1949 (F); Wakulla Co.: Club Sulphur springs, Philips picnic ground, New Port, Col. Nielsen No. 179 (?), July 1948, also Nos. 213, 218, 164, Aug. 1949 (F); also July 23, 1952 (F); New Port: shallow water in log pool, Col. A. Johnston (?), No. 84 (as Stig. lubricum), 11/11/50 (F). Georgia: Burke Co.: Savannah River, on Bamboo stem, Col. Reimer, No. 9(5), S. R. P. #6, Aug. 31, 1955 (PH). Illinois: Chicago: Lake Michigan, 1893 (MICH); Livingston Co.: on wet rocks in the outlet of sewage-disposal plant at the Vermilion River, Pontiac, Col. Fr. Drouet and H. Louderback, No. 5263, Oct. 24, 1943 (F); Cook Co.: Lemont, Col. G. T. Velasquez, O. Richards, and Fr. Drouet, No. 2500, Aug. 4, 1939 (F); Chicago: basal part ? young plant, Col. W. Morrison (F); Kane Co.: on stones in shallow water, west shore of Fox River, south limit of St. **Charles**, Col. Nos. 11797, 11799, May 14, 1949 (F. MICH.) on mussel shell in shallow water of Fox River, south of Main Street, St. Charles, Col. H. Louderback and Fr. Drouet, Col. No. 5333a, April 15, 1944 (F); Col. from Promontory Point, Chicago, culture made from that collection: D. F. Chapp, 1950 (F); Cook Co.: in shallow water of a cattle pond, south of Lincoln highway and east of Illinois Central railway at 215th St. West of Chicago Heights, Col. Louderback and Drouet, No. 5458, July 2, 1944 (F). Indiana: on stones at edge of Thistle thwaite falls, Richmand, Wayne Co. Col. L. J. King, June 1943 (F); Culture collection from Indiana University, Nos. LB.437,433 (IND); Marshall Co.: Lake Maxin Kuckee, on stones, Col. H. W. Clark & B. W. Evermann, No. 44, Nov. 13, 1906 (US) and near the ice house, outlet Bay, Col. Clark & Evermann, No. 269, Nov. 28, 1904 (US). Iowa: Green coatings on moist bottom of old pool bed, road side, 2 miles north of Iowa City, Col. G. W. Prescott, No. Ia, 2, Sept. 18, 1924 (F); in watering trough, Col. C. M. Hobby (US). Maryland: Calvert Co.: on shells in shallow water of the Patuxent River, Solomon Island, Col. Fr. Drouet, E. P. Killip, and F. R. Fosberg, No. 2996, July 26, 1941 (F); Montgomery Co.: Potomac River, r.b. and l.b. on sticks, on rocks, Col. Hohn, Nos. 12(2) & 9(2), June 13, 1956 (PH); also, Hohn, No. 14(3), Aug. 23, 1957, r.b. on log, and Hohn No. 25(3), P.R.S. on plants, June 19, 1956 (PH); Massachusetts: In tidal pools on rocks, Rockport, Col. A. H. Moore, No. 1550, April 19, 1904 (F); Malden: Ex. Herb. F. S. Collins and Peabody Ac. of Sci. April 30, 1884 (F); Malden: Middlesex flora, April 1880, in running brooks (NY); Chestnut Hill, Herb. H. Schrenk, April 24, 1894 (MO); Newton: Herb. B. Moore Davis, 1893 (MICH); Burlington: watering trough, No. 155: M: (FH). Mexico: Texcoco: The national school of agriculture drainage canal on grounds, canal on left of road, no odor of H_2S, covered with Lemna, Col. R. Patrick, No. 169, July 28, 1947 (F); Orizaba: (Stig. tenue Kg. in Conferva Ansonii Ag.) (W); Michigan: Sherman Lake, Kalamazoo Co.: Col. Dr. Wade, July 1959 (Is.); Lake Lansing, Col. D. Jackson, Nov. 7, 1959, April 1960 (Is.); Col. Dr. Guarrera and Dr. Prescott, April-May 1960, from Round Lake and Lake Lansing, (Is.); on aquatic plants in a small lake near Lansing Air Port, Col. P. J. Halicki, May 1958 (Is.); on stones, and floating in Red Cedar River, Col. E. Hansman, 1958, also by N. Islam, 1957, Sept. (Is.); in a small pool, Hort.

Garden, Michigan State University Campus, April 18, 1960 (Is.); in a acid bag, 1 mile from Kellogg Biological Station, M.S.U. Col. H. Graffius, Sept. 24, 1959; Minnesota: Minneapolis: Mississippi River 10th ave. Hennepin Co. Col. Fr. Drouet, No. 4974, Aug. 1943 (F); J. E. Tilden Col. No. 15, 1894, (F.NY.US.); Duluth: Lester River Falls, Aug. 14, 1902 (FH); Mississippi: Hattiesburg: Col. R. L. Caylor, No. 31 (F); Harrison Co.: in shallow water of a freshwater reservoir on the shore of Miss. Sound, west part of Gulfport, Coll. Fr. Drouet and Caylor, R. L. Nos. 9930, 9933, Dec. 12, 1948 (F); Cole's Cr. near Crosby, on woods in a stream, Col. R. Caylor, No. 16 (as Stig. lubricum,)1943 (F); Crosby: from overflow pipe at Mill, where the stream and water mixed for use in boilers, temp. 31 degrees Centigrade, pH 6.8,Col. R. Caylor, No. 14, 1943 (F). Montana: Flathead Co.: on stones; in the shady portion of a cold, rapidly running stream, Cresest (?), Col. F. A. Barkley, No. 6051, May 16, 1942 (F); Yellow Bay, on pine logs on the shore of Flathead Lake near Montana State University Biology Station, frequently washed by big waves, Col. N. Islam, No. M.2, from 21, June to Middle of July, 1958 (Is.); Sand Coulee, near Great Falls, Col. F. W. Anderson, July 1888 (NY); Pond 2, near Ronan: tufts attached to aquatic plant roots in 2 inches of water. Col. J. Schindler, 74 N. Pond 2, July 14, 1953 (Is.). Nebraska: Hall Co.: Sewage disposal outflow, near Grand Island, alt. 1940, Col. W. Kiener, Nos. 15140, 15141, 15144, 15146, 15150, 15152, Aug. 28, 1943 (F.L.MICH.FH.NY.); No. 15149, Aug. 1943 (L); Arthur Co.: on submerged stems, Beeken Lake (?), alt. 3600, Col. W. Kiener, No. 16032, Oct. 22, 1943 (F); Lincoln: North Platte, W. Kiener, Nos. 16869, Feb. 25 and 16972, July 13, 1944 (F.L.MICH.); Lonergan Cr., Lemoyne, W. Kiener, No. 23012, 1948 (F); Lancaster Co: Lincoln. W. Kiener, No. 14146, 1943-44 (F); Dundy: Hatchery House outlet, N. of Parks, floating, No. 21373, March 1947 (F). Nevada: Esmeralda Co.: Silver Peak range, Big springs: scraped off rock in running water, Col. G. C. Christenson, No. 2762, July 17, 1956 (F). New Jersey: Plantae Novae-Caesareae: on dead leaves in pools, river bed, Boontown, Moris Co. Col. H. Habseb, No. 3127, July 2, 1950 (F). New Mexico: On slides suspended in open water for a week in a pond in the lava beds 6-8 miles east of Grants, Valencia Co.: Col. A. Lindsey, 1949 (F). New York: Ontario Co.: scraped from underwater rocks near shore line of Seneca Lake, just south of the mouth of Reed's Cr. Col. D. Haskins, No. 3, 1944 (F); Long Island, near Islip, Herb. Fr. Wolle, Col. T. F. Allen, 1892 (F.FH.); New York City, Brook Summerville, Staten Island, Col. T. E. Hazen, No. 329, April 24, 1900 (F); from Lorillard spring, Bronx Park, Leg. T. E. Hazen, No. 371, May 1, 1900 (F); Lebanon Springs, K. Harrison, Jan. 8, 1895 Johnson (MO.FH); Brook near Rusun(?) Pond, Herb. F. S. Collins, June 1879 (NY); Herb. Collins, F. Water Algae, U. S. C. M. Hobby (NY); New York City: Botany Garden, Bronx Park, Col. T. E. Hazen, Oct. 8, 1904 (F); Herb. G. T. Moore, S. S. Murie, 8, 5, 1889 Johnson (MO). North Carolina: Durham Co.: Col. H. L. B. Jan. 25, 1933 (DUKE); Col. Dr. L. A. Whitford, No. Dd-7, on submerged can, Yadkin River, Davidson Co.: June 25, 1959 (Whit.); West Selma Brook, Johnston Co. Col. L. A. Whitford, No. 5 (Whit.); Richmond Co.: Mountain Cr. Col. L. A. Whitford, No. Rc-13 (expression like young Stig. amoenum), July 24, 1958, (Whit.); Johnston Co.: on rocks in rapids, Neuse River, N. of Clayton, Col. L. A. Whitford, No. W-344, Nov. 17, 1958 (Whit.); Wayne Co.: Sleepy Cr. Rapids, Col. L. A. Whitford, No. Wn-92, Sept. 7, 1958 (Whit.); White Oak River, Onslow Co.: Col.LA. Whitford, 1958 (Whit.);

Wayne Co.: on Sagittaria and Moss, Sleepy Cr. Col. L. A. Whitford, No. WA-7, Jan. 12, 1958 (F). <u>Ohio</u>: Allen Co.: Ottawa River Survey #2, on rock, Col. Hohn No. 1(2), July 3, 1956 (PH); in road side ditch, North Appalachian Expt. Watershed, Coshocton Co.: Col. L. King, No. 1044, June 5, 1943 (FH). <u>Pennsylvania</u>: Berks Co.: rock scrapings, riffle, r. bank, Schuylkill River, west Leesport, Col. J. H. Wallace, No. 4, Oct. 1, 1953 (F); Lititz Run, Disston, Lancaster Co.: Col. J. Wallace, No. 104 c. (F); Lancaster Co.: Lititz Run, Col. J. Blum, No. H. 131, 133, summer, 1948 (F); in Conestoga Cr. at Wabank bridge, Col. R. Patrick, No. 9A, 1948 (F); Bethelhem, Col. Fr. Wolle, 1876, several mounts, (L.IA.FH.); Philadelphia Co.: M. C. A. Survey, Wissahickon, Montgomery, Col. Hohn, I(W), Sept. 12, 1956 (PH); Warren Co.: under running water, on cement, Col. T. Flanagan, No. 72 (as <u>Stig</u>. <u>lubricum</u>) July 21, 1943 (F); Chester Co.: white clay Cr. on rock, Col. Hohn. 2(1), July 17, 1956 (PH); Schuylkill River, Montgomery Co. Col. P. J. Halicki, July 1960 (Is.). <u>South Carolina</u>: Savannah River: Aiken Co.: Col. Dr. S. Robuck, Aug. 19, 1959 (PH); ? Schweinitz Herb. recd. in 1834 (as <u>Conf</u>. <u>lubrica</u>) Col. Jurgenssen

(PH); Allendale Co.: Savannah River, Pr. No. 3, l.b. Col. R. Patrick, 18(5), Jan. 1952 (PH); Barnwell Co.: S.R.Pr. #3, Col. R. Patrick No. 6(3), Jan. 1952 (PH); on log 3rd. dike, Savannah River, Pr. #1, sta. 3, Col. R. Patrick, July 1951 (as 61. Stig. lubricum) (F); Chester Co.: White Clay Cr. on rock, Col. Hohn, No. 2(1), M.C.A.S., July 17, 1956 (PH). Tennessee: Sevier Co.: Gatlingburg, attached to clay in clear road drain, Roaring Fork Rd., Col. H. Silva, No. 701, April 13, 1948, University of Tennessee Herb. (F); Shelby Co.: attached in stream, along hwy. US. No. 70, Col. H. Silva, No. 1087, June 30, 1949 (F); Anderson Co.: Norris Lake Dam Dock, Col. H. Silva No. 635, April 12, 1947 (F); Savier Co.: submerged rocks in mountain streams, grassy patch, Col. H. Silva, alt. 3900, Aug. 1941, No. 39 (F). Texas: Attached to rocks, swift running water in Waller Cr. in Sunshine, Travis Co., Col. F. A. Barkley and C. M. Rowell, No. 3, March 6, 1946 (F); Sutton Co.: Joe Logan Ranch: Edward's Plateau, Caliche tank, Col. E. Whitehouse No. 25107, May 5, 1951 (F); Brownsville, south end of Resaca, Belvedare Park, Col. R. Runyon No. 3751, June 23, 1944 (F). Utah: Salt Lake City; in a pool in the rock-bed of the creek in Memory Park, Col. Fr. Drouet and H. B. Louderback, No. 5727 (F); Utah Co.: from pipe of flowing well, old Resort, Utah Lake, Col. E. Snow, No. D 22 (as Stig. lubricum), also D 11, July 15, 1930 (F); and on stump of flowing well where water sprinkles on it, Old Resort, E. Snow, Aug. 17, 1930 (F); and on old tub in pond, Col. E. Snow, No. 120, July 29, 1930 (F), also No. B 10, July 10, 1930 (F). Virginia: Woods, Spout Pond Brook, Herb. F. S. Collins, presented by N. L. Britton, 1922, Col. No. 4369, May 22, 1903 (F.K.L.C. BUT.FH.NY); Narrows, on rocks at edge of New River sewage disposal plant, Col. H. Forest, No. 2809, July 20, 1953 (F); Smyth Co.: N. Fork, Holston River, on rock, Col. J. H. Wallace, June 29, 1954, Col. Nos. 18(1), 19(1), 26(1), (PH). Wisconsin: W. Sup. on island off Pokeg(?) Bay, Col. C. Bullard, Aug. 27, 1902 (F.FH); Osceola: attached to Ranunculus in trout mere, J. E. Tilden Col. No. 19 (as Stig. nanum (Dillw.) Kg. (NY.K.). Hawaii: Honolulu: Cutress's yard, housing area, University of Hawaii, Col. M. Doty, No. 8767, T.H. III-22, 1951 (F).

CENTRAL AMERICA

Guatemala: Lake Amatitlan, W. A. Kellerman, No. 5069, Jan. 1906 (MICH.FH.F.); Dept. Zacapa, Vicinity of

Zacapa, Col. P. C. Standley, No. 74269 (as Stig. lubricum), Oct. 7-16, 1940 (F); Honduras: On dead branch in rivulet, vicinity of Comayagna, Col. P.C. Standley and J.C.P. No. 5902 (as Stig. lubricum), 12-13 Mar. 1947 (NY); Dept. Morazán: vicinity of El Zamorano, Col. P. C. Standley, No. 181, Nov. 26, 1946--Jan. 9, 1947: attached on rocks in swift cool brook (NY). Jamaica: Golden Grove: St. Thomas, Col. W. R. Taylor, No. 693, April 18, 1956 (MICH). Puerto Rico: Mayaguez; on stones, Col. N. Wille, No. 908, Feb. 8, 1915 (NY.F.); Maricao: Col. N. Wille, No. 1154a, stones, Feb. 15, 1915, Laguna Guanica, N. Wille, No. 1824b. March 17, 1915 (NY.F.); Mayaguez: Auf Garten-mauer, Hotel Paris, Col. N. Wille, No. 984, Feb. 10, 1915 (NY); Arroyo de Los Corchos, Adjuntas to Jayuya, Col. N. Wille, No. 1688a, b, March 13, 1915 (NY).

SOUTH AMERICA

Argentina: Laguna Blanca Grande. Prov. Buenos Aires, Col. Stillman Wright, No. 2108, 1937 (FH); Buenos Aires: Capital, Col. Kühnemann, No. 6494, 14/10/1944 (BA); La Rioja: Famtina, Col. Yacubson, No. 8216, Dec. 1951 (BA); Wittrock and Nordstedt Alg. Ex. No. 515 (as Stig. gracile Kg.), in Rio de Chilecito, Rioja, Col. G. Hieronymus, 1879/13/2: (F. G.). Uruguay: Wittrock and Nordstedt, Alg. Ex. In aqua fluents ad Montevideo, 1891, Leg. Prof. J. Arechavaleta, No. 1429, 9/1891 (K.W.). Brazil: Sao Paulo: Represa, Estãeao Expt. Caca e Pesca, Pirassununga, Col. H. Kleerekoper, No. 6, April 17, 1940 (F.); Dr. Chr. Gobi, Algae rossicae exs. Petropolis: in Neva flumme, prope superficiem aquae, 1873, Col. Chr. Gobi, No. 9A, and Oranienbaum, prope Petropolim, in lapidibus fluminis, Col. Chr. Gobi, No. 9B, 1879 (C); Rio Grande: Do Sul: on Rhynochospora in the Lagõa dos Quadros, Col. H. Kleerekoper (as Stig. lubricum), Dec. 1941,(F); Apiahy ? (as Stig. lubricum var.) May ? (W); Apiahy: "Les Prrhayres" (?), by Puiggari, Oct. 1880, Col. Grunow, 11702 (W); Brasiliae civit Rio Grande do Sul. Cachoerira, Leg. Gust. A:n. Malme, 17/2/1893 (F). Chile: Punta Arenos: On earth, Col. R. Thaxter, No. 7871, 1905-1906 (FH). Peru: Tulumayo River, Catherwood Survey #2, Sta-1, on rocks in shallow water, Col. Hohn, No. 21, (1)c, Sept. 24, 1955 (PH.Whit.). Ecuador: In stream from spring, Col. G. W. Prescott, No. T 371, sta. 21, April 13, 1958 (Pres.).

AFRICA

Gold Coast: On old leaf in stream, mile 66 north of Kumasi on Ejura road, Col. G. W. Lawson, No. A1124, April 12, 1956 (F); Maroc: Daya route de Bous Kouza; and mare pres de Rabat and Sidi-Beltache Haute-Volta, (AL); Algérie: Hamiz an Foudouk (AL). Canaries: (as *Drap. tenuis* Ag.) Despréang, 1838 (G).

ASIA

Japan: Tokyo: Col. J. Yamagishi, No. 5, May 1956 and No. 6, June 1956; Kawada, Kukkui, April 1956 (Akiyama); Matsue, Shimane, Col. Akiyama, No. 3, March 1960; Hokkaido: Asahigawa, No. 20, July 1953 (Akiyama). Nicobar Islands: Hauck et Richter, Phyk. Univ. S. Teresa prope Papiam: in rivulis irriguis, Leg. Dr. L. Montemartini, No. 731 (?) (as *Stig. tenue* var. *lubricum*), 1895 (K.C.PC.NY.). India: Hyderabad: Col. Dr. Suxena, No. 9, in a pond, Public Gardens, free floating (HY); Lalaguda, in a ditch, Col. Dr. Suxena, No. 1 & 7 (HY); Merralum, Col. Dr. Suxena, No. 2, Nallagunta, Col. Dr. Suxena, No. 3, R. Moosa Bridge, No. 5; Seeta-flamandi, No. 11, Col. Dr. Suxena (HY). Pakistan: Dacca: in ponds and road side ditches in clear waters, Col. N. Islam (summers, 1954, 55, 56) (Is.).

Burma: Maymyo, Northern Shan States, May 9, 19[illegible], Col. L. P. Khanna, Nos. 637 and 635 (F).

NEW ZEALAND

Auckland: Ramuera: from running water in a road side ditch off Abbott's way, Col. E. C. M. Segar, 3.11.53 (AKU); Grafton: Col. K. W. Lorch, between 1953 and 1955 (AKU).

EUROPE

Albania: Berat: Karbounara: Fosco d'acqua dolce corrente fra canne. Col. G. de Toni, No. 21.a. 10/5/1941 (F); Austria: Wien: Raaber Bahnhof, A. Grunow, No. 11693, Leg. Marcus (W); Raaber ?, (as Stig. lubricum), H. W. Reichardt (NY); (as Stig. tenue Kg. forma ?) leg. Welwitsch, Col. Alg. C. M. Diesing, Anno. 1842 (W). Azores: Santa Maria, ? 1895 (FH). Belgium: Herb. Lud. Batav.: Kanal von Gent near Terneuzen, Riemen, Leg. Y. Koster, No. 1181, April 7, 1948 (L). Czechoslovakia: Čechy: Prelouč. A. Hansgirg, 7/1887 (W); Stupčice u Tábora, A. H. 8/1888 (W.F.); Rovné u Roudnice, A. H. 7/1884 (W); Budy u Říčan, A. H. 7/1885 (W.F.); Všenory. 6/1883. A. H. (W.F.); Vytok vridla. Karlovary, A. H. 8/1883 (W.F.); Horovice. A. H. 7/1884 (W); Dokey. A. Hansg. 7/1883 (W.F.); Böhmen: Seegrund bei Eichwald A.

Hansg. 7/1883 (W.F.); Steinkirchen ad Budweis, A. Hansg. 8/1888 (W.F.); Wittrock et Nordstedt Alg. Ex. 713 (as *Stig. uniformis*) ad rupes fluvii Tepl, ad Carlsbad. O. Nordstedt. 1884 (NY.K.W.); Kaplitz: A. Hansg. 9/1885 (W.F.); Tannwald, Juli, 1885, A. Hansg. (W); Eichwald nächst Taplitz. A. Hansg. 8/1883 (W.F.); Carlsbad: (as *Palmella nana* from Agardh. Herb. J. A. Dec. 4, 1829 (NY); Čechy: Tune v Troja: In agro Pragensi. 5/1885 (W.F.); Žatec: A. Hansg. 8/1883 (W.F.); Karlsbad. Col. Grunow, No. 11706. Welwitsch (W); Čhechy: Počátky. A. Hansg. 8/1888 (W.F.); Semily, A. H. 7/1885, 2298/2 (W); Benešov: A. Hansg. 8/1883 (W.F.); Chotoviny u Tábora, A. Hansg. 8/1888 (W.F.); Kolin: A. Hansg. 9/1888, (W.F.); Modrang u Prahy. A. Hansg. 9/1888 (W.F.); Čechy: Hostivar u Prahy, A. Hansg. 7/1888 (W.F.); and 4/1888 (F); Celakovice: A. Hansg. 6/1887 (W.F.); Neusohl: Rother thurm bei Neusohl. Leg. Marcus. Col. Grunow, No. 11692 (W.FH); Potnocook (?) bei Neusohl (as *Stig. irregulare*), Markus, No. 34, April 18, 1865 (W); Böhmen: Gewässern bei Kunratic. A. Hansg. 1885, bei der Chlumcaner. Zuckerfabrik nächet Laun, A. Hansgirg, 1884, bei Lobositz. A. Hansgirg, 1884(FW); Čechy: Pribram (as *Stig. lubricum*), A. Hansgirg

9/1884; Hlubocepy: A. Hansgirg: 5/1885 (F); Boehmen: Johannisbad, Abfluss der warmen Quelle, A. Hansg. 7/1885 (F); Neudorfl prope Kreibitz, 8/1889, A. Hansg. (F); Čechy: Bělă; A. Hansg. 8/1883 (W); Böhmen: einem Teiche bei Pisek an Acorus blättern (as Stig. tenue f) epiphyticum Hansg. TYPUS), Col. A. Hansgirg, Aug. 1883 (W).

Denmark: Marienberg, Moen: A. Ingersler, 10.3. 1898 (C). England: ? Ex Herb. Berk. 6/89 (as Drap. tenuis Ag.), W. Hassall, April 3, 1843 (K); Cambridge: (as Drap. tenuis): comm. J. S. Henslow (K); Ex Herb. Berk, 6/89, J. Ralfs, 1841 (non Cambourne) (K); Dorking: sewage grounds effluent, Roy. Comm. Sewage Disposal, 13/3. 1908 (K); Hampshire: Rev. A. E. Eaton, 29.5. 76 (K); Ireland: (as Drap. tenuis Ag.), Ex. Hibernia (C); Gloucestershire: at Fairford: in small pond near River Coln. Col. W. L. Tolstead, No. 8447, Sept. 13, 1944 (F);

Finland: Al. Saltvic, Kvarnbo. Påo stenar i en strid băck. Leg. Runar Collander, 26/6/1914 (H); Tavastehus : dike mellan jarm, Leg. Emrfllăyren (?), 16.9.1934 (H); Nylandia: Helsingfors, Leg. E. Häyrén, 20/5/1923 (H); N. Turby, Klemetokog, Lillan, Carl Cedercreutz, 28/9/1947 (H); Ekenos Stad, Leg. E. Häyrén, 17.8.1920 (H).

France: Herb. Persoon ? (as Conf. lubrica Lyng. and Drap. tenuis Ag.) (L); Herb. Persoon, Deoades ? (as Conf. lubrica) (L); Prés Paris, Petel Chantilly: Herb. Persoon, Herb. Lugd. Batav. (as Drap. tenuis Ag.) (L); Vire: L. H. Buse, No. 294 (as Drap. tenuis Ag.) (L); Volgen, Col. A. Brébisson (L); Falaise: Col. A. Brébisson (L.NY.); Vire: Col. A. Brébisson, 1839 (L); Vire: (as Drap. tenuis var. hypnosa), Chaurin, Herb. Lenormand (L); Angela (L); Vire: Herb. Lenormand (Drap. tenuis ad fontes) (L); Vire: Kuetzing, Herb. No. 353 (L); Caen: La Normandie y Chaurin (L); Yvetot, Herb. Lenormand, No. 351 (L); Caen: Chaurin (Drap. tenuis) Herb. Suringar (L); Vire: (as 187. Myxonema lubrica Fries) (L); ? Crypt. de France, Desmaziéres, No. 464 (as Drap. tenuis Ag.: Conf. protensa, etc.) 1857 (W.K.G.PC); Vire: Leg. Lenormand, 1839 (as Drap. tenuis), Col. Alg. Diesing, Ann. 1843 (W.PC.); Luc (?), Calvados: Ex. J. Chaurin (as Drap. tenuis) (LAU); Merdret (?). Herb. Lebel, No. 351/3(2), 1859 (PC); Valognes le Broc, No. 391, Herb. Lebel, March 11, 1860 (PC); Herb, de L'Abbe P. Frémy: sur vegetaux aquatiques dans im fossé due ? de Lessay (Manché) June 1, 1925, P. Frémy, (NY); Vire: (Calvados): Algues de France (as 490. Stig. tenue var. lubricum) R. Lenormand) (L); Illegible. Herb. Lebel, No. 817, Quineville ?. (PC); Vosges: A. Brébisson: (FH. F.); Vosges: Mougeot. Roum. & Dupray. Alg. des. Eaux Douces (as 1297. Stig. tenue f. irregulare (Kg.) Rab.), Demangeon (K). Germany: Hanau: Herb. Kuetzing, No. 165 (as Stig. stellare (Ag.) Kg.), (L); Flensburg, Hansen, Herb. Suringar (L); Herb. V.D.B. in H.L.B. Aug. 1845, Mb. (L) and Mb, No. 395 (L); Spreé: Herb. Kon. Ned. Bot. Ver. Jan. 28, 1859 (as Stig. tenue (Ag.) Kg. Rab. irregulare (Kg.) Rab.). (L); Leipzig: Rab. Alg. Sach. No. 490. D. Bulnheim (W.G.); Schleswig: An steinem in Teichen im Herzogthum, Col. R. Häcker, No. 418 (as Drap. tenuis, Myx. tenue Fr.), Breutel Alg. Ex. (W); Schleswig : (as Drap. tenuis var. elongata), Leg. Suhr. Col. Alg. C. M. Diesing, Anno. 1841 (W); Levera: Leg. Mertens et Jürgens (as 10. Conf. lubrica Dillw. Drap. tenuis var. elongata) Col. Alg. C. M. Diesing Ann. 1841 (W); Dresden: "Grossen Garten": Im Brunnen, Rab. Alg. No. 935 (as Stig. irregulare Kg.) L.R. 1860 (K.NY.L.G.); Berlin: Col. Grunow, No. 11707 (W); bei Wurzen: on Sphagnum. Herb. Otto Kuntze (NY); Polenz, Leg. Reuter (NY); Freiburg: Herb. Otto Kuntze, Col. de Brébisson; A. Braun, No. 167, 1849 (NY.PC.); Leipzig: (as Drap. tenuis) ? No. 831, 1853 (NY); D. Bulnheim, Dec. 1857 (G); Eisenach: An einem Wehr. Crypt. Germ. Austriae et Helvetiae Ex. Leg. W. Migula, No. 121, Oct. 1905 (G.U.C.NY.Z.); Anger bei Leipzig im Teiche. Auerswald, No. 197 (G); bei Lennep. Rheinland (as _Stig. elongatum_), H. Royers, April 21, 1901 (F.MT.); and also (as _Stig. irregulare_), H. Royers Oct. 26, 1902 (NY); bei Berlin: Bauer No. 29. Aug. 13, 1852 (W); Berlin: Tempelhet ?, A. Grunow, No. 11691, 1849 (W); Schleswig, Leg. Hauker (W); Leipzig: Gráben: Bulnheim (LAU); Schlensingen: (as _Stig. irregulare_ beta _natans_ Kg. and _Stig. tenue_ (Ag.) Rab. var. _irregulare_(Kg.) Rab.) 13 mounts, Herb. Kutzing (L); (as 13. _Chloromitus tenuis_ ?) Herb. Hormany ?, F.R. Kuetzing (NY); Leipzig, bei Dolitz ? (as _Stig. irregulare_ Kg.), June 1873, Leg. Rueter ? Herb. O. Kuntz (NY); Leipzig: D. Bulnheim, No. 490, Herb. E. A. Rau (NY); Leipzig: Leg. Auerswald (as _Stig. flagelliferum_), 21/8/1852 (F). _Holland_: Eindhoven: on fish in an aquarium growing on fish scale fins. Leg. W. A. M. van Bergeijk, 9/7/1952 (L); Neercanne ?, Leg. R. A. M. Geesteranus, No. 6881, 21/3/1950 (L); Velserenel ?, (as _Stig. tenue_ forma _irregularis_ Rab.), Leg. A. Weber v. B. No. 453, April 17, 1887 (L); Leiden: Leg. W. R. Suringar, No. 102, April 1854 (L); Botshol: Leg. C. d. Hartog, No. 2444, March 24, 1957 (L).

Hungary: Magyrarhon virányaból Hazlinszky Frigyes, Sept. L. Markus (NY.BP.); Nagyszekso: Flora Hung. Ex. No. 923; Mens. Leg. F. Filarszky, July 1926 (LD.G.K.BP.MICH.C.FH); Newohl, Ungarn, Leg. Markus (B); Muggotsee ? April 1892 (B); Hortobágy: Kenya farm, from wooden bucket of a well with a lever, Col. E. Kol, No. 114, July 30, 1951 (BP); Flora Hungarics. Leg. F. Filarszky, No. 923 (F.W.). Italy: Herb. Samuel Ashmead, 1850-1864; sq. dacile; Janandini (as 348. Stygeoclonium stellare Kg.) (PH): Genova: Herb. W. van Bosse: Dufour. No. 50, April 1857 (L.PC.G.B.); presso Gradisca (gorizia, Veuezia, Giulia) Leg. L. Ferlan #2 (as Stig. lubricum), Sept. 1946 (F); Faseno prope Firano: A. Hansg. 7/1889 (W.F.); Tirol: Kematen-Zirl. A. Hansg. 1891 (W.F.). Norway: In rivulis ad off. ferr Naes (?), Norvegia (as Conf. lubrica Dillw.), Herb. A. Mørch. Leg. C. Bosenberg (?), 8/7/1899 (C). Portugal: Ramalde near Oporto, Col. Isaac Newton, April 1883, Hauck et Richter, Phyc. Univ. No. 279 (L.W.K.U.C.PC.F.). Roumania: ? Bucurezts-Cotroceni, in rivulus Dimbooita. Dr. E. C. Teodoresco. No. 1239, Dec. 12, 1902 (F); Ciocianesti: in fonte. ad radices plantarum affica. E. C. Teodoresco, No. 7309, April 29, 1903 (F); also

No. 1409, Jan. 31, 1904 (F); Dist. Vlasca: Comana. in alvee aquaris fantes. Dr. E. C. Teodorescu. No. 1225, Oct. 8, 1902 (F); Herb. Alg. Romaniae: in lacunisparvis lacus Babadagh, inter balneas publicas oppidi et lacus, Toprac-chiupru, Col. Dr. E. C. Teodorescu, No. 275, July 1897 (W); Herb. Alg. Romaniae: Inter pag. Siminicea et Grigoresti, ad lapides in rivu. Scoflea. Col. E. C. Teodorescu, No. 969, June 6, 1901 (W). Russia: URSS: urbs Leningrad: in flum Neva, prope insulam Aptekarsky, ad trabem. 2/9/1866 (LE). Scandinavia: Dalia ? Areschong. Alg. Scand. Ex. Gunnarsnäs, Hällans, Skifferbruk, Dr. V. Wittrock. No. 333, 14/7/1866 (NY. W. FH. L.). Sweden: Wittrock and Nordstedt Alg. Ex. Sueciae ad Surte Bohusiae, Col. F. R. Kjellman, No. 61, & 29, 1874 (L. K. NY. G. W. F.); Halland: Verberg, báck pà väg till Träslöva fiskläge. D. E. Hylmö. 20/5/1928 (LD); Ranelid-Jonstata-bäcken, 28/9/1930 (LD); Uppsala: Uppland. Lilla Gottsunda. Al. Nilsson. May 19, 1884 (LD). Switzerland: Valaise: Herb. Lenormand (Drap. tenuis) (L); Les Ponts ? Herb. J. Ernst, 1922, No. 12: 16, Millet, 1911 (Z); and No. 13, 17 See?, Aug. 30, 1911 (Z). Yugoslovia: Istria: Pola: A. Hansg. 4/1889 (W. F.); Pirano: A. Hansg. 4/1889 (F. W.).

<u>EUROPE</u> (Places not definitely mentioned and legible)

? Herb Keutzing (as *Drap. tenuis*) (L); Herb. Kuetzing No. 351(5), July 20, 1859 (L); Kuetzing, No. 391 (6), Prankr (L); Valognet, Thur. Mardret, mars. April, 1859, No. 351(6) (L); Salisburg: Herb. Suringar (as *Drap. tenuis* Ag.) (L); Alteloebern: Feb. 1856 (L); ? Walter 21 (L); ? Herb. Lenormand: M. Leron 45 (L); Herb. Kuetzing, No. 534(6) (as *Stig. tenue* var. *irregulare*) (L); Col. Reichenbach fil. (as *Drap. tenuis*) (W); ? Derber ?: Algac Gall et N. Am. R. Brébissoni 196(as *Stig. tenue* var. *irregulare*) (K); ? Herb. Mus. Paris (as *Conf. lubrica*), D. Beck, 1824 (PC); Herb. Lugd/Batav. Loc. Nieuwendam: IJ. Leg. C. den Hartog and A. F. Mulder No. 1632, 18/10/1953 (L); ? Col. Grunow No. 11710, Marker, No. 38239 (W); ? Dr. Schedringen ? Col. Grunow No. 11709 (as *Stig. lubricum* var.) (W); ? Col. Grunow No. 11703 (W); ? Col. Grunow No. 11701: In Piscinis. Dr. Bulnheim (W); ? Col. Grunow 11700 ? Vadirze ? (W); ? Ex. Herb. Mus. Parisiensis (PC); ? Herb. Crypt. Mus. Paris No. 139 (PC); ? L. Beaumont, Herb. Lebel, 1875 (PC); ? Domfront. Herb. Lebel (PC); ? Herb. Lebel. No. 397 (*St. irregulare* Kg.) ? 1860 (PC); ? Herb. Mus. Paris (*Drap. tenuis*), Meneghiny (PC); ? bei Penoz ? M. Weickez (as *Myx. tenue* Fr.)(W); Herb. Lyngbye

(Conf. lubrica Dillw.), 26th May, 1878 (C); Aus dem Herb. Siegfried: Erworben 1900: Neudamm: in der Darre, Leg. Rothe, No. 6, 11/5/1853 (Z); Nabern bei Neudamm, Leg. Rothe, 22/5/1853 (as 4. Stig. subspinosum Kg.) (Z); Crypt. des Kreuzeckgebietes (as 1115. Stig. protensum var. subspinosum Ebz.) Hans Simmer Brimmentroge (?), April 13, 1898 (Z); Miramar? Hauck. 1360, Col. Grunow No. 11687 (W); Illegible, 1556, jervola, Graben 1870. Col. Grunow No. 11688 (W); Mincheu (Herb. Stockmayer-Ex. Herb. Fr. Brand) 18.1.1894, 15.II.1894 (W); (as Conf. lubrica Dillw.), Dec. Jury? (C); (as Drap. tenuis Ag.) in stagnis pr. Hofmansgave, Aug. 1847 (C); (As Drap. tenuis Ag. and Conf. lubrica (Lyng.) Dillw.) in Pisrinis (?) Hofmannsgave,1815 (C); (as Drap. tenuis Ag.), Kisoigi?, Aug. 1876 (C); (as Conf. stellaris (Ag.)? 23 June, 1839 (L); ? (Herb. J. Ernst. erworben 1922) Les Ponts, 16 Millet, 1911, No. 12 (Z); (Herb. J. Ernst. 1922); oberhofen (?) 17 See, Aug. 30, 1911, No. 13 (Z); ? (as Stig. irregulare Kg.) Juli 1862 ? O. Moil. Col. Grunow, No. 11658 (W); (as Stig. irregulare Kg.) Leg. Sauber (?) Col. T. Grunow, No. 11659 (W); (as Stig. irregulare Kg.) Col. Grunow No. 11655, 1860 (W).

Stigeoclonium tenue (Ag.) var. uniforme (Ag.) Kg.

Pl. 1, Fig. 1

Kuetzing, Spec. Alg. 353, 1849; Wolle, F. W. Alg. U.S. 111, 1887; De Toni, Syll. Alg. I: 197, 1889.

Syn:

Draparnaldia uniformis Ag. in Flora oder Bot. Zeit. 635, 1827; Icon. Alg. Eur. Tab. 37, 1828-35.

Stigeoclonium uniforme (Ag.) Kg., Phyc. Gener. 253, 1843; Tab. Phyc. 3:t.3, f.11, 1853.

Stigeoclonium uniforme Rabenh. Flor. Eur. Alg. 3: 377, 1868.

Stig. tenue (Ag.) Rab. var. uniforme (Ag.) Kg.

Stig. tenue (Ag.) Rab. var. gracile Kg., J. E. Tilden, Am. Alg. Exs. No. 270, 1896.

Stigeoclonium gracile Kuetz. Tab. Phyc. 3:t.4, f.1, 1853 (non Stigeoclonium gracile (West &West) Tiffany, 1937, and non Stig. gracile Skvort, 1946).

Stig. tenue var. uniforme forma gracile Kg. Wolle, loc. cit. 111, Pl. CI, 1887.

Stigeoclonium debile Kg., Tab. Phyc. 3:2, Pl.3, f.3, 1853.

Stig. tenue c) uniforme var. irregulare Hansg. Prodr. I: 66, 1886 (TYPE).

Erect filaments profusely branches, robust; cells of the main axis mostly 10-15(-18) μ wide, 2-4 (-6) times longer than broad; branches mostly opposite from short cells, secondary branches long and slender at the apex, crowded to form long-drawn tufts; cell wall somewhat thick and lubricous;

Lectotype: 143. _Draparnaldia uniformis_ (Ag.) (L), ad Carlsbad in ostio thermarum calore 25 degrees Centigrade, in Dachen und Brunnenkästen.

Specimens studied:

<u>NORTH AMERICA</u>

<u>Georgia</u>: Burke Co. Savannah River, on log, swift water, Col. Reimer No. 5(5), S.R.P. #7, May 17, 1956 (PH); Screven Co.: Savannah River Pr. #7, Col. Reimer No. 7(5) and 2(5), May 15, 1956 (PH). <u>Pennsylvania</u>: Conestoga Cr. North-east of Disston, Warwick Township, Lancaster Co., Col. J. H. Wallace and R. Patrick, Aug. 10, 1948 (PH); 1 mile east of Lititz, Aug. 9, 1948, J.H.W. and R. Patrick (PH). <u>Louisianna</u>: Cross Lake, Shreveport, La No. 126, Col. Alma Levins, Oct. 12, 1938 (Pres.). <u>Vermont</u>: Shore of Lake Champlaine, Herb. of M. Booth (as 164. <u>Stig. tenue</u>) (NY). <u>Souhh Dakota</u>: Aberdeen: attached

to woods receiving spray from artesian well, Col. D. Griffiths, Aug. 1896 (as 270. Stig. tenue var. gracile), J. E. Tilden Alg. Exs. No. 270. (NY.L.Pres. IA.K.US.). Florida: Eastern Florida: Col. J. D. Smith, (as Stig. debile Kg.), Feb. 1878, (US); Southwestern Florida, March 1878, J. D. Smith (as Stig. uniforme) (US).

EUROPE

Austria: Wien: Herb. Zool. Bot. Ges. Im Baaber, Col. H. W. Reichardt (FH). Holland: Amerongen, Rijn, Leg. C. D. Hartog, 24/11, 1957 (L); (as Stigeoclonium debile Kütz.), Herb. Kuetzing No. 395 (L); England:(?): Camb.(?): Ex. Herb. Nordstedt 5.22.95 (as St. tenue Rab. var. gracile Kg.), Herb. G. T. Moore (MO). Czechoslovakia: Carlsbad: (as Stig. uniforme, Stig. tenue (Ag.) Rab. var. uniforme (Ag.) Kg. Drap. uniforme Ag.) Lenne: Agardh (L.PC.); (as Stig. uniforme), Tepl ad Carlsbad, O. Nordstedt. No. 1299 (K); Böhmen: im Bette der Tepl unter Sprudelkolonnade an Steinen, welch von warmen Wasser bespült werden, Karlsbad. (as Stig. tenue c) uniforme var. irregulare Hansg. TYPE), Herb. of Hansgirg, Aug. 1883 (W); Tepl bei Karlsbad: (as Stig. uniforme Kg. Drap. uniforme (Ag.) Welwitsch (W); Bernherd, Tepl ad thermen, Carol. Bohemiae, Welwitsch, No. 165 & 166, 175, 171, 174, (as Drap. uniformis Ag.), Juli, 1838, (W). Carlsbad: In eodem lococum Sphaerozyga bulbosa ad Carlsbad, Sept. 1835 (as 143. Drap. uniformis Ag. Lectotype of Stig. tenue var. uniforme (Ag.) Kg.) 3 mounts (L.W.); Carlsbad: (as Stig. tenue (Ag.) Rab. var. uniforme (Ag.) Kg.: Stig. uniforme Kg. and Drap. uniformis Ag.), Herb. Kuetzing, 10. mounts (L); Carlsbad: (as Drap. uniformis Ag.) from Agardh 4 Aug. 1829, Ex. Herb. Boston Soc. of Nat. Hist. (Herb. J. A. Lowell) (NY); Carlsbad: (as 149. Drap. uniformis (Ag.) Kg.) (C). Germany: Schlensingen: (as Stig. uniforme: Stig. tenue (Ag.) Kg. var. gracile Kg.) Herb. Kuetzing (L); Dresden: Rab. Alg. Europa's No. 1219 (as Stig. tenue Kütz.), L. R. Sept. 1861 (FH.W.G.NY.).

ASIA

India: Hyderabad: pond in Public garden: attached to submerged grass, Col. Dr. Suxena, No. 6 (HY).

NEW ZEALAND

Taupa-see, Col. Dr. F. Hochstetter, No. 72 (as No. 6 Stig. uniforme (Ag.) Kg.) 1859, (W); Waitohu Valley, Otaki, from Botany Department, Auckland University, 27/10/1953 (AKU).

Note: Stigeoclonium tenue is one of the most common and most polymorphic species of the genus, occurring in widely distributed areas. It mostly grows in running water and tolerates the force of strong waves near shores. This species can also withstand a high degree of pollution, such as organic matter from sewage disposal plants, toxic substances like chromium, copper etc. The species may be perennial or annual and does not always show a 'normal' healthy growth. As a result of these different adaptations and tolerances, the plant survives in widely distributed areas. It has been collected from quite warm water and from the shells of molluscs and from fish scales (Text Fig. 59). It shows various growth forms, some of them appearing entirely different from the typical species, and several varieties thus have been established by Kuetzing, Rabenhorst, Hansgirg and others who failed to realize the range of variations of this species under different environmental conditions. Stigeoclonium irregulare Kg. which Rabenhorst put under Stig. tenue as a variety is merely a growth form of the latter species, so also is Stig. stellare (Ag.) Kg. Some of the herbarium specimens distributed under these names, e.g. Stig. irregulare and Stig. stellare do not

belong to Stig. tenue. Anything that showed abnormality or growth form was named by many as Stig. irregulare or a variety irregulare of other species. This latter name therefore, indicates a growth-form rather than a true species or variety and it is better not to assign these variables to any species, unless one is sure.

The illustration of Stig. tenue shown by Kuetzing does not represent a typical form and may be a young stage; so also is the one shown by Hassall and Cooke. Hazen's illustration however, seems to characterize this species convincingly.

Sometimes, Stig. tenue is confused with Stig. lubricum (Dillw.) Kg. by many authors. The reason may be that not all the Dillwyn's (1802-09) original collections of Conferva lubrica do not contain the same type of specimens, but some of them appear as Stig. tenue. Kuetzing's type specimen of Stig. lubricum does seem to be rather young plants. Both Dillwyn's drawing (pl. 57) and Kuetzing's drawing (Pl.6, f.1, 1853) of Stig. lubricum appear more like Stig. tenue and therefore, these two species "have undergone a gradual course of misinterpretation" (Hazen, l.c.). Some Conferva lubrica have actually been placed as a synonym for Stig. tenue by Cooke (1882-84, 189) with which I agree.

This species Stig. tenue creates many problems when these plants grow as reduced epiphytes or sometimes as endophytes. In such a condition they are difficult to identify. It may be that several species, like Stig. gracile Skv., Stig. weissianum Grun., Stig. autumnale Collins, Stig. tenue var. epiphyticum Hansg., and var. lyngbaecolum Hansg. represent special growth forms of Stig. tenue. Wolle's Stig. tenue var. bulbiferum does not seem to be a constant variety for this species, because the swollen cells characteristic of it were found by me in other species, both in living materials and herbarium specimens, such as in Stig. amoenum and Stig. flagelliferum. These types of swollen cells shown by Wolle may be akinetes or may be result of infections by aquatic fungi.

Hazen (l.c. 203) states that "the best specimens of Stig. tenue seem to reproduce Stig. lubricum in miniature" which I think, is not exactly true. On the other hand, it seems to me that well-grown forms of Stig. tenue reproduce Stig. amoenum Kg. in miniature. In all essential features these latter two species are similar, differing only in size, and zygote structure. Stig. amoenum is much bigger and has stellate zygote whereas *Stig. tenue* is quite small, especially in length of the cells, and has a round, smoothwalled zygote. *Stig. lubricum* is quite distinct from these, but poorly-developed plants may appear somewhat like *Stig. tenue* var. *uniforme* (Ag.) Kg.

Under this species two varieties have been recognized: *Stig. tenue* var. *tenue* and *Stig. tenue* var. *uniforme*. The former one shows the simple branching habit. The latter variety includes *Stig. gracile* Kg. and *Stig. debile* Kg. where the cell size is little greater and which show the tendency to produce long plumose tufts at the tips of the branches, and main filaments.

Hazen (1902, p.204) assigns *Draparnaldia uniformis* Ag. as a synonym for *Stig. thermale* Br. and by doing so he has given the wrong impression about both the species. He might have relied much upon the illustrations of *Stig. tenue* var. *uniforme* given by Wolle for his conception of the latter variety, but Wolle 's figure does not represent the same.

Heering (1914) has attempted to classify *Stig. tenue* on the basis of zoospores and gamete size as shown by Klebs, West and Pascher. How far this is beliable is yet to be determined.

Stigeoclonium elongatum (Hassall) Kg.

Pl. 17, Figs. 1-3; Pl. 19, Fig. 9; Pl. 21, Figs. 6-8; Text Fig. 104.

Kuetzing, Spec. Alg. 353, 1849; Phyc. Tab. 3: Pl.9, f.2, 1853; Wille, in Nyt. Mag. Nat. 39:14, 1901.

Draparnaldia elongata Hassall, IX. Des. Brit. F. W. Conf. 428, 1843; Hist. Brit. Fr. W. Alg. I & II: 123, 1845; Pl. 10, f.3, 1852.

Draparnaldia hypnosa Moug. et Nestl. (in Kuetzing, 1849, l.c.) 716. *Stig. pusilla* Rab. Alg. Sachs. resp. Mittel. (*Drap. pusilla* (Hook J. Ag.) Rab.) 1858.

Stig. subspinosum beta *falklandicum* Kg. Spec. Alg. 353, 1849, (TYPE).

Stig. falklandicum Kg. Tab. Phyc. 3: Pl.2, f.3, 1853, 257. *Drap. pusilla* Hook. & Harv. Falkland Island, Port William Stanley Bay (L.W.).

Draparnaldia falklandica, *Drap. pusilla* H & H, Falkland Island. Antarctic Expn. 1839-43, Hooker.

Myxonema attenuatum Hazen, in Mem. Tor. Bot. Club 11(2): 206, Pl. 35, 1902.

Stig. attenuatum (Haz.) Collins, Gr. Alg. N. Am. 221, 1909; Prescott, Alg. W. G. L. A., 115, Pl. 13, f.1, 1951.

Plants dark green tufts, 4-5 cms. (may be more) long, lubricous, erect filaments very slender; cells of main axis cylindrical, little or no constrictions, 7-11 µ in diameter, 3-5(-6) or more times, long, cells producing branches may be somewhat smaller and more rectangular than others; branches sparse below, gradually becoming more above, mostly opposite or 2-4 branches from the same cell, also alternate toward the upper part of the filaments; apical cells of the branches sharply pointed or flagelliform.

Type locality: same as Draparnaldia elongata Hassall: horse trough near Chestnut, England.

This species, which seems to be a good one, has undergone misinterpretations for a long time. Rabenhorst (1868) put it as synonym for Stig. thermale which was followed by De Toni and Wolle. As a result of this, the species has gone practically out of sight except a brief mention by Wille (1901). There seems to be no good justification for placing it as a synonym of Stig. thermale, in which the branching habit is predominantly the alternate or dichotomous type, whereas in Stig. elongatum, both Hassall and Kuetzing described and illustrated more opposite and whorled branching habit. At first glance this species looks

like *Stig. tenue* var. *tenue* but it differs from it by its slender filament and very sharply pointed branch tips. As a matter of fact, it can be said that just as *Stig. tenue* is a miniature *Stig. amoenum*, *Stig. elongatum* is a miniature *Stig. flagelliferum* (see Pl. 19, Fig. 5).

The type of *Stig. falklandicum* appears to be a young stage and it may be placed in any species. Rabenhorst's Col. No. 715 from Falkland Island in 1853 appears to be of quite well-developed, profusely branched plants and appears very much like *Stig. flagelliferum* but in miniature form.

Hazen's description for his new species *Stig. attenuatum* (Haz.) Col. are more or less the same as Kuetzing gave for *Stig. elongatum* (1849) and there is little doubt that these two species are the same.

Hassall's figures of *Draparnaldia elongata* and *Draparnaldia tenuis* are more or less similar but Kuetzing placed the latter species as a synonym for *Stig. lubricum* which seems to be erroneous.

Specimens studied:

NORTH AMERICA

Maryland: In outlet of running cool spring, College Park, Prince Georges Co., Col. L. P. Mc Cann, G. B. Reynard and Fr. Drouet, No. 2312 (as *Stig. attenuatum*

(Haz.) Col.) Aug. 28, 1938 (F); Garret Co.: (as Stig. tenue,)J. D. Smith, July, 1878 (US.NY.F.FH.); Frederick Co. Potomac River, on roots and sticks, Col. Hohn, June 15, 1956, P.R.S. #1, 16(1), 22(1), (PH); Montgomery Co. Potomac River, on rock, Col. Hohn, No. 7(3), P.R.S. #1, June 18, 1956 (PH); Sonora:?: in a small creek about 15 miles southwest of Campus. Col. Fr. Drouet, D. Richards and W. A. Lockhart, No. 2970 (as Stig. attenuatum (Haz.) Collins) Nov. 18, 1939 (NY.F.); Territory of Hawaii: Wittrock et Nordstedt Alg. Ex. In insulie Sandvicensibus, in convalle Nuanu insulae Oahu, Leg. Dr. S. Berggren, No. 110 (as Stig. falklandicum Kg.-- doubtful, mostly like Stig. subsecundum var. tenuis?), July and Aug. 1875 (F.L.W.G.NY.FH.K.W.); J. E. Tilden Am. Alg. Ex. No. 461 (as Stig. falklandicum Kg.), epiphytic on grass in large irrigation ditch, Ewa plantation, Oahu, J. E. T. 7 Je 1900 (U.S.NY.F.K. PC.); Florida: Bay Co. on cement, in the outlet of a freshwater pond in to the Gulf of Mexico, Sunnyside(?), Col. Fr. Drouet,C.S. Nielsen, G. Madsen, D. Crowson and A. Patesm No. 10678 (as Stig. lubricum) Jan. 9, 1949 (F); Michigan: Round Lake: attached to aquatic plants. Col. H. Graffius, May 2, 1960 (MIs.);

? P.B.A. No. 1074 a (*Hyponema aestivale* Has.) (PC. NY.K.); *Pennsylvania*: Conestoga Survey, No. 104, Conestoga Creek, n.-e. Disston and No. 110 a, 1 mile east of Lititz (PH); Chester Co. Brandywine Cr. Survey, Col. J. H. Wallace, No. 2, Oct. 1952 (PH).

EUROPE

Germany: Jörgebach oberfalls Krähwinklerbrücke, bei Lennep, Rheinland, H. Royers, April 21, 1901 (L.FH.F.NY.); Gall, C.E.D. No. 20, Herb. Kuetzing (L); Freiburg; (as 130. *Stig. tenue* var. *gracile*), Herb. Suringar, Col. A. Braun, Mai 1843 (L); *Roumania*: Herb. Alg. Romaniae, Dobrgea: Mangalia, Dr. E. C. Teodoresco, No. 665, April 6, 1900 (W); Pola: Vindob Acqu. 1903 No. 2702, Herb. Hansg. (as *Stig. tenue* var. ?), 4/1889 (W); *England*: Ex. Herb. Berk 6/39 (as *Drap. elongata* Hass.) (K); *France*: In fonte --? Frascati, loco--? Morenol ? No. 16 (PC); ? bei Krems münster ?, Leg. Dr. Poetsch, Col. Grunow, No. 11653 (as *Stig. gracile*), 18/4/1864 (W); *Germany* (?): Berndorf ? Col. Grunow No. 11654 (as *Stig. gracile* var. ?) 11/3/1858 (W); Rhein: A. Grunow, 11/4/1858 (W).

ASIA

Pakistan: Dacca: on aquatic plants, Col. S. Aziz, 1959 (Is.).

SOUTH AMERICA

Falkland Island: (as 716. Stig. pusillum Rab.), Drap. pusilla (Hock. J. Ag.) Rab. Alg. Sach. resp. Mittel. An. Myriophyllum elatinoides in den Lorf-fümfen auf den Falklands-Inselen glf. v. Lechler (No. 37) anv. 1858 (G); as Stig. subspinosum beta falklandicum Kg. TYPE (L); (as Stig. falklandicum and Drap. pusilla) apr. M. Decaisne, 1847 (L).

NEW ZEALAND

Auckland: Floating down Waitakera stream near Golf course, Col. E. C. M. Segar, 26/9/53; from edge of stream, near road at Western Springs, Col. E. C. M. Segar, 22/9/53 (AKU).

<u>Stigeoclonium</u> <u>amoenum</u> Kg.

Kuetzing, Phyc. Germ. 198, 1845; Spec. Alg. 355, 1849; Tab. Phyc. 3: Pl. 6, f.2, 1853; Rabenhorst, Flor. Eur. Alg. 3: 378, 1868; Wolle, F. W. Alg. 113, Pl. 98, f.4, 1887; De Toni, Syll. Alg. I: 200, 1889; Collins, Gr. Alg. N. Am. 219, 1909; Heering in Pascher's Süsswasser. 6: 87-94, 1914; West and Fritsch Brit. F. W. Alg. 185, 1927; Godward, in New Phytol. 41: 293-301, 1942.

<u>Stigeoclonium</u> <u>amoenum</u> forma <u>biforme</u> Collins, Gr. Alg. N. Am. (Supplement), 24, 1912 (reprint 1928).

<u>Myxonema</u> <u>amoenum</u> (Kg.) Hazen, in Mem. Tor. Bot. Club. 11(2): Pl. 29, 1902.

<u>Stigeoclonium</u> <u>fasciculare</u> Kg. P.B.A. Col. Nos. 67 and 828, Leg. I. Holden, May 28, 1893.

Well-developed plants quite long, 20-40 cms., profusely branched, light-green to bright yellowish-green in color; erect part well-developed, prostrate part absent, attached to the substrates by profuse rhizoids; main axis consisting of very long and short cells, the latter usually producing primary and secondary branches, 4-5 or more such short cells produce a node-like appearance; long cells cylindrical, or usually somewhat inflated in different degrees, (12-)-15-39 µ in diameter, at the middle, 3-10 (rarely up to 15) times longer than broad; short cells are mostly angular or slightly rectangular, diameter usually less than the long cells, 1-2 times longer than broad, these short cells appear abruptly, 1-4 or more in a row without any transition (usually) from long cells; branches mostly opposite, sometimes more than two pairs arise from each short cell forming a pseudo-whorl appearance, the branches are long, the lower cells of the branches usually much longer than upper cells, apical cells usually blunt or slightly pointed, not setiferous, rarely a long terminal hair may develop; sometimes short-branches may form irregular pseudo-whorls; branches may develop, especially in the upper part from long cylindrical cells, scattered or alternate; cells of the branches more or less cylindrical or rectangular, little inflated, sometimes equal to or shorter than the diameter; chloroplast in long cells a narrow median band, sometimes draparnaldioid type, in small cells of branches ulotrichoid type; cells of main axis or of branches dividing into many compartments during zoospores formation; zygospore stellate.

Stigeoclonium amoenum Kg. var. *amoenum*

Pl. 1, Fig. 6; Pl. 2, Figs. 1-3; Pl. 28, Fig. 2; Text Fig. 82.

Plant light green, prostrate part absent; long cells of main axis mostly cylindrical, little inflated, 12-18 µ (rarely 20-24 µ) in diameter, 3-10 times diameter in length, (mostly 6-8 times); branches profuse from short cells, mostly opposite, also solitary, sometimes 2-4 branches arise from same cells in different planes; branches may be short or long and delicate; apical cell usually bluntly pointed, rarely with hair; cells of the main axis immediately above the short cells usually long and little more inflated or somewhat club-shaped.

Type locality same as for *Stig. amoenum* Kg., Germany: on *Cladophora glomerata* in Mühlengerinnen bei Weissenfels.

Specimens studied:

NORTH AMERICA

Connecticut: Bridgeport: Island Brook, Col. I. Holden, 17 March, 1889, April 14, 1889, April 29, 1888, April 25, 1886 (FH); Bruce's Brook, P.B.A. No. 67 (as *Stigeoclonium fasciculare* Kg.), I. Holden, May 20, 1893 (F. PC. NY. W. C. H.); Bruce's Brook: P.B.A. No. 328 (as

Stig. fasciculare Kg.), Leg. I. Holden, May 28, 1893 (F.PC.NY.W.C.K.FH); Bridgeport: I. Holden No. 603 (as Stig. tenue (Ag.) Kg.), June 5, 1892 (FH): New Haven: West River, North of Edgewood Ave. Col. H. K. Phinney, Nos. 1093, 1094 (as Stig. tenue (Ag.) Kg.), Aug. 12, 1946 (F); Rhode Island: Pocasset River, Johnstown, P.B.A. No. 1073, Col. F. S. Collins, May 13, 1903 (C.US.K.NY.F.PC.Pres.); Georgia: Danen ?: Reinbild ?: ditches, still water, H. P. Ravanel, No. 39 A. Mar. 15, 1881 (FH.W.); Minnesota: Minneapolis: J. E. Tilden Am. Alg. No. 17. In a pond. Col. H. Tilden, 27 Je 1894 (F.NY.); New Jersey: (as 3. Myxonema lubrica and Stig. longipilus Kg.) Princeton: Leg. K. Brown, May 6, 1892 (NY); Massachusetts: Tyngsboro: (as TYPE: 1788, Stig. amoenum forma biforme Collins), Leg. F. S. Collins, June 1910 (FH); P.B.A. 1788 (as Stig. amoenum forma biforme Collins), on stones in Lawrence Brook, Tyngsboro, F. S. Collins, May 15, 1910 (F.FH.C.US.K.NY.W); ? Lynn, In stringy tufts, upto 40 cms. long, inlet of Birch Pond, F. S. Collins No. 1328 (as Stig. attenuatum (Haz.), June 11, 1905 (F.MICH.K.); Malden, Herb. F. S. Collins, April30, 1884 (L); Hawaii: Sandwich Island, Oahu, Nuanu Valley, Leg. S. Berggren, 1876 (LD); California: On gravelly sand, in 6 inches of water, quiet stream near bottom of upper slide falls, alt. 7600 ft., Tenaya Canyon, Mariposa Co. Yosemite National Park, Sierra Nevada, Col. Annetta Carter, No. 1676, Aug. 17, 1942 (F); Nebraska: In shallow water, attached, Sandpit Lakes, Fremont, Dodge Co. alt. 1200 ft. W. Kiemer, Nos. 13913 and 13948 (as *Stig. lubricum*), April 23, 1943 (F); Tennessee: Herb. Univ. Tennessee on rocks in swift place, clear pool below falls, alt. 1300 ft. Creek Falls, Van Buren Co. Col. H. Silva, No. 671 (as *Stig. lubricum*) May 4, 1947 (F); Virginia: Herb. J. C. Strickland, on rocks and log in small stream in Goshen Pass, Rockbridge Co. Leg. J. R. Meyer, May 4, 1940 (as *Stig. lubricum*) (F); Kansas: Burlington: attached to aquatic plants, Col. W. Vinyard, on U.S. 75 hwy. a small Cr. near Coffey Co. No. 4, April 11, 1958 (Is.); Michigan: Round Lake: attached to floating plant-mass: Col. H. Graffius, May 2, 1960 (Is.); Lake Lansing: attached to aquatic plants like Potamogeton. Col. Dr. S. Guarrera and Dr. G. W. Prescott. April 23, 1960 (Is.); on stones, Red Cedar River, near M.S.U. Campus, E. Lansing, Spring 1958, Col. N. Islam (Is.); South Carolina: Aiken Co.

Three Runs, on twigs, Savannah River, Col. Reimer, No. 3(2), April 11, 1956 (PH); Canada: New Brunswick: Plantae Acadienses: attached to rocky bank and floating free out into "Little River", Grand Falls, Col. H. Habeeb, No. 10042(as Stig. lubricum) June 30, 1947 (F).

SOUTH AMERICA

Argentina: Buenos Aires: on Scirpus, M. No. 5(slide No. 7), Col. Miss Guitman, May 22, 1959 (from Dr. Guarrera).

EUROPE

France: Wittrock and Nordstedt: No. 1058: Galliae, in rivulis prope Angers. Cl. F. Hy. May 5, 1891 (F.K.NY); ? Lestre (?) Herb. Lebel No. 817, June 1864, Illegible (PC); Stirpes Crypt. Vogeso-Rhenanae: (as Stig. lubricum), ad Herbas infundo rivulorum: Hyeme et vere(?), J. B. Mougeot, Bruyeriensis M. D. et C. Nestler Argentinensis Pharm Bruyerii Voge-sorum Tipis M. Vivot, 1815 (F); Vosgon (?) No. 299 (L). ? Stienitz see, Leg. Bauer, No. 27, 1849, Col. Grunow No. 11628 (W); Germany: Col. Grunow 11626, R.A.S. 94, Illegible ? (W); Lepzig: Col. Grunow No. 11625, R.A.S. 217, June 1882, Auerswold ? (W); ? Herb. Boissier, 197, Desueaz ? (G); Franconia: ? , P. F. Reinsch No. 30, (as forma nova), 1874 (K).

ASIA

India: Hyderabad: Adickmet: green filamentous, scraped from leaves in puddle, Dr. Suxema, No. 4 (NY); Pakistan: Dacca: Col. N. Islam (1955, April (Is.).)

AUSTRALIA

New South Wales: ? as Stig. tenue (Ag.) Rab. Lett River Hartley, per Miss A. Brewster (NSW).

Stigeoclonium amoenum Kg. var. novizelandicum Nordstedt

Pl. 1[illegible], Figs. 4-5; Pl. 1[illegible], Fig. 2.

Nordstedt, in Bot. Not., 15[illegible], 1887; in Kongl. Sv. Vet. Akad. Handl. 22(8): 14, 1888; in Notarisia, 45[illegible], 1888; De Toni, Syll. Alg. I: 202, 1889.

Erect filaments stout, cells of main axis usually short and inflated, constricted, somewhat thick-walled, 15-25 µ diameter below, 10-12 µ diameter above, 1½-4-5 times longer than broad; branches mostly opposite sometimes solitary and alternate, from small cells; at the tips secondary branches forming bushy tufts; cells of primary branches little narrower than main axis, 1-2½ times so long, more or less rectangular, inflated or somewhat barrel-shaped, slightly constricted, apical cell bluntly pointed or somewhat attenuate.

Lectotype: S. Berggren Col. No. 69, 1874; Type locality: Auckland, New Zealand: i rännilar; Ins boreal Novae Zelandiae: also Wittrock et Nordstedt, Alg. Exs. No. 909, 1889.

Specimens studied:

NEW ZEALAND

Wittrock and Nordstedt: Alg. Ex. 909, in rivulis ad Auckland, Leg. Prof. S. Berggren No. 69, 18/9/1878 (F.NY.K.W.); Auckland: i rännilar: Ins. boreal, Novae Zelandiae, S. Berggren No. 69, 1874 (LD).

NORTH AMERICA

Massachusetts: Woods Hole: Dillw. 23.6.49 (HUJ); Georgia: Burke Co. sta-5, Log. A. Savannah River Project, No. 3: J. Wallace No. 6(5); Jan. 1952 (PH); Screven Co. S.R.P. No. 4, Col. R. Patrick No. 1(6A), May 1952 (PH); Pennsylvania: Flowing water, Fr. Wolle ? (IA).

<u>Stigeoclonium</u> <u>amoenum</u> Kg. var. <u>insigne</u> (Naeg.) comb. nov.

Pl. 30, Figs. 1-3; Text Fig. 102

Synonyms:

<u>Stigeoclonium</u> <u>insigne</u> Naegeli, in Pflanzen Phys. Unter. I: 36, 1855; Heering, in Pascher's Süsswasser.6: 84, 1914.

<u>Myxonema</u> <u>ventricosum</u> Hazen, in Mem. Tor. Bot. Club. 11(2): 201, Pl. 31, 1902; (No type or lectotype available) = (<u>Stigeoclonium</u> <u>ventricosum</u> (Haz.) Collins 1909).

<u>Conferva</u> <u>fluitans</u> Nobis, Herb. Schweinitz, received by Philadelphia Academy in 1834; Col. from Salem, North Carolina, in the river Sauraton (PH).

Erect filaments well-developed, profusely branched, 10-15 or more cms. long, light green to yellowish-green; main axis with long cells and short cells; long cells somewhat cylindrical, mostly inflated, 25-39 µ in median diameter below, 1½-5 times as long, about 16-25-30 µ diameter above, up to 10-12 times as long, usually cells immediately above the short cells longer than others; branches mostly opposite, also alternate, solitary, or 2-4 pairs approximate, arising from short angular or subglobose or nearly rectangular cells, apical cells broadly flat, blunt, rarely small branches attenuated; chromatophores broad, zonate, draparnaldioid type.

Because no type specimens of either Stig. insigne or Stig. ventricosum were available, the following may be regarded as **the** NEOTYPE for this variety:

Conferva fluitans Nobis, Herb. Schweinitz, recd. in 1834 by Phila. Academy (PH); also No. 269. Stig. lubricum, Col. Evermann and Clark, Nov. 28, 1904, Indiana (F).

Specimens studied:

NORTH AMERICA

North Carolina: in rivulis Sauraton, Salem: (Schweinitz Herb, recd. in 1834) with the label as (Conferva fluitans Nobis and Stig. amoenum Kg.) (PH); Pennsylvania: (as Stig. nudiusculum) Ex. Herb. Wolle Mt. stream (L); Indiana: near the Icehouse, Outlet Bay: algae of Lake Maxinkuckee, Marshall Co. Col. H. W. Clark and B. W. Evermann, No. 269 (as Stig. lubricum) Nov. 28, 1904 (F).

EUROPE

Germany: Baden Baden: Reliq. Brebissoni, Algae Gall et N. America (as 191. Stig. nudiusculum) (K).

Stigeoclonium amoenum Kg. var. aucklandicum var. nov.

Pl. 3, Figs. 2-4

Erect filaments well-developed, straight, 2-3 cms. or more long; cells of the main axis and branches cylindrical and rectangular with little or no constrictions and no inflated cells; branches both from short and long cells, from the former branches whorled in somewhat loose fascicles, from the latter, branches solitary; branches distinctly two types, long and short, the latter forming pseudo-whorls; cells of main axis mostly 12.5-15.6-24 µ in diameter, 4-10 times as long below, subequal to 1-2 times as long above; cells of branches usually small and quadrate, 6-12 µ diameter, 1-2 times (rarely 5-6 times) as long, apical cells usually longer than lower cells and gracefully and bluntly attenuated; chloroplast of long cells quite characteristic, cylindrical band with several pyrenoids, of small cells ulotrichoid type.

Type specimens: Collected from Auckland, New Zealand; Waitakera stream, near Golf course, Col. E. C. M. Segar, 26 Sept., 1953, received from Dr. Segar, Botany Department, Auckland University College, New Zealand (AKU) (mixed with other Stigeoclonium species also from edge of stream near road at Western Springs, Auckland, Col. E. C. M. Segar, 22 Sept., 1959 (AKU).

Stig. amoenum Kg. is also widely distributed and one of the well-established species, showing remarkable constancy in some of its characters. The several varieties seem to be well-defined. Most frequently it is confused with Stig. flagelliferum Kg. in which the main axis also consists of long and short cells, the latter producing branches, making it difficult to separate them from each other. I would like to point out, however, the following features to separate these two species: In Stig. amoenum generally the cells of the main axis are long, cylindrical, slightly or more inflated, sometimes club-shaped or barrel-shaped, In _Stig._ _flagelliferum_ Kg. the cells are not so inflated, small cells producing branches in _Stig._ _amoenum_ are usually cylindrical, angular or somewhat rectangular and less in diameter than the long cells; usually these small cells are abrupt, 2-4 or more in a row between long cells without any transition. In _Stig._ _flagelliferum_ long cells gradually becoming short cells in series, only few of them (usually the middle ones) producing branches. The diameter of these short cells is usually not less than the long cells, sometimes, slightly wider. Branches tend to form fascicles or whorl around the short cells and mostly terminate with long flagelliform or setiferous tips, occassionally with long colorless hairs in _Stig._ _flagelliferum_, whereas in _Stig._ _amoenum_ there is no tendency to produce fascicles like the latter species, and tips of the branches are mostly bluntly pointed, never setiferous, rarely with hairs. In _Stig._ _amoenum_ the zygote is stellate and developed from the fusion of four-ciliate gametes (Godward, 1942; but however, Singh, 1954); whereas in _Stig._ _flagelliferum_ the zygote is round, smooth-walled, developing from the fusion of biflagellate gametes (Tilden, 1896).

Stig. amoenum var. amoenum seems to be the most common and less variable in widely distributed areas. Here the main axis attains the medium, intermediate size between some other varieties of this species. Kuetzing's figure of Stig. amoenum is not entirely convincing, nor is Wolle's. Hazen's illustrations (Pl. 29, 1902) are probably the most faithful ones ever to characterize this species. Unfortunately, Hazen failed to realize the range of variations that this species might show. He has established a new species Stig. ventricosum (Hazen) Collins only on the basis of short, inflated cells, otherwise, the basic pattern of long cells, short cells, branching habit, chloroplast, tips of branches, etc., are very similar to Stig. amoenum, in which the short cells may be rectangular to subglobose also. This type of inflated cells as referred to by Hazen in Stig. ventricosum had already been mentioned by Nordstedt in 1887-1888 in the description of Stig. amoenum var. novizelandicum Nordst. Perhaps, Kuetzing's inadequately described variety Stig. amoenum beta pulchellum Kg. (1849, p.355) might have referred to more inflated cells than possessed by the species itself. This was described by Kuetzing as "ramis ramulisque moniliformibus, articulis ventricosis". As no measurements of figures for this variety are given by Kuetzing, it is difficult to define it. But, it appears quite certain that plants like Stig. amoenum may develop inflated cells as was noted by Kuetzing and Nordstedt. Hazen's Stig. ventricosum may thus be placed either under Stig. amoenum beta pulchellum Kg. or under the var. novizelandicum Nordst. But as we do not know much about the former form, and because the latter variety uniformly consists of comparatively less elongated cells of the main axis, and bears tufted branch tips, it is better to keep it as a separate variety. Although Hazen mentioned that in Stig. ventricosum (Hazen) Collins the long cells are 2-5 times longer than broad, his illustrations suggest that at least the cells immediately above the small branch-bearing cells could be more than five times longer than broad. Reference must be made to Stig. insigne Naegeli, of which Hazen writes (p. 201, 1902) that his species Stig. ventricosum (Hazen) is "perhaps nearer to Stig. insigne Naeg., a beautiful species, ...". I came across with three or four collections (see under specimens studied under Stig. amoenum var. insigne) in which the filaments appear exactly as Stig. amoenum but frequently cells of the main axis and branches are much inflated and median diameter may be up to 39 µ; length may be 2-5 times up to -12 times the diameter. Whether _Stig._ _amoenum_ var. _amoenum_ itself attains a greater dimension is a question. But thus far, in many well-developed plants which produced zoospores and gametes in nature, the diameter was usually found to be up to 20-22 µ. So, I think, it is better to regard the larger form as a distinct variety of the species and for that reason I made the new combination in which _Stig._ _insigne_ has been assigned as a variety of _Stig._ _amoenum_ Kg. There are other considerations in combing these two species, especially the zoospore-formation, chloroplast structures, germling stages, absence of prostrate thallus, similar stellate zygote formed from quadri-ciliate gametes, all suggesting a clear affinity between _Stig._ _amoenum_ and _Stig._ _insigne_. Thus there seems to be no doubt that these two plants belong to the same species. The presence of long colorless hairs in _Stig._ _insigne_ as mentioned by Naegeli (1855) can also be found at certain stages in the life cycle of _Stig._ _amoenum_ as shown by Godward (1942).

We can however, summarize below the differences between these four varieties of Stig. amoenum Kg.:

Stig. amoenum var. amoenum: branching simple, mostly opposite, 15-18 µ diameter, 4-10 times as long, cells cylindrical, little inflated; apical cells mostly blunt.

Stig. amoenum var. novizelandicum: cells usually less elongated, 2-5 times diameter, long, inflated, 20-25 (rarely little more) µ diameter below, 10-13 µ diameter above, secondary branches form tufts at the tip of the branches.

Stig. amoenum var. insigne: cells of main axis much inflated, 25-39 µ diameter, 2-5 (-12) times as long; apical cell usually blunt, may be attenuated or with colorless hair.

Stig. amoenum var. aucklandicum var. nov.: cells of main axis and branches cylindrical, rectangular, not inflated or very little so, branches both long and short, the latter forming pseudo-whorls at the nodes, apical cells gracefully and bluntly tapering, chloroplast cylindrical and zonate.

Tilden's American Alg. Exs. No. 18 bears the label Stig. amoenum Kg. with an epithet var. simplex nov. var. Tilden, and is described as "lower cells 10 µ in diameter, 1-2 times as long as broad, upper cells 7.5 µ wide, 1-1.5 times as long, branches simple, not pinnate, mostly secund, patent or incurved; growing in metal trough at the "flowing well", Belle Plaine, Iowa, Col. W. Tilden, 1894. This specimen seems to be Stigeoclonium tenue (Ag.) Kg.

Recently, I received a specimen which seems to be a comparatively young plant, growing on stones and pebbles at the outlet to Nine Pipe Reservoirs, on U.S. 93, Montana, July 19, 1958, Col. No. M3(Is). Here, the erect filaments, developing from basal subglobose cells are slender; up to a considerable distance from the base no or very little branching, at the middle or upper part alternate or opposite branches develop with tufted tips; apical cells sharply pointed; cells of main axis long, fusiform or moniliform type, with median band-shaped chloroplast, (7-9.5-15 µ in diameter,)8-10-12 times so long below, 1-3 times as long above. Here the shape of the long cells of the main axis appear somewhat like Wolle's figure of Stig. amoenum, the difference however, lies in the tufted branching apex and sharply pointed apical cells. I question whether this could be regarded as a distinct form or variety of Stig. amoenum. As this specimen seems to be young and because more collections are needed to verify it, no new name is given to this plant (Pl. 22, Figs. 1 - 2).

Sometimes, Stig. amoenum may be mistaken for Stig. lubricum, especially when the main axes with long cylindrical cells are covered by branches and only the branches at the upper part are seen. In several collections I found that the upper parts of the filaments of Stig. amoenum bearing short and scattered branches may appear very much like Stig. subuligerum Kg. with broad base and sharply pointed tip of the branches as shown by Hazen for the latter species.

The following specimens were examined, but due to their poor preservations I could not assign them to any variety under Stig. amoenum:

EUROPE

Germany: Constanz: an Cladophora in einem Brunnen, Dr. E. Stizenberger, No. 491 (F.FH.NY.); Herb. H. Royers: on Cladophora in ? purchased in 1938 (F); Die Algen Sachsens: Mittel-Europa s 21 and 22: Dr. L. Rabenhorst. Decade XLIX and L Dresden (F), Herb. Lenormand A1/1 No. 22, St. Goseph, Dr. Lebel, No. 285, 1857 (CN). (all the above specimens were labeled as Stig. amoenum beta pulchellum Kg.)

Stig. amoenum var. *simplex* Tilden (materials were not in good condition).

Stigeoclonium flagelliferum Kg.

Pl. 3, Figs. 1-7; Pl. 7, Figs. 2, 3, 7, 8; Pl. 18, Figs.1; Text Fig. 83.

Kuetzing, Phyc. Germ. 198. 198, 1845; Spec. Alg. 355, 1849; Tab. Phyc. 3:t.10, f.1, 1853; Rabenhorst, Flor. Eur. Alg. 3: 378, 1868; Hansgirg, Prodrom. 58, 1886; Wolle, Fr. W. Alg. U.S. 112, t.97, f.1-2, 1886; De Toni, Syll. Alg. I: 200, 1889; Collins, Gr. Alg. N. Am. 219, 1909; Heering, in Pascher's Süsswasser.6: 81-83, f.118, 119, 121, 1914; Prescott, Alg. W.G.L.A. 115, Pl. 11, f.1, 2. 1951.

Myxonema _flagelliferum_ (Kg.) Rabenhorst. Deutsch. Krypt. Fl. 2(2), 3: 100, 1847. Hazen, in Mem. Tor. Bot. Club 11(2): 199, 1902.

Stigeoclonium _crassiusculum_ Kg. Phyc. Germ. 199, 1845; Spec. Alg. 355, 1849; Tab. Phyc. 3: t.10, f.2, 1853.

Stigeoclonium _flagelliferum_ var. _crassiusculum_ (Kg.) Rab. Flor. Eur. Alg. 379, 1868; Hansgirg, Prodrom. 68, 1886; De Toni, Syll. Alg. 200, 1889.

Draparnaldia _tenuis_ beta _elongata_ (Ag.), Syst. 57, Herb. Kuetzing, No. 20(L); Leg. Com. Suhr. 1841 (W); Leg. Mougeot No. 1604 (K); Falaise (LAU).

Plants 2-5, occasionally 10-15 cms. long, bright green tufts, main branches mostly in pairs, opposite, often 2-5 appearing on small rectangular or broadly angular cells of same or slightly more in diameter as the long cylindrical cells, the latter are usually not inflated, 14-22μ(rarely -25 μ) diameter, 4-8-12 times longer than broad; main axis frequently bearing short rectangular cells here and there in series which may not develop a branch; branches terminating in long flagelliform, setiferous tips or colorless, multicellular hairs; cells of branches 10-12 μ in diameter, 4-6 (rarely -10) times as long; frequently branches may form a whorl or fascicle around the main axis and primary branches, some branches solitary with long colorless hair; cell-wall 1.5-2.5 μ thick; chloroplast a median band. This species also shows wide distribution. The under-developed plants or growth-forms may be confused with several other species, especially, with Stig. amoenum Kg. and Stig. lubricum (Dillw.) Kg. Sometimes, well-developed plants but with reduced branches may appear as Stig. fasciculare Kg. and Stig. nudiusculum Kg. The latter species has cells bearing a resemblance to those of Stig. flagelliferum Kg. in the main axis and the fascicled nature of the branches developing from short rectangular cells is also similar. The difference however, lies in the fact that in the latter species the branches are mostly opposite or in pseudo-whorls and the tips are usually flagelliform and setiferous, whereas in Stig. nudiusculum branches are mostly alternate, fascicled like Draparnaldia and usually end in a long, broad, colorless hair. Stig. crassiusculum Kg., was considered by Rabenhorst as a variety of

Stig. flagelliferum Kg. It was originally separated from the latter species by its stout growth, less profuse branching, and long colorless hairs. I could scarsely find any difference in the basic pattern of the thallus formations of these two species. In the same collection of well-developed Stig. flagelliferum Kg. plants all the stages of these two species may be seen. It seems that Stig. crassiusculum represents a particular stage in the life-cycle of Stig. flagelliferum. Kuetzing's drawing of the latter species might have been executed from a depauperate plant rather than from a well-developed form. It is possible that this species may attain a greater diameter, up to 30 μ.

Hazen (1902), Collins (1909), Heering (1914) and others have described this species as a stout form and slightly larger in diameter than Stig. amoenum. This is only partially true, if we consider the different varieties of the latter species. The above authors have mentioned that branches arise in Stig. flagelliferum from somewhat globose cells. But in this species I did not find any such globose cells which are rather common in Stig. lubricum. On the other hand, in Stig. flagelliferum these shorter cells are more or less rectangular, short cylindrical, or broadly angular, usually non-constricted. They appear in long series and show gradual transitions from the long cells. Sometimes these short cells may not produce any branch either in the main axis or primary branches. This is not so common or remarkable in Stig. amoenum.

It has been mentioned before under Stig. lubricum that some of Dillwyn's original collections of Conferva lubrica contain Stig. flagelliferum and Dillwyn's illustrations of Conferva lubrica, especially Pl. 57, f.C, might have been drawn from one such collection.

Rabenhorst's Stig. flagelliferum var. irregulare Rab. (Flor. Eur. Alg. 379, 1868) is inadequately described without any illustration and it is difficult to judge whether it could be a good variety or a growth form; so also Royer's (in Heering, 1914) form may be regarded as a young plant.

Kuetzing (1849, p.355) doubtfully with a question mark put Conferva fluitans Schweinitz ? as a synonym for Stig. flagelliferum. I think this Conferva fluitans is the same as the one we have studied and considered to be Stig. amoenum var. insigne (Naeg.) comb. nov.

Specimens studied:

NORTH AMERICA

Massachusetts: Denvers, Essex Co. Col. F. S. Collins, No. 5953, Sept. 20, 1903 (FH.NY); Wisconsin: In let to trout lake, Sphagnum bog near Carroll Lake, Col. G. W. Prescott, No. 2W-285 and W 354-2 (Pres.); Minnesota: Minneapolis: University Campus, Col. Miss Caroline, Miss M. C. Crosby and G. Lilley, No. 548, 27F, 1902 (BUT. Pres. F.US.NY.PC); Pennsylvania: Northampton Co. Fr. Wolle (F); Freshwater Algae of U.S.A. trenches flowing water (as Stig. fasciculare Kg.) Fr. Wolle, (L); Ex. Herb. Fr. Wolle, No. 111; Hab. Pools (FH); Bellefonte, in quiet spring water, temp. 10 degrees Centigrade. Miss Ella Levy, 20, 1896, J. E. Tilden, Am. Alg. No. 137 (F.US.); Michigan: Lake Lansing: Col. G. H. Graffius, May 6, 1959 (Is.); Kentucky: Laurel Co. near East Bernstadt, Col. P. C. Standley, No. 92599 (as Stig. lubricum) March 21, 1946 (F); Connecticut: Bridgeport: Collins, Holden, Setchell, P.B.A. No. 408, on stones in swift water, Pequonnock River, Col. I. Holden, No. 1171, Dec. 22, 1895 (FH.NY.); and Dec. 25, 1895 (K.L.C.MICH.F.NY.PC.); New York: Falls of Brook feeding 100th St. stream, Central Park, New York City, Leg. T. E. Hazen, No. 313, April 20, 1900 (F); West Point, Herb. Kuetzing, (as *Stig. elongatum* Kg. and No. 20, *Draparnaldia tenuis* beta *elongata*) (L); ?Sp. No. 5645 (NY); *Iowa*: North end of E. Lake Okoboji, Orleans? on roots, Aug. 4, 1916 (IA); *Virginia*: Woods, Spout Pond Brook, Distributed by Herb. N. Y. Bot. Garden, Ex. F. S. Collins No. 4369 (as *Stig. tenue*) May 22, 1903 (NJJ); *Mexico*: Col. G. W. Prescott No. M 31 (Pres.).

EUROPE

England: Hopton: Herb. Hookerianum (1867) (as one of *Conferva lubrica* Dillw. 57), March 22, 1799 (K); Wareham (as *Stig. stellare* Kg.), Herb. Griff. 1862, Col. Sept. 15, 1847 (K); Ex. Herb. Dillwyn (as *Conferva protensa*) Lound: 3/25, 1809 (K); *France*: Li stangyls (eau douce), mai 17, finitur ricilly touches(?) (PC); Falaise: Herb. Kuetzing Nos. 391 and 390 (L); dans la Sinope, Quineville, Herb. Lebel (PC); Algues de France, Vosges: Remirmont erzil (as 161. *Stig. longipilus* Kg.) Leg. G. Bonnageon (K.L.); Vire: Lenoreu(?), Herb. Boissier, 1855 (G); Desmazieres Crypt. de France (1804, *Drap. tenuis* beta *elongata* Ag.), Dr. Mougeot, (K); par J. B. H. J. (NY); Herb. du Dr. Lebel No. 405, donne au Museum par ses enfants en 1878 (PC); Herb. Lebel, Le Broc. 26, Mai, 1860 and Fermanville, Caplevy, Herb. Lebel No. 371, Mars. 10, 1860, Herb. Lebel No. 392, 1860 (PC); La Claie (?) Ms. Col. de Brébisson (as Stig. amoenum) 1890 (PC); Vire: Herb. Suringar (L); Falaise (as Drap. tenuis var. elongata Ag.) (LAU); Vire: (as Drap. tenuis Ag.) (LAU); Hyeme et vere (?), Moug. et Nestle No. 499 (as Drap. hypnosa Bory.), 3 mounts (LO); Vire: A 1/1. No. 5 (as 490. Stig. tenue), 1839 ? (CN); Volgens (?), Col. A. de Brébisson: Mr. De Suhr, 1840 (as Drap. tenuis beta elongata Ag.), Oestergearde (?) (L); St. Lo. Falaise: Herb. Kuetzing (as 479. Stig. with an epithet brevirameum Lebel, nov. sp. in icone) 19 Avril, 1861 (L); Germany: Schleswig (as Drap. tenuis var. elongata), Col. Alg. C. M. Diesing, An. 1841, Leg. Com. Suhr. (W); Freiburg: (as 162. Stig. tenue Kg.), Leg. A. Braun, May 1, 1848, Herb. Kuetzing (L); Dresden and Leipzig: L. Rabenhorst, No. 118, Leg. Tsigsohn (?) and Rothe (G); Herb. Boissier, Lindeman 6. Leipzig, Auerswald, Dec. 1857; Franconia (in Bavaria ?), P. F. Reinsch, No. 26, 1874 (K); Talmie (?): R. Brébisson No. 192, 1886 ? (K); Bire in Frankreich ? (Lenormand), Riederlansis ?, No. 94 (as Stig. tenue) (L);

Hansen ?: Van Bosse ? (B); Bei Neudamm etc. Rab. Alg. Sachs. Leg. ? and Rothe. No. 118 (W.B.F.K.); Freiburg: A 1/1.19 (as 170. Stig. with an epithet repens), A. Braun, 1849 (CN); Lindeman pr. Leipzig (LAU); Schleswig: Gallia, B. Ex. Herb. Kuetzing (L); Schleswig: Herb. Kuetzing, No. 21 (L); Dresden. Die Alg. Sachs. DR. L. Rabenhorst, 1851, Decade, XI & XII, Die Alg. Europa, Dr. L. Rabenhorst, Decade 251 u 252, 1877 (F); Triesting: Col. A. Grunow, Nos. 11545, 11646 (as Stig. crassiusculum Kg.) 7/1855 (W. FH); Spain: ?: Cangar (?): Algae Schouboeana (?) (as Stig. tenue: Drap. elongata Sch. (Chur.) Schourb (?), in rivulis reg. Tingitan (?) Martis (K); Holland: in rivulo, Th. Spreé, No. 217, 218, 219; Herb. Kon. Ned. Bot. Ver. July 28, 1859 (L); Sweden: Algae Hallandicae: Flora Suecia: Halland: Varberg, bäck Träslov-Galtabäck (as Stig. falklandicum Kg.), Herb. D. Hylmö (LD); Italy: Parma: Marzo, Rab. Alg. Eur. Col. G. Passerini, No. 2513, 1877 (W.G.K.L.F.NY.); Denmark: (?): in rivulis ad Molem Lindved Fionia (as Conferva lactea Roth.), Merteus, Juni, 1814 (C); ? Berndorf: as (Stig. flagelliferum Kg. var. crassiusculum), Leg. A. Grunow (L); Holland: Schleswig, (as 22. Stig. flagelliferum Kg. var. crassiusculum (Kg.)

Rab.), Herb. Kuetzing (L); Col. Grunow, No. 11629 (as Drap. tenuis var. elongata Ag.), Suhr. 1842 (W).

AFRICA

Algeria: Alg. Beni Menaner(?), Herb. Debzay, Nos. 388 and 389, Mars. 23, 1891 (AL.NY.)

ASIA

India: Hyderabad: Merralum, Col. Dr. Suxena, No. 2 (HY); Pakistan: Dacca: Col. S. Aziz, No. 131, on aquatic plants (Is.)

SOUTH AMERICA

Uruguay: Montevideo: (as Drap. sp.) J: Arechavaleta, No. 369, Quimico municipal (LD); Ecuador: Rushes Cundra, Col. G. W. Prescott, No. T379 (Pres.).

Stigeoclonium lubricum (Dillw.) Kg.

Pl. 4, Figs. 1-4; Pl. 5, Figs. 1-4; Pl. 6, Fig. 3; Text Fig. 84.

Kuetzing, Phyc. Germ. 198, 1845; Spec. Alg. 354, 1849; Tab. Phyc. 3: Pl.6, f.1, 1853; Raben. Krypt. Flor. Sach. I: 267, 1863; Berthold, Nova. Acta Leop. 40: Pl. 15, f.9, 11, 12, 14, 1878; Collins, Gr. Alg. N. Am. 218, 1909 (reprint 1928); Heering, in Pascher's Die Susswasser.6: 81, 1914; West and Fritsch, Brit. F. W. Alg. 185, 1927; Prescott, Alg. W. G. L. A., 34, Pl. 10, f.1, 2, 1951a; Tiffany and Britton, Alg. Ill. 34, Pl.8, f.66, 1952.

Stig. tenue (Ag.) Rab. var. lubricum (Dillw. Kg.) Rab. Flor. Eur. Alg. 3: 377, 1868; Kirchner, Krypt, Flor. Schles, 2(1): 68, 1878; Hansgirg, Prodr. Alg. Boehm. I: 66, 1886; Wolle, F. W. Alg. U.S. 111, 1887; De Toni, Syll. Alg. I; 197, 1889; Wildemann, Flor. Alg. Belg. 44, 1896.

Conferva lubrica Dillw., Brit. Conferva, 62, Pl.57, 1809; Agardh, Syn. Alg. Scand. 92, (Conf. lubrica Lyngby. T.52).

Myxonema lubricum (Dillw.) Fries. Syst. Orb. Veg. 343, 1825; Hazen, in Mem. Tor. Bot. Club. 11(2): 195, Pl.

23, f.1, 2. 1902.

Myxonema lubricum var. varians Hazen, loc. cit., 193, pl. 33, f.4, 5; pl. 23, f.3,4.1902;

Stig. lubricum var. varians (Hazen) Collins, Loc. cit. 213, 1909; Hylander, Alg. Conn. Geo. Nat. Hist. S. Bull. 42: 129, 1923.

Conferva exigua Dillw. ?

Stig. with an epithet dendriticum Kg. sp. n. in Kuetzing Herb. Yvetot, Mai, 1860 (L).

Stig. with an epithet repens A. Br. in Herb. Kuetzing, No. 143. Berlin, A. Braun, 1851 (L).

Erect filaments forming bushy tufts, 5 mm. to 5 cms. (up to 30 cms. ?) high, deep green, lubricous, robust; prostrate thallus creeping, often reduced and attached by rhizoids; erect filaments profusely branched, mostly opposite or in pseudo-whorls; alternate branching in the lower part of the main axis and in the upper part of the primary branches; branches on main axis arise from barrel-shaped or subglobose, smaller cells, primary and secondary branches little narrower than main axis; secondary branches often forming loose fascicles or tufts at the tips of the primary branches or main filaments; branches ending in a blunt tip although sometimes setiferous or sharply pointed with hyaline tips; cells of main axis (and primary branches) mostly thick-walled, barrel-shaped, swollen and little constricted, 12-20 μ (rarely 22 μ or more) in diameter, ½-2-4 times longer than broad; longer cells may be cylindrical and produce series of globular or subglobular cells, 2-4-8 successively which bear the branches; cells of secondary branches short, 8-10 μ in diameter, about as long as broad; chloroplast in large cells broadly zonate, draparnaldioid type with several pyrenoids.

Dillwyn (1809) described Conferva lubrica from Lounde, near Yarmouth and from Sketty Burrows near Swansea, in England, as an elegant Conferva growing on stones and woods, frequently from six inches to nearly a foot in length. He observed the alternate and whorled arrangement of the branches from a short joint. Kuetzing's type specimen of Stig. lubricum was collected from Schlensingen, Germany. Neither the type and lectotype specimens nor the illustrations given by these authors, however, represent the true characters of the species as we understand it now. Besides Dillwyn and Kuetzing, other workers like Agardh, Rabenhorst, Hansgirg, Wolle all gave a confused statement about this species, and none of them, it seems, was sure enough to separate it from Stig. tenue. This confusion was also due to the fact that Dillwyn's collections of Conferva lubrica were quite heterogeneous, including more than one species, most of them seeming to be Stig. tenue. It is no wonder that Rabenhorst (1868) put Stig. lubricum as variety under Stig. tenue, because Dillwyn's collections characterize better the latter species. In one of Dillwyn's collections of Conferva lubrica I found Stigeoclonium flagelliferum Kg. which was not described at that time. The figures given by Dillwyn (Pl. 57, f. A.C.) look more like this latter species which usually attains a great length.

Kuetzing (1849) mentioned Drap. tenuis Hassall as one of the synonyms for Stig. lubricum which does not look like the latter species at all. Cooke (1882-84) on the other hand, put the same as a synonym for Stig. tenue, which might be closer to it or any species similar to that but not to Stig. lubricum.

In my opinion Kuetzing was not certain as to how to differentiate clearly between Stig. tenue and Stig. lubricum and his illustrations of these species are poor. And those who followed these illustrations later, have added more confusions. The name of this species lubricum itself is sometimes confusing, since several other species may be equally or more lubricous. Sometimes worker identify any collection as Stig. lubricum, if the specimen is quite lubricous.

As Hazen (1902, p.197) has rightly pointed out, Berthold seemed to be the only author who particularly noted and correctly illustrated this species as Stig. lubricum and with him I fully agree. Berthold's illustrations of Stig. lubricum (1878, tab. 15, f.12), in my opinion should be regarded as a starting point for this species. Although we are not sure where to find the specimens used by Berthold, nevertheless, his illustrations clearly characterize the species. Later on Hazen (l.c.) illustrated similar plants from U.S.A. In this present work we have obtained similar plants from different places in U.S.A., Canada, Asia, and elsewhere. Some of them appear exactly as Berthold's figures, for example, Dr. L. A. Whitford collection No. W-858 from North Carolina, Dr. G. W. Prescott collection No. 2W-97-5, W-312 from Wisconsin; N. L. Gardner No. 325(82) from California, to mention only a few.

Although the cells of the main axis vary a little in shape and size the small cells producing the branches are quite characteristic. Sometimes, the secondary branches are short and form a whorl, when it appears as Stig. fasciculare Kg. But it can be separated from the latter species by its opposite branching, chloroplast structure, thick wall and absence of long hair.

Hazen's Stig. lubricum var. varians (Hazen) Collins does not seem to be a distinct variety. A similar series of small globular and somewhat cylindrical cells could be developed by the species proper. We could not see enough differences between P.B.A. Col. No. 366 (from Massachusetts) and P.B.A. No. 2233 (from San Francisco) distributed as Stig. lubricum, and P.B.A. Nos. 1790 (Isotype) and 1075 both from Massachusetts, distributed as Stig. lubricum var. varians. All these appear to be the same and show transitional stages in their growth form. Silva (1951, p. 146) also reported that the differences between species and variety mentioned above is not consistent and that intermediate stages are present. Sometimes, however, the reduced form of Stig. amoenum may appear as the above variety. The well-developed form of Stig. tenue var. uniforme may appear as Stig. lubricum, especially by its tufts or fascicles at the tips of the branches, but may be separated by the cell shape and branch-producing cells.

Stig. lubricum is perhaps less polymorphic than Stig. tenue but like the latter is equally one of the common species, mostly in cooler and swiftly flowing water. It does not seem to tolerate high pollution as does Stig. tenue. The life-cycle is not well-known.

Specimens studied:

NORTH AMERICA

Alabama: running water near ice plant, Sheffield, Colbert Co., Col. T. F. Hall, No. 1957, Sept. 5, 1949 (F); Alaska: Bot. Expn. to Alaska, 1899, Herb. Univ. California: Unalaska, small stream, Col. W. A. Setchell, No. 5035, June-Aug. 1899 (NY). Arizona: Pima Co: on rocks in a lily pond, University of Arizona Campus, Tucson, Col. Fr. Drouet and others, No. 2777, Oct. 30, 1939 (FH.F.MICH.); Eastern auxiliary Canal and Lat. 3 Hwy. J. D. Wien, No. 40, June 11, 1957 (F); Arkansas: Drew Co. around the pumpframe where some steam and hot water escapes. Ozark Badger Saw Mill, Wilmar, Col. D. Demaree, No. 24603, Aug. 7, 1943 (F); California: San Francisco: on grass in a pond west of Ingleside. P.B.A. No. 2233, Col. N. L. Gardner, 1916 (MICH.C.L.US.NY.F); Col. N. L. Gardner, No. 3257, and 32. March, 1916 (C.G.L.K.NY.MO.LD.F.); Tehama Co. Red Bluff: Sacramento River, D.M.C.S., Col. C. W. Reimer, No. 24(2), L. Bank, plankton, Aug. 11, 1956, No. 20(2)- on rootlets, r. bank (PH); Contra Costa Co. San. Joaquin River: E E Log, l.b. Col. Reimer #13(2), Aug. 16, 1955 and on Scirpus, l.b.S.J.R. Survey, Col. Reimer, 5(1), May 14, 1955 (PH); Tehama Co. Sacramento River, Col. Reimer No. 12(4), 18(3), 1(3), 17(3), Aug. 14, 15, 1956 (PH); Modoc Co.: In a drainage outlet into north fork of the Pit River, Altarus, Col. Fr. Drouet and D. Richards, No. 4137, Sept. 11, 1941 (L.PH.F.NY.MICH.); Marin Co.: Tomales Bay, P.B.A. No. 2235, Col. N. L. Gardner, Jan. 1914 (L); <u>Canada</u>: La Vase River. M. Ferris Co. on Log, L.V.R. Survey, Col. Hohn, No. 1(1), Sept. 24, 1957 (PH); <u>Québec</u>: Montreal: Bout-de-L'ile. sur un ilot dans la riviere des Prairies, en amont du pout du CN.R., Col. J. Brunel, 3,5, Août 13, 1930 (MT); Chambly: dans la riviére Richelieu, prés du Vieux fort, Col. F. Marie-Victorin et J. Rousseau, No. 153, Oct. 7, 1930 (MT); <u>New Brunswick</u>: in brooklet,,Grand Falls, Col. H. Habeeb, No. 10295, Aug. 9, 1947 (doubtful) (NY); Guelph ont. Mr. Klugh, Ex. Herb. Collins (NY); in brooklet, bed of Little River, Grand Falls, Herb. Habeeb, No. 11050, April 17, 1949, also No. 10042, 10295, June 30, 1947, Aug. 9, 1945--doubtful (F); <u>Delaware</u>: New Castle Co., Yorklyn.

sta.-1. Red Clay Cr. attached to rocks in riffles, Col. Hohn, No. 11(1), 9(1), July 23, 1956, M.C.A. Survey (PH); Stanton, sta.-2, White Clay Cr. on stump and rocks, Col. Hohn, Nos. 3(2), 8(2), 12(2), July 19, 1956 (PH); Castle Co. Red Clay Cr. Col. Hohn, Nos. 3(3), 9(3), M.C.A. S. July 19, 1956 (PH); Florida: Wakulla Co. In light house pool, west of St. Marks Light House, on the Gulf of Mexico, at the mouth of St. Marks River, (?), Col. Fr. Drouet, G. Madsen and D. Crowson, No. 11750, Feb. 1, 1949 (F); Sulphur Springs at Phillips Picnic Grounds, New Port, Col. C. S. Nielsen, Oct. 15, 1950 (F); Bay Co. in an outlet of a freshwater pond into the Gulf of Mexico, sunnyside, Col. Fr. Drouet, etc. No. 10678 ?, Jan. 9, 1949 (F); Gainesville; Leg. M. Brannon, No. 162, April 11, 1943 (F); Wakulla Co. Spillway Dam, Phillips Lake, St. Marks Wild Life Refuge, Col. C. S. Nielsen and others, No. 716, 726, 720, Dec. 5, 1948 (F); Hawaii: Kaliki stream, Nina Hosler Loomis, Herb. No. 226 and 717, Col. Minnie Reed, Mar. 4, 1903 (F); Illinois: McHenry Co. surface of pond at Phyotis corner, 1½ miles west of Algonquin, Col. J. E. Nielsen, June 14, 15, 1943 (F.NY.MICH.); La Salle Co. salt marsh along Cr. in bottom of Ill. river,

4 miles east of Starved Rock, Col. J. A. Steyermark and P. C. Standley, No. 40627, July 1941 (NY.F.); Knox Co. Galesburg. on submerged rocks etc. in ponds in Lincoln Park, Col. Richards and Strickland, May 3, 1940 (F); Chicago, In a small pool in a wet meadow by the lagoon, Washington Park, Col. F. Drouet and Louderback, No. 5348 (F); Iowa: on a stick floating in Mississippi River at the foot of second St. Dubuque, Col. Fr. Drouet and Louderback, No. 5718, June 17, 1946 (F); Louisiana: small stream west of Dodson Winn. Parish, Col. L. H. Flint and H. Silva, No. 2171 UT, March 22, 1950; Grand Parish, on *Polygonatum* sp. in sluiceway of small stream just north of Pollock at beginning of new Highway, Col. L. H. Flint H. Silva, No. 2133 UT, March 23, 1950 (F); Iberia Parish: in a drain beside St. Hwy. No. 25, Col. F. Drouet and R. P. Ehrhardt No. 9021, Nov. 12, 1943 (NY.F.); La Fourche Parish; on the wet bank of Bayon La Fourche at Galiano, Col. Fr. Drouet and P. Viosca Jr. No. 9422 (F); Orleans Parish: New Orleans, in a pond beside old Gentilly road at crossing of Louisville and Nashville railroad, Col. Fr. Drouet and P. Viosca Jr. No. 9379 b, Nov. 24, 1943 (F); Tammany Parish: Mandeville, in a pool, Sulphur

spring in municipal park on shore of Lake Poutchartrain. Col. Fr. Drouet and Flint, No. 9538, Dec. 2, 1943 (F); Washington Parish: in a creek beside St. Hwy. 7, 1 mile South of Angia. Col. Drouet and Flint, No. 9753 B. Dec. 4, 1943 (F); Maine: scraped off rocks in falling water, fish hatchery, Caribou. Col. H. Habeeb, No. 11469, July 30, 1949 (F); Maryland: Potomac River Survey: Montgomery Co. on rock. Col. Hohn #1(2), 1957 (PH); Frederick Co. Col. Hohn. No. 16(1), 22(1), l.b. June 1956 (PH); Potomac River sta.-2, l.b. from rock. 3 miles below the mouth of Monocacy river, Col. Hohn, Aug. 21, 1957 (F); Massachusetts: Malden. P.B.A. 866. on stones in brook. Col. F. S. Collins, 29, April, 1901 (C.MICH.PC.L.K.US.NY.W.F. Pres.); Medford: P.B.A. No. 1790 (as Stig. lubricum var. varium (Haz.) Collins), on plants and logs in old clay-pit, May 1, 1901 (C.MICH.L.PC.US.W.F.K.Pres.); in small pond near Tuft College mixed with other species. F. S. Collins 1075 (as Myxonema lubricum var. varians Hazen), May 10, 1903 (K.F.MICH); on log etc. Claypit, F. S. Collins Nos. 3998, 3999 (as Stig. lubricum var. varians) May 7, and 10, 1901 (Pres.); Malden: April 30, 1884 (Myxonema lubrica) (NY); Stream in Pine Beaches(?) Park, Melnue (?) Herb. F. S. Collins, May

1900 (NY); Highland air in Bmh(?), Ex. Herb. F. S. Collins (as Myx. lubricum and Stig. tenue), April, 1880 (NY); Cranberry pond, Leverett, Col. F. Seymour, Aug. 11, 1942 (F); Michigan: shore of harbor, St. James, Beaver Island, Charlevoix Co. Col. Fr. Drouet, and H. B. Louderback, No. 13127, Aug. 20, 1957 (L); Minnesota: Duluth, mouth of Lester River, C. Bullard, Aug. 6, 1902 (FH); Beltrami Co. on stones in shallow water along the Red Lake near fish-packing plant, Redby. Col. Fr. Drouet, No. 12017, June 23, 1954 (G); Minneapolis: on concrete work in a stream, east shore, Lake Isles, Col. Fr. Drouet, No. 5598, Aug. 19, 1944 (L.F.); Mississippi: Drew: from overflow pipe; Jan. 21, 1939, Col. R. L. Caylor No. 37 (F); Harrison Co. on concrete in a drain of a sewer entering Back Bay between Keesler Field and D'Iberville bridge, Biloxi. Col. F. Drouet, No. 10018, Dec. 15, 1948 (F); Missouri: abundant in still water of Spring branch Bennett Spring State Park, Laclede Co. Col. Fr. Drouet, No. 377, June 6, 1929 (MO). Georgia: Screven Co. Savannah River Pr.#7, on twig, r. bank, Col. Reimer No. 7(6), May 15, 1956 (PH); S.R.P. #3, sta.-1. on submerged twig, Col. R. Patrick, Jan. 15, 1952 (PH); Burke Co: S.R.P. #3, sta.-5, r.bank on log, Col.

J. H. Wallace, No. 7(5) (PH); Log A, Col. R. Patrick, No. 14(3), Jan. 1953, r.b. Col. Wallace No. 10(3), Jan. 1952 (PH); Lee Co: r.b. on log, Flint River Survey, Col. R. Patrick, No. 10(1), Sept. 1952 (PH); Savannah: B. Harvey, No. 6809 (as Stig. tenue), Jan. 1918 (NY); Nebraska: Lincoln Co. seepage in side channel, Platte River near Sutherland, Col. W. Kiener No. 14884, Aug. 1, 1943 (FH.MICH.F.) Sandpit Lakes, Cedar Bluffs, 1220 ft. Col. W. Kiener, No. 16615, May 19, 1944 (F); Hall Co. floating attached in ditch, south-east of Grand Island, alt. 1840 ft. Col. W. Kiener, No. 17180a. Aug. 17, 1944 (F); Cherry Co. attached to Potamogeton stem, Dewey Lake. Col. E. Palmatier and T. R. Porter. alt. 2600 ft. No. 13773, June 28, 1936 (F); Dodge Co. shallow water, attached to stem, loc. Fremont, Sandpit Lake. Col. W. Kiener, No. 13958, 13948, 13913, 13944, 13956, 13952, April 23, 1943 (FH); Saunders Co. Sand Cr. Wahoo, Col. W. Kiener No. 13817, April 1943 (FH); Lancaster Co. North Lake, Lincoln, floating, Col. W. Kiener No. 16670, May 27, 1944 (F); Hall Co. near Alda, in a road side ditch, W. Kiener, No. 15179, Sept. 1, 1943 (F); Garden Co. Lewellen, in shallow water of North Platte River, W. Kiener, No. 16258, Nov. 6, 1943 (F);

Keith Co. Limestone in swift channel below Kingsley-Dam. W. Kiener No. 15501, Sept. 13, 1943 (F); Lancaster Co: shallow water, Middle Cr. Lincoln, west of city, W. Kiener, 13597, Feb. 13, 1943; Nos. 13582, 13579, Jan. 12, 1943; Nos. 13616, 13615, Nov. 17, 1942 and March 10, 1943 resp. (F); New Jersey: on flag leaves in rapid water below dam, demarest, Leg. T. E. Hazen, No. 219, Nov. 28, 1899 (F); Elmdale, near Millburn, on rocks and stones in a spring, Col. H. Habeeb, No. 3779, Jan. 12, 1952, Plantae Novae-Caesareae (F); Essex Co. Millburn. in spillway of Rahway River, H. Habeeb, Nos. 3112, 3072, 3783, April 16, 1950 and Jan. 12, 1956 (F); on rocks in streamlet near Passaic River, at S. Orange Ave., H. Habeeb, No. 3820, Feb. 28, 1952 (F); New Mexico: Sierra Co. on a concrete spillway at sewage-disposal plant. Hot Springs, Col. Fr. Drouet and D. Richards, No. 2719, Oct. 26, 1939 (F.FH.); New York: West Point: (as *Draparnaldia tenuis* Ag.), J. W. Baily (NY); Rensselaerville, falls just below dams above falls on rocks, Col. M. S. Markle, No. 5, July 3, 1946 (F); Brooklyn, Prospect Park Lake, Leg. N. Pike, April 9, 1889 (F); North Carolina: Bertie Co. Roquist Creek, Leg. L. A. Whitford, No. Bt.10, June 23, 1959 (Whit.); Wake Co. House Cr.

on rock in rapids. L. A. Whitford, No. W-6, Dec. 1957 (Whit.); North Dakota: Devils Lake, Col. M. A. Brannon, No. 2, Aug. 1913 (F); Pennsylvania: Gibraltar, Berks Co.: Schuylkill River, on leaf, Col. Hohn #15, M.C.A.S., May 9, 1956 (PH); Chester Co. sta-1, White Clay Cr. on rock, Col. Hohn. July 17, 1956 (PH); Chester Co.: Brandywine Cr. Survey, Col. J. H. Wallace No. 2 and 21, Oct. 1952 (PH); Parkesburg, branch of Buck Run, on rock in riffle, M.C.A.S. Col. Hohn, No. 4 and 5, Nov. 11, 1956 (PH); East br. of Brandywine, on rock, Col. Hohn, No. 15 (322) Sept. 10, 1956 (PH); Adams Co. Rock Cr. on rock in riffle, M.C.A.S. Col. Hohn #8(2), 11(3), 12(3), July 26, 27, 1956 (PH); Lancaster Co. in a water tank by Muddy Cr. Adamstown, Col. H. B. Louderback, No. 8606, Aug. 27, 1948 (NY.F.); rock scraping from springs in Lititz Spring Park, Lititz. R. Patrick, No. 105, Oct. 3, 1948 (F); Philadelphia: on stones in Cresheim Cr. Fairmont Park. Col. Fr. Drouet and Hodge No. 3885, July 20, 1941 (F); Connecticut: Bridgeport(?): on submerged plants in still, P. B.A. (as Stig. tenue var. lubricum), May 14, 1893, (C.PC.W.) ???? Bridgeport, I. Holden, April 25, 1886 (NY); I. Holden No. 822 (NY); Nevada: Washoe Co. Verdi, Head trough, State fish

Hatchery, Col. R. C. Summer No. 1623, 27(3), 52(F); White Pine Co. Baker Cr. Col. T. Frantz, No. 1595 and 2983, Sept. 30, 1952; Churchill Co. Edward Cr. Desert-oya Range, Col. Frantz No. 2991, July 31, 1957 (F); Rhode Island: New Port, Col. Mr. Timmons(?), Herb. F. S. Collins, (NY); Ohio: Putnam Co. Auglaize River, on rock, O. R. Survey #2, Col. Hohn, No.13(6) July 5, 1956 (PH); scraping from Diatometer, Col. Hohn. O. R. S. #2, No. 3(5), July 4, 1956 (PH); Ottawa Co. In Lake Erie, south end of S. Bass Island. Col. J. Blum (300?) H. 246 June 15, 1949 (P); South Carolina: Aiken Co. Upper Three Runs- on board, S.R.P. #7, Col. Reimer, No. 11(2), May 11, 1956 (PH); Allendale Co.: on log and swift moving water, Savannah River, Mar. 3, 1960; Aiken Co. on log. Savannah River, Feb. 29, 1960, Col. C. W. Reimer, May 11, 1956 (PH); Orangeburg, from drinking fountain, Lily pond, Botany Garden, Col. R. Patrick, No. 2329, Sept. 9, 1944 (PH.F.); Barnwell Co.: Savannah River, on twig, l.b. S.R.P. #7, Col. Reimer No. 4(3), May 12, 1956 (PH); 2nd Bar Pr. #1, sta-6A, R. Patrick No. 107, July 1951 (F); Edgefield Co. north of Edgefield, Col. P. C. Standley, No. 92531, Mar. 19, 1946 (F); Tennessee: Knox Co.: Old Sevierville PK.1 mile from H.P. Tjams (?), Col. R. Shanks, No. 536, March 19, 1957 (F); Londen Lake at Lost Hollow Cr. Col. H. Silva, No. 534 ..

April 5, 1947 (F); Duncan Rd. 1 mile S-W Tenn. River. Col. H. Iltis, No. 522, Mar. 18, 1947 (F); Fountain City Park, Marble slab lining spring channel. Col. H. Silva, No. 545 March 23, 1947 (F); Sevier Co. road side drain, Roaring Fork near Gatlinburg, Col. H. Silva, Nos. 347, Nov. 24, 1946 and No. 701, April 13, 1948 (F); Utah: Salt Lake City: on street pavement in drain on a hill, State Street south of State Capitol. Col. Fr. Drouet and H. Louderback, No. 5720, Aug. 20, 1946 (F); Liberty Park, cement trough, Col. W. C. Twiss, No. 9, Nov. 1911 (F); Virginia: on rocks in rather swift river, New River at shoal near Pembroke R.R. Station, Giles Co. Col. H. Silva and Magie No. 2812 (as *Stig. amoenum*)(July 21, 1953 (F); Stafford Co: on rock, swift water in rock-flats of Rappahannock, below Falmouth, Col. H. Iltis, No. 3685, Sept. 8, 1947 (F); Md. No. 4595 (as *Myxonema lubricum*) May 23, 1903 (NY); Surry Co.: on rocks, shells etc. in creek flowing into James River below Colham's wharf. Col. J.C. Strickland, No. 761, June 22, 1941 (F); Page Co.: attached to stones in South fork of the Shenandoah River 2 miles north-west of Luray, Col. Luttrell and Strickland, No. 919, July 25, 1941 (F); Wisconsin: Dane Co: at water level on pilings, B. B. Clark Park, north shore of Lake Monona, Madison, Col. H. B. Louderback and Fr. Drouet, No. 5503 and 5508, July 23, 1944 (F); Mendota Wild Goose: ditch near Job Trout Lake. Col. G. W. Prescott, No. 2W 97-5, W312-1 (Pres.).

SOUTH AMERICA

Argentina: Buenos Aires: on Potamogeton: Col. Miss Guitman No. 1, 7/10/1958 (slide No. 6) and on Myriophyllum, slide No. 3, 12/11/1958 (through Dr. Guarrera); Lago San Roque, Leg. Yacubson, No. 6965 (vial. No. 15), 25/4/1949 (BA); Brazil: Plants of the State of Ceará: in swift water of outlet, Acude Choró, Municipio de Quixadá. Col. Fr. Drouet No. 1408, Sept. 1, 1935 (FH.MICH.); (Prov. de S. Paolo, Apiahy, Col. Grunow No. 11669 (as Stig. lubricum with epithet forma Brasiliensis) Leg. J. Puiggari, mai, 1878, same Col. Grunow, No. 11665, Apiahy, in rivulis, Puiggari, 227, 1883 (W)); Minas Geraes, on stones in very swift current, Cascade of Rio Pitanga, Ouro Fino, Col. H. Kleerekoper No. 173 (as Stig. lubricum var. varians), Aug. 21, 1940 (F); Ouro Fino, Back water swamp of Rio Santa, Izabel, No. 253, Aug. 23, 1940 (F); Ecuador: Pichincha: Aequatoriae ad lapides aquae fluentis prope Machachi. Wittrock, Nordstedt, Lagerheim, Alg. Ex. No.

1428, Leg. G. Lagerheim, 7/1892. Herb. de Candolle (G.L.K.NY.W.); Uruguay: ad Montevideo. Leg. Prof. J. Arechavaleta. No. 1429 (Stig. tenue Kg. f.; non Drap. tenuis Ag.) Wittrock, Nordstedt, Lagerheim Alg. Ex. (L.W.).

CENTRAL AMERICA

Venezuela: Aruba, Bron di Rooi Prins, Antilles, Leg. P. W. Hummelinek, No. 104Aa, 26/8/1949 (L); State of Anzoategui, along margin of Rio Querecual, forested rocky slopes, south-west Bergantia, Col. J. A. Steyermark, No. 61512, March 14, 1945 (F); Honduras: Vicinity of Camayagua. on dead branch in rivulet, Col. P. C. Standley and J.C.P. No. 5902, March 12-23, 1947 (F).

ASIA

Burma: Maymyo, northern Shan States, Col. L. P. Khanna, No. 640 (as Stig. lubricum (Dillw.) Fries var. varians Hazen), May 12, 1936 and No. 634, May 9, 1936 (F); Ceylon:(?): Galle (as 285. Stig. with an epithet intumescens icone Lebel), Herb. Kuetzing (L); India: Hyderabad: Col. Dr. Suxena, No. 8, Lalaguda, and Col. No. 12, Maredpalli (HY); Seetafalmandi, Col. Dr. Suxena, No. 10 (HY). Japan: Algae Aquae Japonicae: Kyushu, Ishiki, Kagoshima City, Kagoshima-ken, on pebbles in stream, also in Honshu, Col. Y. K. Okada. No. 8, Jan. 28, 1950 (G.L.US.F.W.Pres.); Chichibu: Saitma. Col. Yamagishi, No. 4, 13, June, 1957; Tokyo: Col. J. Yamagishi No. 14, April, 1956; Col. M. Mori, No. 15, Jan, 1958; Hokkaido, Aizankei, Asahigama, Monbetsu, Col. M. Akiyama, No. 21; Aug. 1956; No. 26, June 1954: No. 27: July, 1953: No. 28: Aug. 1956; Pakistan: Dacca: Col. S. Aziz No. 152 (Is.); Philippine: on submerged stems and grasses at Sampaloc Lake, Laguna, Col. G. T. Velasquez. No. 453 and 454(?), Feb. 25, 1940 (Pres.K.); upper waters of Rio Baco. In midstream where hot sulphur spring comes out of river-bed beneath the cool mountain water, April 16, 1905, Col. R. C. McGregor (F); Nicobar: S. Teresa prope Papiam (as 731. *Stig. tenue* (Ag.) Rab. var. *lubricum* (Dillw.) Kg. Rab.), Leg. L. Montemartini, 1895 (L.W.).

AFRICA

Algerie: Djelfa (AL); Mauritius: Latamer River, Col. N. Pike, No. 70 and 64, Jan. 28, 1870, G.D. (K. NY.); Hammam Melouan (source thermale) 1921, Mme. Gauthier-Lievre (AL).

EUROPE

Czechoslovakia: (as *Draparnaldia uniformis* Kg.), Herb.

Kutz. (PC); ? (as Stig. uniformis and Stig. tenue var. uniforme Kg.) Herb. Lebel (PC); Prag, (as Stig. amoenum), opitz, 6/10/1845, Grun. Col. No. 11624 (W); Böhmen, Karlsbad, im Bette der Tepl., A. Hansgirg (as Stig. tenue C) uniforme var. irregulare HANSG.) Aug. 1383 (F); Böhemiae, Col. Grunow, 11612, Leg. H. Bang (as Stig. pusillum; Myxonema lubricum) (W); Welwitch No. 165, (Stig. uniforme; Drap. uniformis; Drap. tenuis), =In fluvie Tepl. (W); Carlsbad, Col. Reichenbach, Acqu. 1889, No. 32659 (W); Čechy: Chvaly, A. Hansgirg, Herb. VI. 1885 (F.W.); Doksy, A. Hansg. VII. 1883 (F.W.); Klomin nächst Neratovic, April 1883. A. Hansgirg (F); Kunratice, June 1883, A. Hansg. (F); Belá: A. Hansg. Aug. 1883 (F); Maldaütumpel nächst Prag, A. Hang. Mai 1883 (F.W.); Böhmen: Johannisbad: Abfluss der warmen Quelle, A. Hansg. 7/1885 (W): Čechy Hlubocepy, A. Hansg. 5/1885 (W); Pribram, A. Hansg. 9/1884 (W); Branky u Roztok, A. Hansg. 6/1883 (W); Böhmen: Slichov nächst Prag: A. Hansg. 4/1882. Abfluss der warmen Quelle (W); Denmark: Fionia (?) (as Conf. lubrica Lyng. Drap. tenuis Ag. etc.) Herb. A. Morch (C); Ka: Viborg. Sonnalahti, No. 6. Skoljbrygya, E. Häyren, 19/10/34 (H); Austria: Prater bei Wien (as Drap. tenuis), Welwitsch, Col. Grunow, No. 11667 (W); Vindobona (as Conferva lubrica and Drap. tenuis Ag.) Leg. Welwitsch, Col. Alg. C.M.D., Ann. 1842 (W); Wien (as Myxonema protensum Rab.) Col. H. W. Reichardt (FH); France: Falaise: (as Drap. tenuis Ag.) (K); Caen: Herb. Kutzing No. 889 (L); ? Cascade de Mortani, Herb. du Dr. Lebel, donne an museum par ses enfants, en 1878 (PC); (as Conf. lubrica, Drap. tenuis Ag.) L. mertens, 1816 (PC) (as Conferva lubrica), D. Agardh, 1821 (PC); Cher. Vierzon, fontaine de Verdin, Herb. Roussel, No. 398 (12), 3/1867 ? (PC); ? (as Drap. uniformis Ag.), Meneghini (PC); Yvetot, (as Stig. with an epithet dentriticum Kg. sp. n.), Herb. Kuetzing, Mai, 1860 (L); Falaise; Herb. Kuetzing, No. 893 (L), also, A. Brebisson (L); Env. de Rambouillet (as Stig. irregulare Kg.), Donne par Ed. Bornet, 4/91, 4 Mai, 1850 (K.NY.); Rentilly (?), Herb. of Thuret, Donne par Mr. Bornet, 4/91, April, 1847 (as Stig. irregulare Kg.) (K); ? S. River Bruce (?), Herb. de Alton Saunders No. 3007 (as Stig. tenue Kg.), 20/4/46 (FH); Les mares des prairies pries du Howre(?), Moug. Roum and Dupray, Alg. des Eaux Douces. No. 1298 (as Stig. tenue Rab. f. lubricum (Kg.) Rab.) Dupray, Oct. 1891 (K); Germany: Leipzig: Rab. Alg. Sachsens, 490.

(as St. tenue (Ag.) Kg.) Leg. D. Bulnheim (K.B.); Leipzig and Dresden: Auerswald(?) No. 16 (as 217. Drap. tenuis Hass.) Juni 1852 (G.L.NY.K.F.W.); Husbye (?), (as 6. Drap. tenuis Ag.), Jan. 17, 1850 (B); ? Jurgens I (as 10. Conferva lubrica) (L); Bavaria: in rivulis prope Nürnberg, Leg. J. Kaulfuss, No. 233, 6/5.1904 (PC); Berlin; Im Landwehrgraben bei Berlin (as Stigeoclonium with an epithet repens A. Br.) Herb. Suringar and Kuetzing, June 1851, Leg. A. Braun No. 148 (L); 94(?) In Wiessengraben bei Sonnewalde in der Niederlansis Kretschmar (NY.W.L.K.); Im Brunnen bei Dresden (as 935 and 254, Stig. irregulare, Kg. and Stig. flagelliferum var. irregular), L. Rabenhorst, Feb. 1860 (W); Schlensingen (?), 12. Stigeoclonium lubricum (Dillw.) Kg. TYPE: Herb. Kuetzing, 24 Ex. (L); Leipzig: Augerb, Feb. 1863, Auerswald (LAU); Schleswig Hansen (as Stig. tenue; Drap. tenuis Ag.) (L); also Herb. Lenormand (L); Schleswig: Dr. C. Jessen(?) (as Drap. tenuis Ag.) (F), also Col. Grun. No. 11708 (W); Berndorf: (as Stig. lubricum var. irregulare) Leg. A. Grunow (FH); Schlensingen, Leg. Herb. Kuetzing (as Stig. protensum Kg.) (F); Auguer (?) bei Leipzig, Auerswald, 14.7.1863 (NY); Dresden, Rab. Alg. Sach. resp. Mittel. No.823. 1859 (F); Oldenburg: Jever, Jürgens, Leg. Herb.

Royers (Drap. tenuis Ag.) (F); Haideburge (?) (or Hainburg, Austria?), Herb. Agardh. Grun. Col. No. 11666 (W); Berndorf: A. Grunow Col. No. 11668, 1/1856 (W); Baveteisch in Voilan(?), Col. Grunow No. 11672, 1860 (W). England: Laund: Ex. Herb. Dillwyn (as Conferva lubrica Dillw.), 3/25, 1809 (K); Cambridge: Kew No. 15/2824/58 (as Drap. tenuis Ag.), J. S. Henslow (K); (as Conferva lubrica Dillwyn: Myxonema lubrica Fries) Herb. Hookerianum 1867, Aug. (K); Yarmouth and Lound (type locality), (as Conferva lubrica Dillw. Conf. lubrica Lyng.) April 30, 1793. Herb. Hookerianum, 1867 (K); (as 10. Conf. lubrica) Furgens? (W); as Conferva lubrica Dillwyn, 1826, Lieblier (W); Holland: Wassenaar, Meiendel, bei de opening, waar het Rijnwater in een meertje gestort wordt. Leg. A. G. Vorstman. Herb. Lugd. Batav. 29.11, 1956 (L); Leiden, Galgewater, Leg. W. F. R. Suringar, D.D.D. No. 103, April 1854 (L); Amerongen, Rijn, op stenen groeiend, Leg. C. den Hartog, (as Stig. tenue Ag.) Herb. Lugd. Batav, 24/11/1957 (L); (as 10. Conf. lubrica Dillw. Stig. tenue (Ag.) Rab. var. lubricum (Dillw.) Rab. (GRO); Rhenen, Rijn. Herb. Lugd. Batav. Leg. C. Pelsma (as Stig. tenue Kg.) 23 Aug. 1944 (L); Leiden: Hortus Botanicus. Witte, Herb. Lugd. Batav. No. 260 (as (as Stig. tenue (Ag.) Rab.), Leg. J. Th. Koster, 3/3/1939, (L); Switzerland: Geneve (?), Herb. De Candolle, ? m. Hottemanbury (?), 1838 as Conferva lubrica (G.); Italy: Gorizia: di corrente, Gradisca, De Toni, Herb. Brescia, Col. L. Ferlan, No. I/1, 58, 12.X.1946 (F); Poland: Wów Roztocze, Reciborski, Phycotheca Polonica, Zb. J. Wotoszyńska, No. 141 (as Stig. flagelliferum) X. 1911 (W.U.); Roumania: Herb. Alg. Romaniae: prope Monast ?, Dr. E. C. Teodorescu, No. 1124, March 24, 1902 (F); Dr. E. C. Teodorescu, No. 1076, 1079, Feb. 18, 1902 (F); Apud Cotroceni, in fontis secus riv. Dimbovita; E. C. Teodorescu Herb. Alg. Romaniae (1022, Oct. 23, 1901 (W); Bránesti et Burdusani, in riv. Paserea ad plantas, E. C. Teodorescu, Alg. Rom; des Frémy No. 1197, Jun. 3, 1902 (W); Apud Comana, Vlasca, in Valea-Spiridonului, E. C. Teodoresco. Herb. Alg. Rom. No. 566, March 19, 1900 (W); Cotroceni (Bucuresti), riv. Dimbovita, E. C. Teodorescu, Alg. Rom. No. 540, March 9, 1900 (W); ? Vindob. Col. No. 11216 (as Stig. tenue var. lubricum and Stig. lubricum var. with an epithet ramellis), Illegible (W); Apud Cáciulati, Tlfov; E. C. Teodoresco Herb. Alg. Rom. No. 764, June 4, 1900, mavrodin (?) (W); Sweden: Flora Suecia, Halland, Varberg, Falkenbergsvägen, St. Apelviksbäcken, Col. D. E. Hylmö, 9.9.1928

(LD); Col. H. Watts, No. 122, 136, 137 (LD); ? am Gogubei Altdaeh (?), Hasskari Herb. Illegible, Dec. 24, 1856 (L); Yugoslovia: Triesting (?) A. Grunow Col. No. 11675 ? (W). Germany: Teffen(?), No. 163 (as *Stig. uniforme* (debile), *Drap. tenuis*) (W); Baden: Jack, L. u. Stizenberger, Kryptogamen Badens, Aus der reisam im Höllenthale, Phar. Himmelseher, No. 45? (F.M.W.).

Stigeoclonium paihiaensis sp. nov.

Pl. 15, Figs. 1-6; Pl. 20, Figs. 3-7; Text Fig. 86

Plant bright green to yellowish-green, 3-6 cms. or more high, lubricous, sparsely branched below; from middle above profusely branched from node-like cells; branching mostly opposite or 3-4 branches from around the same cell; cells of main axis cylindrical, long, rectangular or short and inflated; cells at the nodes producing branches always having greater diameter than the rest and mostly subglobose to globose, true for both main axis and branches; at the tip the secondary branches forming little tufts; cells of main axis except at the nodes 30-48 µ in diameter, 1-3 times as long; nodal cells wider, up to 60-62 μ (or little more) in diameter, 2/3-1-1¼ times as long; cell walls below quite thick; chloroplast draparnaldioid type with several pyrenoids; cells of primary branches mostly rectangular, inflated and in young branches, cell-shape appearing as the back of the snail's shell, coiling type; cells of secondary branches rectangular; swarmers formed in cells of primary axis, liberated through lateral pore; tip of the branches bluntly pointed.

Type: Leg. V. W. Lindauer, Col. Nos. 105 and 1301 (as *Stig. amoenum* var. *novizelandicum* Nordst.), New Zealand, in freshwater stream and creek, Paihia Road, Bay of Island, March 11, 1939 (K.F.).

This species at first glance appears as a *Draparnaldia*, because of the greater diameter of the cells and I hesitate to put it under *Stigeoclonium*. But after careful studies I found that the branching habit is entirely like *Stigeoclonium* rather than like those forms of *Draparnaldia*, in which the branches are simple and not whorled-fascicled and where they arise from specially modified modal cells like some of the 'advanced type' of *Stigeoclonium* species. Secondly, the formation of swarmers in the cells of the main axis are like *Stigeoclonium*.

It does not belong to *Stig. amoenum* var. *novi-zelandicum* or *Stig. nudiusculum* in which greater diameter of the cells had been reported. Here, the nodal cells producing branches are much prominent and bigger than other cells of the filaments. Wolle's figure of *Stig. flagelliferum* shows slightly broad short cells at the nodes and sometimes the globular cells like this species are found in *Stig. lubricum*; but the branching nature, cell shapes, greater diameter, tips of the branches etc. are so different that it is better to put it under a separate species rather than modifying the descriptions of any well-known species.

Stigeoclonium Nelsonii Prescott

Pl. 10, Figs. 1-3

Prescott, in Hydrobiologia, 7(1-2); 56-59, Pl. 3-4, 1955.

Filaments long, sparsely and loosely branched, somewhat dichotomously branched below, prostrate thallus lacking; cells of main axis cylindrical or slightly inflated, 12-20 μ or little more in diameter, ½-2-5 times as long; branches forming fascicles on the short stalks near the main filaments, alternate or several from the same side; rarely branches are simple, solitary, opposite, non-fascicled; cells producing branches usually smaller than others; at upper part of the main axis series of short, rectangular cells, wider than long, are formed; branches ending in bluntly pointed or spatula-shaped cells; chloroplast a median incomplete parietal band.

Type: Prepared slide in the Herb. of Dr. G. W. Prescott, Botany Department, Michigan State University, mounted from original collections from the shell of a dead snail, floating in a small pond (Black Tern Pond), Montana.

This species closely resembles Stig. nudiusculum Kg. but differs from it by the absence of long colorless hairs and by the lack of sharp difference between long cylindrical cells and short branch-producing cells.

Stigeoclonium nudiusculum Kg.

Pl. 9, Figs. 1-9; Text Fig. 85.

Kuetzing, Tab. Phyc. 3: p.4, t.15, f.2: t.16, f.1, 1853; Rabenhorst, Flor. Eur. Alg. 380, 1868; Hansgirg, Prodrom. 68, 1886; Wolle, F. W. Alg. U.S. 113, Pl. 98, f.1-3, 1887; Hazen, in Mem. Tor. Bot. Club. 11(2); 207, 1902; Heering in Pascher's Susswasser.6(3): 84, 1914.

Draparnaldia nudiuscula Kg. Phyc. Germ. 231, 1845; Spec. Alg. 357, 1849; Tab. Phyc. 3:t.15, f.2, t.16,f. 1, 1853; Forest, in Castanea, 21(1): 15, 1956.

The following description is based upon Kuetzing's herbarium specimens No. 7. *Draparnaldia nudiuscula* Kg. collected from bei Eilenburg, Germany, Sept. 1834.

Erect filaments 1½-3 cms. or little more long; straight; abundant rhizoids from basal cells; main axis dichotomously forked below from small cells, from above middle filaments producing fascicled secondary branches from rectangular cells, mostly alternate, towards the apex the branches usually single, solitary, alternate, not fascicled; branch tips ending in long, colorless hairs; small, secondary branch tips blunt;

cells of main axis and primary branches two types long and short, usually cylindrical, without any constrictions, 16-25 μ in diameter, 4-7 times as long, short cells producing branches about 1-1½ times as long as broad; cells of secondary branches somewhat swollen above and little constricted with blunt tip; cell wall of main axis about 7 μ thick, especially from base up to the middle region of the thallus.

Lectotype: No. 7. Draparnaldia nudiusculum Kg. Herb. Kuetzing. Eilenburg, Germany, Sept. 1834 (L).

This species was originally described by Kuetzing as Draparnaldia nudiuscula with the diameter 46-51 μ in the main axis and 9.7 μ in the branches. Hansgirg and Heering recorded 30-47 μ diameter; De Toni and Wolle recorded 25-40 μ diameter. All authors recorded the cell-length about 1-3 times longer than broad. The lectotype mentioned above seems to be one on which Kuetzing earlier described Draparnaldia nudiuscula Kg. This specimen, besides the Stigeoclonium sp., also includes true Draparnaldia plants. It is, therefore, questionable whether Kuetzing had considered all the filaments on the same slide to be the same and if so, the greater diameter given for this species might include measurements of Draparnaldia species. We could not find the diameter more than 26 μ; more commonly between 16-20 μ for this Stigeoclonium species. This was also observed by Schmidle (1900) who studied the same material mentioned above and recorded the diameter only 16 μ. It seems, therefore, necessary to emend the description of the present species. I think, the diameter of the present species may not be more than 25-26 μ and cells are more elongated -- about 6-8 times the diameter, than 1-3 times as recorded by the earlier workers. I have examined Wolle's Stig. nudiusculum Kg. collection and found it to be a variety of Stig. amoenum (var. insigne comb.nov. .). Tilden's Amer. Alg. Exs. No. 460. Stig. nudiusculum Kg. similarly belongs to the genus Cloniophora. I question whether the authors mentioned above who recorded greater diameter for Stig. nudiusculum actually saw Kuetzing's collections and whether their materials might not be similar to Stig. amoenum var. insigne. Sometimes, Kuetzing's Fig. 2 of Pl. 15 is considered as typical Stig. nudiusculum rather than Fig. 1, of Pl. 16. I found and illustrated both types of filaments and branching habits from the same collection . Kuetzing's figure 2 of Pl. 15 was definitely drawn from upper part of the thallus, whereas the fig. 1. of Pl. 16 was drawn from the middle part. He did not show the lower and basal part.

There is no doubt that this specimen from which I have drawn the figures belongs to Stigeoclonium. The fascicled branches look like Draparnaldia but the main axis does not. Moreover, all the branches, below and above are not fascicled. In many respects it appears as Stig. flagelliferum. The long cylindrical cells have little or no constrictions, thick cell wall, short rectangular or cylindrical cells producing branches all in agreement with the latter species. It may be mentioned that Stig. flagelliferum sometimes produces pseudo-whorls or fascicles at the nodes from short cells. Stig. nudiusculum, however, may differ from the latter species by its more or less dichotomous branching below, strong fascicled branches at the middle or so and by long colorless hairs instead of having setiferous, flagelliform branch tips; and branches are usually alternate, rather than opposite. In certain respects this species superficially approaches Stig. fasciculare Kg. but the latter species is comparatively smaller in size, cells of main axis small, inflated and constricted and the fascicled appearance is due to crowding of short alternate secondary branches at the upper end of the primary branches. In _Stig. nudiusculum_ Kg. the fascicled branches are close to the main axis on short stalk-like branches developed from short cells and the fascicles are little spreading, more like _Draparnaldia_ sp. In _Stig. fasciculare_ Kg. the branches do not arise from any specialized short cells of the main axis. _Stig. Nelsonii_ Prescott may approach very close to _Stig. nudiusculum_ in which fascicled branching, thick-walled cylindrical cells etc. are similar. In the former species, however, the branches do not always arise from any specialized short cells of the main axis and are not, terminated by long, colorless hairs.

Schmidle (1900) described a variety _Stig. nudiusculum_ var. _tomentosum_ Sch. (p. 162, Text Fig. I) from probably saline water in small swamp near sea coast between Cumbella Hill and Volkenshwar, S. India. In this plant the lowermost cells may be 24-40 μ in diameter, 1-2 times as long, diameter becoming less above and the length gradually increasing to 3-6 times the diameter. As no type specimens or any collections under this variety has been seen, it is not possible to judge the systematic position of this variety.

Pascher (1906, p.435) has discussed the formation of only quadriflagellate micro- and macro-zoospores in *Stig. nudiusculum*. He did not see any akinetes, biflagellate swarmers or *Palmella* conditions and concluded that these structures do not occur in this species. He did observe spherical zygote formation in this species.

Specimens studied:

EUROPE

Germany: bei *Eilenburg* (Mülgscha) on *Nitella gracilis* Sm. Herb. Kuetzing (as 7. *Draparnaldia nudiuscula* Kg.), Sept. 1834 (L).

AFRICA

Tunisie: mare dans Les Sedjenane: Col. Mme. Gauthier-Lievre, Labbe 254 (AL.).

Stigeoclonium pachydermum Prescott

Prescott, in Farlowia, 1(3): 350, 1944; Alg. W. G. L. A., 116, 1951 a.

Erect filaments much branched, simple, straight or crooked, attached to substrates by numerous basal, downward projecting rhizoids, prostrate part lacking; cells of main axis below long, cylindrical or small, barrel-shaped, quite thick-walled; branches of main axis regularly or irregularly disposed and varied in form, mostly solitary, alternate or several on the same side, rarely opposite, or they may appear in a plane at right angle to the filament, or erect, simple, often developing from short, rectangular or barrel-shaped, subglobose cells (rectangular cells 1- or 2 at a place whereas the latter types of cells may be several in a row); many thorn-like, irregular and crooked, downward-projecting branches developing from the middle or upper part of the main axis; branches tapering to a blunt tip and rarely secondary branches are setiferous; quadrangular-globose intercalary sporangial cells may appear in the short lateral branches or in main axis; cells of the main axis and primary branches cylindrical, with very little or no constriction, except the barrel-shaped cells, 15-23.5 µ (rarely up to 30 µ) in diameter, 2-8 times as long as broad; cell wall considerably thick, 4.5-7 µ on each side; cells of secondary branches short, rectangular or cylindrical, rarely somewhat inflated.

This species was reported only from Wisconsin by Prescott (1944, 1951). Several collections from the same area made by Prescott have been studied by me and all the figures are drawn from these collections. As the author of this species points out that the irregular and crooked branches are quite characteristic of this species but they may not be specific. These crooked branches at first seems to be some growth-forms due to unfavorable environmental conditions, but in the collections, besides these crooked branches, numerous well-developed filaments can be found where the branching habit is quite 'normal' and does not seem to agree with any other species. In general appearance of the long and short cells of the main axis and thick wall it looks very similar to Stig. nudiusculum but there is no fascicled branches nor long hairs. The downward projecting branches seem to be quite well-developed and may suggest a general tendency which might be peculiar to this species. It does bear little resemblance to Stig. lubricum by its globular cells in the main axis but differs from the latter species by its alternating branches and long, cylindrical cells.

Stigeoclonium pachydermum Pres. var. pachydermum Pl. 11, Fig. 1-5; Pl. 12, Figs. 1-3; Pl. 14, Fig. 4; Pl. 31, Figs. 4-5; Text Figs. 87-88.

Cells of the erect filaments mostly cylindrical from below, little or not inflated except few barrel-shaped cells above; branches regularly or irregularly developed, mostly from short cells, may be downward, crooked, or at right angles to the filament; branch tips bluntly pointed, not setiferous, cells of main axis 15-23.5 μ in diameter, 2-8 times so long, cell wall up to 4.5 μ thick.

Lectotypes: G. W. Prescott Col. No. 2W-51, 2W-53, Wisconsin, Vilas Co., High Lake, on aquatic plants in shallow water, June 22, 1937 (Pres.)

Stigeoclonium pachydermum Pres. var. Whitfordii var. nov.

Pl. 13, Figs. 1-6

Erect filaments straight, stout with profuse basal rhizoids, lower cells of the main axis either cylindrical or barrel-shaped, predominantly alternate or unilateral branching from rectangular or subglobose or barrel-shaped cells; primary branches similar to the main filaments; cells of the main axis cylindrical, slightly undulating, and slightly inflated; secondary branches less abundant, branch tips bluntly tapering, not setiferous; no crooked or downward projecting branches present; cells of main axis often reaching 30 μ in diameter, 2-3 (-6) times as long, in branches may be longer; cell wall up to 7 μ thick.

Type specimen: L. A. Whitford Col. No. Ha-8, North Carolina: edge of run, Mc Neil Pond, Hoke Co. Mar. 12, 1959 (mixed with other Stig. sp.) (Whit.). Other specimens studied: North Carolina: L. A. Whitford Col. No. 872, Wake Co. Rocky Cr., Shallow rapids, April 25, 1959; L. A. Whitford Col. No. Ma-98, Macon Co., brook on Bull Pen Cr., Highlands, March 27, 1959 (Whit.).
Also the specimen bearing the label Stig. irregulare Kg. Ex. Herb. G. Thuret, 4 Mai, 1850. Donne par Mr. E. Bornet, 4/91 (K). (see Pl. 11, Figs. 4-5) may be assigned to this species and variety.

Stigeoclonium pachydermum Pres. var. Prescottii var. nov.

Pl. 14, Figs. 1-3

Erect filaments straight, simple, branching mostly alternate, cells of main axis cylindrical below, 15-23 μ in diameter (mostly 15.6-16 μ), 3-4 times as long, barrel-shaped above, as long as broad; secondary branches more or less whip-like above, with broad base and sharply pointed or setiferous tips, the whole branch may be curved upward or bent downward; intercalary cells usually barrel-shaped near the base, producing swarmers.

Type: Leg. Dr. G. W. Prescott, Col. No. Br. 68; Alaska: Point Barrow, Aug. 1959; other specimens: Leg. G. W. Prescott Nos. Br. 69, Br. 71, Br. 73, Alaska: Point Barrow. Aug. 1959.

This plant was collected from under the ice during late summer in Alaska, 1959. Due to its cell shape and branching habit it has been put under Stig. pachydermum Pres. as a variety. The group of barrel-shaped cells near the base seem to be sporangia and superficially resemble Stig. nudiusculum var. tomentosum Schmidle. Whether sterile and fertile parts of the filaments are separated like this is true or not shall have to be ascertained by more collections or cultural studies.

Chapter III

The genus *Cloniophora* Tiffany

INTRODUCTION

The genus *Cloniophora* was first established by Tiffany (1936) with two species, *Cloniophora willei* Tiffany and *Cloniophora capitellata* Tiffany, as a result of his investigations of N. Wille's (1914-1915) algal collections from Puerto Rico. Since that publication the genus has been reported from few other places. Thus, Bourrelly (1952) reported it from Guadeloupe Island. In that paper Bourrelly transferred certain species of *Stigeoclonium* to *Cloniophora* and proposed two new combinations, such as, 1) *Cloniophora plumosa* (Kuetz.) Bourrelly, which included *Stig. plumosum* Kg., *Stig. spicatum* Schmidle, *Stig. Askenaysi* Schmidle, *Clon. willei* Tif. and *Clon. capitellata* Tif.; and 2) *Cloniophora macrocladia* (Nordstedt), Bourrelly, which included only *Stig. macrocladium* (Nordstedt) Schmidle.

Later on Bourrelly (1954) gave the geographical distributions of the above proposed *Cloniophora plumosa* from Guadeloupe Island to Guyane, Java, Sumatra, Australia, Sandwich Island (Hawaii), Puerto

Rico and New Caledonia, mainly based on the reports of above-mentioned *Stigeoclonium* and *Cloniophora* species. Besides this, Mme. Gayral (1954) from Maroc, Africa, as well as Hirose and Takashima (1955) from several places in Japan, reported *Cloniophora* with the above-mentioned proposed species *Cloniophora plumosa* (Kg.) Bourrelly. Recently, Whitford (1960a) reported that the genus *Cloniophora* is quite common in Peruvian rivers in the Amazon watershed.

During my recent investigations of the genus *Stigeoclonium* I came across many herbaria and preserved specimens of the above-mentioned species of both the genera, as well as many unidentified specimens, and thus, it was possible to set aside these materials to make a critical study of them. Here, in this section, a general review of the genus *Cloniophora* and results of my critical studies are given with a view to clarify the systematic positions of several species belonging to *Stigeoclonium*, *Cloniophora* and *Draparnaldia*.

International rules of Botanical Nomenclature, 1956 have been followed in making new combinations and varieties.

The names of herbaria which provided us with many specimens have been mentioned already under the section _Stigeoclonium_. The abbreviated names of herbaria will be mentioned below in parenthesis after each specimens studied. The abbreviations of herbarium names proposed by Lanjouw and Stafleu (1956) are followed.

Besides these herbaria specimens, several individual workers kindly have supplied me with their recent collections of preserved materials. They are: Dr. G. W. Prescott, collected from Ecuador, Feb. 1958; Dr. M. Hirano, collected and sent from Japan, Feb. 1960; Dr. Akiyama, also collected and sent from Japan, March 1960, Mr. D. C. Jackson, collected and sent from Puerto Rico, June, 1960; Mme. Gauthier-Lievre from Alger University, Algeria, kindly sent us many of her beautiful pencil drawings, some of which represent _Cloniophora_ species. Recently, Dr. Whitford has sent me some Peruvian collections of _Cloniophora_ from North Carolina. I am extremely grateful to all of them for their generous cooperations.

Further distributions of this genus _Cloniophora_ in addition to those given by Bourrelly (l.c.) are mentioned later in this section under each species (also see Map 1).

SYSTEMATIC DISCUSSION

The plants referred to the new genus *Cloniophora* by Tiffany in 1936 who placed it between *Stigeoclonium* and *Draparnaldia*, were not altogether unknown and undescribed. Kuetzing's descriptions of *Stig. plumosum* Kg. (1849, p.356) based on type specimens Le Prieur No. 829 from Cayanne, are almost the same as given by Tiffany for *Cloniophora*. This is supported here by the study of the Type specimens. Nordstedt (1878, p.22) had reported a similar plant as *Draparnaldia macrocladia* Nordst. from Honolulu which Schmidle later (1900) transferred to *Stigeoclonium* as *Stig. macrocladium* (Nordst.) Schmidle. Schmidle (1895, 1896) also added two new species to *Stigeoclonium*, viz., *Stig. spicatum* from Sumatra and *Stig. Askenaysi* from Australia. Nayal (1935) further added one new variety, *Stig. macrocladium* var. *Egyptiacae* Nayal from Egypt. All these *Stigeoclonium* species are similar in habit to those of *Cloniophora* species.

It seems, however, that the systematic positions of these characteristic plants were not clear for a long time, especially, since Kuetzing's time, and authors from time to time were confused as to whether these plants should be placed under Draparnaldia or Stigeoclonium. Schmidle (1900) was the first who noticed that Nordstedt's Draparnaldia macrocladia was not a typical Draparnaldia and therefore, transferred it to Stigeoclonium. In the same paper (p. 152) Schmidle brought to our attention that the four species of Stigeoclonium, viz., Stig. macrocladium, Stig. nudiusculum var. tomentosum, Stig. spicatum, and Stig. Askenaysi, all form a rather different group from the rest of Stigeoclonium species, because in all these forms the main axis is too wide with very narrow and short branches, all have median chloroplasts (like Draparnaldia) and all have well-developed rhizoids at the base. He also expressed his doubt whether some other species could be placed in this group. Wildemann in the same year (1900, p.62) also questioned the validity of the "poorly defined" species Stig. spicatum and doubted whether this species should be assigned to Stigeoclonium. Although neither of these two authors established a new genus nor transferred these species of questionable systematic positions to any other genus, it is necessary to give them credit, because they recognized and pointed out the characteristic habits of this plant-group, and illustrated them well. Unfortunately, Tiffany (l.c.) who dealt with exactly similar kinds of plants, has failed to refer to any one of the studies by Kuetzing, Nordstedt, Schmidle, Wildemann and Nayal. On the other hand, Tiffany did suggest that this genus Cloniophora should be compared with Ireksokonia Meyer (1927), and Myxonemopsis Meyer (1930), both of which, according to him, appear to be quite near Stigeoclonium. But, there is doubt whether those two genera are clearly chaetophoraceous because of their reticulate chromatophores, thick laminated cell-wall and very large size, which suggest certain cladophoraceous characters.

Bourrelly (1952) however, was the first to recognize that all the four species of Stigeoclonium, namely, Stig. plumosum, Stig. macrocladium, Stig. spicatum and Stig. Askenaysi, should be placed under Cloniophora, although with his proposed combinations one may not agree completely.

Even now there still exists confusion and difference of opinion in respect to the systematic positions of these species-groups. Forest (1956) still recognizes, although "with reluctance" the "most consistently Stigeoclonium-like" Draparnaldia macrocladia and considers that Draparnaldia nudiuscula is a juvenile Draparnaldia. He further refers Tilden's Amer. Algae Exs. No. 460. Stig. nudiusculum from Hawaii to Draparnaldia macrocladia. This latter specimen as well as Tilden's Am. Alg. Exs. No. 459: Stig. amoenum var. novizelandicum Nordst. have been studied by me and both are considered here as a species of Cloniophora (i.e. Clon. macrocladia).

There are several herbaria specimens bearing certain names which also confuse the systematics of those plants. Thus, for instance, G. W. Fergusson's Col. Nos. 360 and 387 bear the label Draparnaldia uniformis Kg. var. ? from Ceylon which are considered here as Cloniophora species. Similarly, some other herbaria specimens bearing the names, such as, Stig. lubricum (Dillw.) Kg., Drouet Col. Nos. 9800, 9803, 9823, 9824 from Mississippi (Chicago Herb.); Stig. amoenum Kg. forma, Leg. R. Junger, from Africa (under Wittrock and Nordstedt Exs.); others bearing the label as Stig. with an epithet polakowskyi n.sp. Grun. and Stig. with an epithet neocaledonicum Grun. sp.n. and so on. All these have been placed under proper species of Cloniophora (see notes under specimens studied). The latter two as new species of

Stigeoclonium could not be found in any literature by me but only on the herbarium sheets (both from Vindob Herb. Wien.) and thus according to Int. Rules of Bot. Nom. these names are considered invalid. It is doubtful whether *Stig. nudiusculum* var. *tomentosum* should be assigned to *Cloniophora* because of its long, colorless hair which is totally lacking in the latter genus.

From a comparative study of a large number of *Stigeoclonium* specimens and from our knowledge of *Draparnaldia* species it appears to me that the genus *Cloniophora* Tiffany stands quite unique among other chaetophoraceous plants and although it shows many transitions from *Stigeoclonium* to *Draparnaldia* and possesses certain common characters of both, yet it differs from either of them in certain other characters which it maintains quite uniformly and fairly constantly over a wide geographic range. Thus the specimens from Ecuador, Peru, Puerto Rico and several places from Japan for example, are quite identical and it is difficult to state which one is from which place if there were no labels attached to them.

Tiffany (l.c. p. 174) pointed out that the chloroplast structure, attachment by means of profuse rhizoidal growth from lower parts of the plants, absence of prostrate system, many pyrenoids and many short lateral branches of Cloniophora (same descriptions as given by Schmidle, 1896, 1900 for his new species of Stigeoclonium) are all like Draparnaldia and the forms and origin of secondary branches are often similar to Stigeoclonium; only difference from either genus, he mentions, is the nonsetiferous terminal cells of the branchlets (a point also stressed by Kuetzing, 1849, for Stig. plumosum Kg.; by Nordstedt (1878) for Drap. macrocladia Nord.; by Schmidle (1895, 1896) for Stig. spicatum and Stig. Askenaysi Schm., always there was a consistent absence of hairs). The absence of prostrate part, presence of rhizoids, hairless branch tips etc. however, may be found in certain species of Stigeoclonium and Draparnaldia. In spite of all these similarities, the differences are striking. Here, in Cloniophora, however, the main axis which is mostly like Draparnaldis, the branching habit, on the whole, does not resemble it, nor Stigeoclonium. The cell-shape, the difference in diameter between main axis and secondary branches and most important, the arrangement of the latter on the main axis or on primary branches are characteristics for this genus. The main axis consistently bears two types of branches; 1) long, many-celled branches of indefinite growth, straight, rebranched or unbranched, slightly narrower than main axis and bearing secondary, short branches; usually producing the zoospores or gametes; these are regarded here as primary branches; 2) short, one to few-celled long, very narrow branches of definite growth; may be curved or erect, mostly unbranched, irregularly scattered on main axis and primary branches. These are called here secondary branches. The origin of these almost thorn-like secondary branches or of primary branches is definitely not like _Stigeoclonium_. In _Stigeoclonium_, the origin of branches by lateral divisions or by evection of the cells are clear, but in _Cloniophora_ these are not evident. It seems to one as if these small branches are foreign epiphytic growths occurring irregularly on the filaments without any definite order. The cell-shape in this genus is also characteristic; capitellate, infundibulliform, tumid or almost cylindrical or club-shaped. All these types of cell shapes may be found in the same collection. In certain species of _Stigeoclonium_, for example, _Stig. subuligerum_ Kg. irregularly scattered branches are found but these are usually setiferous, and cells are of same size as main axis and moreover, the cells of the main axis produce zoospores or gametes.

INTERGENERIC RELATIONSHIPS

Below is presented a key to separate from each other the closely related genera of the family Chaetophoraceae, namely, *Stigeoclonium*, *Cloniophora*, and *Draparnaldia*. This key may be regarded as tentative until such time as the discovery of additional species or more critical examination of presently known forms may introduce a reconsideration.

I. a). Plants with less difference between main axis and branches; in many species branches arise from modified cells and differently shaped from others in the main axis; where this difference is not sharp, all the cells of main axis and branches look alike, branches are simple, mostly setiferous, with hairs; usually prostrate and erect parts of the thallus are present; zoospores and gametes produced mostly in the main axis but may come also

from the branches; intercalary and diffuse growth present; vegetative cells mostly between 10-25 μ in diameter.

------*Stigeoclonium*

I. b). Plants big sized, with remarkable size difference between main axis and branches; branches setiferous or nonsetiferous and blunt; branches are not developed from any specialized cells (or cells producing branches are not different from those not producing branches); prostrate part always lacking; basal cells of erect part producing profuse rhizoids; zoospores and gametes always from lateral branches; growth intercalary, diffuse or trichothallic.

------ 2

2. a). Plants with irregularly-arranged or scattered short branches which are solitary, crowded or loosely aggregate, not in true whorls or fascicles; vegetative cells of main filament and branches capitellate, inflated, tumid, infundibulliform, almost cylindrical, with or without constriction; branch tips not setiferous, hairs absent; apical cells of branches conically rounded or blunt; vegetative cells of main axis mostly between 20-50 μ in diameter; growth intercalary or diffuse. ------*Cloniophora*

2. b). Plants with regularly organized short branches in whorls or fascicles on the main axis or primary branches; apical cells of branches setiferous, with long colorless hair; vegetative cells cylindric, barrel-shaped or tumid; growth usually trichothallic; vegetative cells of main axis mostly between 40-150 μ in diameter. ------Draparnaldia

Chaetophora differs from all these genera by the fact that its filaments are radiate or divergent from a center and usually enclosed, even at maturity, within a copious, firm mucilagenous matrix, and the branches developed at the periphery than at the central part of the colony and it shows intercalary growth. Draparnaldiopsis has the same feature as Draparnaldia, differing only in the presence of two types of cells in the main axis, long and short, the latter usually producing lateral branches (see however, Forest, 1956a) and by intercalary growth. In the former respect Draparnaldiopsis bears a resemblance to certain "advanced forms" of Stigeoclonium (for example, Stig. amoenum Kuetz. Stig. nudiusculum Kg. etc.). The illustrations given by Kuetzing for Draparnaldia ornata and Drap. comosa (1853, Pl.16, Figs. 2, 3) appear to be very similar to Cloniophora, especially, the former species, Drap. ornata. But in the absence of authentic material they are omitted from this study.

Cloniophora Tiffany, Brittonia, 2(2): 173. 1936

Thallus gelatinous, 5-15 cm. high, profusely branched; branches of two types, long of indefinite growth, further branched or unbranched, usually producing zoospores or gametes, erect, straight, little smaller in diameter than main axis; and short, 1-few-celled secondary branches, erect or curved, irregularly scattered on main axis, and sometimes dense, crowded, verticillate, or solitary, uniseriate, all may be in same plant; plants attached to substratum by profuse rhizoids from lower, narrow cells of main axis; cells of main axis and primary branches above wider and longer, cylindrical, tumid, capitellate or infundibulliform, club-shaped, or swollen, inflated, not all of same length, but many

times wider than secondary branches, with or without constriction between the cells; cells of secondary branches small, rectangular, repand or inflated, swollen, with or without constrictions; tips of branches blunt, obtuse, round or flat conical; hairs absent; chromatophore solitary with several pyrenoids, in the main axis a broad median band or zonate with laciniate margin (Draparnaldia type), in small branches a parietal band with fewer pyrenoids (Ulothrix type); gametes or zoospores (biflagellate so far known) from cells of long or short lateral branches, several per cell escaping through lateral pore at one side of the characteristic protrusion of the cell wall; sometimes, branches producing swarmers become long, slender and coiled. The time of swarmer-formation was found to be variable in different collections. Thus, for example, the swarmers were found in Ecuador specimens collected in Feb. 6, 1958 (Prescott Col. No. T-52); in Peruvian specimens collected in last week of September and early October, 1955; in Puerto Rican specimens collected in June 20, 1960; in Mississippi specimens collected in December 8, 1948.

The following key to separate the species of

Cloniophora is based on cell-shape, size, and secondary branch arrangements.

Key to the species of Cloniophora:

1\. a). Cells of main axis cylindrical, mostly capitellate, with little or no constrictions, cell diameter between 20-46 µ.

------ 2

1\. b). Cells of main axis much inflated, swollen, cell diameter between 30-60 µ.

------Cl. macrocladia (Nordst.) Bourrelly

2\. a). Cells of main axis mostly cylindrical, slightly capitellate, with little or no constriction at partition wall; mostly 20-25 µ (rarely up to 32 µ) in diameter, 2-7 times as long (mostly 3-5 times); secondary branches verticillate.

------Cl. plumosa (Kg.) comb.nov.

2\. b). Cells of main axis mostly tumid, strongly capitellate, slightly constricted, diameter mostly between 30-40 µ, ½-2-3 times as long; secondary branches form tufts at the end of lateral branches.

------Cl. spicatum (Schmidle) comb. nov.

Cloniophora plumosa (Kg.) Bourrelly

Pl. 35, Fig. 1; Pl. 36, Figs. 7-8; Pl. 39, Figs. 7-8

Bourrelly, Alg. d'douce de la Guadel., p. 203; Pl. 26, f. 430, 1952.

Stigeoclonium plumosum Kg. 1849. Spec. Alg. p. 356; Tab. Phyc. 3:T.11, f.2; De Toni, Syll. Alg. I: 203, 1889.

Thallus 2-5 cm. in length; main axis slender, profusely branches; cells of main axis cylindrical, slightly capitellate, with little or no constriction, 20-25 μ (rarely up to 32 μ) in diameter, 2-4-7 times as long (mostly 3-5 times); short secondary branches sparsely scattered below, dense above, becoming verticillate or subfasciculate; apical cells of branches obtuse, conical or slightly cylindrical, longer than lower cells but without any hair formations; rhizoids present; zoospores from lateral branches.

Holotype: same as *Stig. plumosum* Kg. Type, Cayenne, Ex. Herb. Kuetzing No. 24 (L).

This species differs from Clon. spicata and Clon. macrocladia by its slender, narrower filaments which never attain the dimensions of the latter two species. The cells of thallus are more cylindrical and relatively longer and the cell walls are somewhat irregularly thickened below; above less thin and slimy. Measurements as given by Kuetzing are much less than we found in the Type and other specimens. His illustration (1853, pl. 11, f.2) is not satisfactory.

Bourrelly (1952) made a new combination under this name and included Stig. plumosum, Stig. spicatum, Stig. Askenasyi, Cloniophora willei and Clon. capitellata but these latter four species are comparatively larger in size, i.e. cells are wider and shorter but in Stig. plumosum cells are longer and narrower; moreover, in the former group of species secondary branches form a tufted cattail-like appearance on the lateral branches but do not form distinct verticillate, node-like appearance like the latter species and for this reason it has been separated from the above four species and made a new combination Cloniophora plumosa (Kg.) comb. nov.

Specimens studied:

SOUTH AMERICA

Cayenne: Stig. plumosum Kg. TYPE (L); Le Prieur No. 829, Herb. de C. Montagne (PC).

ASIA

Ceylon: Colombo, mouth of Kelany River, Leg. W. Ferguson, No. 360, 387, as Draparnaldia uniformis Kg. var. ? (L.W.);

NORTH AMERICA

Hawaii: Oahu Island, in Nuuanu, Leg. A. A. Heller, No. 2298, as Stig. nudiusculum, May 10, 1895 (G.NY. Z.FH.L.US.).

Cloniophora macrocladia (Nordstedt) Bourrelly.

Draparnaldia macrocladia Nordstedt, 1878, in Minesskr. Fys. Sallsk, Lund. 7: 22-23, t.II, f.20-21; De Toni, Syll. Alg. I:193, 1889; Forest, in Castanea, 21(1): 14, 1956.

Stigeoclonium macrocladium (Nordst.) Schmidle, in Hedwigia, 39:162-166, 1900.

Stigeoclonium amoenum var. novizelandicum Nord. J.E. Tilden Am. Alg. Exs. No. 459.

Stigeoclonium nudiusculum Kuetz. J.E. Tilden Am. Alg. Exs. No. 460.

Thallus 3-5(-15) cms. long; main axis profusely branched from below; primary branches almost of equal size like main axis and bearing many short, few-celled branches, irregularly scattered, sometimes these secondary branches crowded on the main axis or primary branches, but they are solitary and do not give a fasciculate or verticillate appearance; produce zoospores or gametes; rhizoids well-developed from stout basal cells, slightly cylindrical, but cells of main axis mostly short, swollen, barrel-shaped, inflated or club-shaped, constricted at the partition wall; short and long cells may be present in the same plant, 25-50-60 μ in diameter, $\frac{1}{2}$-2(-3) times as long; cells of short branches 6-10(-14) μ in diameter, 1-2 times as long, mostly inflated, or club-shaped, constricted; blunt or round tips; hairs absent.

Type locality: Honolulu, Oahu (type specimens not seen)

This species which was originally described as *Draparnaldia macrocladia* by Nordstedt is quite remarkable, although showing polymorphism, sometimes shows characters of *Cloniophora spicata* (Schm.) comb. nov. by having a little longer cells and occasionally crowded branches appear as tufts like the latter species. It however, differs from other species by the characteristic cell-shape, mostly inflated, swollen or barrel-shaped and by deep constrictions. Secondary branches are mostly solitary and sparsely scattered. Bourrelly (1952) mentions that rhizoids in this species are less profuse which I found not to be true. The rhizoidal base is quite well-developed and more or less the same as that in other species.

There are several collections (see below) from geographically isolated areas, mostly from Pacific Islands, showing a remarkable transition between this species and *Clon. spicatum*-group and thus difficult to place under any species. Occasionally, the basal part looks like typical *Clon. macrocladia* when the upper parts appear as *Clon. spicatum*; sometimes, the reverse is also true. An extreme condition like this has been found in several collections from Mississippi, U.S.A. which have been regarded as a new variety of this species.

Cloniophora macrocladia (Nordst.) Bourrelly var. macrocladia

Pl. 35, Fig. 2; Pl. 36, Figs. 1-6; Pl. 37, Fig. 6

Draparnaldia macrocladia Nordstedt, 1878, loc. cit.
Stigeoclonium macrocladium (Nordstedt) Schm. loc. cit; Prescott, in Trans. Am. Micros. Soc. LXX(1): 16-17. 1951.
Stig. macrocladium var. Egyptiacae Nayal, 1935, Egypt University Bull. Fac. Sc. 13: 1-15; in Rev. Alg. 8: 311-319, 1939.
Stig. amoenum Kg. forma Nordstedt, Bot. Not. 1897, p. 132.

Thallus same as described for the species; cells are mostly inflated, swollen or barrel-shaped, mostly 35-50 (-60) μ in diameter, 1-2 times as long; secondary branches very short, 6-10 μ (-14 μ) in diameter, partition wall deeply constricted.

Gayral's (1954, p.212, f.43) Clon. plumosa (Kg.) Bour. should belong to this variety of Clon. macrocladia (Nordst.) Bour.

Specimens studied:

NORTH AMERICA

Hawaii: In swiftly flowing waters, attached to sides of irrigation troughs, Peninsula, Pearl City, Oahu; J. E. Tilden Am. Alg. Exs. No. 460, as Stig. nudiusculum Kg. 6 Je, 1900 (K.NY.PC.US.IA); Kaliawaa, Makao, Koolauloa, J. E. Tilden Am. Alg. Exs. No. 459, as Stig. amoenum var. novizelandicum, Je, 1900, (K.US.NY.PC.F.IA.) This specimens No. 459 are **not the same in all** collections from different herbaria).

CENTRAL AMERICA

Panama Canal Zone: Balboa, Col. G. W. Prescott, No. CZ.111-1, 1937 (as Stig. macrocladium (Nord.) Schm. (Pres.). Costa Rica: Flora Costaricensis. Lef. Dr. H. Polakowsky, Juli 1875 (Col. Grunow No. 11714 in Vindob Herb. Wien (W), as Stigeoclonium with an epithet Polakowskyi Grun. n. sp.). Guadeloupe Island: Basse terre: Casses andessus. alt. 160 m. 1890 ? (as 191. Stig. plumosum Kg. ?) (K).

AFRICA

Cameruniae ad Bibundi: Wittrock, Nordstedt and Lagerheim Alg. Exs. Leg. dr. R. Jungner No. 1426

(as *Stig. amoenum* Kg. forma) 1/1891 (W.K.G.); Lac de-Banfora, Haute-Volta: Col. Mme. Gauthier-Lievre (AL).

ASIA

Malay Archipelago: *Java*: in rivulo ad Plaboehan: Wittrock Nordstedt and Lagerheim, Exs. 1427 (as *Stig. amoenum* Kg. forma) Leg. dr. Hj. Moller 25/7/1897 (W.K.G.); *Isle of Saleyer*: Communicata ex Lugduno-Batavo (as *Stig. Ashenasyi* Schm.), Leg. A. A. Weber-van Bosse. Jan. 1889 (F).

Cloniophora macrocladia var. *mississippiensis* var.nov.

Pl. 37, Figs. 1-5; Pl. 39, Figs. 5-6

Thallus well-developed; cells of main axis up to 45 μ in diameter, 2-3 (-3½) times as long; rhizoidal growth profuse; lower cells of main axis short, inflated but above more club-shaped and elongated, less inflated; lateral branches similarly shaped; less constriction at the partition wall than in the typical, especially in the upper part of the thallus; zoospores from lateral branches; tip truncate, or rounded.

Type: Fr. Drouet Col. No. 9303, Dec. 8, 1948, as Stigeoclonium lubricum (Dillw.) Kg. (F); Locality: Mississippi: Hancock Co.: In springy spots on the sea wall near high-tide mark on the shore of Miss. River Sound between Bay St. Louis and Waveland (F).

This variety shows the intermediate characters, especially in cell shape and arrangement between Cloniophora macrocladia var. macrocladia and Cloniophora spicata (Schm.) comb. nov., and may be regarded as a geographical variety.

Other specimens studied: Mississippi: Hancock Co.: above high mark in seepage on the sea wall shore of Mississippi and on concrete in a freshwater drain entering Miss. Sound, between Bay St. Louis and Waveland. Col. Fr. Drouet. Nos. 9300, 9823, 9824, Dec. 8, 1948 (F).

<u>Cloniophora</u> <u>spicata</u> (Schmid.) comb. nov. (Emend.)

Pl. 38, Figs. 1-6; Pl. 39, Figs. 1-4 & 9

Text Figs. 101, 115, 116

<u>Stigeoclonium</u> <u>spicatum</u> Schmidle, 1895, in Hedwigia, 34: 294-296; Wildemann, 1900, in Les Algues de Flore de Buitenzorg, Java, Leide, p. 61, Pl. 13, f.1-6.

<u>Stigeoclonium</u> <u>Askenasyi</u> Schmidle, 1896, in Flora, 82: 297-313, Pl. 9.

<u>Cloniophora</u> <u>willei</u> Tiffany in Brittonia, 2(2): 173, Pl. 3, f. 47-48, 1936.

<u>Cloniophora</u> <u>capitellata</u> Tiffany, in Brittonia, 2(2): 174, Pl. 3, f.43-46. 1936.

Thallus 2-5(-10) cms. long, profusely branched; well-developed rhizoids from narrow elongated basal cells; primary branching dichotomous type; cells of main axis and primary branches mostly capitellate or tumid, rarely near-cylindrical with slight constrictions at the partition wall, mostly the cell walls are depressed on both sides near the middle of the cell, 22-48 μ (mostly 30-40 μ) in diameter, ½-3 times as long; cells of secondary branches may be

capitellate, rectangular, or inflated and constricted, those producing zoospores are somewhat swollen at the middle or may be repand; secondary branches short, solitary, uniseriate, opposite or crowded on main axis and primary branches, usually forming fascicles or tufts at the end of the lateral branches; zoospores many in each cell.

There is practically no difference among the four species, Stig. spicatum, Stig. Askenaysi, Clon. willei, Clon. capitellata in respect to the cell-shape, size and branching habits. Schmidle (1896) differentiates Stig. Askenaysi from Stig. spicatum by: 1) its long and short cells in the main axis (Text Figs. 115, 116), well-developed basal part with regular, almost rectangular cells and 2) plants covered with lime substances. Wildemann (1900) however, showed well-developed basal part in Stig. spicatum, collected from Java. Tiffany (l.c.) has also separated his two species mainly on the cell size and shape. This was not found to be constant in those two species, seen in the isotypes, rather in the same plant there is a great range in size as well as in shapes of cells. The long-celled and short-celled condition as mentioned by Tiffany was also stressed by Schmidle for his Stig. Askenaysi and now we think that this character is not sufficient for species separation; it seems to be the common feature for the whole genus Cloniophora under which the above Stigeoclonium species are placed.

Schmidle (1900) possibly, was the first to point out the similarities between Draparnaldia macrocladia, Stig. spicatum, and Stig. Askenasyi, because, all these species have similar wider main axis with very narrow, short branches about 8 u diameter, all have a median chloroplast and well-developed rhizoids at the base. But Draparnaldia macrocladia, however, has inflated cells of considerable dimensions, and both Stig. spicatum and Stig. Askenasyi have rectangular cells, mostly smaller cells in lngth in the former species and somewhat longer cells, narrow down below in the latter species. It is, not always true, however, as has been mentioned before. So, the separation of these two latter species was not justified and therefore, it is reasonable to place them along with two species of Cloniophora which exhibit the same characters of cell-shape, size and branching habit. Stig. plumosum Kg. cannot be combined with this group because of its different type of branching habit, mostly cylindrical and narrow cells and their size. Thus, we may summarize the differences of the above two species as follows: Cloniophora spicata (Schm.) comb. nov. differs from Clon. plumosa (Kg.) Bourrelly by its 1) characteristic tufts at the end of the branches; 2) wider and shorter cells, the latter capitellate, mostly tumid; 3) short secondary branches; 4) lack of verticillate or cylic arrangement of secondary branches on the main axis and primary branches, forming a node-like appearance. Clon. plumosa, on the other hand, shows consistently 1) much longer and cylindrical cells, narrower than any other species; 2) secondary branches short and sparse below, but above quite long and slender with verticillate or cyclic arrangement; 3) cell wall usually thinner than other species; 4) usually less tufted branch apex.

Hirose and Takashima's Clon. plumosa (Kg.) Bour. (1955. p.233-237, f.1-3) should belong to this species.

Specimens studied:

SOUTH AMERICA

Ecuador: near Rio Toachi in water fall of small stream, on stones. Col. Dr. G. W. Prescott No. T-52, Feb. 6, 1958 (Pres.); Peru: Cava de Pavos; Catherwood Survey #2: Sta-3, Fast water, Col. R. Patrick

No. (3) 6/21, Oct. 1, 1955; Tulumayo River, Sta-1, on rocks in shallow water, Col. Hohn, No. (1)c/21, Sept. 24, 1955; in riffle, lower end of island, Col. Hohn, No. (1)c/17; Sept. 24, 1955; on bank, in debris, Col. Hohn, No. (1)c/42, Sept. 24, 1955; attached to rocks, Col. Hohn, No. (1)c/7, Sept. 24, 1955; Amazon River, Sta-5, on log, center of river, Col. Hohn, No. (5) 6/41, Sept. 13, 1955 (Whit.PH.IS.)

CENTRAL AMERICA

Puerto Rico: Maricao: Auf steinen im Bache auf Wege Nordlich von Maricao, Leg. N. Wille, Col. Nos. 1239a, 1237 (Isotypes of *Clon. capitellata* Tiffany), Feb. 20, 1915; also same by N. L. Britton, Feb. 22, 1915 (These specimens are labeled as *Stigeoclonium lubricum* (Dillw.) Kg. by Fr. Drouet in NY.F.); Sedreto de los Pampanos, near Ponce, in shallow river at the time of collection, Leg. D. C. Jackson, Col. Nos. 1 and 2, June 20, 1960 (Jack.Is.).

NORTH AMERICA

Florida: Marion Co.: on leaves of larger water plants, west shore of Orange Lake. Col. Fr. Drouet, M. A. Bannon and D. McKay, No. 11035, Jan. 19, 1949 (F); Canada: New Brunswick, in Falls brook, Grand Falls, Plantae Acadienses, Col. H. Habeeb No. 11015a. Jan. 14, 1949 (as *Stig. lubricum*) (F);

Jamaica: as unidentified specimen No. 366 without date and collection data; presented to the N.Y. Bot. Gardens by N. L. Britton, 1922, Col. Humply ?; most probably the place is near New York, either Jamaica Bay or Jamaica Plain near Boston, Mass. (NY).

EUROPE

Boehmen: Slichov nächst Prag, Leg. A. Hansgirg, April 18, 1882 (F).

The above three specimens from Florida, Canada and Boehmen are doubtfully added to this species here.

ASIA

West Sumatra: tussen Matoea en Fort de Koch, Leg. A. Weber-van Bosse, No. 686 (as Stigeoclonium sp.), 1888 (L); Java: Tjibodas, Leg. A. Weber-van Bosse, No. 737 (as Stigeoclonium sp.), 1888 (L); Japan: Hamada, Shimane: Col. M. Akiyama, No. 17, Aug. 1959; Matsu, Shimane, Col. M. Akiyama, No. 18, July 1958 and No. 22, Sept. 1959; Hinomi Saki, Shimane: Col. M. Akiyama, No. 23, June, 1959; Yukomanbetsu, Hokkaido, Col. M. Akiyama, No. 25, Aug. 1956 (all from Dr. Akiyama); Wakayama-prefecture, Ogawaguchi, in river Kitayamagawa, Col. H. Hirano, Feb. 1960 (from Dr. M. Hirano).

AUSTRALIA

On stones in Reynolds Creek, Queensland, Col. A. B. Cribb, No. 21.1 (as Stig. Askenasyi Schm.), July 30, 1949 (F.MICH.)

NEW CALEDONIA

Thio, im Flusse, Leg. A. Grunow, Col. No. 11712 and 11713 (as Stigeoclonium with an epithet Neocaledonicum Grunow), Sept. 11, 1884 (W).

DISTRIBUTIONS

From the specimen lists given under each species and those found in the literatures we can summarize the general distribution-pattern of this genus Cloniophora Tiffany. Although collected from few places, still the genus shows a world-wide distribution. It may be noticed in the lists above that almost all the Cloniophora specimens have been collected from cool, running freshwater habitats as attached forms; but, interestingly, the lands (or areas) are not far away from the sea coasts. Mostly, they were found in small islands surrounded by seas in almost all sides. Greatest concentrations may be mentioned in the islands of Hawaii, Central America, Japan and Malay Archipelago extending up to the eastern coasts of Australia including New Caledonia. It seems that on the continents this genus is restricted in its distribution mostly to the coastal areas. For example, we may state that the genus is well-distributed throughout northern border of Africa from Maroc to Cairo along the Mediterranean coasts as well as along the eastern coast of North America from Maritime Province (New Brunswick) to Florida and in the northern parts of South America from Ecuador to Cayenne. Whether this distribution of the genus along the coastal areas not far from the seas shows a general ecological-pattern of its adaptation, or simply because not many collections have been made from main island waters, far away from the seas, can not be stated with certainty until more collections from wider areas of the world are made.

At the moment it seems that Cloniophora species prefer to grow where the salt content of the water is probably higher than inland waters. This contention is supported by the fact that in most instances the places of collections are very near the sea coasts, often within a range of 5-15 miles (or less) and it is possible that in some instances at least, habitats have been influenced by tidal sea water. It may be also presumed that inland fresh-water bodies in Maritime Provinces may not be directly connected with the sea, but may have a high salt content as a result of the deposition of sea water carried by the strong winds. One may consider, however, the following places of collections which are very close to sea coasts:

1) Cayenne--extreme mid-north coast of S. America.
2) Indrapura (town)--near west coast of Sumatra.
3) Basse terre--S.West coast of Guadeloupe Island.
4) Maroc--Alger--Cairo--all bordering Mediterranian sea in the Northern coast of Africa.
5) Honolula, Oahu--on the east coast of the island in Pacific.
6) Balboa--near the mouth of Panama Canal Zone.
7) Maricao--near Mayaguez on the west coast of Puerto Rico, connected by river.
8) Costa Rica--both sides surrounded by Oceans.
9) Grand Falls--in New Brunswick, Canada, a maritime province, connected by river and few miles from the sea.

10) New Caledonia--Little island, surrounded by Pacific.

11) Queensland--on eastern coast of Australia.

12) Mississippi Sound, near high tide mark, Miss. Hancock Co.--few miles from sea coast.

13) Japanese islands (including Hokkaido)--surrounded by Pacific ocean.

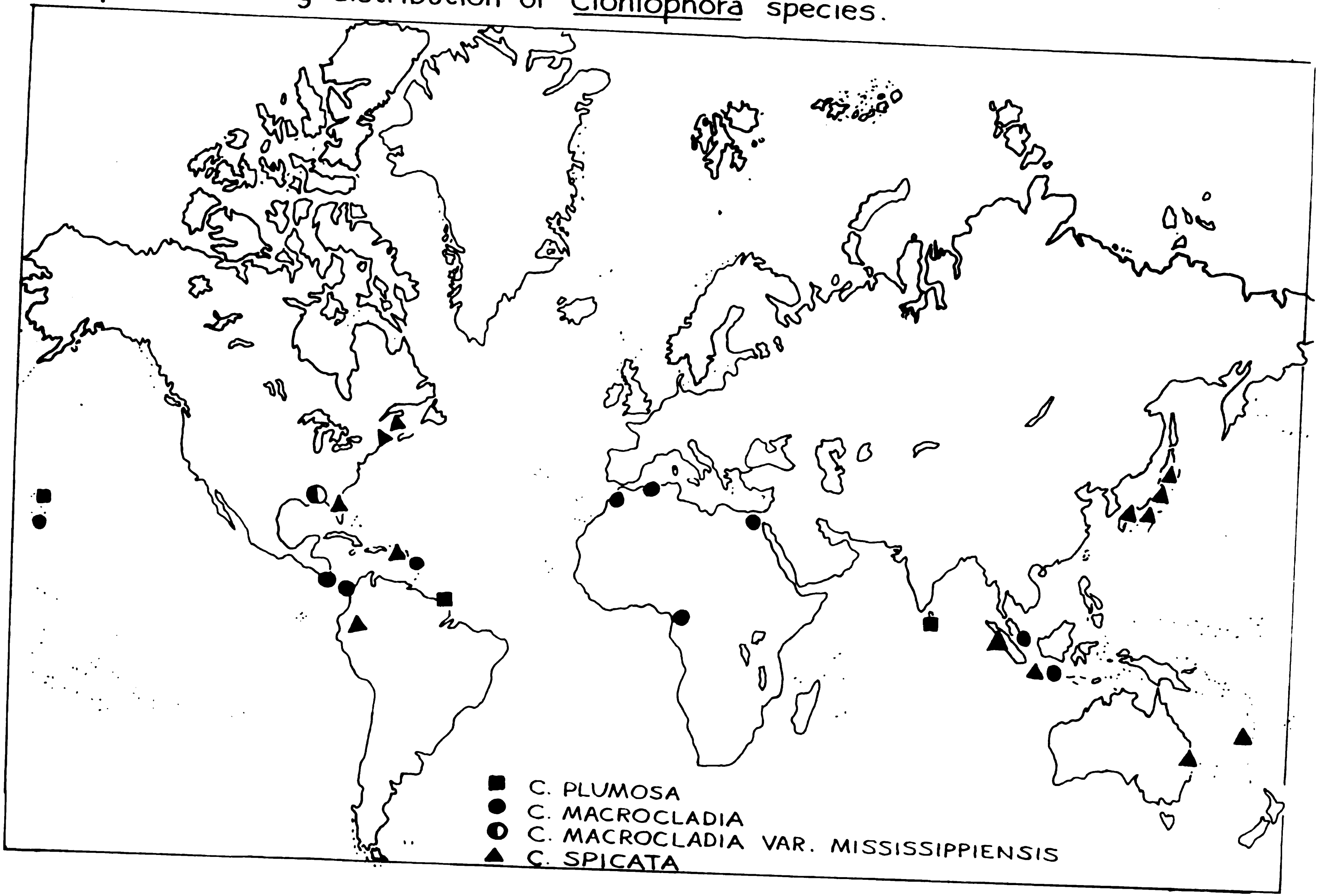
14) Colombo, Ceylon--mouth of Kelayni River--south-west coast on Indian Ocean.

15) Florida--both sides bordered by oceans.

Most of these places are more or less within the subequatorial belt. Many collections were made in the months of January and February showing zoospores (also gametes ?) productions.

From the map of species distributions, (See Map 1) it appears that probably the entire central American islands including parts of North and South America are dominantly represented by Cloniophora spicata; so also the entire Japanese islands and Malay Archipelago extending to New Caledonia are all represented by the same species. In the latter islands this species shows greater polymorphism, whether due to geographical isolations or hybrid formations, we are not sure at present. On the other hand, it seems that *Clon.* *macrocladia* is well-distributed throughout northern parts of Africa, with a sporadic appearance in Mississippi in U.S.A. and Hawaii. These places are more or less within a narrow latitudinal belt. Similarly, *Clon.* *plumosa* shows a sporadic appearance in Hawaii, northern part of S. America and in Ceylon in the fairly same type of climate.

Map 1. Showing distribution of *Cloniophora* species.



Chapter IV

List of accepted and discarded species of Stigeoclonium

(Species with asterisks are accepted here)

* 1. Stig. aestivale (Hazen) Collins. - may be a good species but has strong resemblance to Stig. thermale Br. If the latter species grows equally well in cool water and maintains the same habit, then the former species would be questionable.

* 2. Stig. amoenum Kg.--A good species, fairly constant all over the world with several distinct varieties, e.g. var. amoenum, var. novizelandicum Nordst., var. insigne (Naeg.) comb. nov., var. aucklandicum var. nov.

3. Stig. Askenasyi Schmidle.-- now transferred to the genus Cloniophora and placed as synonym under Clon. spicata (Schm.) comb. nov.

4. Stig. attenuatum (Haz.) Collins-- The type specimen is not seen. Here, it is considered as a synonym of Stig. elongatum (Hass.) Kg.

5. *Stig. australense* Moebius -- Very doubtful as a full-grown plant; may be a young stage or form of *Stig. fasciculare* Kg.

6. *Stig. autumnale* Collins -- Not a good species. The type specimen strongly resembles *Stig. aestivale* and hence, it is placed under the latter species as a synonym.

* 7. *Stig. Biasolettianum* Kg. -- May prove to be a good species when more materials are studied in the future collected from widely different areas. So far reported only for few times from Europe.

* 8. *Stig. carolinianum* sp. nov. -- Superficially resembles *Stig. fasciculare* Kg.

9. *Stig. chroolepiforme* (Szym.) Heering -- Not a good species. May be a growth form and related to other endophytic forms which may grow well under favorable conditions.

10. *Stig. condensatum* (Hassall) Kg. -- Not a good species; may be related to either *Stig. pusilla* or *Stig. subuligerum* Kg. (Type not seen).

11. _Stig._ _crassiusculum_ Kg. -- Not a good species. Here, considered as a form of _Stig._ _flagelliferum_ Kg. which may represent a particular stage in the life-cycle of the latter species.

*12. _Stig._ _curvirostrum_ Skuja -- Type specimen not seen. Only once reported. It is considered here as a doubtful species until the type and other materials are available for study. Probably original specimens represent young stage.

13. _Stig._ _debile_ Kg. -- Not a good species. Here, it is considered a synonym of _Stig._ _tenue_ var. _uniforme_ Kg.

*14. _Stig._ _elongatum_ (Hass.) Kg. -- May be a good species with much variations.

15. _Stig._ _falklandicum_ Kg. -- Here it is considered a synonym for _Stig._ _elongatum_. The type specimen seems to be a young plant, but other collections from the same area in the Falkland Island shows well-developed plants which seem to characterize well the latter species.

* 16. Stig. farctum Berthold. -- May be a good species, but more collections and studies are needed to verify this; the three varieties, namely, var. pygmaeum Hansg., var. simplex Fritsch and var. rivulare Butcher may represent the growth forms of some other species.

* 17. Stig. fasciculare Kg. -- A good species. The type specimens may be a young stage of growth. Characters emended.

18. Stig. fastigatum (Ralfs) Kg. -- Not a good species. Considered here a synonym of Stig. longipilum Kg.

* 19. Stig. flagelliferum Kg. -- A good species, sometimes with variations. The two varieties, namely, var. irregulare Rab. and var. crassiusculum (Kg.) Rab. are considered invalid.

20. Stig. glomeratum (Hazen) Collins -- Not a good species. Considered here as a variety of Stig. fasciculare Kg.

21. Stig. Grunowii Rab. -- Not a good species. Considered here as synonym of Stig. variabile Naeg.

22. Stig. gracile Kg. -- Not a good species. Considered as synonym of Stig. tenue var. uniforme Kg.

23. Stig. gracile (West & West) Tiffany -- Invalid for using the same name already used by Kuetzing before. The plant described is same as Stig. farctum var. simplex Fritsch. However, it is doubtful whether this small plant could be considered as a well-developed species of Stigeoclonium or belong to the genus Pseudochaete West & West under which it was originally placed.

24. Stig. gracile Skvortzow -- Invalid for using the same name already used by Kuetzing. However, this species does not seem to be new. Similar illustration had been given by Cooke for Stig. tenue and hence, it is considered as a synonym for the latter species.

* 25. _Stig._ _helveticum_ Vischer -- This species was mainly based on culture materials where it is not impossible to change the habit of the plant. Here, it is considered as a doubtful species until it is verified by more collections from widely different areas. May be related to _Stig._ _setigerum_ Kg. and _Stig._ _Biasolettianum_ Kg.

26. _Stig._ _Hookeri_ Reinsch. -- Not a good species. Needs verification.

27. _Stig._ _Huberi_ Heering -- Not a good species; may be a growth-form.

28. _Stig._ _hydrosulphureum_ Fior.Maz. --The specimens No. 232 of Erbar. Crittogam. Ital. ser. II Col. Fiorini, 1868 (G) has been studied by me. This specimen seems to be a species of _Ectocarpus_ due to the presence of abundant plurilocular sporangia which are borne on the lateral branches. De Toni (1889) also put a question mark whether this plant should actually belong to the genus _Stigeoclonium_. It strongly suggests that the plant must have been collected from sea water or brackish water near the sea, although

on the label it says that it was collected from mineral water. It is possible that the water was highly saline, because the place of collection, Terracina, is a seaport town in Italy and in the collection many filaments of *Enteromorpha* are present, strongly suggest the brackish nature of the habitat. The chloroplast is not too well-preserved. But plurilocular sporangia are very well-developed and suggest its affinity to some *Ectocarpus* species.

29. *Stig. insigne* Naeg. -- Type specimen was not available. It is considered here as a variety of *Stig. amoenum*, a new combination.

30. *Stig. irregulare* Kg. -- Not a good species. May be a growth form of *Stig. tenue*. Its variety *natans* Kg. was not well-described by Kuetzing, may be a growth-form.

* 31. *Stig. Lebelii.* sp. nov. -- habit *Draparnaldia*-like.

32. *Stig. longearticulatum* (Hansg.) Heering -- Not a good species. May be a form of *Stig. subsecundum* Kg.

* 33. <u>Stig.</u> <u>longipilum</u> Kg. -- A good species with variations. Its varieties <u>majus</u> Kg. and <u>minus</u> Hansg. may only represent stages of growth; var. <u>lacustre</u> Chodat may belong to different species; var. <u>cylindricum</u> var. nov. is provisionally placed under this species due to its similar branching habit and rhizoids.

* 34. <u>Stig.</u> <u>lubricum</u> (Dillw.) Kg. -- A good species, but the species was nicely illustrated and described by Berthold and Hazen than Dillwyn and Kuetzing. The var. <u>varians</u> (Hazen) Collins is doubtful and not considered as a good variety. The forma <u>salina</u> Dixit is not seen by me. Inadequate description and lack of any illustration make it difficult to understand it and assign the systematic position of this forma. It is doubtful whether this species at all grows in saline water. Moreover, similar name <u>salina</u> has already been used by Kufferath for his new species <u>Stig.</u> <u>salinum</u> Kuff. in 1919 and possibly they may be same.

35. <u>Stig.</u> <u>macrocladium</u> (Nordst.) Schm.-- It has been transferred to the genus <u>Cloniophora</u> including its variety <u>egyptiacae</u> Nayal.

36. Stig. minus (Hansg.) Collins -- This is the same as Stig. longipilus var. minus Hansg. It is doubtful whether this should be regarded as a separate species. I even do not consider it as a distinct variety of Stig. longipilum.

37. Stig. Sp., Moebius, (Endoclonium ? Moebiusianum De Toni) -- This was described by Moebius as Stig. sp. It is doubtful whether this kind of epiphytic form without much development of the erect part should be regarded as a distinct species. De Toni put it under Endoclonium with a question mark.

38. Stig. Najadeanum Skvortzow -- Not considered as a good species. The illustrations given by Skvortzow are very much similar to what Moebius gave for the above species No. 37 which De Toni doubtfully considered as a species of Endoclonium. If, however, these two thalli belong to the genus Stigeoclonium they should be considered as reduced forms and may be very close to Stig. farctum-like plant, and not a separate species.

* 39. Stig. nanum (Dillw.) Kg. -- May be a good species.

* 40. <u>Stig.</u> <u>Nelsonii</u> Prescott -- May be a good species. Only once collected. It has resemblance to <u>Stig.</u> <u>nudiusculum</u> and needs to be verified in future.

* 41. <u>Stig.</u> <u>nudiusculum</u> Kg. -- May be a good species as I understand it from the specimen obtained from Kuetzing's Herb. (now in Leiden). Its variety <u>tomentosum</u> Schm. was collected from brackish water; material not seen; doubtful.

* 42. <u>Stig.</u> <u>pachydermum</u> Prescott -- A good species with variations.

* 43. <u>Stig.</u> <u>paihiaensis</u> sp. nov. -- Habit like giant <u>Stig.</u> <u>lubricum</u>; also cells are somewhat like <u>Draparnaldia</u> but not branching habit.

44. <u>Stig.</u> <u>plumosum</u> Kg. -- Transferred to the genus <u>Cloniophora</u>.

45. <u>Stig.</u> <u>polymorphum</u> (Franke) Heering -- Not a good species. May be a growth-form of <u>Stig.</u> <u>variabile</u> Naeg.

46. <u>Stig.</u> <u>polyrhizum</u> Jao -- Not a good species. Considered here as a synonym of <u>Stig.</u> <u>longipilum</u> Kg.

47. *Stig. prolixum* Jao -- Doubtful. May be a form of *Stig. lubricum*, or *Stig. amoenum*.

48. *Stig. prostratum* Fritsch -- Not a good species. May be a growth form of some species of *Stigeoclonium* or may belong to other genus, especially *Epicladia* ?

* 49. *Stig. protensum* (Dillw.) Kg. -- A good species with great variations.

* 50. *Stig. pusillum* (Lyngb.) Kg. -- May be a good species, but still doubtful. Its var. *irregulare* Rab. may be a growth-form.

51. *Stig. pygmaeum* Hansgirg. -- Not a good species. Hansgirg later put it as a variety of *Stig. farctum* Berth. but the type specimen suggests that it is same as *Stig. weissianum* Grun. and other reduced forms and all of them may belong to *Stig. variabile* Naeg. and accordingly I put it under the latter species as a synonym.

52. *Stig. radians* Kg. -- Not a good species. Here considered as a synonym of *Stig. longipilum* Kg.

53. Stig. rangoonicum Zell. -- Specimens studied are not in good condition. Looks more like Stig. thermale Br. and considered as a synonym of the latter species.

54. Stig. salinum Kuff. -- Specimens not available. The illustration given by Kufferath (1919, fig. 3) strongly suggests its affinity to Microthamnion-like plant as regards the branching habit and chloroplast structure are concerned. It is also somewhat similar to Stig. helveticum Vischer. As no specimen of this species was seen, it is not possible to determine its position. The species was reported only once from brackish water from Belgium.

* 55. Stig. segarae sp. nov. -- Regarded as new species until further materials are collected and verified. Habit Chaetophora-like.

* 56. Stig. setigerum Kg. -- A doubtful species.

57. Stig. spicatum Schm. -- It is transferred to the genus Cloniophora.

* 58. Stig. stagnatile (Hazen) Collins -- A doubtful species. It needs to be seen whether this is

a particular stage in the life-cycle of Stig. protensum.

59. Stig. stellare Kg. -- Not a good species. May be a growth-form of any species, especially, Stig. tenue.

60. Stig. submarinum Kuff. -- Type specimen not seen. It is another brackish water species. The illustration given by Kufferath (1919, fig. 4) looks like a growth-form of some species, like Stig. tenue where the cells appear swollen in high salt-water medium.

* 61. Stig. subsecundum Kg. -- A good species with variations in size. Its variety tenuis Nord. has to be verified; var. ulotrichoides Teod. may belong to Stig. variabile.

62. Stig. subsimplex Collins -- Not a good species. The type specimen looks exactly similar to Stig. weissianum, which however, is considered as a synonym of Stig. variabile Naeg.

63. Stig. subspinosum Kg. -- Very doubtful; the type specimen strongly suggests its affinity with Stig. variabile Naeg. and accordingly put as synonym under the latter species.

64. Stig. subtile Reinsch -- Type specimen not available. Highly doubtful whether this parasitic form belongs to Stigeoclonium. Reinsch (l.c.) suggests its affinity with Stig. setigerum Kg.

* 65. Stig. subuligerum Kg. -- A good species.

* 66. Stig. tenue (Ag.) Kg. -- A good species but highly polymorphic. Only two varieties are recognized, namely, Stig. tenue var. tenue and Stig. tenue var. uniforme (Ag.) Kg.

67. Stig. terrestre Iwanoff -- Type specimen not available, and thus difficult to determine its position. Pascher (1905, 1906) however, transferred it to a new genus, Iwanoffia, on the basis of zoospore characters.

* 68. Stig. thermale A. Br. -- May be a good species. It has to be seen whether it always grows in hot water or can equally grow well in cold water. It has strong affinity with Stig. aestivale.

69. Stig. uniforme (Ag.) Kg. -- Considered here as a variety of Stig. tenue as was considered first by Kuetzing (1949).

* 70. Stig. variabile Naeg. -- May be a good species but as the name indicates it is one of the very highly variable species of the genus.

71. Stig. ventricosum (Hazen) Collins -- Not a good species. Here considered as a synonym of Stig. amoenum var. insigne (Naeg.) comb. nov.

72. Stig. weissianum Grun. in litt. -- The type specimen suggests its affinity with Stig. pygmaeum Hansg. and other reduced-forms and here, considered as a synonym of Stig. variabile Naeg.

Bibliography : Stigeoclonium

Ackley, A.B. 1932. Preliminary report on Michigan Algae exclusive of Desmids and Diatoms. Papers from Botany Department No. 272. Ohio State University, Ph.D. Thesis, 1930.

Agardh, C.A. 1812-15. Algarium, Decas 1-4. Lundae.

________. 1824. Systema Algarum.

________. 1828-35. Incones Algarum Europearum.

Andrews, F.M. 1910. A list of Algae (chiefly from Monroe County, Indiana). Proc. Ind. Acad. Sc. 19: 375-380.

Bachmann, Hans 1921. Beiträge zur Algenflora des Süsswassers von Westgrönland. Nat. Gesel. in Luzern.Mit.8:1-131, 4 Pls.

Berthold, G. 1878. Untersuchungen uber die Verzweigung einiger Süsswasser-algen. Nova Acta der Ksl. Leopold. Carol. Deutschen Akad. der Naturforscher. XL (5): 169-230. Pl.2, f.1-5.

Blum, J. L. 1956. The ecology of River Algae. Bot. Rev. 22(5): 291-341.

________. 1957. An ecological study of the algae of the Saline River, Michigan. Hydrobiologia. IX(4): 361-408.

__________. 1960. Algal populations in flowing waters, in The Ecology of Algae, The Pymatuning Symposia in Ecology, Special Publ. No. 2. University of Pittsburgh, pp. 11-21.

Borge, O. 1909. Nordamerikanische Süsswasser-algen. Arkiv. f. Bot. 8(13): 2.

__________. 1913. Die von Dr. A. Löfgren in Sao Paulo gesammelten Süsswasser-algen. Archiv. f. Bot. k. Svenska Veten. 15(13): 85.

Bourrelly, P. 1952. In Algues d'eau douce de la Guadeloupe. Sedes. Paris. 202-204, f.414, 415, 430. (By Bourrelly P. et E. Manguin).

Bourrelly, P. et Manguin, E. 1954. Contribution A la Flore Algale d'eau douce des Iles Kerguelen. Mem. de L'Institut Sc. de Madagascar. ser. B. Tome V: 54.

Bradley, W.H. 1929. Freshwater algae from the Green River formation of Colorado. Bull. Tor. Bot. Club. 56: 421-428, Pl.22, 23.

Braun, A. 1853. See under Henfrey.

Britton, M.E. 1937. The freshwater algae of Puerto Rico. M.S. Thesis. Ohio State University, Columbus.

__________. 1944. A catalog of Illinois Algae. Northwestern Univ. Evanston. Ill. pp. 407.

Buchanan, R.E. 1907. Notes on the Algae of Iowa. Proc. Iowa Acad. Sci. 14:47-84.

Butcher, R.W. 1932. Notes on Algae from beds of rivers. New Phytol. 31: 289-309.

Campion, Mary. 1956. A survey of the green algae epiphytic on the shells of some freshwater mollusks. Hydrobiologia. 8(1-2): 38-53.

Chang, F.K. 1952. On the Laboratory Culture and Life history of <u>Stigeoclonium subsecundum</u> Kg. M.S. Thesis. Iowa State Univ. Iowa City (See also under Kuo, F.C.).

Chapman, F.B. 1934. The algae of the Urbana (Ohio) Raised Bog. Ohio Jour. Sc. 34: 327-332.

Chodat, R. 1902. Algues vertes de la Suisse. Pleurococcoides-Chroolepoides. Beitr. Krypto. flora Schweiz. 1(3): i-xi & 1-373.

Cholnoky, B.R. 1929. Ueber Bau und Entwicklung des Stigeoclonium tenue (Ag.) Kg. Arch. f. Hydrobiol. 20(2): 325-337. 2 Pls.

Cienkowski, L. 1876. Zur morphol. d. Ulotricheen. Bull. Acad. Imp. Sci. XXI. p.531 et seq. St. Petersbourg.

__________. 1876. Ueber Palmellenzustand bei Stigeoclonium. Bot. Zeit. 34: 17-26; 70-71. Pl. I.f.1-19.

__________. 1876a. Ibid. Bot. Not. 117-118.

Clausen, J., D.D. Keck and W.M. Heisy. 1939. The concept of species based on experiment. Am. Jour. Bot. 26: 103-106.

Collins, F.S. 1909. The green algae of North America. Tufts College Sci. ser. Reprinted by G.E. Stechert. 1-400. 1928.

__________. 1912. The green algae of North America. Supplementary paper. Tufts College Studies Sc. 1-47. Pl.1-3.

_________. 1912a. Ibid. Second Supplementary paper with 3 plates. 1-106.

_________. . 1917. Notes from Woods Hole Lab. Rhodora. 20: 14-143.

_________. 1918a. Green Algae of North America. 2nd. Supplement. Tufts College Stud. Sci. 4: 1-106, Pl.1-3.

Conn, H.W. and L. W. Webster. 1908. A report on the algae of the freshwaters of Connecticut. Hartford, Conn. Geological and Nat. History Survey, Bull. No. 10, p.47.

Cooke, M.C. 1882-84. British Freshwater Algae. I & II. London.

_________. 1902. Introduction to Freshwater Algae with an enumeration of all the British species. The International Sc. ser.LXIX. London.

Corda, A.C.I. 1837. Icones Fungorum. Huc. Congr. Prage.

Coupin, H. 1907 (?). Album general des Cryptogames. Paris. Pls.1-394.

Coyle, E.E. 1930. The algal food of Pimephale promelas (Fathead minnow). Ohio Jour. Sci. 30(1): 23-35.

Davidson, P.W. 1932. The algae of Westerville region. M.A. Thesis. Ohio State Univ. Columbus.

De Toni, G.B. 1889. Sylloge Algarum, Vol. I.

Dillwyn, L.W. 1802-1809. British Confervae, or colored figures and descriptions of the British Plants referred by Botanists to the genus Conferva.

Dixit, S.C. 1937. The Chlorophyceae of the Bombay Presidency, India. I. Proc. Ind. Acad. Sci. 5(1): 20.

Drouet, Fr. 1956. A preliminary study of the algae of Northwestern Minnesota. Minn. Ac. Sc. Proc. 22-134.

Du Rietz, G.E. 1930. The fundamental units of biological taxonomy. Svensk. Bot. Tidskr. 24: 333-423.

Elenkin, A.A. 1914. Ueber zwei grüne Algen aus Gattung Stigeoclonium. Bull. Jard. Imp. Bot. Pierre le Grand. 14.

Fanning, M.G. 1901. Observations on the algae of the St.Paul City water. Minn. Bot. Stud. V: 609.

Fink, Bruce. 1905. Some notes on certain Iowa Algae. Proc. Iowa Acad. Sci. 12: 21.

Fiorini-Mazzanti, Elisabetts. 1861. Microficee osservate nelle acque minerali di Torracina. Atti Doll' Acad. Pontificia de'Nuovi Lincei. Session IV. March, 1861. 239-240.

Forest, H.S. 1954. Handbook of Algae (with special reference to Tennessee Valley and S-E United States). Univ. Tenn. Press. Knoxville. pp. 467.

__________. 1955. Phylogeny and classification in the Chlorophyceae (Ulotrichaceae and Chaetophoraceae) C.R. 8me. Congr. Inter. Bot. 17: 6.

__________. 1955a. First conclusions from a Jump at <u>Stigeoclonium</u>. Phyc. News Bull. 8(23): 6.

__________. 1956. Some aspects of evolution in the isogamous filamentous Chlorophyceae and their relation to the classification of the Chlorophyceae.

Forest H.S. (cont.)

Bull. Tor. Bot. Club. 83(2): 141-150.

______. 1956a. A study of the genera *Draparnaldia* Bory and *Draparnaldiopsis* Smith and Klyver. Castanea. 21(1): 1-29.

______. 1957. The remarkable *Draparnaldia* species of Lake Baikal, Siberia. *Ibid*. 22(4): 126-134.

Franke, M. 1883. *Endoclonium polymorphum*. Beiträge zur Biol. der Pflanzen. 3:365-375, t. 20. Breslau.

Fremy, P. 1930. Algues provenant des recoltes de M. Henri Gadeau de Kerville dans le Canton de Bagneres-de-Luchon (Houte-Garonne). Bull. Soc. nat. de Rouen (ann. 1928 et 29), 159-227.

Fries, E.M. 1825. Systema orbis vegetabilis Plantae Homonemeae. p.345. Lundae.

Fritsch, F.E. 1902. Algological notes I. observations on species of *Aphanochaete* Br. II. Germination of zoospores in *Oedogonium*. Ann. Bot. 16: 403-412.

———————. 1903. Observations on the young plants of Stigeoclonium. Beih. Bot. Centralbl. 13: 368-87.

———————. 1906. Algae in the Wild Fauna and Flora of the Royal Botanic Gardens, Kew. Kew Bull. Add. ser. v. 187- et seq.

———————. 1918. Contribution to our knowledge of the freshwater algae of Africa. 2.A first report on the freshwater algae mostly from the Cape Peninsula in the herbarium of the S. African Museum. Ann. S. Africa Museum IX: 483-611.

———————. 1929. Evolutionary sequence and affinities among Protophyta. Biol. Rev. and Biol. Proc. Camb. Phil. Soc. 4(1-7): 103-151.

———————. 1935. The Structures and Reproductions of Algae. Vol. I. Cambridge, England. pp.791.

Fritsch, F.E. and E. Stephens. 1921. Contribution to our knowledge of the freshwater algae of Africa. 3. Freshwater algae (exclusive of Diatoms), mainly from Transkei Territories, Cape Colony. Tran. Roy. Soc. S. Africa. IX: 1-72, Text Fig. 1-29.

________ and F. Rich. 1924. Contributions to our knowledge of the freshwater algae of Africa, 4. Freshwater and subaerial algae from Natal. Ibid. XI: 297-398.

________ and ________. 1930. Ibid. 7. Freshwater algae (exclusive of Diatoms) from Griqualand West. Ibid. XVIII: 1-92.

________ and ________. 1937. Ibid. 13. Algae from Belfast Pan, Transvaal. Ibid. XXV. part II.

Gayral, Mme. P. 1954. Recherches Phytolimnologiques Au Maroc. Trav. De L'Institut Sc. Chérifien ser. Bot. No.4.

Gay, F. 1891. Recherches sur le developpement et la classification de quelques Algues vertes. Paris.

Gojdics, Mary. 1953. The genus Euglena. The University of Wisconsin Press. Madison. pp.263.

Godward, M. 1942. The life-cycle of Stigeoclonium amoenum Kütz. New Phytol. 41: 293-301.

Guarrera, S.A.y. O. Kühnemann. 1949. Catalog de las "Chlorophyta" y "Cyanophyta" de Agua Dulce de la Republica Argentina. Lilloa. XIX: 219-318.

Hansgirg, A. 1884. Beiträge zur Kenntnis der böhmischen Thermalalgenflora. Oesterreich. Bot. Zeitshrift. 34: 276-284.

________. 1886. Algarum aquae dulcis species novae. Ibid. 36: 109-111.

________. 1886a. Prodromus der Algenflora von Böhmen. Part I. vol. I: 64-69.

________. 1887. Beiträge zur Kenntnis der Bergalgenflora Böhmens. Ibid. 37(3): 99-101.

________. 1888. Prodromus der Algenflora von Böhmen. Part I. Heft II. Die Rhodophyceen. Phaeophyceen und Clorophyceen. Prag.

________. 1893. Ibid. Part 2. Stitz. k. Böhn. Ges. Wiss. Prag.

________. 1902. Algologische schlussbemerkungen. Ibid.

Harvey, F.L. 1888. The freshwater algae of Maine. I: Bull. Tor. Bot. Club. 15: 155-161.

Harvey, W.H. 1852. Nereis Boreali Americana. Part I. Smithsonian Contribution to Knowledge, Vol. 3.

Hassall, A.A. 1843. LX. Description of the British freshwater Confervae, mostly new, with observation on some of the genera. 428.

________. 1845. History of the British Freshwater Algae.

________. 1852. A History of the British Freshwater Algae. I & II. London.

Hayden, Ada. 1910. The algal flora of the Missouri Botanical Garden. 21 Rep. Mo. Bot. Garden. 25-38.

Hazen, T.E. 1902. Ulotrichaceae and Chaetophoraceae of the United States. Mem. Tor. Bot. Club. XI(2): 135-250.

Hedberg, O. 1957. Afroalpine vascular plants. Symb. Bot. Upsal. 15: p.1411.

Heering, W. 1914. Ulotrichales, in Pascher's Die Süsswasserflora: Deutschland, Oesterreichs und der Schweiz. Heft 6. Jena.

Henfrey, A.(Edit.). 1853. I: The phenomenon of Rejuvenescence in Nature, by Dr. A. Braun. (Translated into English by A. Henfrey). Bot. and Physiol. Mem. Roy Soc. London. pp.567.

Hobby, C.N. 1880. List of species of freshwater algae found in Iowa. Proc. Iowa Acad. Sci. Appendix. p.28.

Hodgetts, W.J.1926. Contribution to our knowledge of the freshwater algae of Africa. 6: Some freshwater algae from Stellenbosch, Cape of Good Hope. Trans. Roy. Soc. S. Africa XIII: 49-103.

Huber, J. 1892. Contribution à la connaissance des Chaetophorées épiphytes et endophytes. Ann. Sci. Nat. Bot. 7. Ser. XVI: 265-359.

Hughes, E.O. 1943. Freshwater algae of the Maritimes Provinces. Doctoral Dissertation. Ohio State University, Columbus.

Hylander, C.J. 1928. The Algae of Connecticut. State Geological and Natural History Survey. State of Conn. Bull. No. 42. 123-130.

Iwanoff, L. von. 1899. Ueber neue Arten von Algen und Flagellaten (Stigeoclonium, Vaucheria, Spirogyra, Gonyostomum), welch an der biologischen station zu Bologoje gefunden worden sind. Bull. de la Soc. Imp. des Natur. de Moscou. Nouvelle Ser. Tome XIV: 423-449.

Jao, C.C. 1940. Studies on the freshwater algae of China. V. Some freshwater algae from Sikang. Sinensia. 11(5-6): 531-547.

________. 1947. Ibid. XIV. Some freshwater algae from Kansu. Bot. Bull. Acad. Sinica. I: 67-75.

__________. 1947a. Ibid. XVII. Ulotrichales, Siphonocladiales and Siphonales from Kwangsi. Ibid. I: 257-269.

Juller, E. 1937. Der generations und Phassenwechael bei <u>Stigeoclonium subspinosum</u> Kg. Arch. f. Protistenk. 89(1): 55-93.

Kellerman, W.A. 1902. Proposed algological survey of Ohio. Ohio Naturalist. 2(5): 219-223.

Kirchner, O. 1878. Kryptogamen-flora von Schlesien. Breslau.

Klebs, G. 1896. Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen. i -xviii: 1-543. Jenn.

Krieger, W. 1943-44. Süsswasseralgen aus Griechenland. Ber. d. Deutsch. Bot. Gesell. 61: 250- 270.

Kuetzing, F.T. 1833. Alg. aquae dulcis Germanicum. Flora. 16: 692-701; 1834, 17: 710.

__________. 1843. Phycologia generalis, odor Anatomie, Physiologie, und Systemkunde der Tange. Leipzig.

__________. 1843a. Ueber die Systematische Eintheilung der Algen. Linnaea. 17: 75-105.

__________. 1845. Phycologia Germanicae. Nordhausen.

__________. 1847. Diagnosen und Bemerkungen zu neuen Algen. Bot. Zeit. 5:177.

__________. 1849. Species Algarum. Lipsiae.

__________. 1853. Tabulae Phycologicae. III.

Kufferath, H. 1919. Essais de Culture des algues monocellulaires des eaux Saumatres. Annales de Biologie lacustre, 9(1-3): 1-11, f.1-4.

Kukk, E. 1958. Personal letter. Dec. 18, 1958. Botany Dept. Tartu State Univ., Estonia, SSR. Tartu.

Kuo, C.F. 1958. On the Laboratory culture and life history of <u>Stigeoclonium subsecundum</u> Kg. Acta. Bot. Sinica. 7(2): 87-96.

Lagerheim, G. 1883. Bidrag till Sveriges alg. flora. Kongl. Vet. Akad. Förhandl. 40(2): 37-78.

Lanjouw, J. and F.A. Stafleu. 1956. Index Herbariorum. Part I. Third Edition. 1956. Utrecht.

Larsen, E. 1907. Ferskvandsalger fra Vest-Grønland. Arbejder fra den Bot. Have i København. Nr. 36.

Leake, D.V. 1945. The algae of Crystal Lake, Cleveland Co. Oklahoma. Amer. Midland Nat. 34(3): 750-768.

Lemmerman, E. 1893. Versuch einer Algenflora der Umgegend von Bremen (excl. Diatom). Abhandl. naturw. Vereins zu Bremen. 12: 515.

Lewis, I.F., C. Zirkle and R. Patrick. 1933. Algae of the Charlottesville and vicinity. Jour. Elisha Mitchell Sc. Soc. 48(2): 207-222.

Lhotsky, O. and K. Rosa. 1955. Soupis Moravsko-slezskych sinic A Ras. Nakladatelstvi Cesk. akd. ved. Praha. 176-177.

Li, Ching. 1932. Freshwater algae of China. Ph.D. Thesis. Botany Dept. Ohio State University, Columbus.

Lillick, L.C. and I.M. Lee. 1934. A check list of Ohio Algae with additions from the Cincinnati Region. Amer. Midland Nat. 15(6): 726.

Linnaeus, C. 1957. Species Plantarum, a facsimile of the first edition of 1753, Vol. I. with an introduction by W.T. Stearn. Ray Soc. London. 566 pp.

Livingston, B.E. 1900. Change of form in polymorphic green algae. Bot. Gaz. 30: 289-317.

__________. 1905. Notes on the physiology of Stigeoclonium. Ibid. 39: 297-300.

__________. 1905a. 'Chemical stimulation of a green alga'. Bull. Tor. Bot. Club. 32:1-34.

Love, L.M. and R.L. Rogers. 1933. Some algae of Vigo, Greene and Davies Counties. Proc. Ind. Acad. Sc. 42: 80. 1932(1933).

Lyngbye, H.C. 1819. Tentamen Hydrophytologiae Danicae, cum 70 tab. acn. Hafniae.

Madge, M.A.P. 1940. Zoospore formation in a species of Stigeoclonium. New Phytolog. 39: 277-282.

McInteer, B.B. 1939. A check list of the algae of Kentucky. Castanea. 4(3): 27-37.

Mc Naught, J.B. 1920. Algae of Kansas Reservoirs. Trans. Kansas Acad. Sci. Semi Centennial. 29: 142-172.

McNeill, E.M. 1948. A contribution to the knowledge of West Virginia Algae. Castanea. Jour. So. App. Bot. Club, XIII.

Meneghini, G. 1853. On the Animal nature of Diatomeae (1845), in Henfrey's Translation (see under Henfrey).

Meyer, K.I. 1930. Einige neue Algonformen des Baikalsees. Archiv. f. Protistenkunde. 72: 153-175.

Migula, W. 1907. Kryptogamen-Flora von Deutschland, Deutsch-Oesterreich und der Schweiz. in Anschluss an Thomes Flora von Deutschland. Band II. Algen I b. Berlin.

Moebius, M. 1888. Ueber einige in Portorico gesammelte Süsswasser-und Luft-Algen. Hedwigia. 27:221-249. t.IX.f.3.

_________. 1892. Australische Süsswasseralgen. Flora. Heft 3: 435.

__________. 1892. Morphologie der haar artigen organe bei den Algen. Biol. Zentralbl. 12(3): 71-87.

Moewus, L. 1953. About the occurrence of fresh-water algae in the semi desert round Broken Hill (New South Wales, Australia). Bot. Not. 4: 399-416.

Moore, G.T. 1917. Algological Notes. II. Preliminary list of Algae in Devils Lake. North Dakota. Ann. Mo. Bot. Garden. 4: 293-303.

__________. and N. Carter. 1923. Algae from the lakes in the north-eastern part of North Dakota. Ann. Mo. Bot. Garden. 10: 393-422.

Moshkova, N.A. 1958. A new <u>Stigeoclonium</u> sp. for the Ukranian SSR-Flora. Ukrain. Bot. Zhurn. 15(2): 84-87.

Naegeli, C. 1855. Bildung der Schwärmsporen bei <u>Stigeoclonium insigne</u> Naeg. Pflanzen-physiologische Untersuchungen (by Naegeli and Carter) I: 36-42.

Nayal, A.A.El. 1935. Egyptian freshwater algae. Bull. Fac. Sc. No. 4. The Egyptian Univ. 32-33. f.45.

________. 1937. On some freshwater algae of Egypt. Ibid. No. 13: 1-15.

________. 1939. On some new freshwater algae from Egypt. Rev. Alg. 8: 311-319.

Nigrelli, R.F. et al. 1958. Histozoic algal growth in fish. Copea. No. 4: 331-333.

Nordstedt, Otto. 1878. De Algis aquae dulcis et de Characeis ex insulis Sandvicensibus a Sv. Berggren. 1875. reportatis. Minesskr. Fys. Sallsk. Lund. 7: 1-24.

________. 1887. (4). Utdrag ur ett arbete öfver de af Dr. S. Berggren pa Nya Seland och i Australien samlade sötvattensalgerna. Bot. Not. 153-164.

________. 1888. Freshwater Algae collected by Dr. S. Berggren in New Zealand and Australia. Kongl. Sv. Vet. Akad. Handl. 22(8): 1-98.

________. 1897. Sötvattensalger från Kamerun. Bot. Not. 131-133.

________. 1906. Algological Notes. 4. _Myxonema_ or _Stigeoclonium_. Bot. Not. 97-124.

Oltmanns, F. 1922. Morphologie und Biologie der Algen. 2 Auflage. Band I. Jena. 459 pp.

________. 1923. Ibid. 2 Auflage. Band III. Jena. 558 pp.

Palmer, C.M. 1929. Algae of Indiana - check list. Proc. Ind. Acad. Sc. 38: 109-121.

________. 1959. Algae in Water Supplies. U.S. Public Health Service Pub. No. 657.

Pascher, A. 1905. Zur Kenntnis der geschlechtlichen Fortpflanzung bei _Stigeoclonium_ (_Stig._ _fasciculare_ Kg.?) Flora odor Allgem. Bot. Zeitung. I: 95-107.

________. 1905. Ibid. Archiv. f. Hydrobiol. u. Planktonkunde, Band I: 399-401.

________. 1906a. Ueber die Reproduktion bei _Stigeoclonium_ _nudiusculum_ und

Pascher (cont.)

Stigeoclonium spp. Arch. f. Hydrobiol. u. Planktonkunde. I: 433-38.

_________. 1906b. Ueber die Zoosporen reproduktion bei *Stigeoclonium*. Oesterreich Bot. Zeit. 56: 395-417.

_________. 1907(?). Neuer Beitrag zur Algenflora des südlichen Böhmerwaldes (aus dem botanischen Institute der K.K. deutschen Universitätzu Prag). 149-184.

_________. 1915. Animalische Ernährung bei Grünalgen. Ber. deutsch. bot. Gesellsch. 33: 427-442.

_________. 1918. Ueber amoeboide Gameten, Amoebozygoten und diploide Plasmodien bei einer Chlamydomonadine. Ber. deut. bot. Gesellsch. 36: 352-359.

Patrick, Ruth. 1949. A proposed biological measure of stream conditions, based on a survey of the Conestoga Basin, Lancaster Co.Penna. Proc. Acad. Nat. Sci. Phila.CI:277-341.

Patrick (Cont.)

_________. 1950. Biological measure of stream conditions. Sewage and Industrial Wastes. 22(7): 926-938.

Phinney, H.K. 1951. Some filamentous algae from North Michigan. Trans. Amer. Micros. Soc. 70(2): 143.

Prescott, G.W. 1931. Iowa Algae. Univ. Iowa Stud. Nat. Hist. 13(6): 86-87.

_________. 1944. New species and varieties of Wisconsin Algae. Farlowia. I(3): 347-385.

_________. 1951. Ecology of Panama Canal Algae. Trans. Amer. Micros. Soc. LXX(1): 1-24.

_________. 1951a. Algae of the Western Great Lakes Area. Cranbrook Institute of Science. No. 31. Michigan. pp.946.

_________. 1955. The freshwater algae of Montana. I. New species of Chaetophoraceae. Hydrobiologia. VII(1-2): 56-59.

Printz, H. 1927. Chlorophyceae (nebst Conjugatae, Heterocontae und Charophyta)

Printz (Cont.)

in Engler-Prantl's "Die natürlichen pflanzenfamilien" 2nd Edn. 3.

Pringsheim, N. 1861. Ueber die Dauerschwärmer des wassernetzes und ueber einige ihnen verwandte Bildungen. Monatsber. Akad. d. Wiss. Berlin. 1860: 775-794.

Rabenhorst, L. 1847. Deutschlands Kryptogamen Flora. 2(2): 87-115.

________. 1863. Kryptogamen-Flora von Sachsen, der Ober-Lansitz. Thüringen und Nordboehmen. I: 230-274.

________. 1868. Flora Europa Algarum. 3. Leipzig.

Reich, K. 1926. I. Zur Kenntnis der Entwicklungsgeschichte und Zytologie von Stigeoclonium. Arch. f. Protis. 53: 435-458.

Reinhardt, L. 1876. Die copulation der zoosporen bei Chlamydomonas pulvisculus Ehr. und Stigeoclonium sp. Arbeit. d. Naturf. Gesell. Univ. Charkoff. 10(8).

Reinsch, P.F. 1867. Die Algenflora des mittleren Thieles von Franken. Nuernberg.

________. 1877. Freshwater Algae from Kerguelen's Island. Linn. Soc. Jour. XV: 216-217.

Reynolds, N. 1948. The morphological development of certain epiphytic Algae from ponds in Glamorgan. Ph.D. Thesis. Univ. of Wales. Gr. Britain.

________. 1950. Senior studentship of the Exhibition of 1851 Final Report. England.

Rich, F. 1932. Contribution to our knowledge of the freshwater algae of Africa. 10. Phytoplankton from South Africa Pans and Vleis. Trans. Roy. Soc. S. Africa, XX: 149-188.

Saunders, De A. 1894. Flora of Nebraska. Protophyta, Phycophyta, Coleochaetaceae, Characeae. Univ. Nebraska. Sem. I:1-68.

Schmidle, W. 1895. Einige Algen aus Sumatra. Hedwigia, 34: 294-296.

________. 1896. Süsswasseralgen aus Australien. Flora, 82: 297-313.

Schmidle (Cont.)

__________. 1900. Ueber einige von Prof. Hansgirg in Ostind. des Süsswasseralgen. Hedwigia. 39: 162-166.

Schmidt, P. 1943. Ueber einige neue, frei wachsende Chaetophoracae in der Helgoländer Algenflora. Deutsch. Bot. Ges. Berichte. 61: 20-36.

Setchell, W.A. 1926. Tahitian algae collected by W. A. Setchell, C.B. Setchell and H.E. Parks, Univ. Calif. Pub. Bot. 12: 61-142.

Silva, H. 1951. Algae of the Tennessee Valley Region: A Manual for Identification of Species. Ph.D. Thesis. Michigan State College.

Silva, P.C. 1952. A review of nomenclatural conservation in the algae from the point of view of the type method. Univ. Calif. Publ. in Bot. 25(4): 241-324.

__________. 1959. Remarks on Algal Nomenclature. II. Taxon. VIII (2): 60-64.

Singh, R.N. 1954. A comparative study of the life-cycle of two species of the genus *Stigeoclonium* (*S. farctum* and *S. amoenum*). Rev. Alg. n.s. 1: 1.

Skvortzov, B.V. 1928. On some freshwater algae from Ceylon collected by W.P. Lipsky in 1908. Ceylon Jour. Sci. A. Bot., Ann. Roy. Bot. Garden, Peradeniya, 11(1): 109.

__________. 1946. Species novae et minus cognitae Algarum. Flagellatarum et Phycomicetarum Asiae, Africae, Americae et Japoniae nec non Ceylon anno 1931-45 descripto et illustrato per tab. 1-18. Proc. Harbin (Manshuria) Soc. Nat. Hist. and Ethnography, No. 2, 1946. 1-34.

Skuja, H. 1949. Zur Süsswasseralgenflora Burmas. Nova Acta Reg. Soc. Sci. Uppsala. ser. IV: 14(5): 1-188.

Smith, B.H. 1931. The Algae of Indiana. Ph.D. Thesis. Botany Dept. Ohio State Univ. Columbus.

Smith, E.A. 1919. Illustrating biological Manuscript. Trans. Am. Micros. Soc. 38(1):1-19.

Smith, G.M. 1920. Phytoplankton of the inland lakes of Wisconsin. Part I. Bull. No. 57. Wiscon. Geol. and Natur. Hist. Survey.

_________. 1933-and 1950. The freshwater algae of the United States. 1st and 2nd editions. Mc Graw Hill Book Co. Inc. N.Y.

Snow, Edna. 1932. A preliminary report on the algae of Utah lake. Utah Ac. Sci. IX: 21-28.

Starr, R.C. 1955. A comparative study of Chlorococcum Meneghini and other spherical, zoospore-producing genera of the Chlorococcales. pp. 1-111. Indiana University Press. Bloomington.

Stebbins, G.L. 1950. Variation and Evolution in plants. Columbia Univ. Press. N.Y.

Stone, G.E. 1900. Flora of Lake Quinsigamond. Ann. Report Worcester Nat. Hist. Soc.

Ström, K.M. 1921. Algological Notes III. The germination of zoogonidia of

Ström (Cont.)

Stigeoclonium tenue. Nyt. Mag. f. Natur. LIX: 1-14.

____________. 1926. Norwegian Mountain Algae. Oslo. 1-263.

Szymanski, F. 1878. Ueber parasitische Algen. Breslau.

Taft, C.E. 1939. Addition to the Algae of Michigan. Bull. Tor. Bot. Club. 66: 77-85.

Teodoresco, E.C. 1907. Materiaux por la flore algologique de la Roumanie. Beih. z. Bot. Centralbl. 21: 103-219.

Thompson, R.H. 1939. A preliminary survey of the freshwater Algae of Eastern Kansas. Sci. Bull. Univ. Kansas. 25(1938): 5-83.

Tiffany, L.H. 1926. The filamentous algae of Northwestern Iowa with special reference to the Oedogoniaceae. Trans. Am. Micros. Soc. 45(2): 69-132.

____________. 1937. The filamentous algae of the west end of Lake Erie. Amer. Midland Natur. 18(6): 911-951.

Tiffany, L.H. and M.E. Britton. 1944. Freshwater Chlorophyceae and Xanthophyceae from Puerto Rico. Ohio Jour. Sc. 44(1): 39-50.

________. and ________. 1952. The Algae of Illinois. Univ. Chicago Press. pp.407.

Tilden, J.E. 1894. List of freshwater algae collected in Minnesota during 1893. Minn. Bot. Stud. I(9): ser. II: 25-31.

________. 1895. Ibid. during 1894. Ibid: 228-236.

________. 1896. Ibid. during 1895. Ibid: 597-600.

________. 1896. A contribution to the life-history of <u>Pilinia diluta</u> Wood and <u>Stigeoclonium flagelliferum</u> Kg. Minn. Bot. Stud. Bull. I (9). Bot. ser. II: 601-635.

________. 1937. The Algae and Their Life-Relations: Fundamentals of Phycology. Univ. of Minnesota Press. pp.550.

Transeau, E.N. 1913. The annotated list of the algae of Eastern Illinois. Ill. Acad. Sc. 6:69-89.

Transeau (Cont.)

_______. 1913. The periodicity of Algae in Illinois. Trans. Am. Micros. Soc. 32(1): 31-40.

_______. 1916. Periodicity of Freshwater Algae. Amer. Jour. Bot. 3: 121-133.

_______. 1917. The algae of Michigan. Ohio Jour. Sc. 17(7): 217-232.

Uspenskaia, V.I. 1936. The physiology of nutrition and development of the thallome of Stigeoclonium tenue Klebsi. Microbiol. 5(1): 1-31.

_______. 1936. The influence of lighting intensity and concentration of nitrates on the development of Thallome and the formation of zoospores and gametes in Stigeoclonium tenue Klebsi. Ibid. 5(3): 307-321.

Venkataraman, G.S. 1957. The algal flora of the ponds and puddles inside the Benaras Hindu University grounds. Ind. Jour. Bombay Natur. Hist. Soc. 54(4): 908- 919.

Vischer, W. 1933. Ueber einige kritische Gattungen und die Systematik der Chaetophorales. Beih. Bot. Centralbl. 51(1)-1-100.

Vinyard, W. 1958. Algae of Oklahoma. Ph.D. Thesis. Botany Dept. Michigan State Univ. East Lansing.

Wade, W. E. 1948. A limnological investigation of Jordan Lake, Michigan, with particular reference to the algae which cause "water bloom". M.S. Thesis. Michigan State Univ. East Lansing.

West, G.S. 1904. A treatise on the British Freshwater Algae. Cambridge Univ. Press.

__________. 1904. West Indian Freshwater Algae. Jour. Bot. 42: 281-294.

__________. 1912. Freshwater Algae (Report No. 14. of the Percy Sladen Memorial Expn. in South-west Africa, 1908-11). Ann. S. African Mus. IX: 61-89.

West, G.S. (Cont.)

_________. 1914. A contribution to our knowledge of the freshwater algae of Columbia. Mem. Soc. Neuchatel Sc. Nat. V:1013-1051.

West, G.S. and F.E. Fritsch. 1927. British Freshwater Algae. A Treatise. Cambridge Univ. Press. pp.534.

West, W. and G.S. West. 1894. On some freshwater algae from West Indies. Jour. Linn. Soc. Bot. 30.

West, W. and G.S. West. 1895. The freshwater algae of Madagascar. Trans. Linn. Soc. Bot. London, ser.2,5: 41-90.

_________. and _________. 1896. On some new interesting freshwater algae. Jour. Roy. Micros. Soc., .149-165.

_________. and _________. 1897. A contribution to the freshwater algae of the south of England. Jour. Roy. Micros. Soc. .467-511.

_________. and _________. 1901. The algal-flora of Yorkshire, Leeds. Bot. Trans. Y.N.U. 5:1-239.

West, W. and G. S. West. 1903. Notes on freshwater algae III. Jour. Bot. 41: 33-41.

_______. and _______. 1906. A comparative study of the plankton of some Irish Lakes. Trans. Roy. Irish Acad. 33. sec. B. part II: 77-116.

_______. and _______. 1907. Freshwater algae from Burma, including few from Bengal and Madras. Ann. Roy. Bot. Garden. Calcutta. VI. part II: 175-260.

Whitford, L.A. 1943. The freshwater algae of North Carolina. Jour. Elisha Mitchell Sc. Soc. 59(2): 131-170.

_________. 1955. Algae in the Giant Springs of Florida. Phyc. News Bull. 8(23):4.

_________. 1956. The communities of algae in the springs and spring streams of Florida. Ecology. 37(3): 433-442.

_________. 1960. The current effect and growth of freshwater algae. Trans. Amer. Micros. Soc. 79(3): 302-309.

_________. 1960a. Ecological distribution of freshwater algae, in The Ecology of Algae. The Pymatuning Symposia

Whitford (Cont.)

in Ecology, University of Pittsburgh. Special Publication No. 2: 2-10 pp.

Wildemann, E. De. 1896. Flore des Algues de Belgique. Bruxelles. p.43-44.

________. 1900. Les Algues de la Flore de Buitenzorg: Essai d'une flore algologique de Java. Leide. pp.457.

Wille, J.N.F. 1883. Ueber Akineeten and Aplanosporen bei den Algen. Bot. Centralbl. 16: 215-219.

________. 1897. Chlorophyceae, in Engler and Prantl's Nat. Pflanzenfamilien. Teil. I. Abt. 2: 36-101.

________. 1897. Om Faerðernes Ferskvandsalger og om Fersk. Spredniugsmaader. Bot. Not. 1-32; 49-61.

________. 1901. Studien ueber Chlorophyceen I-VII. Biol. Station Drobak Vidensk. Skrift. 6: 1-46.

________. 1901. Algologische Notizen. VII. Zur Verbreitung der Süsswasseralgen in Südlichen Norwegen. Nyt. Mag. Nat. Band 39: 1-22.

Wille, J.N.F. (Cont.)

________. 1911. Conjugatae und Chlorophyceae. Nachträge zum I. Teil: 2 Abteilung, in Engler's Die

*________. 1915.] Natür. Pflanzenfam. Leipzig.

Wittrock, V.B. and O. Nordstedt. 1880. Algae aquae dulcis exsiccatae. Bot. Not.1880: 113-122.

Wolle, Fr. 1887. Freshwater Algae of United States. I and II. Bethlehem, Pennsylvania.

Wood, H.C. 1872. A contribution to the History of freshwater algae of North America. Smith. Contrib. to Knowledge. 19(241): 1-262.

Woodson, B.R.Jr. 1957. An ecological and taxonomic survey of the Chlorophyta of the James River Basin, Virginia. Ph.D. Thesis. Michigan State University.

Yatsu, N. 1905. Cytological differences between the *Palmella* and filamentous forms of *Stigeoclonium*. Torreya. 5: 100-104.

*Report of an Expedition to Porto-Rico for collecting freshwater Algae. Jour. New York Bot. Garden. 15: 132-146.

Zeller, G. 1873. Algen gesammelt con. S. Kurz in Arracan und British Burma, bestimmt und systematisch geordnet von Dr. G. Zeller in Stuttgart. Hedwigia. No. 11: 168-175; No. 12: 191. (also in Jour. Asiatic Soc. Bengal. XLII; II: 175; XI. ser. II: 175).

Appendix

1. Savannah River Biological Survey. South Carolina and Georgia; Progress Report for E.I. Du Pont de Nemours and Company. S.R. Plant. Acad. Nat. Sc. Phila. 1957.
2. A Biological Survey of the La Vase Rivers, Canada, for Du Pont Company of Canada Ltd. Acad. Nat. Sc. Phila. 1958.
3. Biological and Chemical Studies for the SOHIO Chemical Comp. Lima, Ohio. Acad. Nat. Sc. Phila. 1956.
4. Biological and Chemical studies for the Lima Refinery Standard Oil Company (Ohio). Summer. 1956. Acad. Nat. Sc. Phila. 1957.
5. A study of Rivers Recovery for the Manufacturing Chemists' Association. Supplementary Report. Acad. Nat. Sc. Phila. 1958.
6. River Survey Report for the Potomac Electric Power Co. Summer Survey. 1956. Acad. Nat. Sc. Phila. 1957.
7. San Joaquin River, California. Stream Survey Report for the Organic Chemicals Division. E.I. Du Pont de Nemours and Company. Acad. Nat. Sc. Phila. 1956.
8. Savannah River Biological Survey. South Carolina and Georgia. June 1951-May 1952: Final Report

for E.I. Du Pont de Nemours and Company. S.R. Plant. Acad. Nat. Sc. Phila. 1953.

9. Biological Survey of the Conestoga Creek Basin; A report to the Sanitary Water Board Commonwealth of Pennsylvania. Acad. Nat. Sc. Phila. 1949.

10. International Code of Botanical Nomenclature. Edited by J. Lanjouw et al. 1956. Utrecht, Netherlands.

Bibliography : *Cloniophora*

Bourrelly, P. 1954. *Cloniophora plumosa* en Nouvelle-Calédonie. Rev. Alg. N.S.T. fasc. 1: 43-44.

Bourrelly, P. et E. Manguin. 1952. Algues déau douce de la Guadeloupe et dépendances. Paris. 1-276.

Britton, M.E. 1937. The fresh water algae of Puerto Rico. M.S. Thesis. Ohio State University, Columbus.

Forest, H.S. 1956. A study of the genus *Draparnaldia* Bory and *Draparnaldiopsis* Smith and Klyver. Castanea, 21(1): 1-29.

Gayral Mme. Paulette. 1954. Recherches Phytolimologiques an Maroc. Trav. De L'Institut Sc. Chérifien. Ser. Bot. No. 4. (p. 212, f.48) pp. 1- 306.

Hirose, H. and H. Takashima. 1955. The green algal genus *Cloniophora*, newly found from Japan. Jour. Jap. Bot. 30 (8): 233-237.

Kuetzing, F.T. 1849. Species Algarum. Lipsiae.

__________. 1853. Tabulae Phycologie. Vol. 3.

Meyer, K.I. 1927. Les Algues de l'extre'mite septentrionale du lac Baikal. Arch. Russes d. Protistol. 6(1-4): 93-118.

__________. 1930. Einige neue Algenformen des Baikal sees. Archiv. f. Protistenkunde; 72: 158-175.

Nayal, A.A. 1935. Egyptian freshwater Algae. Egyptian Univ. Bull. Fac. Sc. No. 4: 32-33 : f.45.

__________. 1937. On some new freshwater algae from Egypt. Egypt. Univ. Bull. Fac. Sc. 13: 1-15.

__________. 1939. Ibid. Rev. Alg. 8: 311-319.

Nordstedt, Otto. 1878. De Algis aquae dulcis et de Characeis ex insulis Sandvicensibus a Sv. Berggren 1875 reportatis. Minesskr. Fys. Sallsk. Lund. 7: 1-24: f.20-21.

Prescott, G.W. 1951. Ecology of Panama Canal Algae. Trans. Am. Micros. Soc. LXX(1): 1-24.

Schmidle, W. 1895. Einige Algen aus Sumatra. Hedwigia. 34: 294-296.

__________. 1896. Süsswasseralgen aus Australien Flora, 82: 297-313.

__________. 1900. Uber einige von Prof. Hansgirg in Ostind. ges Süsswasseralgen. Hedwigia, 39: 162-166.

Tiffany, L.H. 1936. Wille's collection of Puerto Rican Freshwater algae. Brittonia. 2(2): 165-176.

Whitford, L.A. 1960. Ecological distribution of Freshwater Algae. in The Ecology of Algae. The Pymatuning Symposia in Ecology. Special Publication No. 2: 2-10. University of Pittsburgh.

Wildemann, E.De. 1900. Les Algues de Flore de Buitenzorg; Essai dune flore algologique de Java. Leide. p.61. pl.13.f.1-6.

Plate 1

Fig. 1 Stigeoclonium tenue (Ag.) Kg. var. uniforme (Ag.) Kg., X 100. (drawn from material from PH).

Figs. 2-4. Stigeoclonium tenue (Ag.) Kg. var. tenue
Fig. 2. X 215, drawn from Brunel's collection, Canada; Fig. 3, X 215, from living material collected by Dr. Wade, Michigan; Fig. 4, X 150, from a living material from Flathead Lake, Montana (Is.)

Fig. 5. Stigeoclonium subuligerum Kg., X 100 (drawn from Kew Herb. as No. 30. Norvegiae ad Finshöe, 1868, O. Nordstedt).

Fig. 6. Stigeoclonium amoenum Kg. var. amoenum, X ? (Redrawn from Godward).


1
2
3
4
5
6

Plate 2

Figs. 1-3. *Stigeoclonium amoenum* Kg. var. *amoenum*, (Figs. 1-2, X 100, drawn from living material from Round Lake, Michigan; Fig. 3. redrawn from Godward, 1/2 original size).

Pl.2

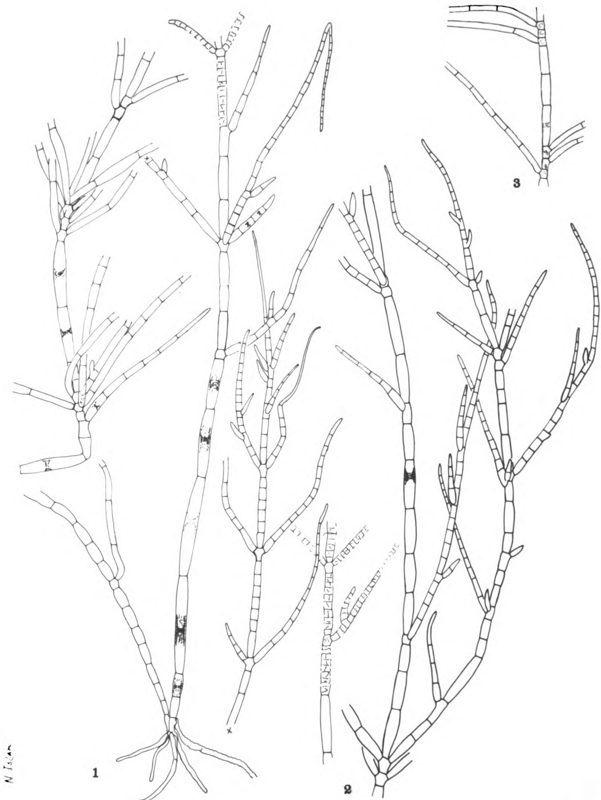


Plate 3

Figs. 1-7. Stigeoclonium flagelliferum Kg. (Figs. 1-2, X 105, drawn from (PC) as Stig. amoenum Kg., La Clare 1890, Col. De Brebisson; Fig. 3, X 105, from Herb. Kuetzing (L) as Stig. crassiusculum Kg., Holland, Schleswig; Figs. 4-5, X 220, from East Pakistan; Fig. 6, X 220, drawn from Draparnaldia tenue var. elongatum Hassall; Fig. 7, Redrawn from Kuetzing, Pl. 10, f.1, X½ original size.).

Pl.3

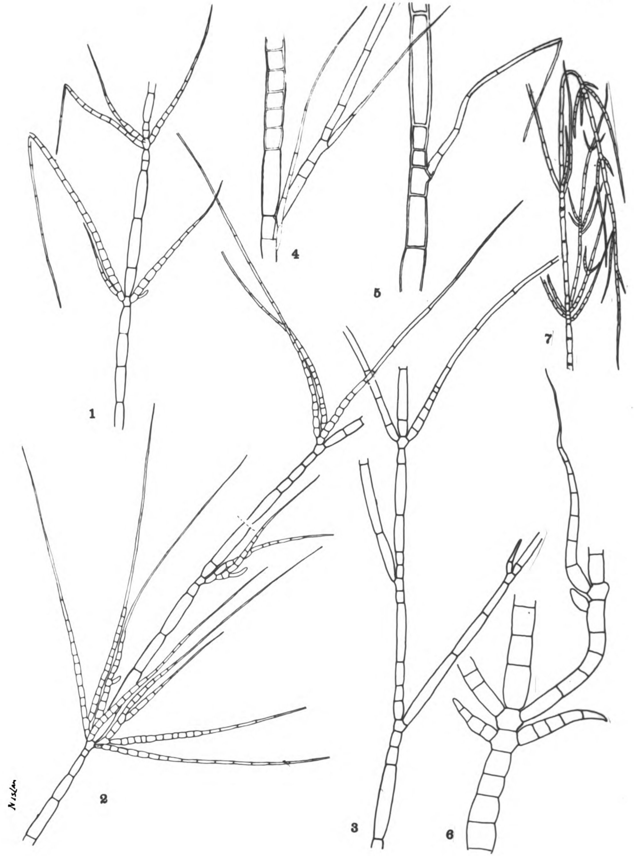


Plate 4

Figs. 1-4. Stigeoclonium lubricum (Dillw.) Kg. (Fig. 1, X 100, drawn from P.B.A. No. 2233, California, 1916; Fig. 2, X 100, drawn from Whitford Col. No. W 858, N. Carolina; Fig. 3, X 215, drawn from S. Forest Col. No. 545, 1947, Tennessee; Fig. 4, X 215, drawn from R. Patrick Col. No. 2329 (F), S. Carolina).

Pl.4

Plate 5

Figs. 1-4. Stigeoclonium lubricum (Dillw.) Kg., X 220 (Figs. 1-2, drawn from Herb. Ducommun. Leipzig, 1863 (LAU); Figs. 3-4, drawn from Silva and Margie Col. No. 2812 (F), Virginia).

Fig. 5. Stigeoclonium protensum (Dillw.) Kg., X 220 (drawn from Daily's Herb. (BUT) as Stig. stagnatile (Haz.) Col., collected from S. Carolina).

Fig. 6. Stigeoclonium variabile Naeg., X 330 (drawn from TYPE specimen).

Pl.5

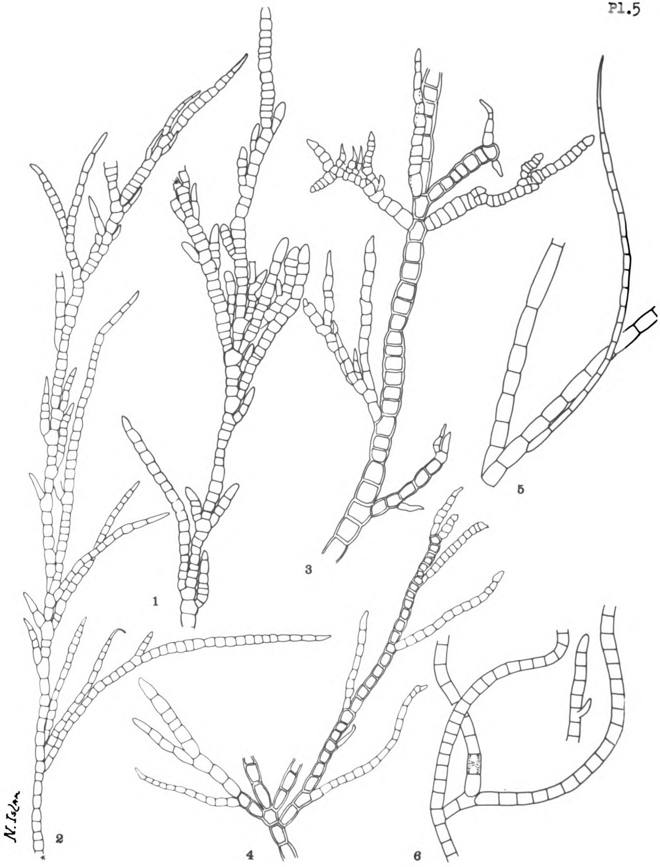


Plate 6

Fig. 1. <u>Stigeoclonium</u> <u>tenue</u> (Ag.) Kg. forma. X 150 (drawn from <u>Draparnaldia</u> <u>tenuis</u>. (C), 1815)

Fig. 2. <u>Stigeoclonium</u> <u>nanum</u> (Ag.) Kg., X 150 (drawn from P.B.A. 2234).

Fig. 3. <u>Stigeoclonium</u> <u>lubricum</u> (Dillw.) Kg. forma X 325 (drawn from (PH), No. 3(6 A), collected from Georgia) (lower part).

Fig. 4. <u>Stigeoclonium</u> <u>longipilum</u> Kg. X 325 (drawn from TYPE specimen of <u>Stig</u>. <u>radians</u> Kg. (L). (lower part).

Fig. 5. <u>Stigeoclonium</u> <u>subsecundum</u> Kg. var. <u>subsecundum</u> X 162 (drawn from living specimen from Michigan).

150

815)

rawn

a

ected

n

L).

undum

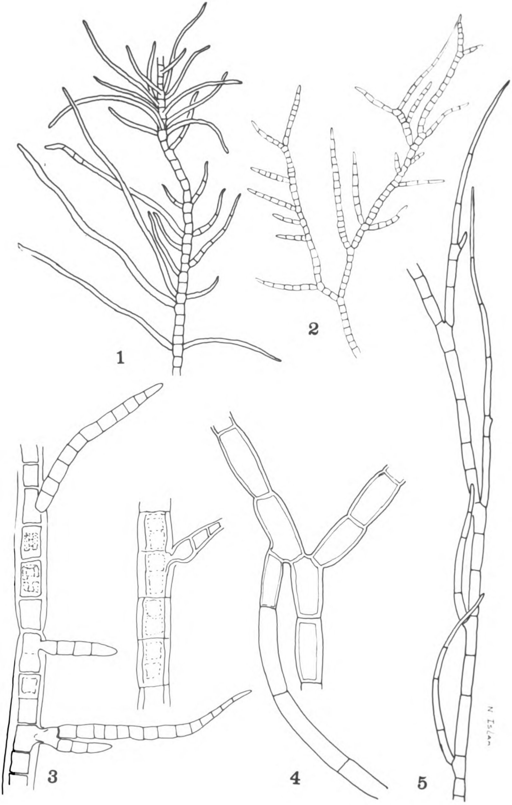


Plate 7

Fig. 1. Stigeoclonium protensum (Dillw.) Kg. X 215 (drawn from No. 114 as Stig. stagnatile (Hazen) Col., collected from Arkansas (F)).

Figs. 2-3. Stigeoclonium flagelliferum Kg. forma, X 215 (drawn from living material collected from Lake Lansing, Michigan, Col. Graffius).

Fig. 4. Stigeoclonium sp. stagnatile ? X 100 (drawn from Dr. Whitford Collection. North Carolina).

Figs. 5-6. Stigeoclonium variabile Naeg., Fig. 5, X 215; Fig. 6, X 325 (drawn from TYPE of Stig. subspinosum Kg. from (L).).

Figs. 7-8. Stigeoclonium flagelliferum Kg. forma ?, X 215 (drawn from Whitford Col. No. Bt.8, North Carolina).

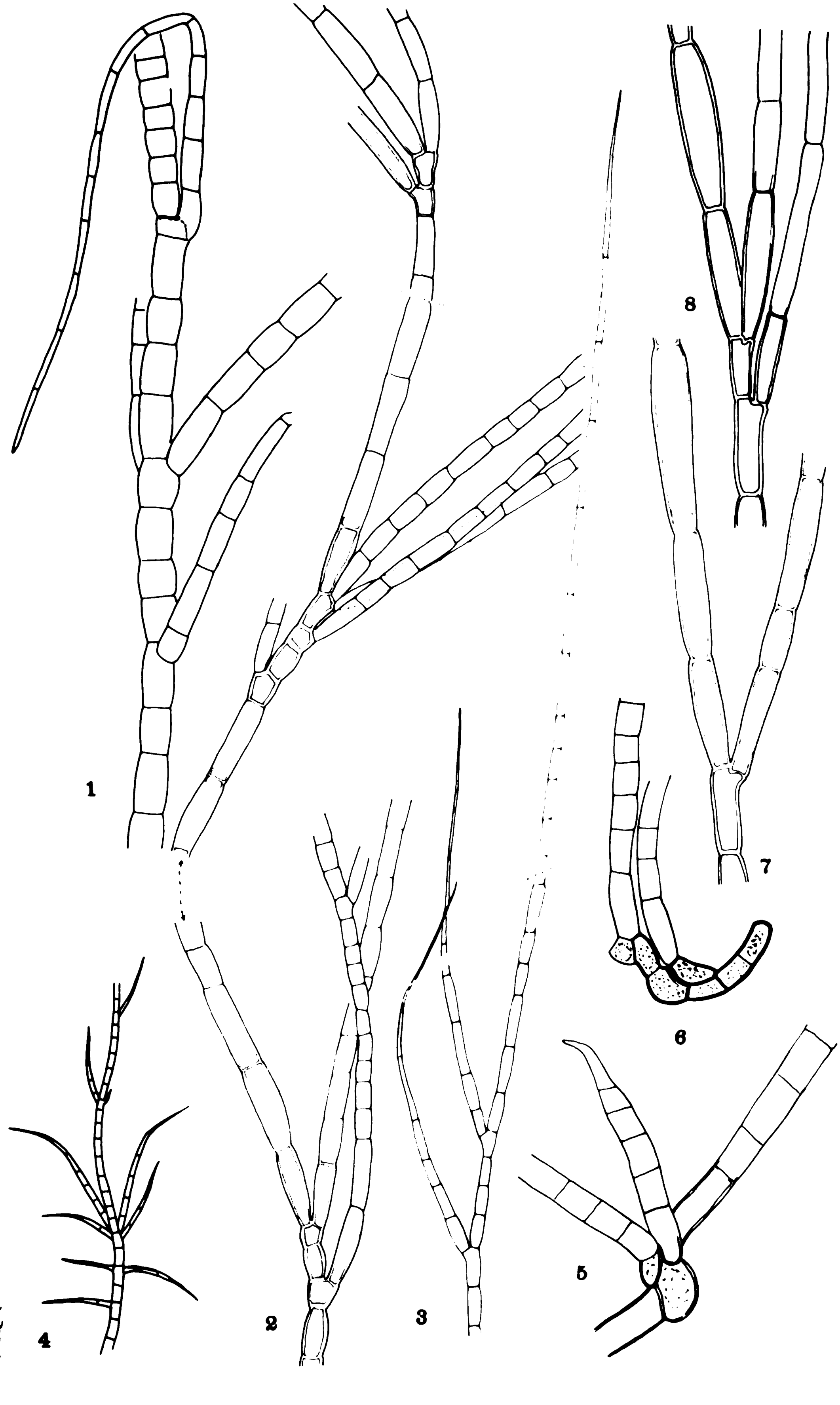

1
2
3
4
5
6
7
8

Plate 8

Fig. 1. Stigeoclonium subuligerum Kg., X 134 (drawn from Vinyard's collection from Kansas).

Figs. 2-4. Stigeoclonium amoenum Kg. var. aucklandicum var. nov., X 144. (drawn from specimen collected at Waitakera stream, New Zealand).

Fig. 5. Stigeoclonium tenue (Ag.) Kg. var. tenue, X 67 (drawn from Whitford Col. No. Dd 7, N. Carolina).

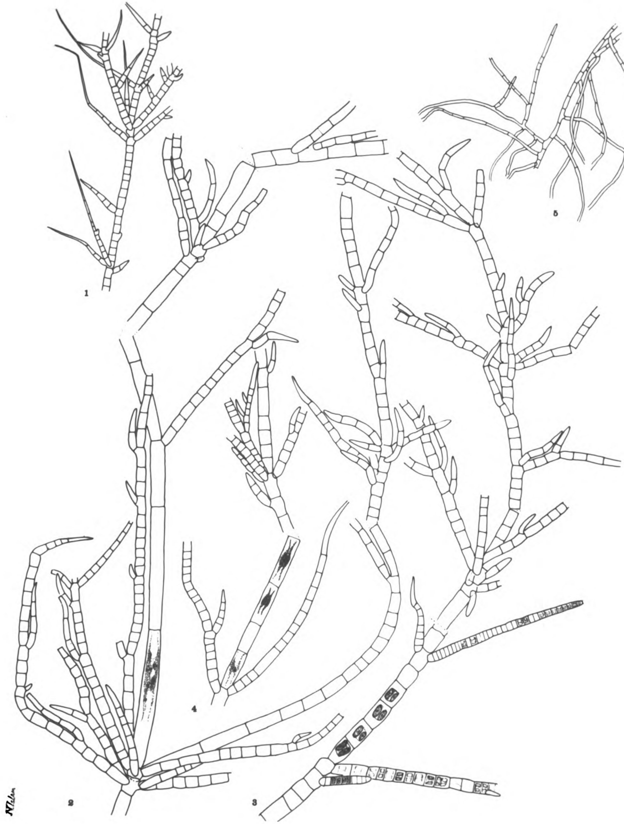

1
2
3
4
5

Plate 9

Figs. 1-9. *Stigeoclonium nudiusculum* Kg., Fig. 1, X 50; Figs. 2-6, X 215 (all drawn from Kuetzing Herb. (L) as *Draparnaldia nudiuscula* Kg., 1834); Figs. 7-9. drawn from pencil sketches by Mme. Gauthier-Lievre, Alger University.

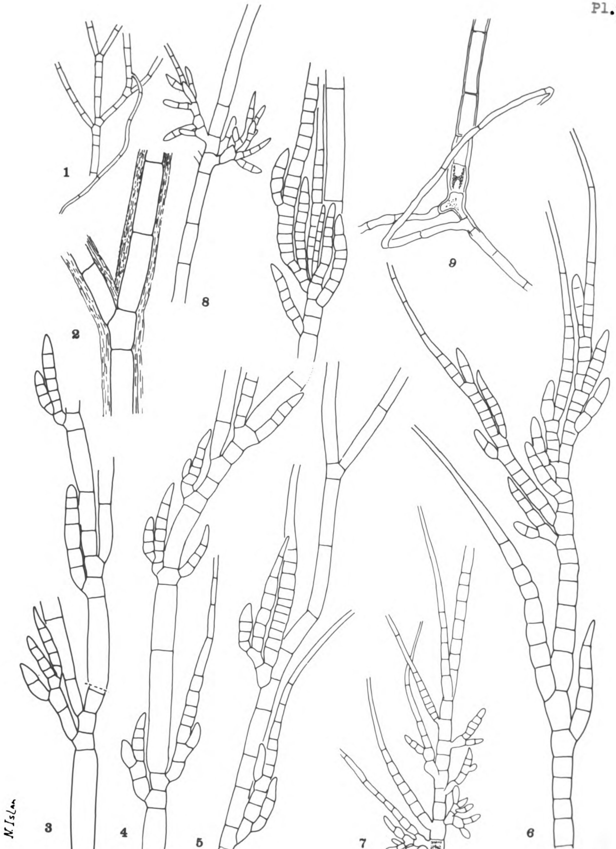

1
2
3
4
5
6
7
8
9
N. Islam

Plate 10

Figs. 1-3. *Stigeoclonium Nelsonii* Prescott. X 215 (drawn from TYPE).

Figs. 4-5. *Stigeoclonium nanum* (Dillw.) Kg. Fig. 4, X 215 (drawn from Ex. Herb. Dillwyn, (Kew); Fig. 5 X 75 (drawn from P.B.A. No. 2234).

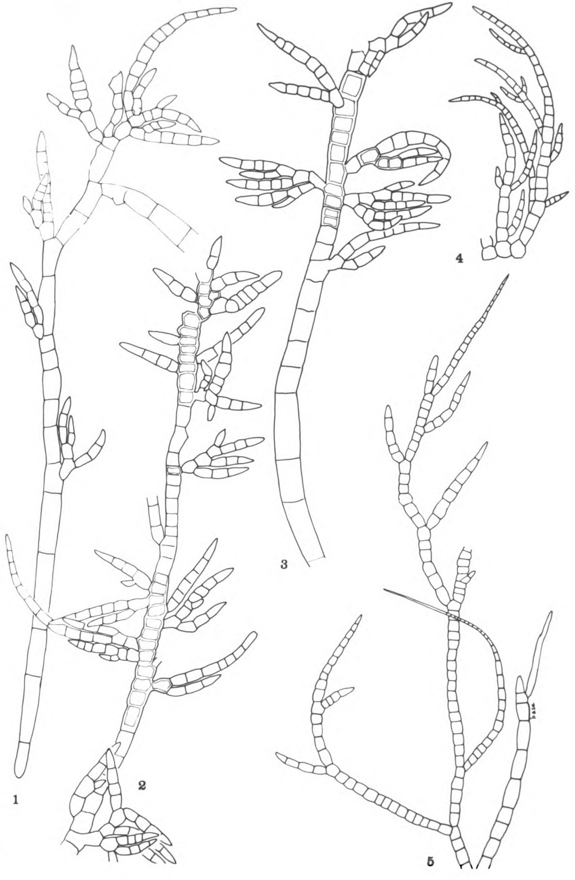

1
2
3
4
5

Plate 11

Figs. 1-5. *Stigeoclonium pachydermum* Prescott var. *pachydermum*. Figs. 1-3, X 100 (drawn from Prescott's Col. No. 2W-51, (Lectotype). Wisconsin); Figs. 4-5, X 215 (drawn from Kew Herb. as *Stig. irregulare* Kg.).

ar.

n from

e).

from

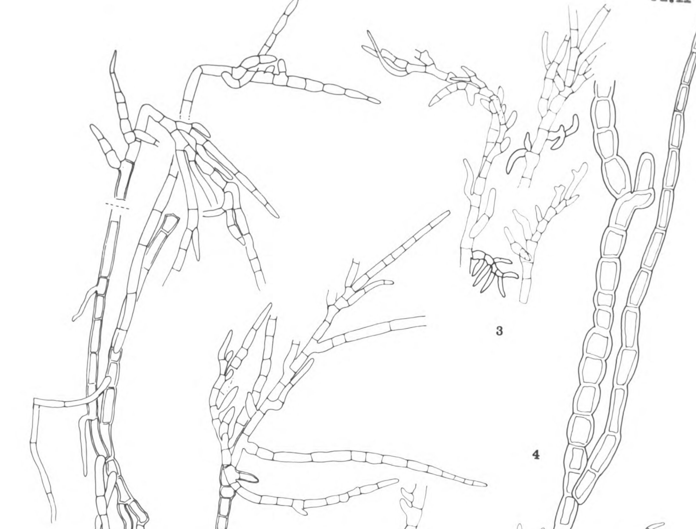
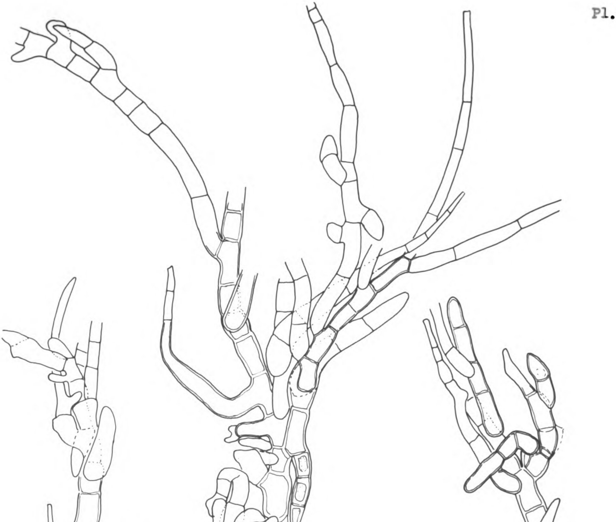


Plate 12

Figs. 1-3. Stigeoclonium pachydermum Prescott var. pachydermum. X 215 (drawn from Prescott Col. No. 2 W-51 (Lectotype).



1 2 3

Plate 13

Figs. 1-6. *Stigeoclonium pachydermum* Prescott var. *Whitfordii* var. nov. X 100 (drawn from Whitford Col. No. Ha 8, N. Carolina).

Figs. 7-8. *Stigeoclonium aestivale* (Hazen) Collins. Fig. 7, X 125 (drawn from East Pakistan Collection (Is.); Fig. 8, X 100 (drawn from Brunel's Collection, Canada).

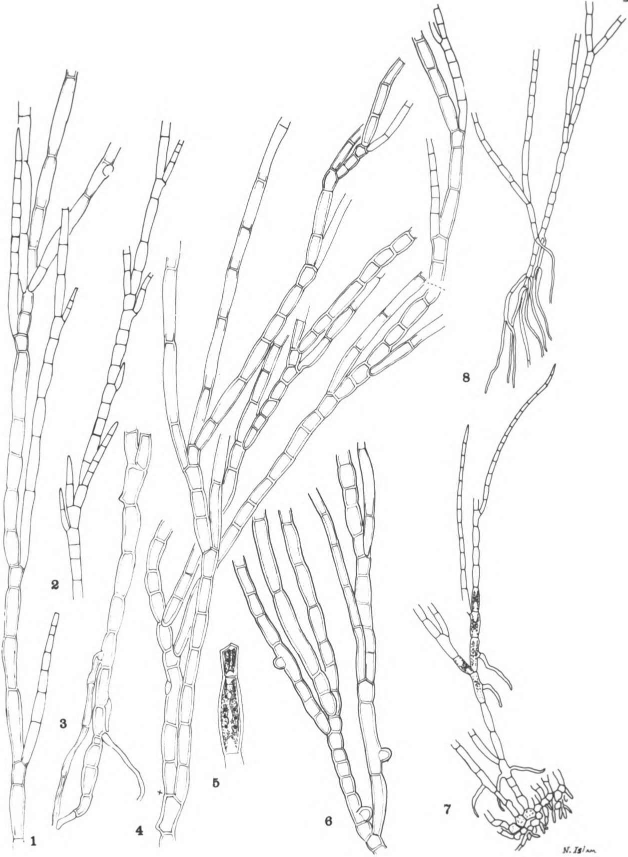

1
2
3
4
5
6
7
8
N. Islam

Plate 14

Figs. 1-3. *Stigeoclonium pachydermum* Prescott var. *Prescottii* var. nov. Figs. 1-2, X 215; Fig. 3, X 50 (all drawn from Prescott Col. Br. 63, Alaska).

Fig. 4. *Stigeoclonium pachydermum* var. *pachydermum* (redrawn from Prescott) X 95.

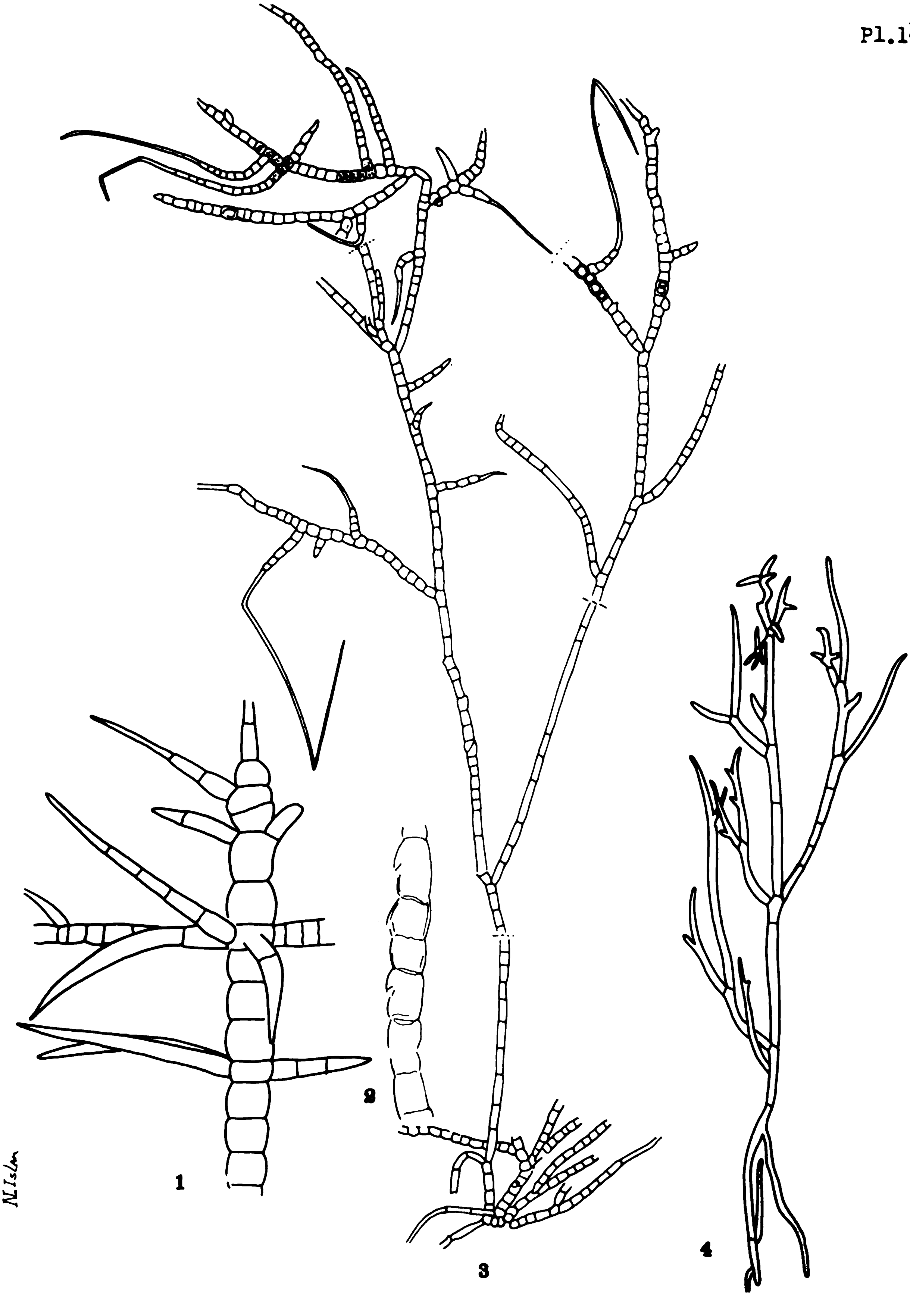

1
2
3
4

Plate 15

Figs. 1-6. Stigeoclonium paihiaensis sp. nov., Fig. 1, X 75; Fig. 2, X 115; Figs. 3-5, X 150; Fig. 6, X 325 (all drawm from Kew Herb. V. W. Lindauer Col. Nos. 105 & 1301).

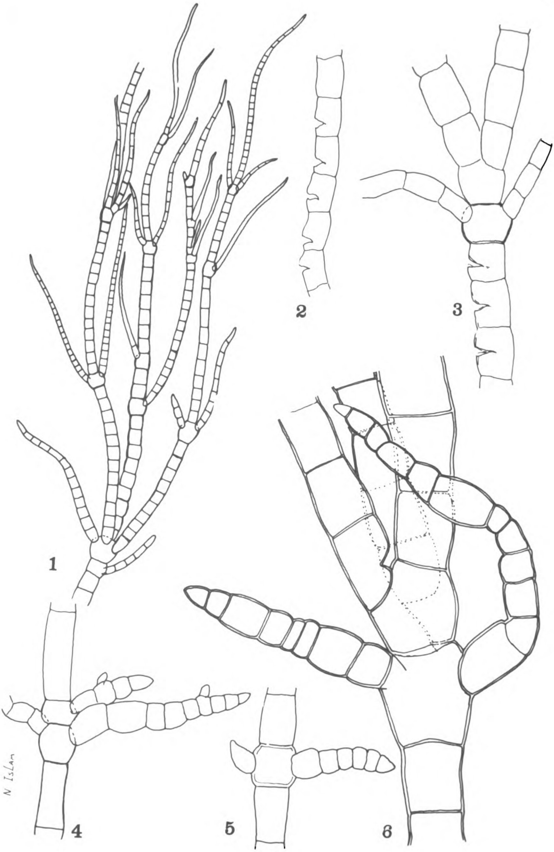

1
2
3
4
5
6

Plate 16

Figs. 1-3. Stigeoclonium stagnatile (Hazen) Collins. Figs. 1-2, X 220; Fig. 3, X 180 (all drawn from Whitford Collection from N. Carolina, Wayne Co. Sleepy Cr.).

Figs. 4-5. Stigeoclonium amoenum var. novizelandicum Nordst., X 220 (Fig. 4 drawn from Whitford Col. No. Hr 45, Nector Cr. N. Carolina; Fig. 5. drawn from Berggren Col. No. 89 (Lectotype), Auckland, N.Z. (Wittrock & Nordstedt Col. No. 909. (W)).

Figs. 6-7. Stigeoclonium nanum (Dillw.) Kg., X 105 (Fig. 6. redrawn from Wolle; Fig. 7. drawn from P.B.A. No. 2234).

) Collins.
(all
rom
).
landicum
Whitford
olins;
o. 39
ook &
105
7.

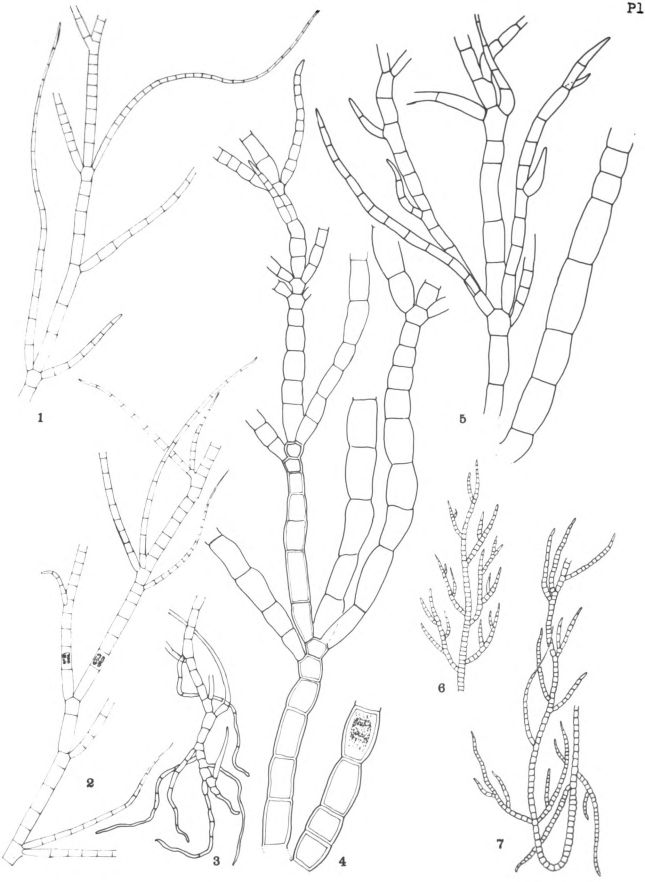


Plate 17

Figs. 1-3. *Stigeoclonium elongatum* Kg., X 215 (Figs. 1-2 drawn from *Stig. attenuatum*, No. 2970 from Sonora (F); Fig. 3, drawn from Kuetzing Herb. German Gall (L)).

Fig. 4. *Stigeoclonium nanum* (Dillw.) Kg., X 75 (drawn from P.B.A. No. 2234).

Fig. 5. *Stigeoclonium setigerum* Kg., X 215 (drawn from Leiden Herb.).

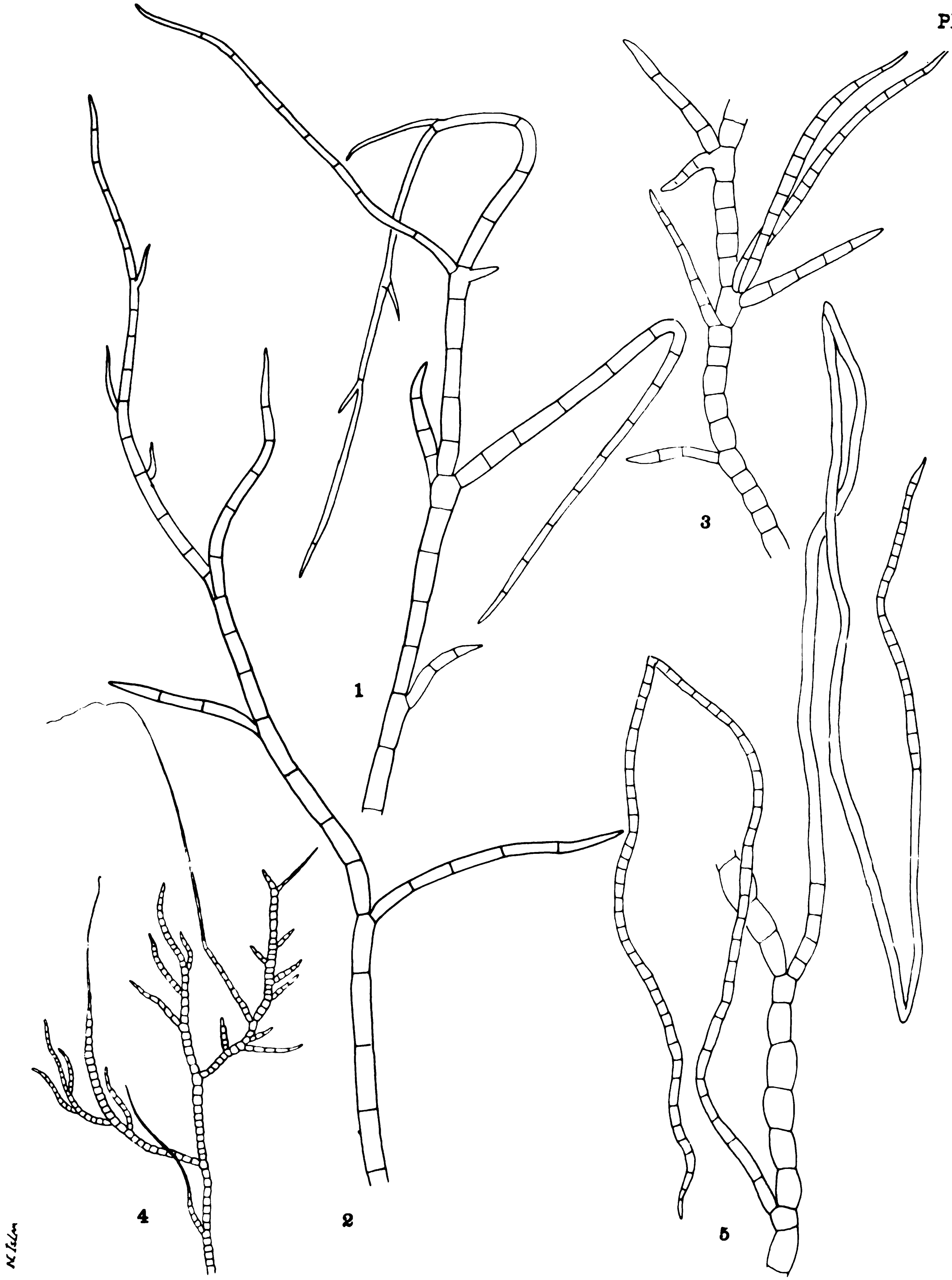

1
2
3
4
5

Plate 18

Fig. 1. Stigeoclonium flagelliferum Kg., X 162 (drawn from Wolle's collection).

Fig. 2. Stigeoclonium amoenum var. novizelandicum Nordst., X 162.

Fig. 3. Stigeoclonium amoenum Kg. var. amoenum, X 162.

Figs. 4-5. Stigeoclonium sp. X 162. (showing bulbous cells).

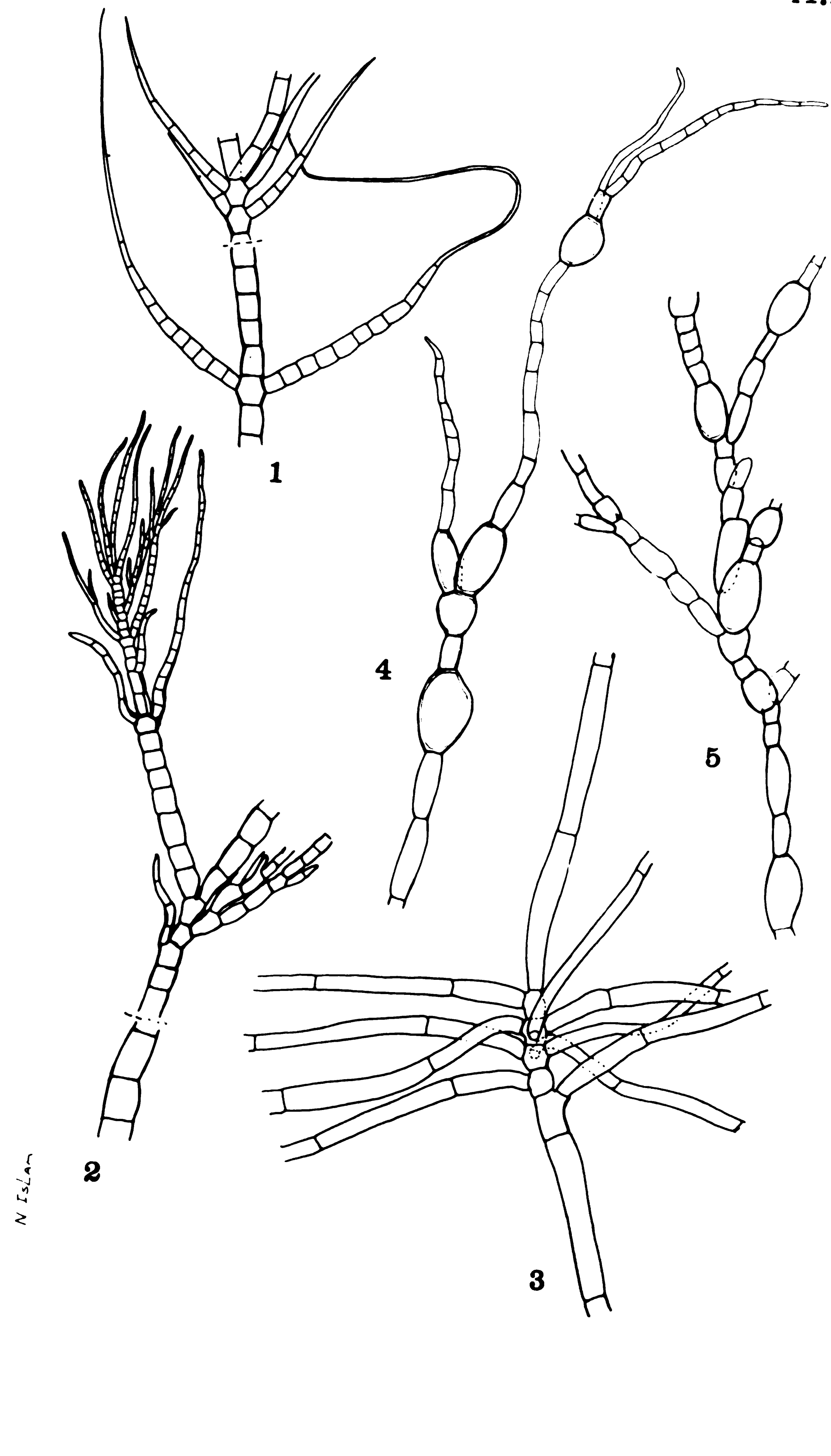

1
2
3
4
5
N Islam

Plate 19

Figs. 1-2. Stigeoclonium variabile Naeg. forma, X 500 (Redrawn from Teodorescu as Stig. subsecundum var. ulotrichoides Teod.)

Figs. 3-4. Stigeoclonium sp. farctum-like, X 215 (drawn from Schindler Col. No. M 97, Montana).

Fig. 5. Stigeoclonium subsecundum var. tenuis Nordst. (Redrawn from pencil sketch on herb. sheet by Teodorescu (W). X ?).

Fig. 6. Stigeoclonium variabile Naeg., X 215 (drawn from Indiana Culture collection, Bloomington).

Fig. 7. Stigeoclonium variabile Naeg. ?. X 75 (drawn from (W) as Stig. stellare).

Fig. 8. Stigeoclonium variabile Naeg., X 215 (drawn from Stig. weissianum Grun. 1884 (FH).)

Fig. 9. Stigeoclonium elongatum (Hassall) Kg., X 75 (drawn from Stig. pusillum, Rab. Alg. Sachs. No. 716).

Pl.19

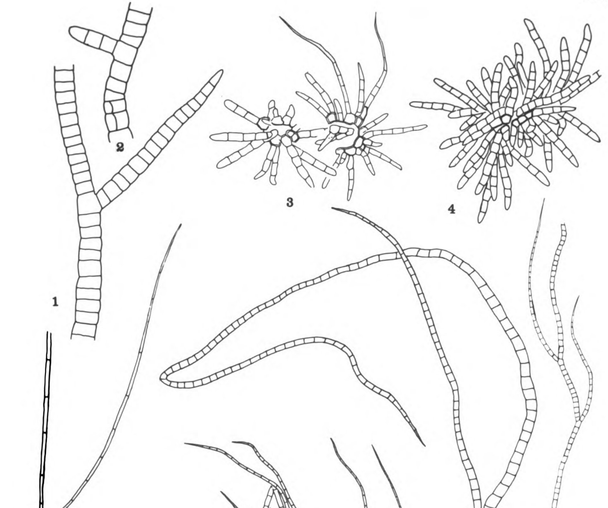


Plate 20

Figs. 1-2. *Stigeoclonium Lebelii* sp. nov., X 80 (drawn from (L) as *Stigeoclonium* with an epithet *pulchellum* Lebel).

Figs. 3-7 *Stigeoclonium paihiaensis* sp. nov., X 175 (same as Plate 15).

2
3
4
5
1
6
7

Plate 21

Figs. 1-3. *Stigeoclonium protensum* (Dillw.) Kg., X 75 (Figs. 1-2 drawn from (K) as *Conferva protensa* Dillw., 1804, Ex. Herb. Hooker; Fig. 3, drawn from Ex Herb. Dillwyn, (K).)

Fig. 4. *Stigeoclonium subsecundum* Kg. var. *subsecundum*, X 175 (drawn from Prescott Col. No. 234, from East Andes).

Fig. 5. *Stigeoclonium fasciculare* Kg, var. *fasciculare* forma, X 100 (drawn from living material from Lake Lansing, Michigan).

Figs. 6-8. *Stigeoclonium elongatum* (Hass.) Kg., X 215 (drawn from (L), TYPE of *Stig. subspinosum* beta *falklandicum* Kg.)


1
2
3
4
5
6
7
8

Plate 22

Figs. 1-2. Stigeoclonium amoenum Kg. forma, Fig. 1, X 100; Fig. 2, X 215 (drawn from Montana collection (Is.).)

Fig. 3. Stigeoclonium subsecundum Kg. var. subsecundum X 215 (drawn from living material collected from a Michigan bog).


N.Jalan
1
2
3

Plate 23

Fig. 1. Stigeoclonium variabile Naeg., X 325 (drawn from TYPE of Stig. subspinosum Kg. No. 87, 1847).

Fig. 2. Stigeoclonium protensum (Dillw.) Kg., X 115 (drawn from 5. Conferva protensa Dillw. (L), from Herb. Suringar).

Fig. 3. Stigeoclonium subsecundum Kg. var. tenuis Nordst., X 325 (drawn from Wittrock & Nordst. Alg. Exs. No.110, Stig. falklandicum Kg.).

Fig. 4. Stigeoclonium protensum (Dillw.) Kg. ? (or St. variabile ?), X 115 (drawn from Herb. Lenormand, Caen (L).).

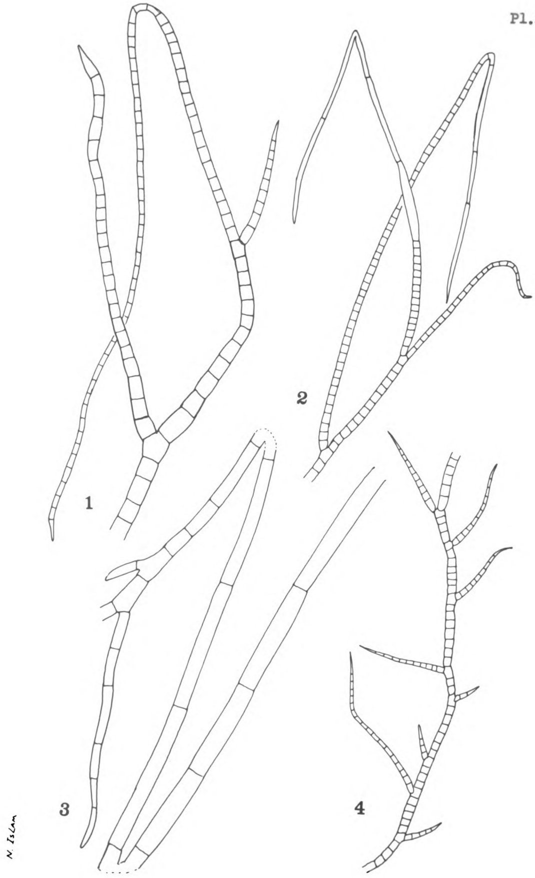

1
2
3
4
N. Islam

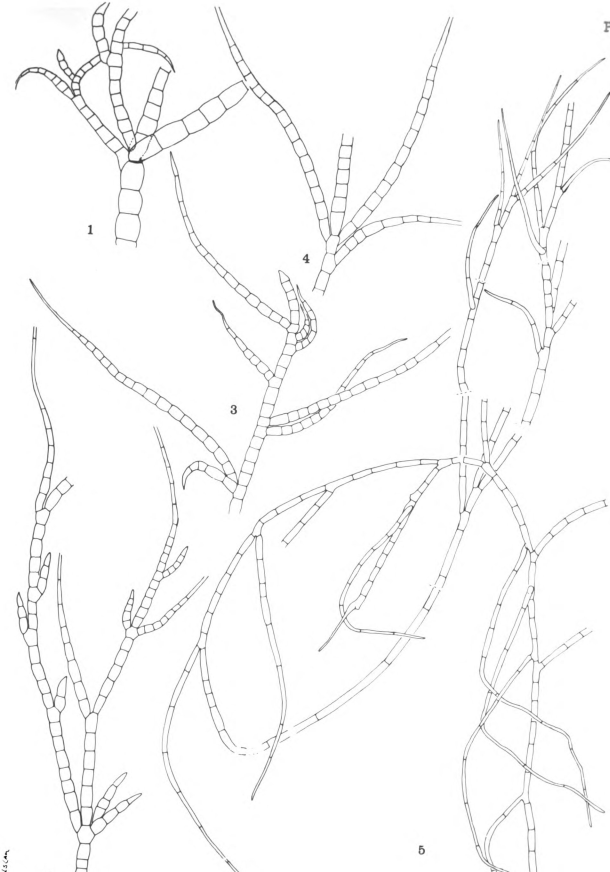
Plate 24

Fig. 1. Stigeoclonium fasciculare Kg. var. fasciculare, X 215 (drawn from TYPE).

Figs. 2-4. Stigeoclonium pusillum (Lyngb.) Kg., X 215.

Fig. 5. Stigeoclonium subsecundum var. subsecundum, X 210 (drawn from living material from a Michigan bog.)

Pl.24



Figs. 1-4. Stigeoclonium helveticum Vischer, (redrawn from pencil sketches by Mme. Gauthier-Lievre, Alger University), X 180 ?

Figs. 5-7. Stigeoclonium pusillum Kg. (redrawn from pencil sketches by Mme. Gauthier-Lievre, Alger University), X 180 ?

Figs. 8-9. Stigeoclonium variabile ?, X 100 (drawn from Brunel Col. No. 395 (MT).).

Pl.25

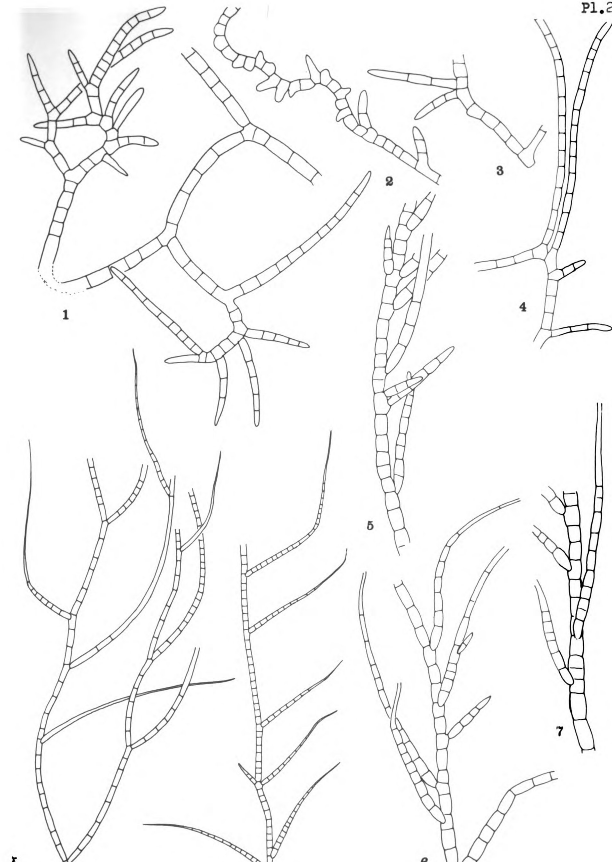
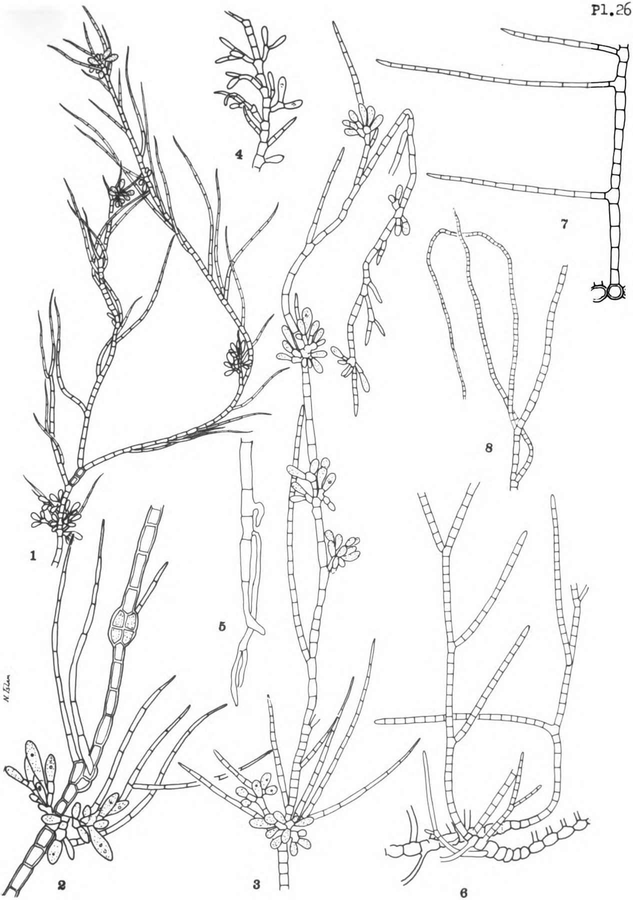


Plate 26

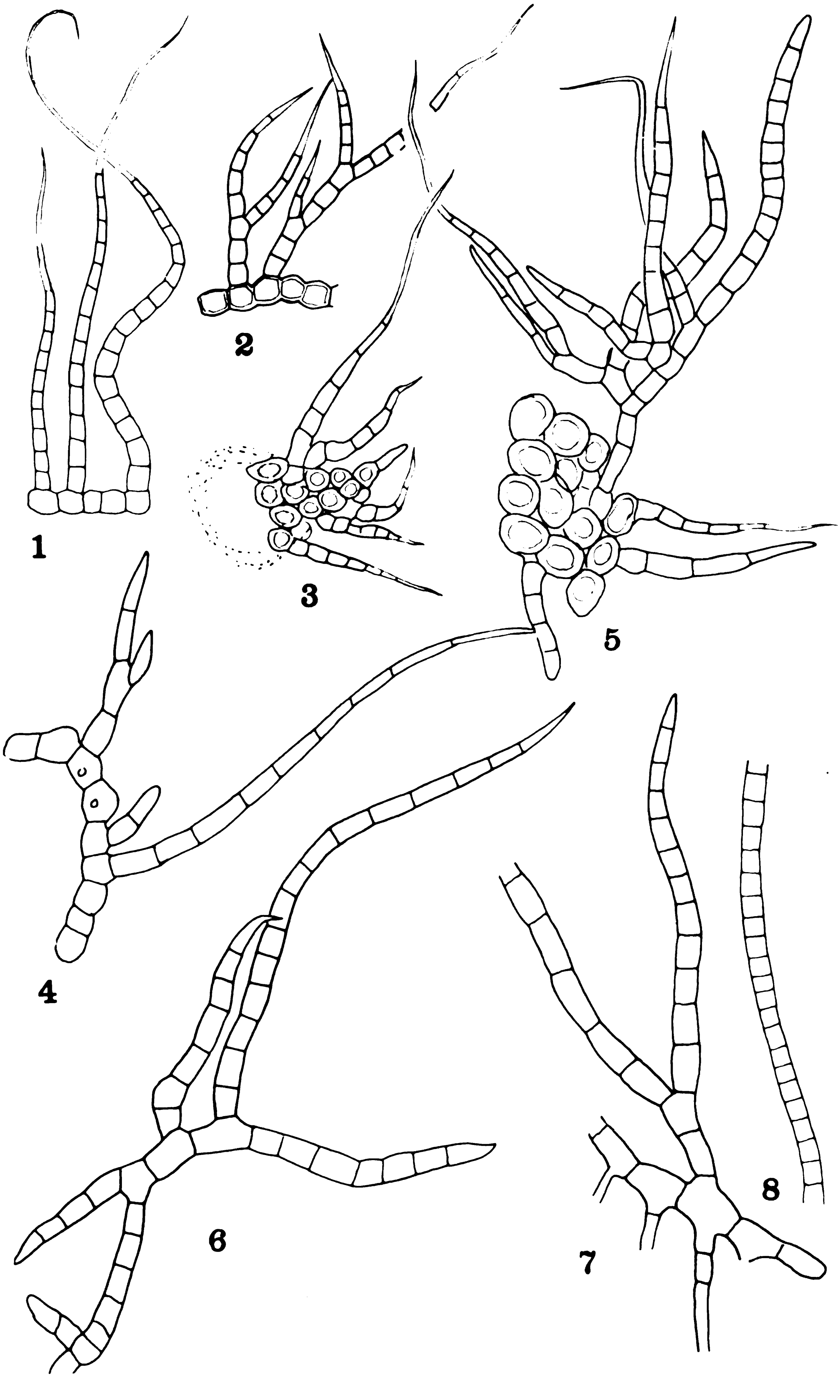
Figs. 1-5. *Stigeoclonium carolinianum* sp. nov. Fig. 1, X 75; Fig. 2, X 225; Fig. 3, X 130; Fig. 4, X 225; Fig. 5, X 215 (all drawn from Whitford Col. No. Bt.8 North Carolina).

Figs. 6-7. *Stigeoclonium farctum* Berth., X 215 (drawn from Indiana Culture collection No. LB 439 and 440).

Fig. 8. *Stigeoclonium setigerum* Kg., X 75 (drawn from Kuetzing Herb. (L), Eisleben, 1832).


1
2
3
4
5
6
7
8

Figs. 1-8. Stigeoclonium variabile Naeg. - complex, all X 325 (Figs. 1-5. drawn from Stig. pygmaeum Hansg. TYPE (W); Fig. 6. drawn from Indiana Culture No. LB 435; Figs. 7-8 drawn from Stig. weissianum Grunow, from (FH).)



N. Islam

Plate 28

Fig. 1. Stigeoclonium protensum (Dillw.) Kg., X 125 (drawn from Herb. Kuetzing, (L).).

Fig. 2. Stigeoclonium amoenum Kg. var. amoenum, X 215 (drawn from Vinyard's collection from Kansas).

Fig. 3. Stigeoclonium variabile Naeg., X 215 (drawn from Stig. subsimplex Collins, TYPE (NY.FH.)

Fig. 4. Stigeoclonium variabile Naeg., X 215 (drawn from Stigeoclonium weissianum Grun. (FH).).

Fig. 5. Stigeoclonium longipilum Kg., X 100 (drawn from Nordstedt and Wittrock Alg. Exs. No. 514. as Stig. gracile Kg.)

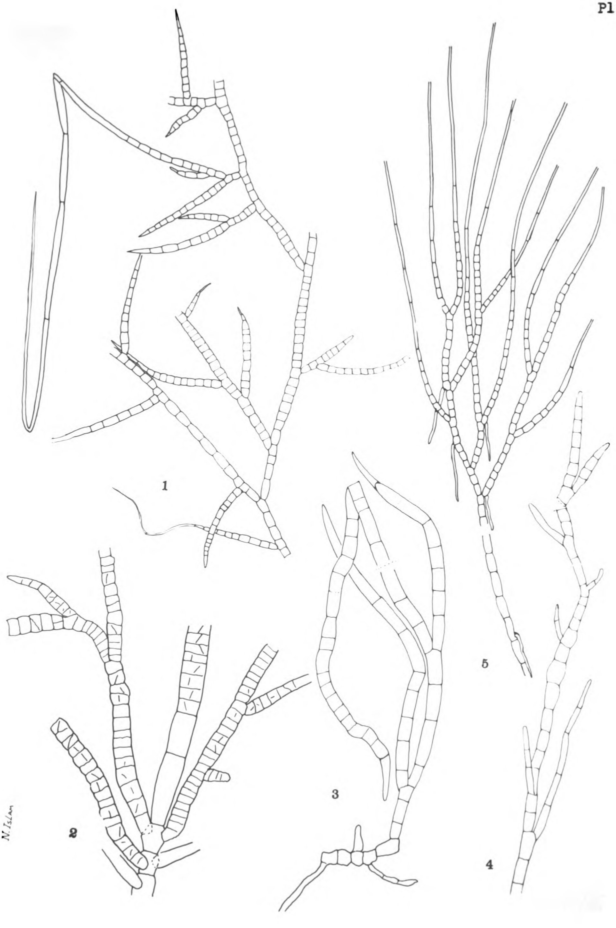

1
2
3
4
5
N.Islam

Plate 29

Fig. 1. Stigeoclonium Biasolettianum Kg., X 215 (drawn from Rabenhorst's Alg. Exs. No. 1665. as Stig. tenue var. irregulare Kg. Col. Grunow, 1863).

Figs. 2-6. Stigeoclonium helveticum Vischer, X 215 (Fig. 4, drawn from Cambridge Culture Col. (F), as Stig. helveticum var. minus; rest from Indiana Culture collection).

Pl.29

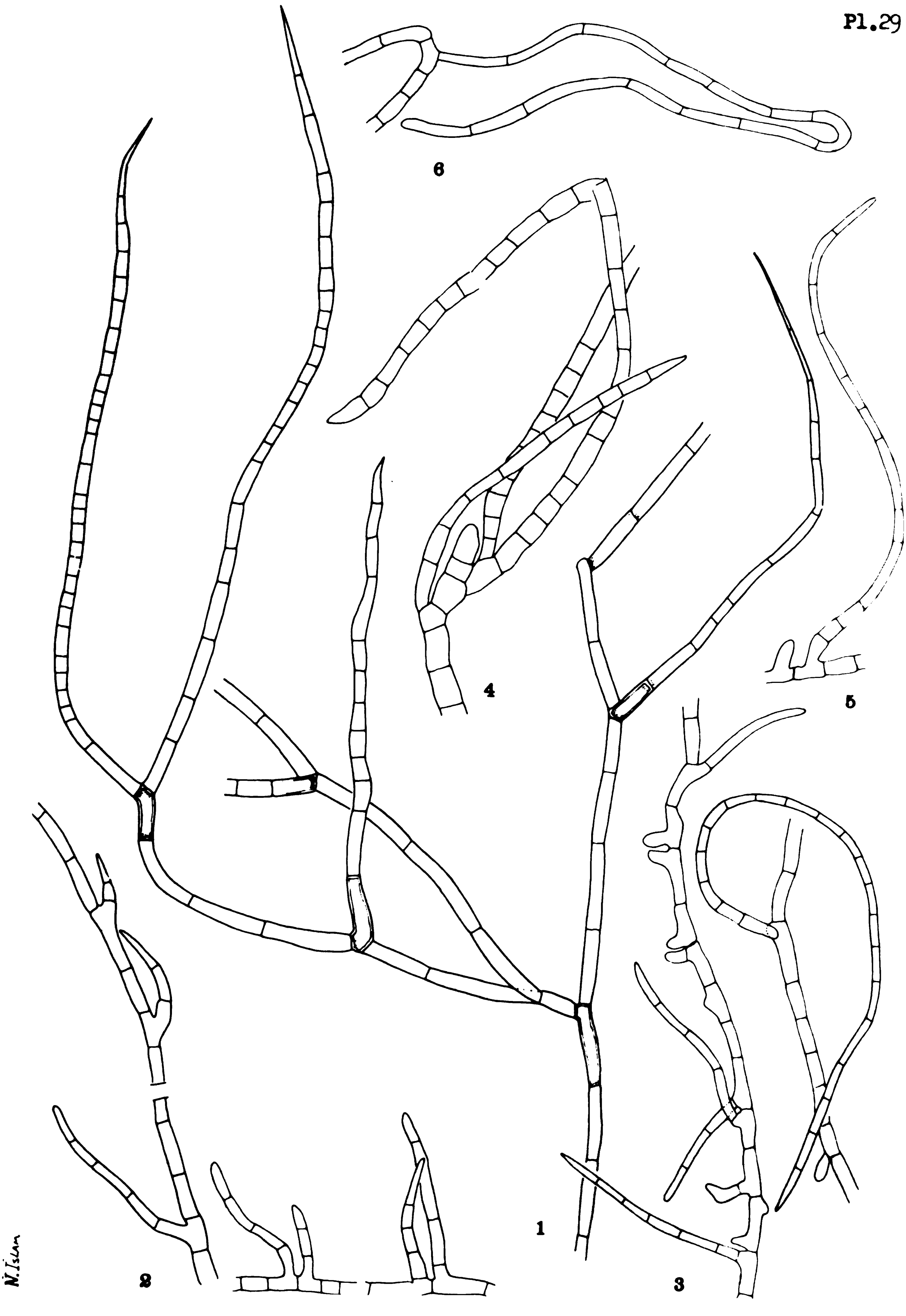


Plate 30

Figs. 1-3. *Stigeoclonium amoenum* Kg. var. *insigne* (Naegeli) comb. nov. X 100. (Fig. 1 drawn from (PH), collected from Salem, North Carolina as *Stig. amoenum* Kg.; Figs. 2-3. drawn from collection near Ice House, Outlet Bay, Marshall Co., Indiana (F).).

Fig. 4. *Stigeoclonium aestivale* (Hazen) Collins, X 100 (drawn from Brunel's collection, Canada (MT).)

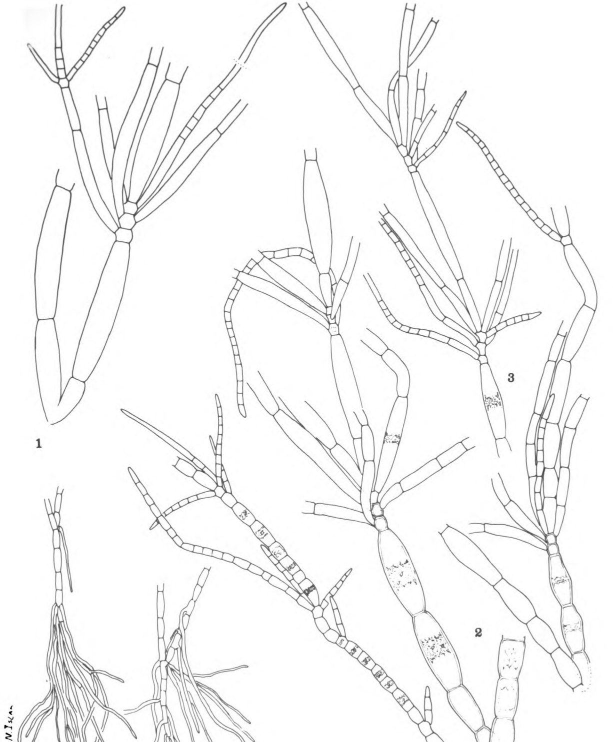

1
2
3
4

Plate 31

Figs. 1-3. Stigeoclonium thermale Br., Figs. 1-2, X 100 (drawn from TYPE (L); Fig. 3, X 75 (drawn from Wolle's collection).

Figs. 4-5. Stigeoclonium pachydermum var. pachydermum (Redrawn from Prescott). Fig. 4, X 490, Fig. 5, X 250.

Figs. 6-8. Stigeoclonium curvirostrum Skuja (Redrawn from Skuja). Fig. 6, X 330, Figs. 7-8, X 435.

Pl.31

Fig. 1. *Stigeoclonium longipilum* Kg., X 80 (drawn from Kuetzing Herb. (L). material as *Stig. fastigatum Kg.* Dolgelly, N.Wales, Col. J. Balfs, No. 23).

Figs. 2-4. *Stigeoclonium longipilum* Kg. var. *cylindricum* var. nov. (?) X 220 (drawn from material from E. Pakistan).

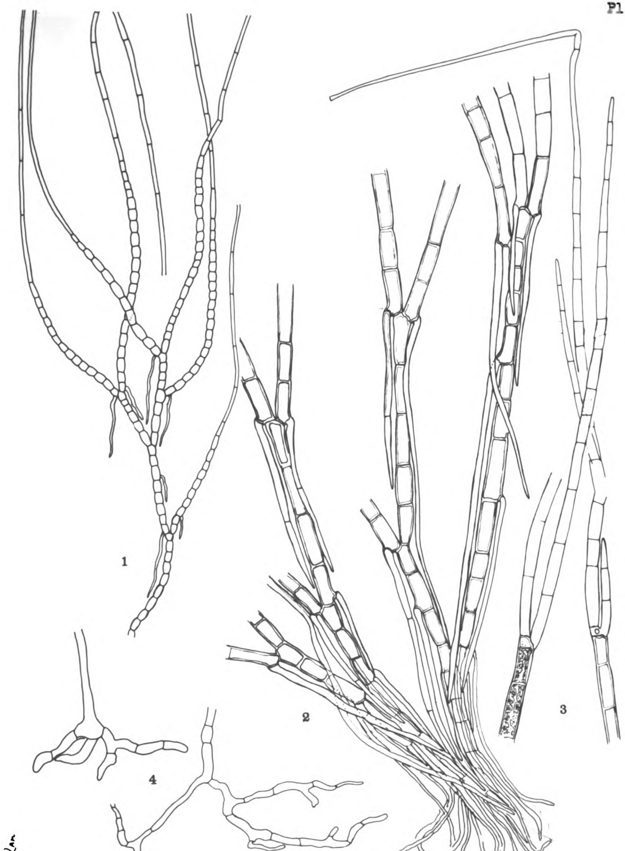

1
2
3
4

Plate 33

Figs. 1-5. Stigeoclonium fasciculare Kg., Figs. 1-2, X 75 (drawn from No. 363(19), Holland, Gallia (L);). Figs. 3-5, X 215 (drawn from TYPE specimen, 180(19) (L).).


1
2
3
4
5
N. Islam

Plate 34

Figs. 1-5. *Stigeoclonium segarae* sp. nov., Figs. 1-2, X 215; Figs. 3-5, X 100 (all drawn from E.C.M. Segar collection from Auckland University College, N.Z.)

Pl.34

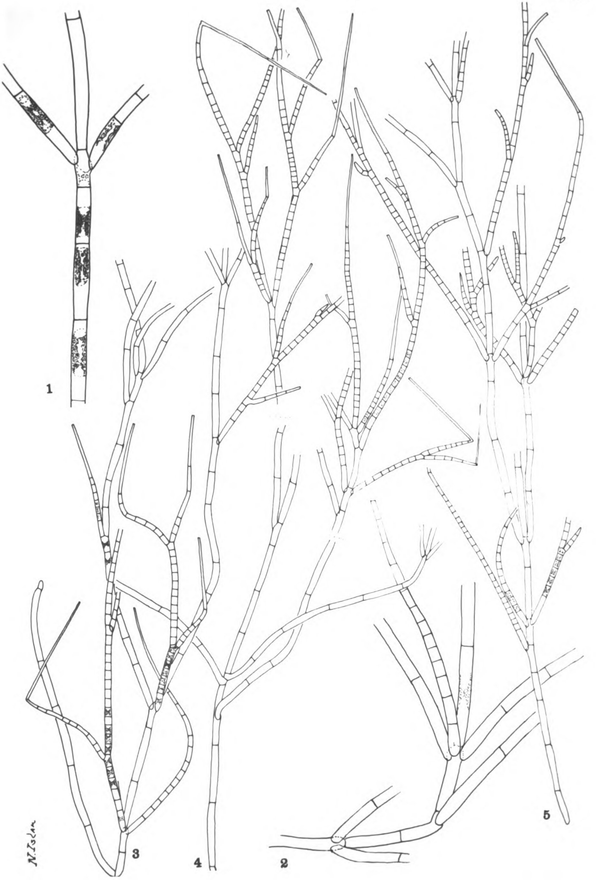


Plate 35

Fig. 1. Cloniophora plumosa (Kg.) Bourrelly ;. forma, X 108 (drawn from Tilden Am. Alg. Col. No. 459 as Stig. amoenum var. novizelandicum from Hawaii).

Fig. 2. Cloniophora macrocladia (Nordst.) Bourrelly var. macrocladia, X 90. (redrawn from Nordstedt 1878 as Draparnaldia macrocladia)

Figs. 3-5. Cloniophora plumosa (Kg.) forma; (drawn from G. W. Fergusson Col. Nos. 360 and 387, collected from mouth of Kelany River, Colombo, Ceylon; (W); Fig. 3, X 215 (a branch); Figs. 4-5, X 100 (middle and lower part of the same plant).

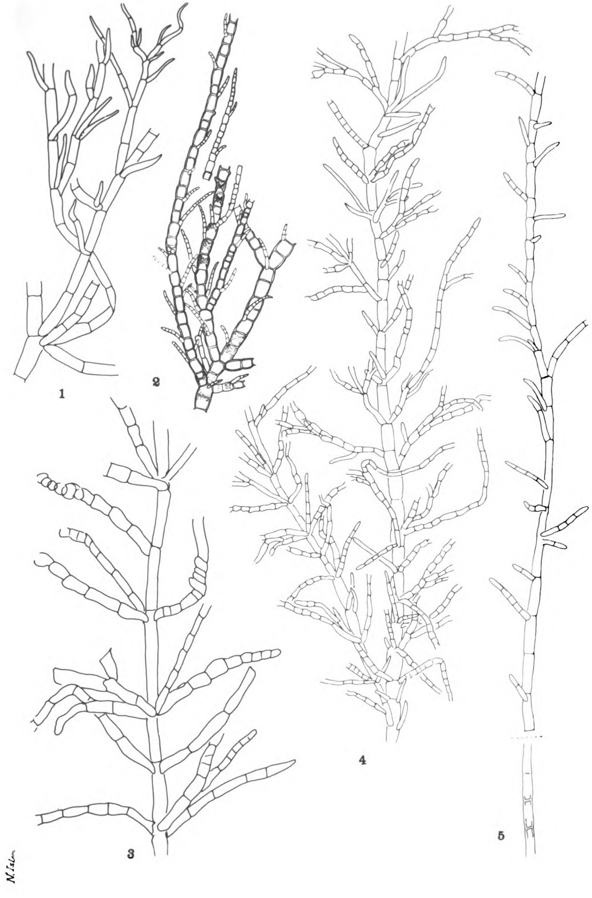
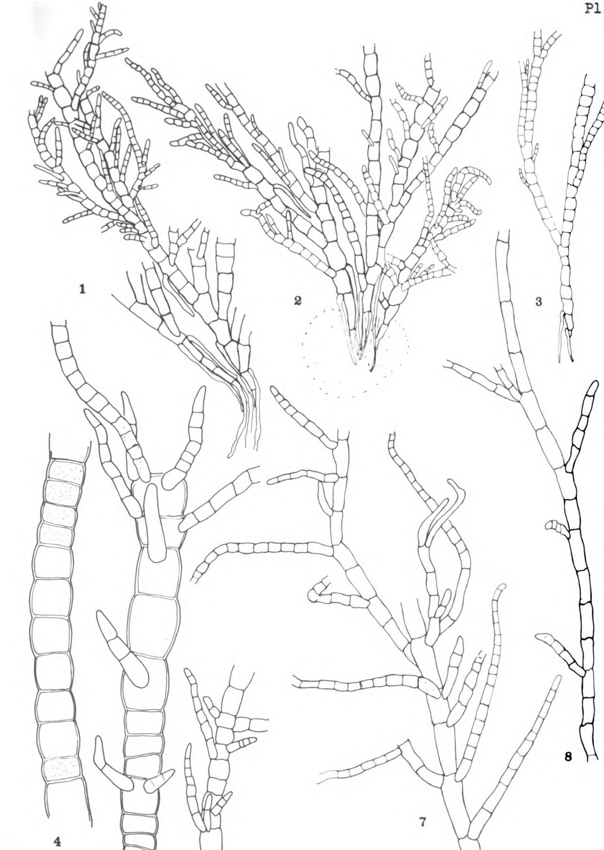

1
2
3
4
5

Plate 36

Figs. 1-6. Cloniophora macrocladia (Nordst.) Bourrelly var. macrocladia, Fig. 1, X 75 (drawn from Wittrock and Nordstedt Exs. No. 1426. As Stig. amoenum Kg. forma from Africa); Fig. 2, X 100, (drawn from (F) as Stig. Askenaysi Schmidle, from Malay); Fig. 3, X 50 (drawn from (W) as Stigeoclonium with an epithet Polakowski Grun.); Figs. 4-6, X 215, (drawn from Wittrock and Nordstedt Col. No. 1427, as Stig. amoenum Kg. forma, from Asia).

Figs. 7-8. Cloniophora plumosa (Kg.) Bourrelly, X 215 (drawn from TYPE of Stigeoclonium plumosum Kg. from (L) No. 67).

Pl.36



Figs. 1-5. Cloniophora macrocladia (Nordst.) var. mississippiensis var. nov. Figs. 1-2, X 100; Figs. 3-4, X 215 (all drawn from (F), Drouet Col. No. 9808 as Stig. lubricum (Dillw.) Kg.).

Fig. 6. Cloniophora macrocladia (Nordst.) Bourrelly var. macrocladia X 100 (drawn from Tilden's Am. Alg. No. 460 as Stig. nudiusculum Kg. from Hawaii).

1
2
3
4
5
6

Figs. 1-6. _Cloniophora spicata_ (Schmidle) comb. nov., Figs. 1-3, X 75; Figs. 5-6, X 215 (all drawn from Prescott Col. No. T 52 from Ecuador (Pres.); Fig. 4, X 215 (drawn from specimens from Puerto Rico, col. by D. C. Jackson, July 1960).

Pl. 38

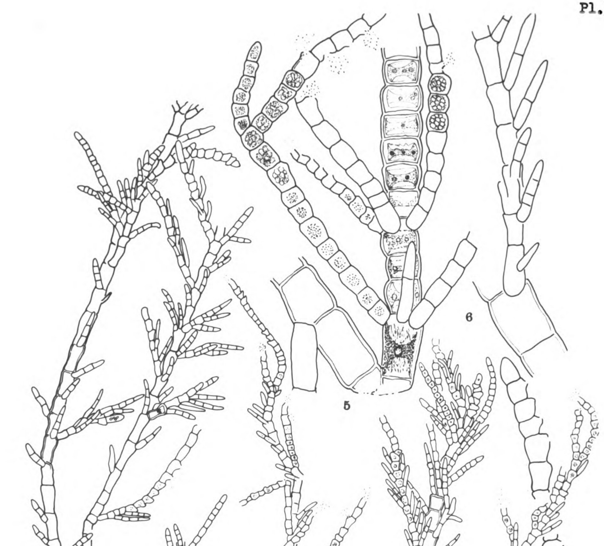


Plate 39

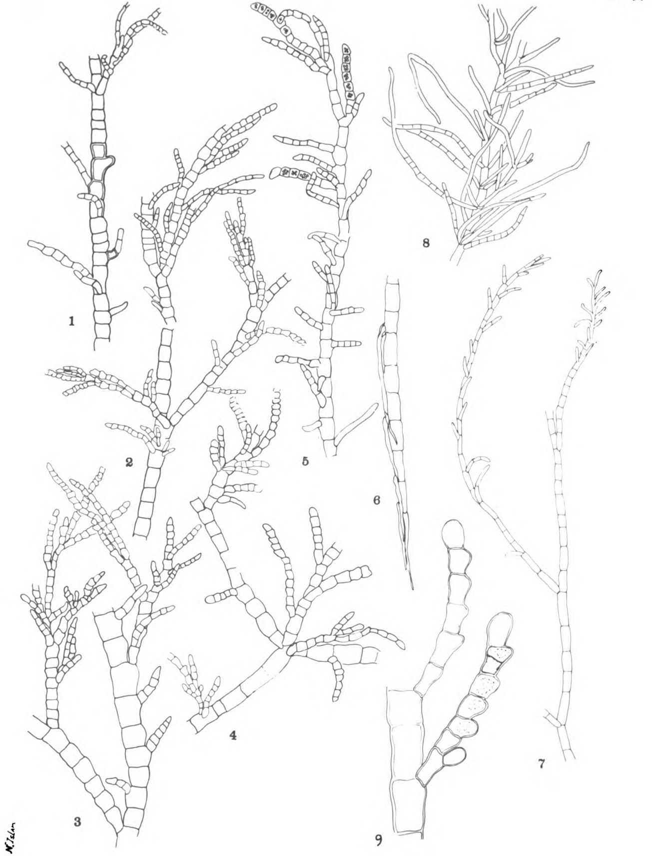
Figs. 1-4. Cloniophora spicata (Schmidle) comb. nov., forma, Figs. 1-2, X 75; Figs. 3-4, X 100 (all drawn from Specimen No. 686 (L) No. 206, from West Sumatra).

Figs. 5-6. Cloniophora macrocladia (Nordst.) var. mississippiensis var. nov., X 100 (all drawn from (F), Drouet Col. No. 9823 as Stig. lubricum (Dillw.) Kg.)

Figs. 7-8. Cloniophora plumosa (Kg.) Bourrelly, Fig. 7, X 75; Fig. 8, X 215 (all drawn from (W), Col. No. 360, as Stig. uniformis Kg. from Ceylon).

Fig. 9. Cloniophora spicata (Schmidle) comb. nov. X 215 (drawn from D. C. Jackson collection from Puerto Rico, July 1960).

Pl. 39



INDEX

(Includes only important genera & species)