Bull. Shimane Univ. (Natural Sci.), No. 15, pp. 96−117. December, 1965.

SOME SOIL ALGAE FROM JAPAN*

By

Masaru AKIYAMA

Institute of Biology, Shimane University

Introduction

A good deal of attention has been paid to the study of soil algae concerning with their distribution, ecology and taxonomy during the present century. Many an exellent study (e. g. BRISTOL, 1920; PETERSEN, 1931; JOHN and FRITSCH, 1942) by means of cultures of soil samples has shown that there are many interesting algal communities consisting of various algal taxa in respectively diverse soils each varied in those of chemical ingredients and physical conditions. Recently a considerable amount of work on the soil algae has been done dealing with their life cycles, morphological details, physiology and ecology of those algae. And those succesful results are owing to the establishment of methods in axenic cultures of algae. On the life cycles and taxonomic details of Chlorococcacean and Chlorosphaeracean algae, several noteworthy studies have been published by BOLD (1942), STARR (1955), HERNDON (1954, 1958), DEADSON (1959), TRAINOR and MCLEAN (1964) and others. On the other hand a good deal of survey in distribution and ecology of soil algae has been issued by many authors viz. BROOK (1952, 1956; distribution and ecology of *Fritschiella tuberosa* IYENGAR), CRIBB (1956, 1958; Australian flora), DURRELL (1959; Colorado), GORI (1960, 1961; Texas and alpine flora), HILTON and TRAINOR (1963, Connecticut), JOHNSON (1962, Malayan and New Guinean flora) and SHIELDS and DROUET (1962, Nevada Test Site).

Very little is known about the algal flora of Japanese soils as yet, and the basic problem of the vegetation of both trrestrial macro-algae and subterranean micro-algae is not clear. In 1941 OKADA investigated for the first time the soil algal vegetation of acid soils under the *Sasa paniculata* community in Mt. Hakkôda, Tohoku region of Japan, and it was observed that the most common species of this region were such algae as *Hormidium flaccidum* A. BROUN, *Stichococcus bacillaris* NAEGELI and *Chlorella vulgaris* BEYER. Recently in 1960 AKIYAMA and HIROSE recorded an interesting terrestrial alga, *Fritschiella tuberosa* IYENGAR from several localities in Japan. Later in 1961 a preliminary report dealing with an ecology and taxonomy of the macro-vegetation of soil algae in San-in region of Japan was given by the present author. In this report, more detailed algal components of Japanese soil flora was given, and forty-five algal taxa belonged to the each of Chlorophyceae, Xanthophyceae, Cyanophyceae and Rhodophyceae were listed. Still later the present author begins a series of study on the micro-algal components of the Japanese soil

* The research is supported in part by Grant No. 4084 of the Ministry of Education of the Japanese Government.

flora by means of cultures of soil samples, and several accounts of new records and ecological notes will be given elsewhere.

In this paper, the author wishes to make an account of the outline of algal vegetation of Japanese soils and presents a list of algae examined.

The author wishes to express his great thanks to Professor Emeritus Y. YAMADA of Hokkaido University for his kind guidance and criticism through the course of this study.

Thanks are also to be offered to Professor H. HIROSE of Kobe University for his valuable suggestions and encouragement.

Materials and Methods

The soil samples used in this study were obtained from varied localities in Japan (Text-fig. 1.), and the samples were collected from varied regions such as arable lands, gardens, forests and grassy plains.

The collection of soil materials was generally done by a sterilized grass tube.

A crude culture (primary) was mainly used for the general inspection of soil algal communities (PL. V. Figs. 6, 7) and in case of need an unialgal curture (secondary, non bacteria-free) was used. The culture medium most generally used was BRISTOL's agar (BOLD, 1949). Both artificial and natural light were used in illuminating the cultures, and the intensity of the light reaching the cultures was generally ranging from ca. 200 to 300 lux. The cultures were set up at temperatures which fluctuated, according to season, between ca. 20° to 30°C.

Ecological Notes

1) General aspect on the components of Japanese soil algae.

In the soils examined in this study, Chlorophyceae and Xanthophyceae are the most remarkable in those of specific component and number of individuals. The most abundant (dominant) species found in various soils are such algae as *Chlorococcum* (including several not identified species), *Hormidium flaccidum* A. BROUN, *Stichoccocus bacillaris* NAEG. and *Monodus subterraneus* PETERSEN, and such algae as *Ourococcus bicaudatus* GROBÉTY, *Bracteacoccus irregularis* (PETERSEN) STARR, *Monocilia viridis* GRENECK and *Dactylococcopsis rhaphidioides* HANSGIRG are comparatively rare. The common generic component of subterranean micro-algal community compared with that of terrestrial algal community is shown in table I.

TABLE I.

Classes and Orders	Macro-algal flora	Micro-algal flora
CHLOROPHYCEAE		
Volvocales	*Chlamydomonas*	*Chlamydomonas*
Tetrasporales	*Ourococcus, Coccomyxa*	*Ourococcus*
Ulotrichales	*Stichococcus, Hormidium*	*Stichoccocus, Hormidium*
Chaetophorales	*Fritschiella, Microthamnion, Trentepohlia Cephaleuros,*	*Fritschiella, Microthamnion, Gongrosira*

	Phycopeltis	
Oedogoniales	*Oedocladium*	
Chlorococcales	*Chlorococcum, Scenedesmus, Protosiphon*	*Chlorococcum, Palmellococcus, Scotiella, Ankistrodesmus, Selenastrum, Scenedesmus*
Zygnematales	*Zygogonium, Cosmarium, Cylindrocystis*	*Zygogonium, Cosmarium, Cylindrocystis*
XANTHOPHYCEAE	*Botrydium, Vaucheria*	*Botrydiopsis, Monodus, Bumilleria, Monocilia*
CYANOPHYCEAE	*Phormidium, Oscillatoria, Lyngbya, Nostoc, Cylindrospermum, Schizothrix, Scytonema, Stigonema*	*Phormidium, Oscillatoria Lyngbya, Nostoc, Cylindrospermum, Dactylococcopsis, Westiellopsis, Stigonema*
RHODOPHYCEAE	*Porphyridium*	
EUGLENOPHYCEAE		*Euglena*

It should be noticed that most algae would be to form into both terrestrial macro-colony and subterranean micro-colony (or solitary form), in the case of certain algae such as *Gongrosira terricola* BRISTOL, *Stichococcus bacillaris* NAEG., *Monocilia viridis* GRENECK, *Ankistrodesmus falcatus* (CORDA) RALFS, *Selenastrum westii* G. M. SMITH, *Dactylococcopsis rhaphidioides* HANSG. and certain species of *Euglena* can be recognized only under the cultural condition, namely, it seemes that those algae are distributed as small colonies or solitary cells under the natural condition. On the contrary, in sometimes, the following algae form into varied large macro-colonies (viz. *Trentepohlia*, *Hormidium*, *Fritschiella*, *Zygogonium*, *Botrydium*, *Vaucheria*, *Oscillatoria*, *Cylindrospermum*, *Stigonema*, *Porphyridium* and etc.). The type of colonization of macro-colonial terrestrial algae was already described in a previous paper by the present author (1961). The summerized data on the quantity of species appeared from soil cultures comparing with those of terrestrial macro-algae is shown in table II.

TABLE II.

Classes	Macro-flora [*1]	Micro-flora	Tot.
CHLOROPHYCEAE	30	51 (11)	70
XANTHOPHYCEAE	3	12 (2)	13
CYANOPHYCEAE	11	26 (5)	32
RHODOPHYCEAE	1		1
EUGLENOPHYCEAE		2	2
BACILLARIOPHYCEAE		15	15
Tot.	45	106 (18) [*2]	138

*1 based upon the data of survey in 1961.
2* the species found in both flora.

The table II shows clearly that Chlorophycean and Cyanophycean algae are remarkable in both case of micro-and macro-flora of Japanese soils; moreover, on the speciation of the soil algae the most part of algal members is occupied by unicellular and filamentous Chloropyceae. The dominancy of Chlorophycean algae in the soil flora has been recognized also in the case of English soil (JOHN, 1942; JOHN and FRITSCH, 1942) and American soil (HILTON and TRAINOR, 1963). On the contrary, in such cases of Europian soil (PETERSEN, 1931), English soil (BRISTOL, 1920) and New Guinean and Malayan soil (JOHNSON, 1962), it was observed that the Bacillariophyceae or Cyanophyceae was most abundant in their communities. According to JOHN (1942), the distribution or occurence of algae is influenced by certain soil conditions such as pH and concentration of Calcium Carbonate, and, moreover, it was regarded that most Cyanophycean algae thrive in alkaline region, and Chlorophycean algae mostly occur in acid region. It is therefore assumed that one of the cause of the dominancy of Chlorophycean algae in Japanese soil flora is owing to an environmental factor of acidic agro-type.

2) **Agro-type and algal vegetation.**

An agro-type is one of the most important factor of soil algae relating to their distribution and ecology. Some examples of the data of the chemical ingredients and physical conditions of the soil samples examined in this study are given in table III.

TABLE III.

Agro-types	Humidity (water content) (%)*1	pH	Chlorinity *2 (mgr/soil 1 gr.)	Total Nitrogen *3 (mgr/soil 1 gr)	Electric conductivity ($\mu℧/cm^2$)
Cultivated soils	—	4.4~7.2	—	0.143~ 4.260	61~440
Forest soils	17.8~ 36.5	4.0~6.9	—	0.156~ 5.535	26~420
Alpine soils	—	4.4~7.4	—	0.213~ 0.426	20~100
Reclimed soils	—	3.6~6.5	0.06~ 3.02	0.970~ 3.140	630~ 3200

*1 treated at 120°C (3 hrs.); *2 by MOHR's method; *3 by Semi-Micro KJEHLDAHL's method

As will be seen from the table, the most part of Japanese soils examined shows a characteristic acidic agro-type. Additionally the souces of soil samples examined are varied, and those are weathering products of such rocks as Granite, Limestone, Basalt, Rhyolite, Andesite, Serpentinite and Volcanic ashes.

Table IV gives an agro-type and each of the element of that algal communities.

The relation of an agro-type and algal community shown in table IV would lead us to suppose that the cultivated soils show the most complicated algal components in their communities, on the contrary, the alpine soils show relatively poor vegetations in their algal elements. It is also clear that *Hormidium flaccidum* (KUETZ.) HEERING, *Chlorococcum* spp., *Phormidium* spp., and *Monodus subterraneus* PETERSEN occur in any of the agro-type, and also such algae as *Stichococcus bacillaris* NAGE., *Nitzschia obtusa* var. *scalpelliformis* and *Hantzschia amphioxys* (EHR.) GRUN. frequently occur in varied soils.

TABLE IV.

	Cultivated soils	Garden soils	Forest soils	Alpine soils	Reclimed soils
CHLOROPHYCEAE					
Chlamydomonas spp.	+	+	+	+	+
Ourococcus bicaudatus	+				
Stichococcus bacillaris	+	+	+	+	+
Hormidium flaccidum	+	+	+	+	+
Microthamnion kuetzingi.	+				
Fritschiella tuberosa	+				+
Gongrosira terricola	+	+		+	
Trentepohlia sp.			+		
Chlorococcum spp.	+	+	+	+	+
Bracteacoccus irreg.	+			+	
Scotiella nivalis		+	+	+	
Scenedesmus bijuga	+	+			
Sc. dimorphus	+				
Sc. quadricauda	+				
Sc. perforatus	+				
Ankistrodesmus falc.	+				
Selenastrum westii	+	+			
Protosiphon botryoides	+	+			+
Oedogonium sp.	+				
Spirogyra sp.	+				
Mougeotia sp.	+				
Zygogonium ericetorum	+	+			+
Cosmarium urceum	+	+			
Cylindrocystis brebbis.	+	+			
XANTHOPHYCEAE					
Monodus subterraneus	+	+	+	+	+
Botrydiopsis arhiza	+	+		+	
Botrydium granulatum	+				
Bumilleria exilis		+	+		
Monocilis viridis	+		+		
Vaucheria sp.	+				
CYANOPHYCEAE					
Dactylococcopsis rhaph.	+			+	
Phormidium spp.	+	+	+	+	+
Nostoc spp.	+	+	+	+	+
Cylindrospermum majus	+	+			
Oscillatoria spp.	+	+	+		
Stigonema ocelatum		+			
Westiellopsis prorifica					+
BACILLARIOPHYCEAE					
Nitzschia obtusa var. *scalpelliformis*	+	+	+		+
Hantzschia amphioxys	+	+	+		+
Frusturia rhomboides			+		
Eunotia arcus		+			

It is also evident that the nature of basic rock, soil substrate, has an important ecological influence upon the soil algae. In the case of limestone regions (Ak. V.1～7; Ak. VII. 1～7; Ni. VII. 1～8, cf. Fig. I.) such algae as *Hormidium flaccidum* (KUETZ.) HEERING, *Stichococcus bacillaris* NAEG., *Zygogonium ericetorum* KUETZ., *Chlorococcum* sp. and *Monodus subterraneus* PETERSEN are common in that regions and some instances such algae as *Fritschiella tuberosa* IYENGAR, *Scotiella nivalis* (SHUTT.) FRITSCH and *Bracteacoccus* sp. are also occur, however, in generally, the vegetation is raretively poor or monotonus as compared with that of another region.

On the contrary the volcanic ash regions, the so-called "Kuroboku" (Oh. IV. 1～10; Sh. sa. IV 1～15; Sh. sa. IX. 1～7 cf. Fig. I.) have fairly complicated algal communities, namely, the following algae are commonly occurred; *Chlamydomonas snowiae* PRINTZ, *Raphidonema terrestris* AKIYAMA, *Stichococcus bacillaris* NAEG., *Hormidium flaccidum* (KUETZ.) A. BR., *Chlorococcum* sp., *Bracteacoccus irregularis* (PETERS.) STARR, *Radiosphaera* sp., *Dictyochloris* sp., *Trochischia aspera* (REINSCH) HANSG., ? *Planktosphaeria*, sp. *Scotiella nivalis* (SCHUTT.) FRITSCH, *Protosiphon botryoides* (KUETZ.) KLEBS, *Scenedesmus quadricauda* (TURPIN) BRÉBBISON, *Cylindrocystis brebissoni* MENEGH., *Zygogonium ericetorum* KUETZ., *Monodus subterraneus* PETERSEN, *Characiopsis minima* PASCHER, *Botrydiopsis arhiza* BORZI, *Bumilleria exilis* KLEBS, *Monocilia viridis* GRENECK, *Euglena pascheri* SUIR. and certain species of Pennate diatoms and Cyanophycean species.

But for the present state of our knowledge, we have not as yet sufficient data on the distribution of soil algae to give an accurate consideration on the relation of between soil algal communities and agro-types.

Taxonomic Notes

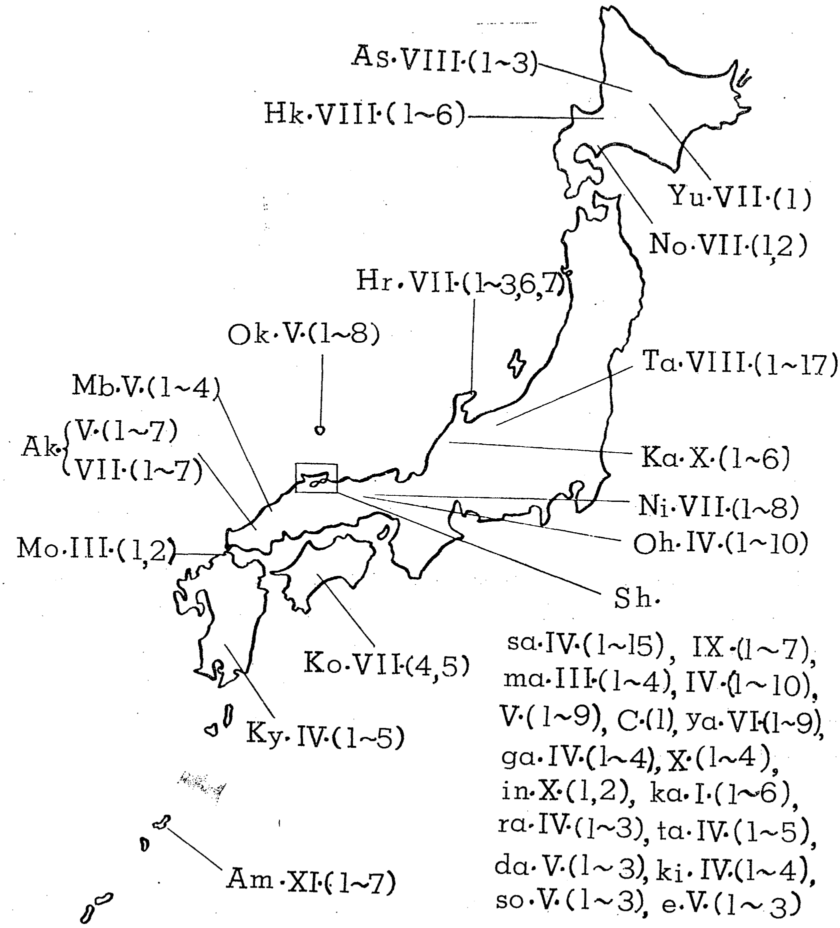
As already shown in table II, fifty-one kinds of Chlorophyceae, tweleve Xanthophyceae, two Euglenophyceae, fifteen Bacillariophyceae and twenty-seven Cyanophyceae, and total of one hundred and seven kinds of algae are recognized from the cultures of Japanese soil samples. The locations and the abbreviations of the localities in which the soil samples were obtained are shown in the following map (Text-figure I.). In the following taxonomic list, the arrangement of the genera, families and orders is generally based upon G. M. SMITH (1950).

A List of Japanese Soil Algae

CHLOROPHYCEAE

Fifty-one kinds of Chlorophycean algae including four kinds of Volvocacean algae, two kinds of Tetrasporalean algae, three kindr of Ulotrichalean algae, five kinds of Chaetophoralean algae, twenty-seven kinds of Chlorococcalean algae, one kind of Oedogonialean alga, and nine kinds of Zygnematalean algae, are recognized. The following algae are new records from Japan, viz. *Gongrosira terricola* BRISTOL, *Chlorococcum echinozygotum* STARR, *Bracteacoccus irregularis* (PETERSEN) STARR, *Palmellococcus protothecoides* (KUETZ.) CHOD. and certain species of Chlorosphaeralean algae.

Ecologically such algae as *Stichococcus bacillaris* NAEG., *Hormidium flaccidum* (KUETZ.) A. BR. and *Chlorococcum* sp. are important dominant members of soil community.



Explanation of Locality Abbreviation in Figure I.

As. VIII. (1~3) : Asahigawa, Hokkaido (cultivated soils) ; Aug. 1963.
Hk. VIII. (1~6) : Sapporo, Hokkaido (cultivatcd soils, and garden soils) ; Aug. 1963.
No. VII. (1, 2) : Noboribetsu, Hokkaido (forest soils) ; July 1963.
Yu. VII. (1) : Mt. Yubari, Hokkaido (alpine soil ; serpentine region) ; July 1963.
Hr. VII. (1~3, 6, 7) : Noto-hiratoko, Ishikawa Pref. (forest soils) : July 1964.
Ka. X. (1~6) : Kanazawa, Ishikawa Pref. (garden soils) ; Oct. 1964.
Ta. VIII. (1~17) : Mt. Tateyama, Toyama Pref. (alpine soils) ; Aug. 1964.
Ni. VII. (1~8) : Niimi, Okayama Pref. (forest soils ; limestone region) ; July 1964.
Oh. IV. (1~10) : Hirusenbara, Okayama Pref. (volcanic ash region) ; Apr. 1965
Ok. V. (1~8) : Oki Islands. Shimane Pref. (forest soils and cultivated soils) ; May 1965.
Mb. V.(1~4) : Masuda, Shimane Pref. (forest soils) ; May 1965.
Ak. V. (1~7), VII (1~7) : Akiyoshidai, Yamaguch Pref. (grassy plain ; limestone region) ; May 1965, July 1964.
Mo. III. (1, 2) : Moji, Fukuoka Pref. (grassy plain) ; March 1965.
Ky. IV. (1~5) : Kobayashi, Miyazaki Pref. (cultivated soils) ; Apr. 1965.
Ko. VII. (4, 5) : Sagawa, Kochi Pref. (forest soils) ; July 1964.
Am. XI. (1~7) : Amami. Islands (limestone region) ; Nov. 1963.
Sh. sa. IV. (1~15) : Mt. Sanbe, Shimane Pref.(volcanic ash region) ; Apr. 1963.
Sh. sa. IX. (1~7) : Mt. Sanbe ; Sept. 1964.
Sh. ma III. (1~4), ma. IV. (1~10), ma V. (1~12), ma. C. (1) ; Matsue, Shimane Pref. (cultivated soils, forest soils) ; March 1964, Apr. 1962, May 1963, may 1962.
Sh. ya. VI. (1~9) : Yasugi, Shimane Pref. (reclimed region) ; June 1962.
Sh ga. IV. (1~4) ga. X. (1~4) : Matsue. Shimane Pref. (forest soils) ; Apr. 1964, Oct. 1964
Sh' in. X. (1, 2) : Matsue, Shimane Pref. (grassy plain) ; Oct. 1964.
Sh. ka. I. (1~6) : Kawamoto, Shimane Pref. (cultivated soils, forest soils) ; Jan. 1965.
Sh. ra. IV. (1~3) : Matsue. Shimane Pref. (garden soils) ; Apr. 1965.
Sh. ta. IV. (1~5) : Izumo, Shimane Pref. (forest soils) ; Apr. 1965.
Ph. da. V. (1~3) : Matsue, Shimane Pref. (cnltivated soils) ; May 1965.
Sh. ki. IV. (1~4) : Matsue, Shimane Pref. (forest soils) ; Apr. 1965.
Sh. so. V. (1~3) : Izumo, Shimane Pref. (grassy plain) ; May 1965.
Sh. e. V. (1~3) : Matsue, Shimane Pref. (forest soils) ; May 1965.

Order Volvocales

Frequently, the palmelloidal stage of *Chlamydomonas* were obseved in varied soils, and mostly they occurred in moist soils.

Chlamydomonas umbonata PASCHER

Loc. Ok.V. (6).

Chlamydomonas snowiae PRINTZ

Loc. Sh. sa. IX.(2, 7).

Chlamydomonas pseudo-elegans FRITSCH et JOHN

Loc. Ni. VII.(1).

Chlamydomonas sp.

Loc. Sh. da.V. (1).

Order Tetrasporales

An interesting Tetrasporalean alga *Ourococcus bicaudatus* GROBÉTY has been recognized from the macro-algal community of San-in region (AKIYAMA, 1961).

Gloeocystis gigas (KUETZ.) LAGERH.

It seems that the occurrence of this alga is an abnormal case.

Loc. Am. XI. (3).

Ouroccocus bicaudatus GROBÉTY

Loc. Sh. ga. IV. (1) ; Ky. IV. (3) ; Sh. so. V. (1, 2).

Order Ulotrichales

Hormidium flaccidum (KUETZ.) A. BR. is a common alga found in macro-algal community, and *Stichococcus bacillaris* NAEG. is one of the most abundant species in micro-community.

Raphidonema terrestre sp. nov.

Cellulae singulae vel binae, elongatae ad fusiformes, lateribus rotundatis, 10 μ longitudine mediocri, 2 μ latitudine mediocri. Chromatophori cellularum iuniorum solum parietales. Pyrenoidea nulla.

Propagatio asexualis per divisionem cellulis.

Propagatio sexualis ignota.

Loc. Sh. ga. IV. (1) ; Oh. IV. (7) ; Sh. sa. IX. (3).

Stichococcus bacillaris NAEG.

Loc. Sh. ga. IV. (2, 3) ; Sh. ya. VI. (5) ; Hr. VII. (7) ; Am. XI. (5) ; Mb. V. (3) ; Ky. IV. (1, 3, 4) ; Ka. X. (2) ; Sh. sa. IX. (3, 4, 5, 7) ; Yu. VII. (1).

Hormidium flaccidum (KUETZ.) A. BR.

Loc. Sh. sa. IV. (2~7) ; Sh. ya. VI. (2, 10) ; Sh. da. V. (2, 3) ; Sh. ga. IV. (2, 4) ; Ka. X. (5, 6) ; Oh. IV. (1~10) ; Hr. VII. (2) ; Ta. VIII. (7, 10, 13, 14) ; Am. XI. (3, 5) ; Ni. VII. (3, 4).

Order Chaetophorales

Althongh, *Fritschiella tuberosa* IYENGAR is one of the most abnndant species in macro-community, the distribntion of this alga is restricted in the neighbonring districts of ponds and rice-fields. On the contrary *Gongrosira terricola* BRISTOL occurs in varied soils. It seems that the case of *Stigeoclonium* is an abnormal.

Microthamnion kuetzingianum NAEG.

Loc. Sh. ma. V (6) ; Sh. so. V. (3) ; Sh. ya. VI. (5) ; Sh. ma. C. (1) ; Am. XI. (2, 3).

Stigeoclonium sp.

Loc. Ya. XI. (2, 3) ; Sh. ma. IV. (5).

Gongrosira terricola BRISTOL

Loc. Hr. VII. (2, 7) ; Ta. VIII. (7) ; Mb. V. (1) ; Ko. VII. (4) ; Ka. X. (1, 3) ; Sh. sa. (1) ; Sh. ga. IV. (1～3) ; Ok. V. (3). New to Japan.

Trentepohlia sp.

Loc. Sh. ma. III. (1) ; Ni. VII. (5) ; Ak. VIII. (1).

Order Chlorococcales

This group is the most remarkable in both of that quantity and quality. The abundant members are *Chlorococcum*, *Bracteacoccus*, *Scenedesmus* and *Planktosphaeria*, but the specific identification of certain taxa snch as *Chlorococcum*, *Bracteacoccus*, *Spongiochroris* and etc. is very difficult and needs a careful observation under an axenic or unialgal culture.

Chlorococcum echinozygotum STARR?

Loc. Sh. sa. IX. (5) ; Ok. V. (2) ; Ka. X. (5). New to Japan.

Chlorococcum sp.

A number of *Chlorococcum* has been recognized from cultures of varied soils but the zoospore formation has not been observed.

Trebouxia sp.

Loc. Sh. ga. IV. (4) ; Mo. III. (1).

Bracteacoccus irregularis (PETERSEN) STARR

Loc. Sh. ga. IV. (3) ; Oh. IV. (2, 4) : Ta. VIII. (10). New to Japan.

Bracteacoccus sp.

Loc Ni. VII. (1) ; Ok. V. (8) ; Oh. IV. (5) ; Yu. VII. (1).

Radiosphaera sp. ?

Loc. Sh. sa. IX. (7).

Spongiochloris sp.

Loc. Ni. VII. (7) ; Ok. V. (5).

Dictyochloris sp.

Loc. Oh. IV. (2).

Palmellococcus protothecoides (KUETZ.) CHOD.

Loc. Ta. VIII. (2) ; Sh. sa. IV. (1, 3) ; Yu. VII. (1). New to Japan.

Trochiscia aspera (REINSCH) HANSG.

Loc. Oh. IV. (2).

Planktosphaeria sp. ?

Loc. Ta. VIII. (9, 10, 13, 15) ; Mo. III. (2) ; Sh. ki. IV. (2) ; Oh. IV. (1) ; Ni. VII. (6).

Scotiella nivalis (SCHUTT.) FRITSCH

Generally this alga is common as a cryophytes in colonred snow such as reddish brown snow and brown snow of alpine region of Japan and other countries (FUKUSHIMA, 1963, GARRIC, 1965), nevertheless, the alga occurs freqnently both in alpine and lowland soils. In young cultures the cells are green and frepuently 2, 4, 8 autospores are formed, and in old cultnres cells contain yellowish orange coloured granules.

Loc. Ta. VIII. (7, 10, 13, 14) ; Sh. ta. IV. (5, 6) ; Ok. V. (4) ; Oh. IV. (5) ; Ak. VII. (7).

Protosiphon botryoides (KUETZ.) KLEBS

Loc. Sh. sa. IX. (6) ; Sh. ya. VI. (5, 6) ; Ka. X. (2) ; Ok. V. (4, 7).

Characium sp.

Loc. Am. XI. (3).

Scenedesmus bijuga (TURPIN) LAGERH

Loc. Sh. so. V. (1, 3) ; Sh. ma. C. (1) ; Sh. ga. X. (1, 2) ; Hr. VII. (2) ; Ka. X. (2) ; Ok. V. (4) ; Ni. VII. (5) ; Am. XI. (1, 4).

Scenedesmus perforatus LEMM.

Loc. Sh. ma. C. (1).

Scenedesmus quadricauda (TURP.) BRÉB.

Loc. Am. XI. (2, 4) ; Sh. sa. IV. (12).

Scenedesmus quadricauda (TURP.) BRÉB. var. **parvus** G. M. SMITH

Loc. Sh. ma. C. (1).

Scenedesmus quadricauda (TURP.) BREB. var. **quadrispina** (CHOO.) G. M. SMITH.

Loc. Am. XI. (3).

Scenedesmus obliquus (TURP.) KUETZ.

Loc. Am. XI. (1～4).

Scenedesmus abundans (KIRCHN.) CHODAT var. **brevicauda** G. M. SMITH.

Loc. Am. XI. (2).

Scenedesmus dimorphus (TURP.) KUETZ.

Loc. Sh. ga. IV. (1).

Schroederia setigera (SCHROED.) LEMM.

It seems that the occurrence of this alga is a probably abnormal case.

Loc. Am. XI. (2).

Ankistrodesmus falcatus (CORDA) RALFS

Loc. Sh. ma. C. (1) ; Sh. ma. V. (9) ; Ok. V. (4, 7) ; Am. XI. (3, 4).

Selenastrum westii G. M. SMITH

Loc. Sh. ma. C. (1) ; Hr. VII. (20).

Kirchneriella obesa (W. WEST) SCHMID. var. **aperta** (TEIL.) BRUNTH.

It seems that the occurrence of this alga is a probably abnormal case.

Loc. Am. XI (2).

Kirchneriella obesa (W. WEST) SCHMID. var. **major** (BERN.) G. M. SMITH

It seems that the occurrence of this alga is a probably abnormal case.

Loc. Am. XI. (3).

Order Chlorosphaerales

Althongh certain members of Chlorosphaeralean algae were occurred, the details of those algae have not been examined.

Order Oedogoniales

Oedocladium operculatum TIFFANY has been collected from several localities in Japan by the present author , but the alga has not been occurred in cultures.

Oedogonium sp.

Frequently sterile filaments of this alga were occurred, but the occurrence of this alga is probably abnormal case.

Order Zygnematales

Cylindrocystis brebissonii MENEGH., *Mesotaenium* sp. and *Zygogonium ericetorum* KUETZ. are often occur in macro-algal communities of moist soils. But in the case of *Zygogonium*, the growth in culture is unfavourable. It seems that an occurrence of filamentous members snch as *Mougeotia* and *Spirogyra* is an abnormal case.

Mesotaenium sp.

Loc. Sh. ma. V. (5, 7) ; Sh. ma. IV. (5,6).

Cylindrocystis brebissonii MENEGH.

Loc. Sh. ga. IV. (1~3) ; Sh. e. V. (3) ; Ka. X. (2, 5) ; Sh. sa. IX. (6) ; Oh. IV. (5).

Cosmarium granatum BRÉB.

Loc. Am. XI. (3).

Cosmarium urceum W. et G. S. WEST.

Loc. Am. XI. (5) : Sh. ga. IV. (1) ; Ka. X. (2).

Cosmarium holmiense LUND var. **integrum** LUND.

Loc. Sh. ma. III. (2).

Cosmarium rectangulare GRUN. var. **africanum** W. et G. S. WEST.

Loc. Sh. ma. III. (2).

Zygogonium ericetorum KUETZ.

Loc. Sh. ma. V . (7) ; Sh. ga. IV. (1, 2) ; Sh. ya. VI. (1) ; Ak. V. (1, 7) ; Ka. X. (2, 5) ; Ko. VII. (4, 5).

Mougeotia sp.

Loc. Sh. ga. IV. (1) ; Sh. ma. IV. (4, 6) ; Am. XI. (7).

Spirogyra sp.

Loc. Sh. ma. V. (5) ; Sh. ma. IV. (5, 6).

XANTHOPHYCEAE

Tweleve kinds of Xanthophycean algae including six kinds of Heterococcalean algae, four kinds of Heterotrichalean algae and two kinds of Heterosiphonalean algae are recognized. The following algae are new records in Japan, viz. *Monodus snbterraneous* PETERSEN, *Monodus dactylococcoides* PASCHER, *Monodus acuminata* CHODAT, *Chlorocloster inaequalis* PASCHER, *Bumilleria exilis* KLEBS and certain species of *Monocilia*.

Order Heterococcales

Monodus subterraneus PETERSEN is one of the most common species in Japanese soil flora, and occurs in varied soils.

Monodus subterraneus PETERSEN

Loc. Sh. sa. IX. (2) ; Sh. sa. IV. (1, 2, 4) ; Sh. ga. IV. (2) ; Sh. so. V. (1, 2) ; Sh. ya. VI. (10, 14) ; Sh. ta. IV. (1, 2) ; Ni. VIII. (7) ; Oh. IV. (1, 3) ; Ok. V. (5) ; Yn. VII. (1) ; K y. IV. (1~5) ; Ta. VIII. (1, 9). New to Japan.

Monodus dactylococcoides PASCHER

Loc. Sh. ma. C. (1) ; Sh. ma. IV. (5) ; Sh. ma. V. (4, 5, 6) ; Ok. V. (5) ; Hk. VIII. (1, 2, 5) ; No. VIII. (1). New to Japan.

Monodus acuminata CHODAT

Loc. Ka. X. (1). New to Japan.

Chloroclοster inaequalis PASCHER

Loc. Ka. IX. (1). New to Japan.

Characiopsis minima PASCHER ?

This alga is also obtained from the surface of leaves of *Camelia.*

Loc. Sh. sa. IX. (1). New to Japan.

Botrydiopsis arhiza BORZI

Loc. Sh. sa. IX. (1, 4) ; Sh. in. X. (2) ; Sh. ga. IV. (2) ; Ka. X. (2, 3) ; Ky. IV. (4) ; Mb. V. (3) ; Ok. V. (3).

Order Heterotrichales

Bumilleria exilis KLEBS shows a relatively common distribution in San-in region, but this alga has not been recognized in natural condition. An interesting heterotrichous Heterotrichalean alga *Monocilia* often occurs in the forest soils of San-in region.

Bumilleria exilis KLEBS.

Loc. Sh. sa. IX. (1, 4) ; Sh. ta. IV. (1, 2, 4, 5) ; Sh. so. V. (2) ; Sh. e. V. (1, 3) ; Sh. ki. IV. (1, 4) ; Ak. V. (7) ; Oh. V. (2, 6, 7) ; Ky. IV. (4). New to Japan.

Tribonema aequale PASCHER

Loc. Sh so. V. (3) ; Ok. V. (7).

Monocilia viridis GERN.

Loc. Sh. sa. IX. (1) ; Sh. in. X. (1, 2) ; Sh. ka. I. (3). New to Japan.

Monocilia mainxii (VISCHER) ?

Loc. Sh. ta. IV (2). New to Japan.

Order Heterosiphonales

In the macro-algal flora, *Botrydium* is one of the most common terrestrial alga in Japan, however, the distribution of this alga is restricted in the cultivated areas, and the growth in culture is unfabourable.

Botrydium granulatum (L.) GREV.

Loc. Sh. ma. V. (1) ; Sh. da. V. (1).

Vaucheria sp.

Loc. Sh. ma. V. (5) ; Sh. ma. III. (2).

EUGLENOPHYCEAE

This free-living aquatic member rarely occurs in soil flora, and mostly in a cyst form.

Order Euglenales

Euglena pascheri SUIR.

Loc. Sh. sa. IX. (5).

Euglena sp.

Loc. Sh. ga. IV. (1) ; Oh. IV. (3, 7).

BACILLARIOPHYCEAE

Fifteen kinds of Pennate Diatoms are recognized. Certain species of *Nitzschia* are commonly occurred in varied soils.

Order Pennales

Eunotia arcus EHREMB.
Loc. Mo. III. (1, 2) ; Sh. ra. IV. (3).

Eunotia sp.
Loc. Ni. VII. (3) ; Ok. V. (6) ; Ky. IV. (2).

Cocconeis scutellum EHREMB.
Loc. Am. XI. (4) ; Ok. V. (2).

Pinnularia moralis GRUNOW
Loc· Ky. IV. (4).

Pinnularia braunii (GRUN.) CL. var. **amphicephara** (H. MAYER) HUST.
Loc. Oh. IV. (9).

Pinnularia borealis EHREMB.
Loc. Ak. V. (3).

Frustulia rhomboides (EHREMB.) DE TONI var. **saxonica** (EHR.) DE TONI.
Loc. Hr. VII. (2) ; Ky. IV. (1, 4) ; Oh. IV. (9).

Frustulia sp.
Loc. Am. XI. (2).

Cymbella tumida (BREB.) VAN HEUR.
Loc. Sh. ma. V. (6).

Rhopalodia gibberula (EHREMB.) O. M.
Loc. Hr. VII. (7).

Rhopalodia sp.
Loc. Am. XI. (1).

Nitzschia vermicularis (KUETZ.) GRUNOW.
Loc. Sh. ma. (5).

Nitzschia obutusa W. SMITH var. **scalpelliformis** GRUNOW.
Loc. Sh. ma. (5, 6, 9,) ; Sh. ya. VI. (6, 7, 14) ; Sh. e. V. (3) ; Sh. ga. X. (2, 3) ; Ka. X. (1) ; Ni. VII. (3, 5).

Nitzschia palea (KUETZ.) W. SMITH.
Loc. Sh. ya VI. (4).

Hantzschia amphioxys (EHREMB.) GRUNOW.
Loc. Sh. ma. C. (1) ; Sh. ma. V. (9) ; Sh. ma. IV. (9) ; Sh. in. X. (1) ; Sh. e. V. (3) ; Sh. ga. (2, 3) ; Sh. ta. IV. (1, 4) ; Sh. ya. VI. (6, 14) ; Sh. sa. IX. (6) ; Ok. V. (2, 3, 6, 8) ; Ka. X. (2) ; As. VIII. (1).

CYANOPHYCEAE

Twenty-seven kinds of Cyanophycean algae including five Chroococcalean algae and twenty-one Oscillatorialean algae are recognized.

Order Chroococcales

Aphanocapsa grevillei (HASS.) RABENH.
Loc. Sh. ma. III. (3).

Eucapsis terrestris sp. nov.
Coloniae quadratae vel cubico-sarcinoidae. Cellulae primo solitariae, binae vel quaternae,

deinde plurimae in familias cubicas aut sarcinaeformes. Mucilagine coloniarum nulla. Familiae juveniles 4-cellulares ca. 10 μ in diametro, familiae adultores 32-et 64-cellulares ad ca. 30 μ in diametro.

Propagatio per divesionem familiarum vulgo in duas partes.

Loc. Oh. IV. (1).

Dactylococcopsis rhaphidioides HANSG.

Loc. Sh. sa. IV. (9) ; Sh. ma. C. (1) ; Am. XI. (2) ; Hr. VII. (2) ; Ta. VIII. (17).

Aphanothece nidulans RICHTER

Loc. Sh. ya. VI. (14).

Aphanothece naegelii WARTM.

Loc. Am. XI. (7).

Order Oscillatoriales

Oscillatoria willeii GARDN. em. DROUET.

Loc. Am. XI. (2, 3, 4, 5) ; Sh. ta. IV. (2).

Oscillatoria animalis AG. ex GOM.

Loc. Am. XI. (6, 7).

Oscillatoria proteus SKUJA.

Loc. Am. XI. (6).

Oscillatoria agardhii GOM.

Loc. Sh. ma. IV. (5, 6).

Oscillatoria autumnale (AG.) GOM.

Loc. Sh. ma. IV. (6).

Phormidium tenue (MENEGH.) GOM.

Loc. Sh. ya. (14) ; Sh. ma. IV. (4) ; Sh. ma. III. (1) ; Ok. V. (1) ; Am. XI. (2, 4, 6) ; As. VIII. (1, 3) ; Hk. VIII. (1) ; Yu. VII. (1).

Phormidium rubroterricola GARDN.

Loc. Sh. ma. V. (2) ; Sh. ya. VI. (14).

Phormidinm uncinatum (AG.) GOM.

Loc. Am. XI. (2).

Phormidium subincrustatum FRITSCH et RICH.

Loc. Sh. ma. V. (2, 10) ; Ni. VII. (4, 5) ; Ak. V. (7) ; Oh. IV. (1, 2, 5) ; Hk. VIII. (5).

Lyngbya hieronymusii LEMM. var. **crassivaginata** GHOSE.

Loc. Ak. VII. (5).

Microcoleus sp.

Loc. Sh. ya. VI. (14).

Schizothrix penicillata (KUETZ.) GOM.

Loc. Sh. ta. IV. (2).

Aulosira prolifica BHARADW.

Loc. Sh. ma. C. (1) ; Sh. ma. IV. (3) ; Sh. ya. VI. (14) ; Ka. X. (2) ; Am. XI. (6).

Nostoc sp.

A good deal of juvenile stage of *Nostoc* occurs in cultures of varied soils.

Loc. Sh. ma. III. (3) ; Sh. e. V. (3) ; Sh. ta. IV. (4) ; Sh. ya. VI. (5) ; Sh. sa. IX. (3) ; Ok. V. (1, 8) ; Ky. IV. (3) ; Am. XI. (1, 3, 4, 7) ; Yu. VII. (1).

Cylindrospermum majus KUETZ.

Loc. Sh. ma. IV. (6) ; Sh. ma. III. (2) ; Ka. X. (1).

Nodularia spumigena MERTENS ex BORN. et FLAH.

Loc. Am. XI. (6).

Scytonema schmidlei J. DE TONI

Loc. Am. XI. (6).

Tolypothrix fragilis (GARDN.) GEITL.

Loc. Sh. ma. III. (3).

Stigonema ocellatum (DILLW.) THURET

Loc. Ak. VII. (7).

Hapalosiphon welwitschii W. et G. S. WEST

Loc. Am. XI. (7).

Calothrix sp.

Loc. Am. XI. (7) ; Sh. ka. I. (1).

Westiellopsis prolifica JANET

Loc. Sh. ya. VI. (5) ; Hr. VII. (1). New to Japan.

Résumé

A floristic study on the Japanese soil algae by means of cultures of soil samples has taken. The following results are noteworthy.

1) The following algae are the most abundant species in Japanese soils ; viz. *Chlorococcum* spp. (including several not identified species), *Hormidium flaccidum* A. BR., *Stichococcus bacillaris* NAEG., and *Monodus subterraneus* PETERSEN.

2) The cultivated soils have the most complicated algal vegetations, and the alpine and forest soils have relatively poor vegetations.

3) Fifty-one kinds of Chlorophycean algae, tweleve Xanthophycean algae, two Euglenophycean algae, fifteen Bacillariophycean algae and twenty-seven Cyanophycean algae are recognized from the Japanese soils.

4) The following algae are new records from Japan, viz. *Gongrosira terricola* BRISTOL, *Chlorococcum echinozygotum* STARR, *Bracteacoccus irregularis* (PETERSEN) STARR, *Palmellococcus protothecoides* (KUETZ.) CHOD. *Monodus subterraneus* PETERSEN, *Monodus dactylococcoides* PASCHER, *Monodus acuminata* CHODAT, *Chlorocloster inaequaris* PASCHER, *Characiopsis minima* PASCHER, *Bumilleria exilis* KLEBS, *Monocilia viridis* GERN., *Monocilia mainxii* (VISCHER), *Westiellopsis* and *prolifica* JANET.

5) *Rhaphidonema terrestre* sp. nov. and *Eucapsis terrestris* sp. nov. are new to science.

Literature

AKIYAMA, M. and H. HIROSE (**1960**) : A Newly Found Terrestrial Alga From Japan, Fritschiella tuberosa IYENGAR. *Bot. Mag. Tokyo* **73** : 365–368.

...... (**1961**) : Aerial and Terrestrial Algae in San-in Region of Honshu, Japan. *Bull. Shimane Univ.* **10** : 76–89.

ARCE, G. and H. C. BOLD (**1958**) : Some Chlorophyceae from Cuban Soils. *Amer. Jour. Bot.* **45** : 492–503.

BRISTOL, B. M. (**1920**) : On the alga-flora of some Desiccated English Soils. *Ann. Bot.* **34** : 35–79.

BROOK, A. J. (**1952**) : The occurrence of terrestrial alga Fritschiella tuberosa IYENGAR in Africa. *Nature* **164** : 754.

...... (**1956**) : A note on the ecology of the terrestrial alga Fritschiella tuberosa in the Sudan. *New Phytol.* **55** : 130–132.

BURGES, A. (**1958**) : Micro-organisms in the Soil *Hutch. Univ. Libr.* London.

CAMERON, R. E. (**1962**) : Soil Algae of Southern Arizona. *Amer. Jour. Bot. Abst.* **V**, **49** : 671.

DEADSON, T. R. (**1959**) : Three Chlorophyceae from Cuban Soil. *Amer. Jour. Bot.* **46** : 572–578.

DURREL, L. W. (**1962**) : Algae of Death Valley. *Trans. Amer. Microscop. Soc.* **81** : 267–273. (*Biol. Abst.* **40**.).

FRITSCH, F. E. (**1922**) : The Moisture Relation of Terrestrial Algae I. *Ann. Bot.* **36** : 1–20.

...... and R. P. JOHN, (**1942**) : An Ecological and Taxonomic Study of the Algae of British Soils II. Consideration of the Species observed. *Ann. Bot. New Ser.* **VI** : 371–395.

FUKUSHIMA, H. (**1963**) : Studies on cryophytes in Japan. *Jour. Yokohama Munic. Univ.* Ser. C **43** : 1–146.

GARRIC, R. K. (**1965**) : The cryoflora of the Pasific Northwest. *Amer. Jour. Bot.* **52** : 1–8.

HERNDON, W. (**1958**) : Studies on Chlorosphaeracean Algae from Soil. *Amer. Jour. Bot.* **45** : 298–308.

...... (**1958**) : Studies on Chlorococcacean Algae. *Amer. Jour. Bot.* **45** : 308–323.

HILTON, R. L. and F. R. TRAINOR (**1963**) : Algae from a Connecticut Soil. *Plant and Soil* **XIX** : 396–399.

HOWLAND, L. J. (**1929**) : The Moisture Relation of Terrestrial Algae III. *Ann. Bot.* **XLIII** : 173–202.

ISLAM, N. (**1960**) : Some Subaerial Green Algae from East Pakistan. *Trans. Amer. Microsc. Soc.* **LXXXIX** : 471–479.

ISLAM, N. (**1962**) : A New Species of Oedocladium from East Pakistan with Notes on the Genus. *Trans. Amer. Microscop. Soc.* **LXXXI** : 372–379.

ITANO, N. (**1931**) : Soil Microbiology (in Japanese). Tokyo.

IYENGAR, M. O. P. (**1932**) : Fritschiella, A New Terrestrial Member of the Chaetophoraceae. *New Phytol.* **31** : 329–335.

...... (**1925**) : Note on Two New Species of Botrydium from India. *Ind. Bot. Soc.* 193–201.

JOHN, R. P. (**1942**) : An Ecological and Taxonomic Study of the Algae of British Soils I. The Distribution of the Surface Growing Algae. *Ann. Bot. New Ser.* **VI** : 323–349.

JOHNSON, A. (**1962**) : A Short Note on some Soil Algae from New Guinea. *Gard. Bull. Singapore* **XIX** : 375–377.

...... (**1962**) : Precursory Studies on the Epiterranean Soil Algae of Singapore and Malaya. *Gard. Bull. Sing.* **XIX** : 379–384.

KAMIYA, T. (**1960**) : On the Botrydium in the Middle Part of Japan. *Jap. Jour. Bot.* **35** : 172–178.

LUND, J. W. G. (**1962**) : Soil Algae in *Physiology and Biochem. of Alg.* Edit. LEWIN. pp. 759–770.

MITRA. A. K. (**1950**) : Two New Algae from Indian Soils. *Ann. Bot. N. S.* **XIV** : 457–464.

NAYAL, A. A. (**1935**) : Two New Members of the Chaetophorales from Egypt. *Ann. Bot.* **XLIX** : 205–212.

OKADA, Y. (**1941**) : An Intriduction to Soil Microbiology (in Japanese) Tokyo.

O'KELLEY, J. C. and W. R. HERNDON (**1961**) : Alkaline earch elements and zoospore release and development in Protosiphon botryoides. *Amer. Jour. Bot.* **48** : 796–802.

PARKER, B. C. and B. C. BOLD, (**1961**) : Biotic Relationship between Soil Algae and other Microorganisms. *Amer. Jour. Bot.* **48** : 185–196.

PETERSEN, J. B. (**1931**) : The Algal Vegetation of Hammer Bakker. *Bot. Tidiskr.* **42** : 1–48.

...... (**1932**) : Einige neue Erdalgen *Arch. Protist.* **76** : 395–408.

POCOCK, M. A. (**1962**) : Algae from Deklip soil culture *Arch. Mikrobiol.* **42** : 56–63. (*Biol. Abst. Pl. Sci.* **40**).

SAXENA, P. N. (**1961**) : Algae of India I. Chaetophorales. *Bull. Nat. Bot. Gard. Ind.* **57** : 1–59.

SHIELDS, L. M. and F. DROUET (**1962**) : Distribution of terrestrial Algae within the Nevada Test Site. *Amer. Jour. Bot.* **49** : 547–554.

SINGH, R. N. (**1941**) : On Some Phases in the Life History of the terrestrial Alga, Fritschiella tuberosa IYENGAR, and its Autoecology. *New Phytol.* **XL** : 170–182.

STARR, R. C. (**1954**) : Reproduction by Zoospores in Tetraedron bitridens. *Amer. Jour. Bot.* **41** : 17–20.

...... (**1955**) : A Comparative Study of Chlorococcum MENEGHINI and Other Spherical Zoospore producing Genera of the Chlorococcales. *Indiana Univ. Press.*

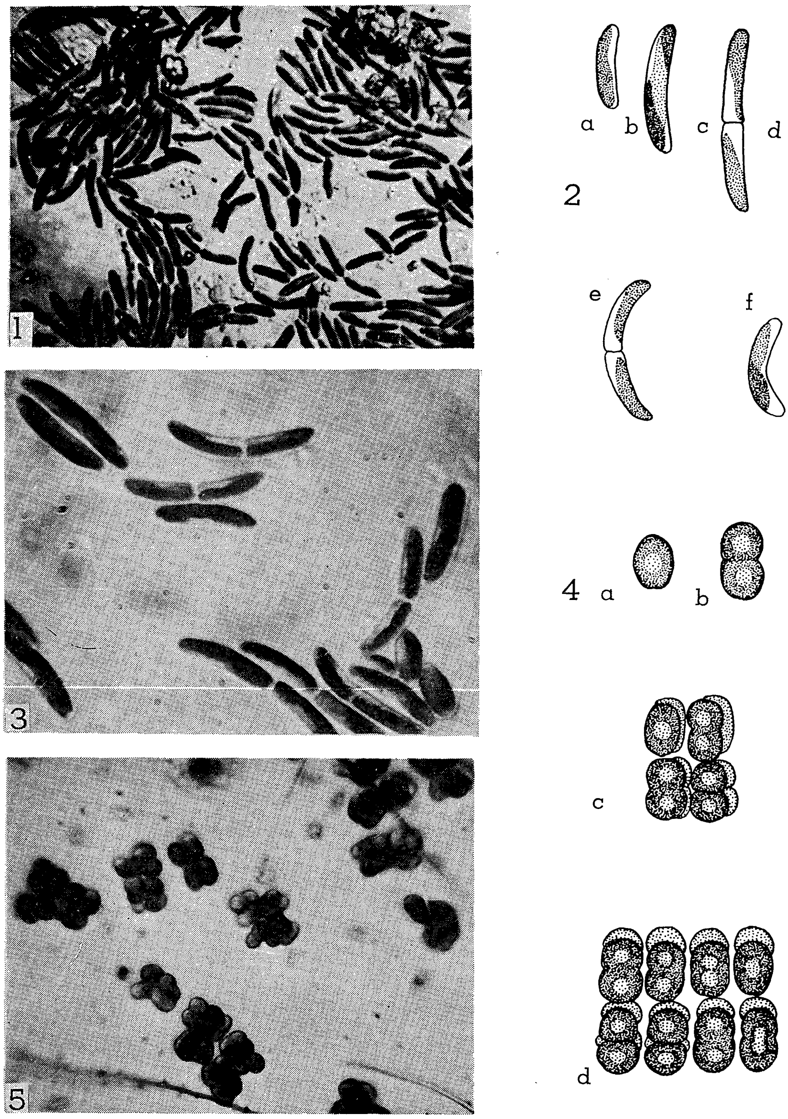
SULTANUL, AZIZ, K. M. and N. ISLAM (**1962**) : A New Species of Fritschiella IYENG. from East Pakistan. *Trans. Amer. Microsc. Soc.* **LXXXI** : 185–189.

TRAINOR, F. R. (**1962**) : Temperature tolerance of Algae in dry soil. *Phycol. News Bull.* **15** : 3–4.

...... and R. J. MCLEAN (**1964**) : A Study of a Species of Spongiochloris introduced into sterile Soil. *Amer. Jour. Bot.* **51** : 57–60.

VISCHER, W. (**1933**) : Ueber einige kritische Gattungen und die Systematik des Chaetophorales. *Beih. Bot. Centralbl.* Abt. I, **51** : 1–100.

[MANUSCRIPT RECEIVED SEPTEMBER 6, 1965]



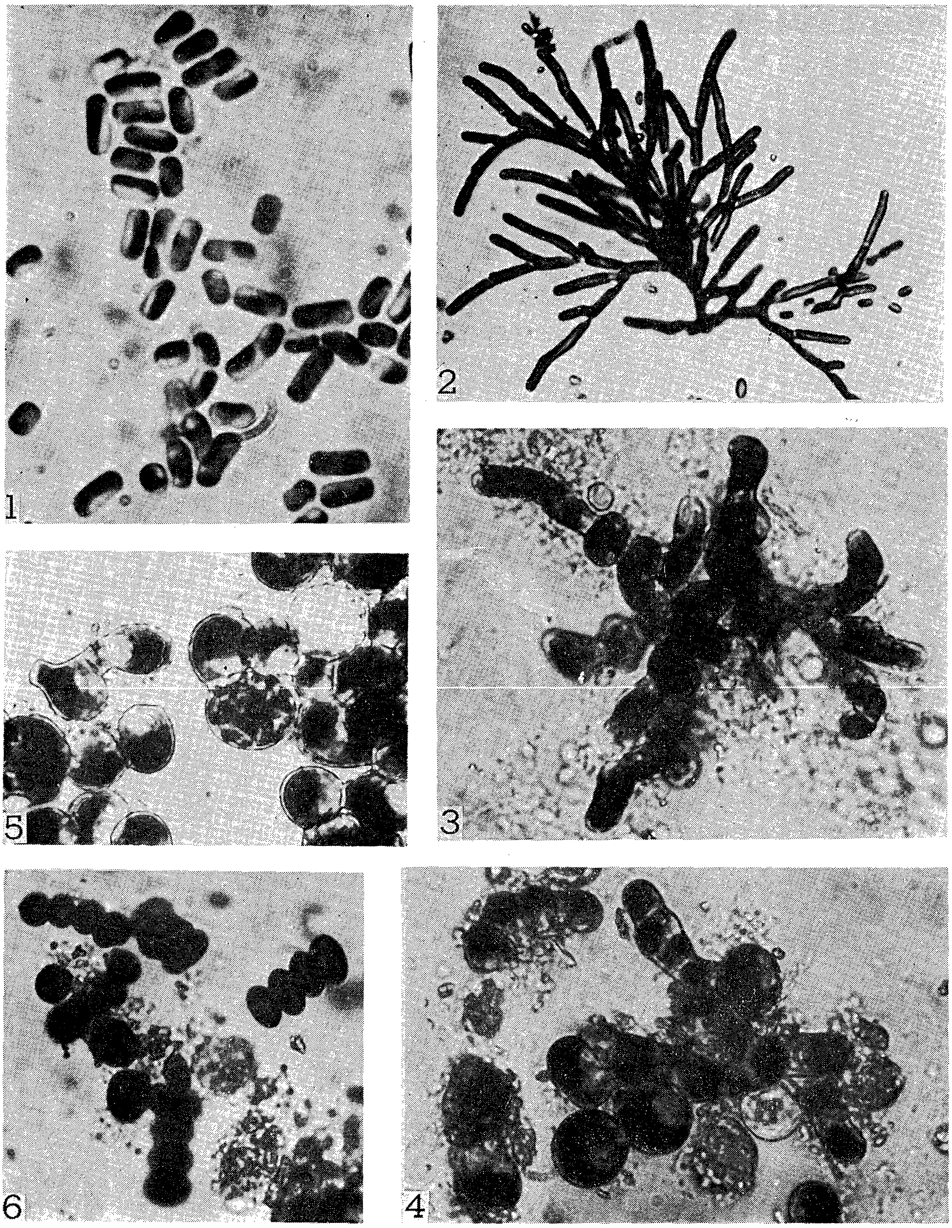
Explanation of PLETE I.

Figs. 1–3. **Rhaphidonema terrestre** sp. nov.

1 : colony of algae. (×400). 2, 3 : magnificated unicellular and 2-celled algae. (×1000)

Figs. 4, 5. **Eucapsis terrestris** sp. nov.

5 : 8–32-celled adult colonies. (×400). 4 : (×1000).



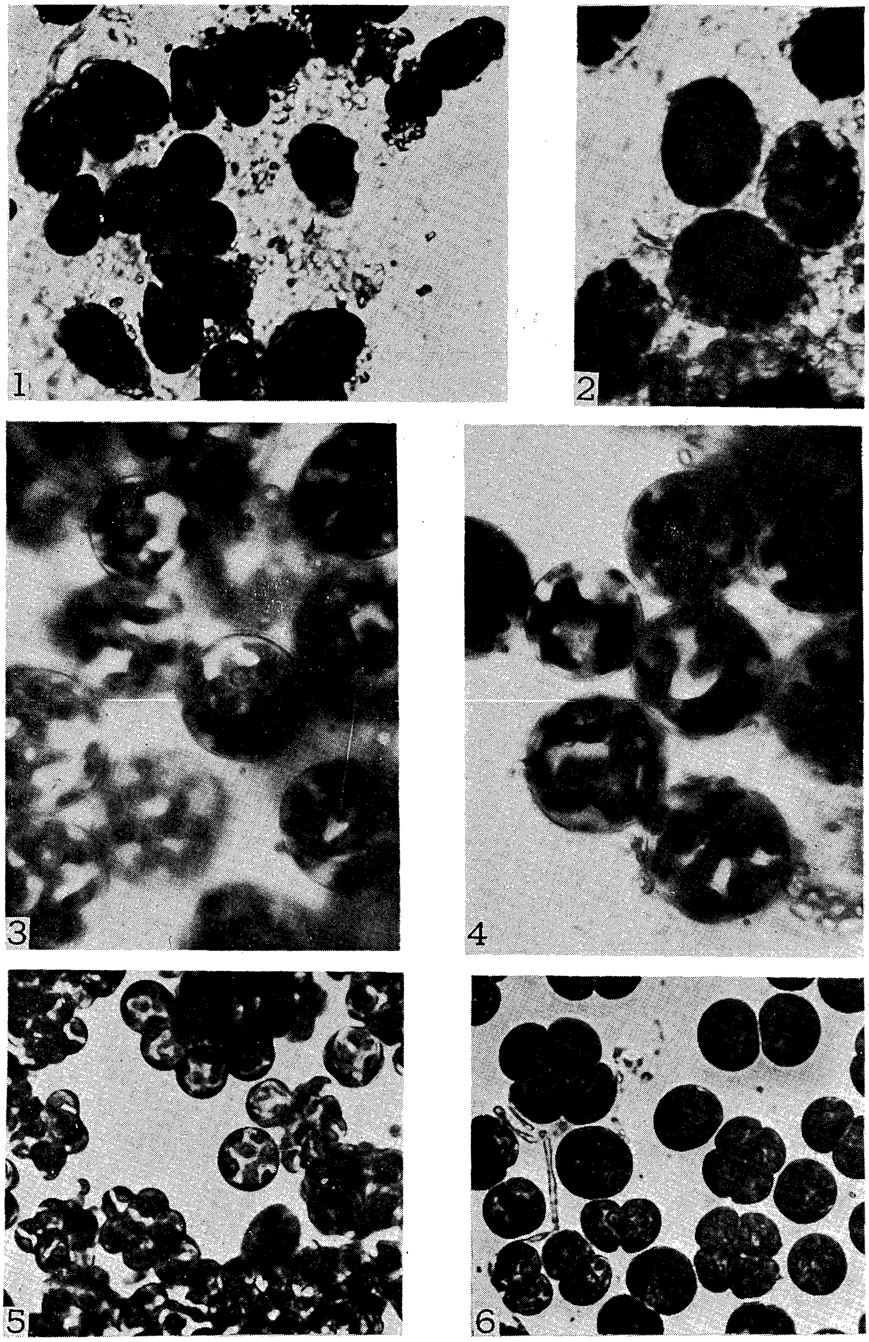
Explanation of PLETE II.

Fig. 1 : **Stichococcus bacillaris** NAEG. (×1000).

Fig. 2 : **Microthamnion kuetzingianum** NAEG. (×300).

Figs. 3, 4, 5 : **Gongrosira terricola** BRISTOL (×600).

Fig. 6. **Scenedesmus bijuga** (TURP.) LAGERH. (×800).



Explanation of PLETE III.

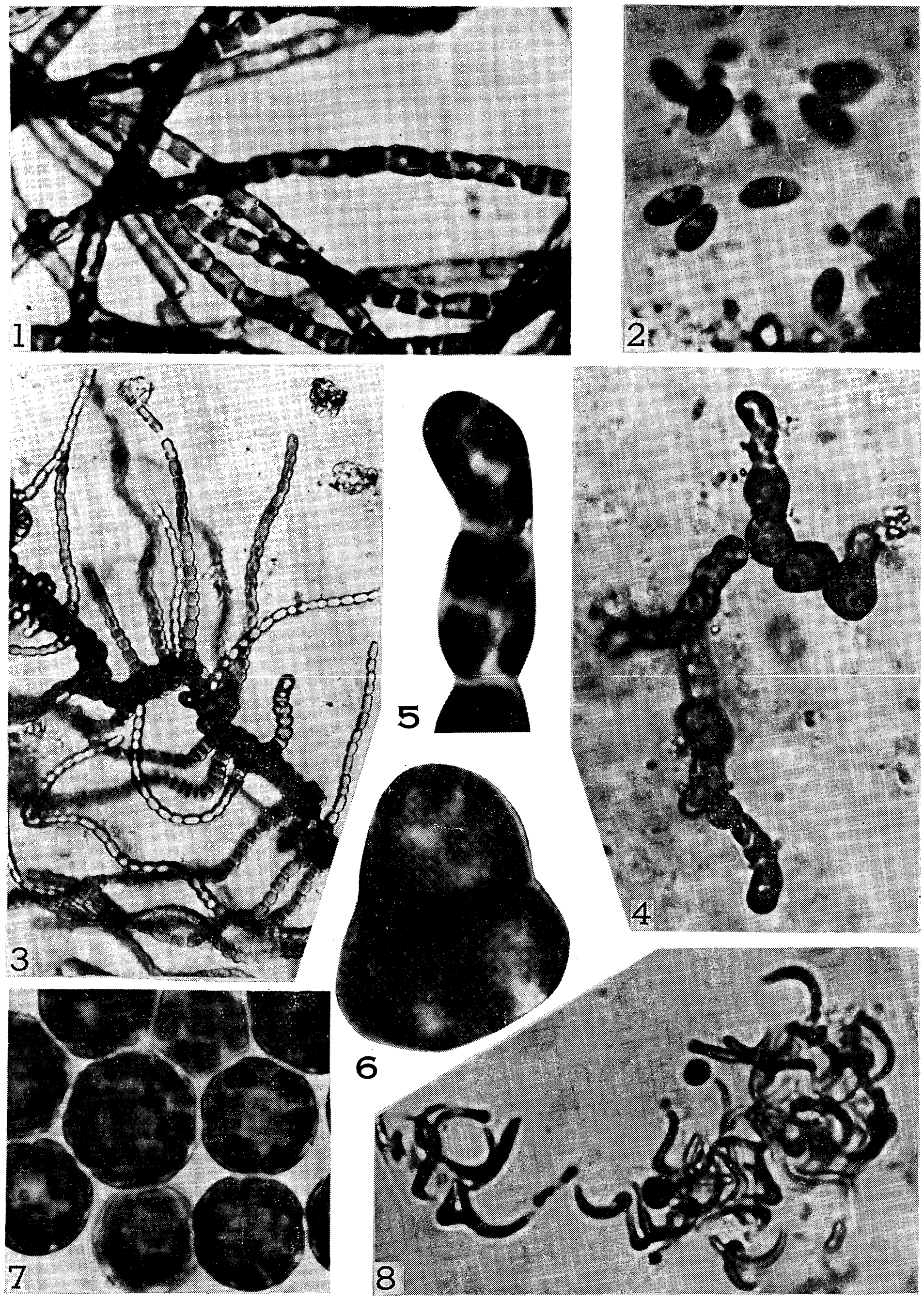
Figs. 1, 2 : **Bracteacoccus irregularis** (PETERSEN) STARR,
1 : vegetative cells. (×500). 2 : formation of zoospores. (×600).

Fig. 3 : **Spongiochloris** sp. (×1000).

Fig. 4 : **Dictyochloris** sp. (×1000).

Fig. 5 : **Bracteacoccus** sp. (×1000).

Fig. 6 : a member of Chlorosphaeralean alga. (×1000).



Explanation of PLETE IV.

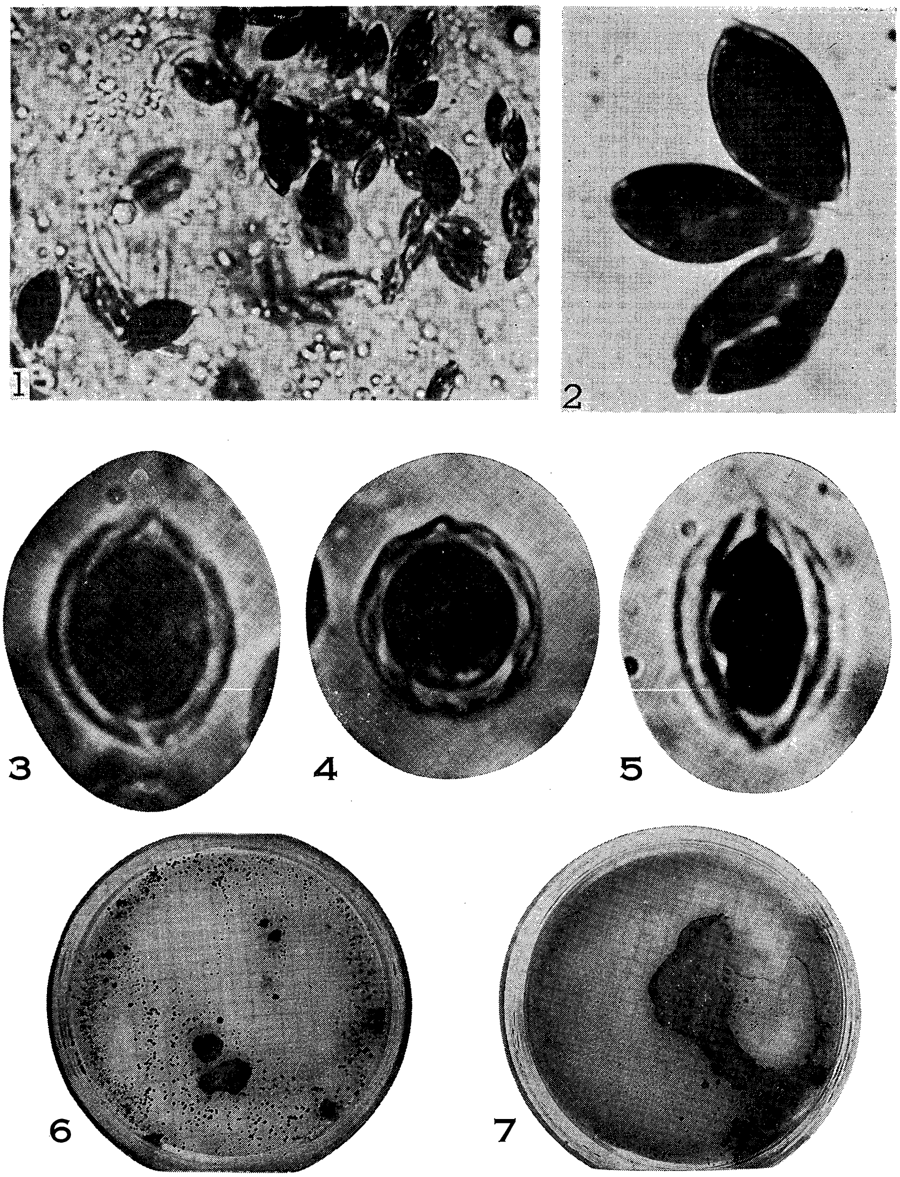
Fig. 1 : **Bumilleria exilis** KLEBS (×500). Fig. 2 : **Monodus subterraneus** PETERSEN (×1000).

Fig. 3 : **Westiellopsis prolifica** JANET (×250).

Figs. 4, 5, 6 : **Monocilia viridis** GERN, 4 : whole thallus (×400). 5 : apical region of filament. (×1000), 6 : coccoidal cells. (×1000).

Fig. 7 : **Botrydiopsis arhiza** BORZI (×1000).

Fig. 8 : **Dactylococcopsis rhaphidioides** HANSG. (×1000).



Explanation of PLETE V.

Figs. 1–5 : **Scotiella nivalis** (SCHUTT.) FRITSCH

1 : colony of algae. (×250). 2 : two Vegetative cells and one cell in autospore formation. (×500). 3 : a side view of a cell. (×500). 4 : an oblique view of a cell. (×500). 5 : a plasmolysed cell showing a replication pattern of cell wall. (×500).

Figs. 6, 7 : algal colonies on agar-plates. (×0.5).