MARINE CYANOPHYCEAE OF AMAMI-OSHIMA ISLAND

ISAMU UMEZAKI
Department of Fisheries, Kyoto University, Maizuru

With One Table and 7 Text-figures

I. Introduction

In April 1955, the writer had an opportunity to work on the marine Cyanophyceae of Amami-Oshima island, main island of the Amami Islands which belong to the Prefecture of Kagoshima in Kyushu. The Amami Islands, a group of the Satsunan Islands stretching from lat. 27°N. to lat. 31°N., between Tanega-Shima and Yoron-Tô, lie in the southernmost part of the sea of Japan, under the present law, and consist mainly of five islands: Amami-Oshima (or Oshima), Kikai, Tokuno-Shima, Okinoerabu, and Yoron-Tô. Among these islands Amami-Oshima is the largest and is geographically situated between lat. 28°N. and lat. 28° 32′N. and between long. 129° 7′E. and long. 129° 45′E.

For many years past, the marine flora of Japan (including southern Saghalien, the Kuriles, the Loochoos and Formosa) has been rather precisely studied by many Japanese phycologists; and the whole aspect of the geographical distribution along the Japanese coasts has been made clear. The regret is that the Satsunan Islands including the Amami and Tokara Islands have not been visited by phycologists, to study the marine Cyanophyceae and other classes of algae, because of the inconvenience of communications and of other difficulties.

With the object of studying the marine Cyanophyceae the writer visited that island in April 1955, staying for twenty days. This study will contribute towards showing the flora of the marine Cyanophyceae of the island, thus giving a hint to solve phytogeographical problems of the Japanese marine flora. In 1955 the writer published a list of the marine Cyanophyceae of the Tokara Islands lying a little north of Amami-Oshima, and mentioned 21 species from there though the majority of them were cosmopolitan. Though the present study is treated on the basis of a smal collection which he got during his short trip, 7 families, 21 genera, 51 species were discovered there. In addition to the floristic study of the island this paper deals with ecological observation and the phytogeographical problems involved.

Publ. Seto Mar. Biol. Lab., V (3), 1956. (Article 24)

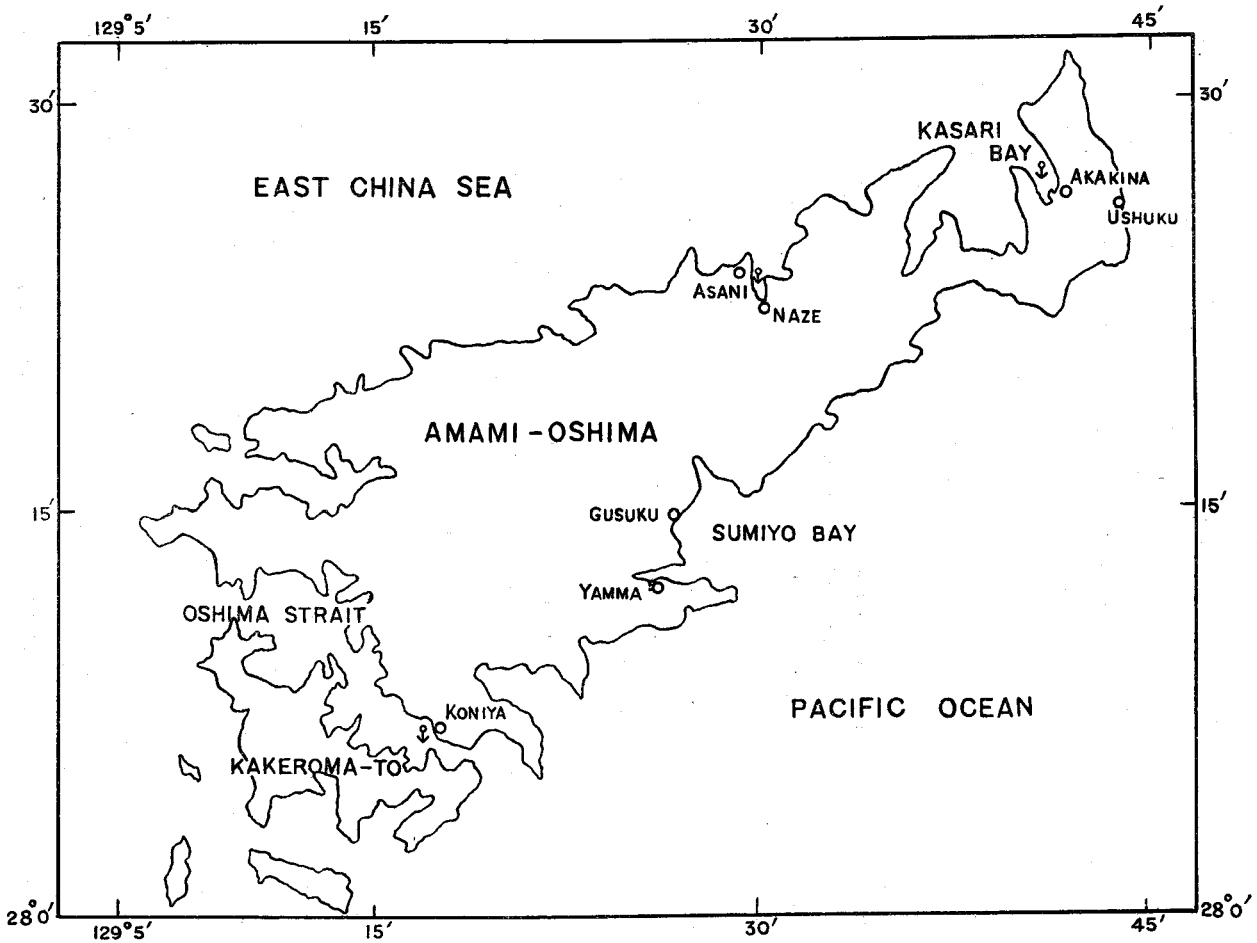

Fig. 1. Map showing the site of collecting stations in Amami-Oshima island.

II. Brief Note on the Collecting Stations

It is needless to say that for the study of the algal flora of a certain district it is necessary to visit there several times, staying there as long as possible. The period of the present collector's stay there, however, was short — only twenty days —, and the stations he visited were restricted to only seven regions: Naze, Asani, Akakina, Ushuku, Yamma, Gusuku, and Koniya, as is shown in Fig. 1. Fortunately, all of the localities visited were convenient for him to investigate the conditions of the growth of the algae. Still more fortunately, while he stayed in the island it was just spring-tide at full moon. All the material was collected by wading on rocks in the intertidal belt during two or three hours at low tide after the tide was turned. The following is the general description of the stations visited and the general appearance of the algal growth at each station.

1. Naze Station: The west coast of Naze Port (about 2,500 meters in distance from Naze street to Yagi-Jima) is a good locality for collecting the algae, and the coast is of sand and of huge or small rocks. This region is also just suitable for collecting them within two or three hours at one tide.

2. Asani Station: The shallow coast of Asani which is located at about 2,500 meters west of Naze town is a monotonous zone composed of coral reefs and small pebbles. On rocks in the upper littoral zone a number of the fronds of *Symploca hydnoides*, whose occurrence is conspicuous at this station, were found. The flora of the marine algae of other classes than the blue-green algae was scanty.

3. Akakina Station: The eastern coast of Akakina which forms the Akakina Port of Kasari Bay resembles that of Asani. The algal growth along this coast was also scanty. But *Calothrix pilosa* and *Rivularia polyotis* were luxuriant here.

4. Ushuku Station: The coast of Ushuku, Kasari-mura (about 4,000 meters east of Akakina), is a good locality for collecting the marine algae because at low tide it extends to about 200 meters off the shore, where there are flat rocks with many small tide pools or rock depressions. The green and red algae, not the blue-green algae, were plentiful; and on shaded rocks in tide pools there were growing a number of the large tufts of *Chamaedoris orientaris*, a green alga. The large plants of *Anacystis aeruginosa* were abundantly found growing on rocks in the upper littoral zone.

5. Gusuku Station: Gusuku in Sumiyo Bay is just at the middle region between Naze and Koniya, and the coast line consists of both sandy and rocky beaches where rocks are comparatively large. When the waves are high, collecting the materials is very difficult or almost impossible. The alga *Brachytrichia Quoyi* showed plentiful growth in the lower littoral zone where it entirely covered rocks and coloured the surface deep blue-green or dark green. The blackish-violet fronds of *Oscillatoria nigro-viridis* were abundantly found covering the surface of rocks in the upper littoral zone.

6. Yamma Station: Yamma, which lies along the southern shore of Sumiyo Bay where a large wood of mangrove trees is luxuriant, is very poor regarding the marine

algae of other classes, except for abundant growths of *Ulva pertusa* and *Nemalion pulvinatum*. Cyanophyceae, on the other hand, were rather plentiful as compared with other groups of algae.

7. Koniya Station: Koniya (the largest port and town next to Naze) is at the southernmost end of the island. For collecting the materials the coast is very convenient because of having a widely extended rocky coastal line here and there, and luxuriant growths of the blue-green algae as well as algae of other classes were found. Especially Tean, about 4,000 meters west of Koniya and Seisui, 3,000 meters east of the Koniya, are the excellent localities in this vicinity. At Tean, *Gardnerula corymbosa*, *Rivularia polyotis*, and *Calothrix pilosa* were found in great abundance; while at Seisui, plentiful growths of *Hormothamnion enteromorphoides*, *Scytonema polycystum*, and *Lyngbya confervoides* were found. On the coast of both Tean and Seisui several species of *Caulerpa*, a green alga, grew abundantly on sands about one meter below low tide level. Among the above-mentioned stations, this region was the most luxuriant floristically.

III. Composition of the Species in Each Station

The following is a list showing the composition of the Cyanophycean vegetation in each station. As is shown in the list, Koniya, where two-thirds of the all listed species were collected, was the best station in regard to the floristic composition; while Naze, Akakina, and Ushuku were poor, although Ushuku was a good station for marine algae of other classes than the blue-green algae. Especially noteworthy species for the Japanese flora, *Gardnerula corymbosa*, *Fremyella vitiensis*, *Scytonema polycystum*, and *Hormothamnion enteromorphoides* were found only in the Koniya coast. *Rivularia polyotis* and *Calothrix pilosa* were collected at both Akakina and Koniya. *Symploca hydnoides* was found on the coasts of Naze, Asani, and Gusuku. *Brachytrichia maculans* was obtained from all other stations excepting Ushuku, and *B. Quoyi* from the five stations other than Yamma and Ushuku. All of the species belonging to Chamaesiphonaceae, Stigonemataceae, Scytonemataceae, and Nostocaceae were discovered at the Koniya station. Among these species listed, especially *Entophysalis conferta*, *Calothrix crustacea*, *Brachytrichia maculans*, *B. Quoyi*, *Microcoleus tenerrimus*, *M. chthonoplastes*, *Hydrocoleum lyngbyaceum*, and *H. cantharidosmum*, were rather widely and comparatively abundantly distributed on this island. *Oscillatoria chalybea* and *O. Bonnemaisonii* were quite rarely and scarcely encountered only at Koniya. Among 51 species in all, 9 were recorded from Naze, 10 from Akakina and Ushuku, 13 from Gusuku, 19 from Asani, 20 from Yamma, and 38 from Koniya.

1. Naze Station: *Entophysalis conferta*, *Calothrix crustacea*, *Brachytrichia muculans*, *B. Quoyi*, *Oscillatoria nigro-viridis*, *Lyngbya semiplena*, *Microcoleus chthonoplastes*, *Hydrocoleum glutinosum*, and *Symploca hydnoides*.

2. Asani Station: *Entophysalis conferta*, *E. deusta*, *Calothrix aeruginea*, *C. crustacea*, *Brachytrichia maculans*, *B. Quoyi*, *Mastigocoleus testarum*, *Plectonema terebrans*,

P. norvegicum, Oscillatoria nigro-viridis, Phormidium epiphyticum, Lyngbya infixa, L. gracilis, L. confervoides, Microcoleus tenerrimus, M. chthonoplastes, Hydrocoleum cantharidosmum, H. coccineum, and *Symploca hydnoides.*

3. Akakina Station: *Calothrix balearica, C. crustacea, C. pilosa, Rivularia polyotis, Brachytrichia maculans, B. Quoyi, Lyngbya semiplena, Microcoleus tenerrimus, M. chthonoplastes,* and *Hydrocoleum lyngbyaceum.*

4. Ushuku Station: *Anacystis aeruginosa, Entophysalis conferta, Mastigocoleus testarum, Plectonema terebrans, Spirulina tenerrima, Phormidium epiphyticum, Lyngbya sordida, Microcoleus chthonoplastes, Hydrocoleum lyngbyaceum,* and *H. coccineum.*

5. Gusuku Station: *Calothrix aeruginea, C. crustacea, Brachytrichia maculans, B. Quoyi, Plectonema norvegicum, P. calothrichoides, Oscillatoria nigro-viridis, Lyngbya Nordgardhii, Microcoleus Voukii, Hydrocoleum lyngbyaceum, H. cantharidosmum, H. coccineum,* and *Symploca hydnoides.*

6. Yamma Station: *Coccochloris stagnina, Entophysalis conferta, E. deusta, Calothrix aeruginea, C. scopulorum, C. balearica, C. crustacea, Brachytrichia maculans, Plectonema norvegicum, P. calothrichoides, P. Nostocorum, Spirulina tenerrima, Oscillatoria nigro-viridis, Phormidium Corium, P. epiphyticum, Lyngbya semiplena, L. lutea, Microcoleus tenerrimus, Hydrocoleum lyngbyaceum,* and *H. glutinosum.*

7. Koniya Station: *Anacystis dimidiata, A. aeruginosa, Agmenellum thermale, Entophysalis conferta, E. deusta, Calothrix parasitica, C. aeruginea, C. scopulorum, C. confervicola, C. pilosa, C. crustacea, Isactis plana, Gardnerula corymbosa, Rivularia atra, R. polyotis, Brachytrichia maculans, B. Quoyi, Mastigocoleus testarum, Fremyella vitiensis, Scytonema polycystum, Hormothamnion enteromorphoides, Oscillatoria Bonnemaisonii, O. chalybea, Phormidium Corium, Lyngbya Rivulariarum, L. gracilis, L. sordida, L. semiplena, L. majuscula, L. confervoides, L. lutea, L. aestuarii, Microcoleus tenerrimus, M. chthonoplastes, Hydrocoleum lyngbyaceum, H. cantharidosmum, H. glutinosum,* and *H. coccineum.*

IV. Ecological Observations

In habit the marine blue-green algae show greater variations than any class of marine algae, some species being found epiphytic on larger algae, some endophytic in other algae, some planktonic, some on rocks, some in limestone or shells, and so on. From the viewpoint of habit the writer has classified into five forms: (1) planktonic form; (2) lithophytic form; (3) epiphytic form; (4) endophytic form; and (5) shell-perforating form.

The species such as *Anacystis dimidiata* and *Agmenellum thermale* come under the category of the planktonic form, although these species were found floating among the filaments of other algae, not being planktonic in the water. Most of the species here recorded, especially those of Rivulariaceae, were abundantly found on rocks in intertidal belt where they formed conspicuous growths. *Calothrix scopurolum, C. crustacea, Isactis plana, Gardnerula corymbosa, Rivularia atra, R. polyotis, Brachytri-*

Table 1. A list of the Cyanophycean species of Amami-Oshima island and an outline of their geographical distribution in the world.

Species \ Locality	Japan										
	Honshu	Hokkaido	China	Southeast Asia	Warmer Pacific Ocean	Pacific coast of North America	West Indies	Australia	Europe	Cosmopolitan or probably cosmopolitan	Freshwater species
Chroococcaceae											
1. *Coccochloris stagnina* SPRENGEL	+	−	−	−	−	+	+	+	+	+	+
2. *Anacystis dimidiata* (KG.) DR. & DAILY	+	−	−	−	+	+	+	−	+	+	+
3 *A. aeruginosa* (ZANARD.) DR. & DAILY	+	−	−	−	−	+	+	−	+	−	−
4. *Agmenellum thermale* (KG.) DR. & DAILY	+	+	−	+	+	+	+	−	+	+	+
Chamaesiphonaceae											
5. *Entophysalis conferta* (KG.) DR. & DAILY	+	+	−	+	+	+	+	+	+	+	−
6. *E. deusta* (MENEGH.) DR. & DAILY	+	+	−	−	+	+	+	+	+	+	−
Rivulariaceae											
7. *Calothrix parasitica* (CHAUV.) THUR.	+	+	−	−	+	+	−	−	+	+	−
8. *C. aeruginea* (KG.) THUR.	+	−	−	+	+	+	+	+	+	+	−
9. *C. balearica* BORN. & THUR.	+	−	−	−	−	−	−	−	+	−	+
10. *C. scopulorum* (W. & M.) AG.	+	+	−	+	+	+	+	+	+	+	−
11. *C. confervicola* (ROTH) AG.	+	+	−	−	−	+	+	+	+	+	−
12. *C. crustacea* THUR.	+	+	−	+	+	+	+	+	+	+	−
13. *C. pilosa* HARV.	+	−	−	+	+	+	+	−	−	−	−
14. *Isactis plana* (HARV.) THUR.	+	+	−	−	+	+	+	+	+	−	−
15. *Gardnerula corymbosa* (HARV.) J. DE TONI	+	−	−	−	+	−	+	−	+	−	−
16. *Rivularia atra* ROTH	+	+	−	−	−	+	−	+	+	+	−
17. *R. polyotis* (AG.) BORN. & FLAH.	−	−	−	−	−	−	−	+	+	−	−
Stigonemataceae											
18. *Brachytrichia maculans* GOM.	+	+	+	+	+	−	−	−	−	−	−
19. *B. Quoyi* (AG.) BORN. & FLAH.	+	+	+	+	+	+	+	+	−	−	−
20. *Mastigocoleus testarum* LAGERH.	+	+	−	−	+	+	+	−	+	−	−
Scytonemataceae											
21. *Fremyella vitiensis* (ASK.) J. DE TONI	−	−	−	−	+	+	+	−	−	−	−
22. *Scytonema polycystum* BORN. & FLAH.	−	−	−	−	+	−	−	−	−	−	−
Nostocaceae											
23. *Hormothamnion enteromorphoides* GRUNOW	−	−	−	+	+	−	+	−	−	−	−
Oscillatoriaceae											
24. *Spirulina tenerrima* KUETZ.	−	−	−	−	+	−	−	−	+	+	+
25. *Oscillatoria Bonnemaisonii* GROUAN	+	−	−	−	+	+	+	−	+	+	−
26. *O. chalybea* MERTENS	+	+	−	−	−	+	+	−	+	+	+
27. *O. nigro-viridis* THWAITES	+	−	−	+	+	+	+	−	+	+	−
28. *Plectonema terebrans* BORN. & FLAH.	+	−	−	−	+	+	−	−	+	+	−
29. *P. calothrichoides* GOM.	−	+	−	−	−	+	−	−	+	−	−
30. *P. norvegicum* GOM.	−	−	−	−	−	−	−	+	+	−	−
31. *P. Nostocorum* BORN.	−	−	−	−	+	−	−	−	+	+	+
32. *Phormidium Corium* (AG.) GOM.	+	+	−	+	−	+	+	−	+	+	+
33. *P. epiphyticum* GARDN.	+	+	−	−	−	+	+	−	−	−	−
34. *Lyngbya Rivulariarum* GOM.	+	−	−	−	+	−	−	−	+	+	+
35. *L. infixa* FRÉMY	+	+	−	−	−	−	+	−	+	−	−
36. *L. Nordgardhii* WILLE	+	+	−	−	−	+	+	−	+	−	−
37. *L. gracilis* RABENH.	+	−	−	−	−	+	+	−	+	−	−
38. *L. sordida* (ZANARD.) GOM.	+	−	−	−	+	−	+	+	+	−	−
39. *L. majuscula* HARV.	+	−	−	+	+	+	+	+	+	+	−
40. *L. confervoides* C. AG.	+	−	−	+	+	+	+	+	+	+	−
41. *L. semiplena* (C. AG.) J. AG.	+	+	−	−	+	+	+	+	+	+	−
42. *L. lutea* (AG.) GOM.	+	+	−	−	−	+	+	+	+	+	+
43. *L. aestuarii* (MERT.) LIEBM.	+	+	−	+	+	+	+	−	+	+	+
44. *Microcoleus tenerrimus* GOM.	+	+	−	−	+	+	+	−	+	+	−
45. *M. chthonoplastes* THUR.	+	−	−	−	−	+	+	−	+	+	−
46. *M. Voukii* FRÉMY	+	−	−	−	−	−	−	−	+	−	−
47. *Hydrocoleum lyngbyaceum* KUETZ.	+	+	−	+	+	+	+	+	+	+	−
48. *H. cantharidosmum* (MONT.) GOM.	+	+	−	+	+	−	+	+	−	−	−
49. *H. glutinosum* (AG.) GOM.	+	−	−	−	+	+	+	+	+	+	−
50. *H. coccineum* GOM.	+	−	−	−	+	+	−	−	+	−	−
51. *Symploca hydnoides* KUETZ.	−	−	−	+	+	+	+	+	+	+	−
Total	42	24	2	17	34	37	37	21	43	29	11

chia maculans, *B. Quoyi*, and *Symploca hydnoides* grew in solitary fashion, not associating with one another; while *Microcoleus tenerrimus*, *M. chthonoplastes*, and *Hydrocoleum lyngbyaceum*, associated with other algae or with one another, sometimes formed intricate fronds or *Phormidium*-like sheets on rocks. The former group which grew on rocks in littoral zone may be the true lithophytic form. The epiphytic form, which grows attached to algae of other classes or even on filamentous Cyanophyceae, were also abundantly discovered. In habit, two types of *Hormothamnion enteromorphoides* were observed, one growing on large algae such as *Hypnea cervicornis* and *Sargassum* sp. when young, the another floating freely when aged. The cortical tissues of *Nemalion* and *Codium* seem to be suitable for growth of some Cyanophyceae. Four species, *Calothrix parasitica*, *Lyngbya Rivulariarum*, *Microcoleus Voukii*, and *Hydrocoleum coccineum* are the endophytic form here. The study of algae not only Cyanophyceae but Chlorophyceae and Rhodophyceae boring into limestone or shells seems to be very interesting both taxonomically and ecologically. Three species were found associating with one another in mollusc shells.

The following is a list of the species classified into 5 forms.

1. Planktonic Form: *Coccochloris stagnina*, *Anacystis dimidiata*, *Agmenellum thermale*, *Oscillatoria chalybea*, and *O. Bonnemaisonii*.

2. Lithophytic Form: *Anacystis aeruginosa*, *Entophysalis deusta*, *Calothrix scopulorum*, *C. balearica*, *C. crustacea*, *C. pilosa*, *Isactis plana*, *Gardnerula corymbosa*, *Rivularia atra*, *R. polyotis*, *Brachytrichia muculans*, *B. Quoyi*, *Scytonema polycystum*, *Oscillatoria nigro-viridis*, *Phormidium Corium*, *Lyngbya majuscula*, *L. confervoides*, *L. semiplena*, *L. lutea*, *L. aestuarii*, *Microcoleus tenerrimus*, *M. chthonoplastes*, *Hydrocoleum lyngbyaceum*, *H. cantharidosmum*, and *Symploca hydnoides*.

3. Epiphytic Form: *Entophysalis conferta*, *Calothrix aeruginea*, *C. confervicola*, *Fremyella vitiensis*, *Hormothamnion enteromorphoides*, *Spirulina tenerrima*, *Plectonema norvegicum*, *P. calothrichoides*, *P. Nostocorum*, *Phormidium epiphyticum*, *Lyngbya infixa*, *L. Nordgardhii*, *L. gracilis*, and *L. sordida*.

4. Endophytic Form: *Calothrix parasitica*, *Lyngbya Rivulariarum*, *Microcoleus Voukii*, and *Hydrocoleum coccineum*.

5. Shell-perforating Form: *Entophysalis deusta*, *Mastigocoleus testarum*, and *Plectonema terebrans*.

V. On the Geographical Distribution

Table 1 shows a list of the Cyanophycean species from Amami-Oshima island and an outline of their geographical distribution. As compared with the marine algae of other classes, the bulk of the marine blue-green algae are cosmopolitan in their geographical distribution, with the exception of some conspicuous species. 29 cosmopolitan or probably cosmopolitan species were found. Among the total of 51 species here enumerated, 42 have already been recorded from Honshu (UMEZAKI 1950–56 a, 1955 a), 25 from Hokkaido (UMEZAKI 1956 b), 2 from the China coast (TSENG 1936,

1940), 17 from Southeast Asia (DAWSON 1954; GOMONT 1901), 34 from the warmer Pacific (DROUET 1936; MAY 1953; NIEL 1930; SETCHELL 1926; TAYLOR 1945, 1950; TILDEN 1910; WEBER-VAN BOSSE 1913, 1926), 37 from the Pacific coast of North America (JAO 1948; GARDNER 1918; SETCHELL and GARDNER 1903, 1919, 1924), 37 from the West Indies (FRÉMY 1939, 1941; GARDNER 1932; TAYLOR 1942; TILDEN 1910), 21 from Australia (GUILER 1952; WOMERSLEY 1946, 1950), and 43 from throughout Europe including the Mediterranean, the Adriatic sea and the British Isles (BATTERS 1902; BORNET & FLAHAULT 1886–88; FELDMANN 1937; FRÉMY 1934; GOMONT 1892, 1899; GEITLER 1932; LINDSTEDT 1943; MOELDER 1945; NEWTON 1931). 11 species which are known to occur in general habitats in fresh water were discovered on this Amami-Oshima, although they occasionally occur in marine water. The following seven species, *Rivularia polyotis*, *Fremyella vitiensis*, *Scytonema polycystum*, *Hormothamnion enteromorphoides*, *Plectonema norvegicum*, *P. Nostocorum*, and *Symploca hydnoides* have not yet been known from Honshu and Hokkaido, being new to Japan. Among of them, *Plectonema norvegicum* is known from arctic and north temperate regions and *Symploca hydnoides* is cosmopolitan in its geographical distribution. From the viewpoint of geographical distribution, the following four species, *Gardnerula corymbosa*, *Fremyella vitiensis*, *Scytonema polycystum*, and *Hormothamnion enteromorphoides*, are considered to be of tropical origin rather than of subtropical origin. Among them, *Gardnerula corymbosa*, however, was collected by the writer himself (1956 c) in November 1951 on the Shirahama coast of Honshu, where the alga was rather dwarf, having a length of 150–1300μ, and very rare in occurrence, undoubtedly because of the desirability of lower temperatures of water for growth. As far as the writer knows, Bermuda in the Atlantic Ocean seems to be a northernmost station for the species in the Atlantic Ocean, and Shirahama may be its northernmost region in the Pacific Ocean. From the floristic point of view the writer came to the conclusion that the marine Cyanophycean composition of Amami-Oshima island is subtropical, and he found that for the abundance of its flora the island is in good condition.

VI. Enumeration of Species

The systematic arrangement of the classification here adopted is that proposed by DROUET (1951), and the classification for Chroococcaceae and Chamaesiphonaceae is that of DROUET & DAILY (1956), that for Rivulariaceae, Stigonemataceae, Scytonemataceae and Nostocaceae that of BORNET & FLAHAULT (1886–88), and that for Oscillatoriaceae that of GOMONT (1892), unless otherwise indicated. All of these specimens are kept in the writer's herbarium.

Division CYANOPHYTA

Family Chroococcaceae

Coccochloris stagnina SPRENGEL

Yamma: On rocks in the upper littoral zone, with other Cyanophyceae (Herb. Umez. 1747 in part).

Geogr. Distrib.: Cosmopolitan.

Anacystis dimidiata (KUETZING) DROUET & DAILY

Koniya: Among the filaments of *Lyngbya* sp. and *Hydrocoleum cantharidosmum* (1869 in part); among the fronds of *Hydrocoleum lyngbyaceum* (1803 in part); among the filaments of *Calothrix pilosa* (1808 b); among the masses of *Lyngbya aestuarii* (1784 b).

Geogr. Distrib.: Cosmopolitan.

Anacystis aeruginosa (ZANARDINI) DROUET & DAILY

Koniya: Among the fronds of other filamentous Cyanophyceae (1769 in part). Ushuku: On rocks along high tide level (1857 b).

These local specimens are quite similar to illustrations of *Aphanocapsa sesciacensis* by FRÉY.

Geogr. Distrib.: Japan, North America, West Indies, Europe.

Agmenellum thermale (KUETZING) DROUET & DAILY

Koniya: Floating among other Cyanophyceae (1802 in part).

The plant resembles illustrations of *Merismopoedia elegans* of A. BRAUN.

Geogr. Distrib.: Cosmopolitan.

Family Chamaesiphonaceae

Entophysalis conferta (KUETZING) DROUET & DAILY

Koniya: On *Lyngbya aestuarii* (1756 in part). Asani: On *Bostrychia binderi* (1700); on *Calothrix aeruginea* (1701 in part); on *Calothrix crustacea* (1695 in part); on *Gelidium* sp. (1707); on *Caulacanthus* sp. (1709). Naze: On *Lyngbya semiplena* (1840 b); on *Caulacanthus* sp. (1842 b). Yamma: On *Lyngbya semiplena* (1736 in part, 1742 in part).

Various forms which have been in general described as *Chlorogloea conferta, Dermocarpa sphaerica, D. Marchantae, D. Leibleiniae, D. protea,* and *Dermocarpella hemisphaerica* are here referred to under the specific name *Entophysalis conferta.*

Geogr. Distrib.: Cosmopolitan.

Entophysalis deusta (MENEGHINI) DROUET & DAILY

Asani: On *Brachytrichia maculans* (1699 in part). Koniya: On rocks and *Brachytrichia maculans* (1752 in part); perforating in a dead mollusc shell with

Mastigocoleus testarum (1839 b). Yamma: With *Hydrocoleum lyngbyaceum* on rocks in the upper littoral zone (1747 in part).

Geogr. Distrib.: Cosmopolitan.

Family Rivulariaceae

Calothrix parasitica (CHAUVIN) THURET

Koniya: In *Nemalion pulvinatum* (1778 in part).

Geogr. Distrib.: Japan, Pacific Ocean, North America, Europe, North Africa.

Calothrix aeruginea (KUETZING) THURET

Asani: On *Gelidium* sp. (1701 in part). Gusuku: On *Gelidium* sp. and *Nemalion pulvinatum* (1721 in part, 1722 in part). Koniya: On *Liagora* sp. (1810).

Geogr. Distrib.: Cosmpolitan.

Calothrix scopulorum (WEBER & MOHR) AGARDH

Yamma: On rocks in the upper littoral zone (1746 in part). Koniya: On rocks and living mollusc shells in the upper or lower littoral zone (1759, 1785 b, 1788 a).

Geogr. Distrib.: Cosmopolitan.

Calothrix confervicola (ROTH) AGARDH

Koniya: With *Fremyella vitiensis* on *Laurencia* sp. (1782 b).

Geogr. Distrib.: Cosmopolitan.

Calothrix balearica BORNET & FLAHAULT

Yamma: On vertical concrete along high tide level (1735 in part). Akakina: On *Hypnea* sp. in the upper littoral zone (1868).

Geogr. Distrib.: Europe.

Calothrix crustacea THURET

Asani: On rocks in a small rock depression in the upper littoral zone (1695 in part, 1698 a). Gusuku: On rocks in a rock depression a little above high tide level (1725 in part, 1729 a, 1730 in part). Yamma: On rocks and vertical concrete along high tide level (1735 in part, 1746 in part). Koniya; In association with *Lyngbya semiplena* on rocks in the upper littoral zone (1790 a, 1794 a, 1818). Naze: On rocks along high tide level (1853 a). Akakina: On rocks in the lower littoral zone (1864 b, 1867 b).

Geogr. Distrib.: Cosmopolitan.

Calothrix pilosa HARVEY

Koniya: On rocks along high tide level or in the upper littoral zone (1753 a, 1807 a, 1808 a). Akakina: On rocks along high tide level (1870 b).

Geogr. Distrib.: Japan, Pacific Ocean, Southern Asia, North America, West Indies.

Isactis plana (HARVEY) THURET

Koniya: On rocks and living mollusc shells (1761, 1785 c, 1788 b).

This local plant belongs to var. *plana.*

Geogr. Distrib.: Japan, Pacific Ocean, North America, West Indies, Australia, Europe, North Africa.

Gardnerula corymbosa (HARVEY) J. DE TONI

Koniya: On rocks in the upper littoral zone or along high tide livel (1787, 1798 b, 1799, 1800, 1801, 1802).

Geogr. Distrib.: Japan, North America, Atlantic Ocean, South Asia, Mediterranean, West Indies.

Rivularia atra ROTH

Koniya: On rocks along high tide level or a little below low tide level (1776, 1793, 1838 c).

Geogr. Distrib.: Cosmopolitan.

Rivularia polyotis (AGARDH) BORNET & FLAHAULT

(Fig. 2)

Koniya: On rocks in the upper littoral zone (1796 a). Akakina: On rocks along high tide level (1870 a).

Fronds light or dark olive green, soft, up

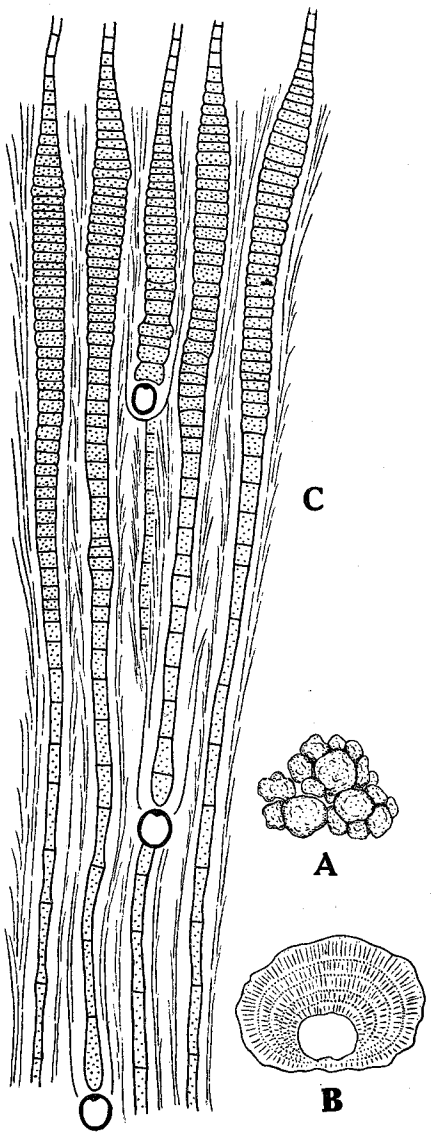

Fig. 2. *Rivularia polyotis* (AGARDH) BORNET & FLAHAULT.
A, habit of fronds, ×⅔. B, vertical section of a frond. ×4. C, part of the vertical section of a frond. ×350.

to 1 cm long or mostly confluent with one another; filaments readily separable under pressure; sheaths thick, colourless or light brown; trichomes 8.5–12μ broad in merismatic region, 2.5–5μ broad near heterocysts; cells in merismatic region 3–9μ long, below 12–30 (40)μ long; basal heterocysts 9–18μ broad.

Geogr. Distrib.: North America, Australia, Europe.

Family Stigonemataceae

Brachytrichia maculans GOMONT

Asani: On rocks in the upper littoral zone (1697, 1699 in part). Yamma: On rocks along high tide level (1740, 1747 in part). Koniya: On rocks in the upper littoral zone (1752 in part, 1774, 1777 in part, 1797 b). Naze: On rocks near high tide level (1854). Akakina: On rocks along high tide level (1864 a, 1867 a). Gusuku: On rocks in the upper littoral zone (1719, 1725 in part).

Geogr. Distrib.: Japan, China, Southern Asia, Pacific Ocean.

Brachytrichia Quoyi (AGARDH) BORNET & FLAHAULT

Asani: On rocks in the upper littoral zone (1703). Gusuku: On rocks in the lower littoral zone (1724). Koniya: On rocks in the upper littoral zone or the lower littoral zone (1768, 1804). Naze: On rocks along high tide level (1852). Akakina: On rocks in the upper littoral zone (1871 a).

Geogr. Distrib.: Japan, Southern Asia, China, Pacific Ocean, North America, West Indies, Australia.

Mastigocoleus testarum LAGERHEIM

Asani: In company with *Plectonema terebrans* in oyster shells (1712 a). Ushuku: In company with *Plectonema terebrans* in a mollusc shell (1876 a). Koniya: In oyster shells and in a dead mollusc shell (1782 c, 1839 a).

Geogr. Distrib.: Japan, Europe, North America, Pacific Ocean, West Indies.

Family Scytonemataceae

Fremyella vitiensis (ASKENACY) J. DE TONI

(Fig. 3)

Koniya: On *Laurencia* sp. with *Calothrix confervicola* (1782 a).

Filaments up to 600μ long, 7–9.2μ broad at the middle; sheaths colourless, thin; trichomes light blue-green, sometimes slightly tapering above, 5(4.5)–6.1μ broad at the middle, not constricted at the cross walls, rarely slightly constricted above; cells 2.5–6(9)μ long; heterocysts basal, usually single, hemisphaerical.

Geogr. Distrib.: Pacific Ocean, North Africa, North America, West Indies.

Scytonema polycystum BORNET & FLAHAULT

(Fig. 4)

Koniya: On rocks in the upper littoral zone (1758 a); on rocks and on *Bostrychia binderi* (1791).

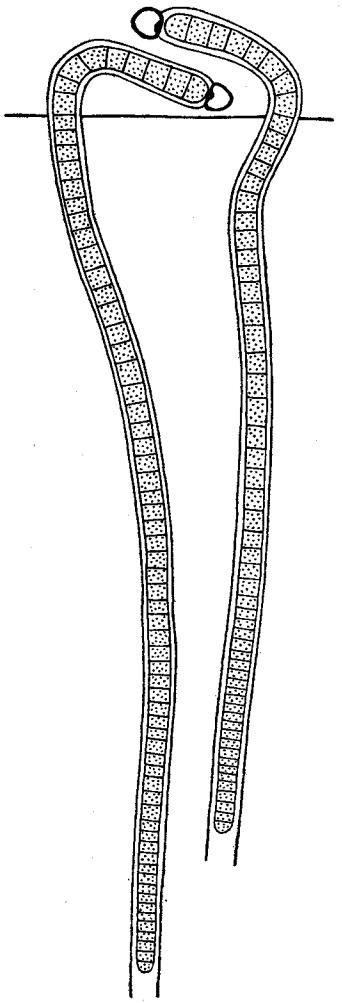

Fig. 3. *Fremyella vitiensis* (ASKENACY) J. DE TONI. Two filaments. ×350.

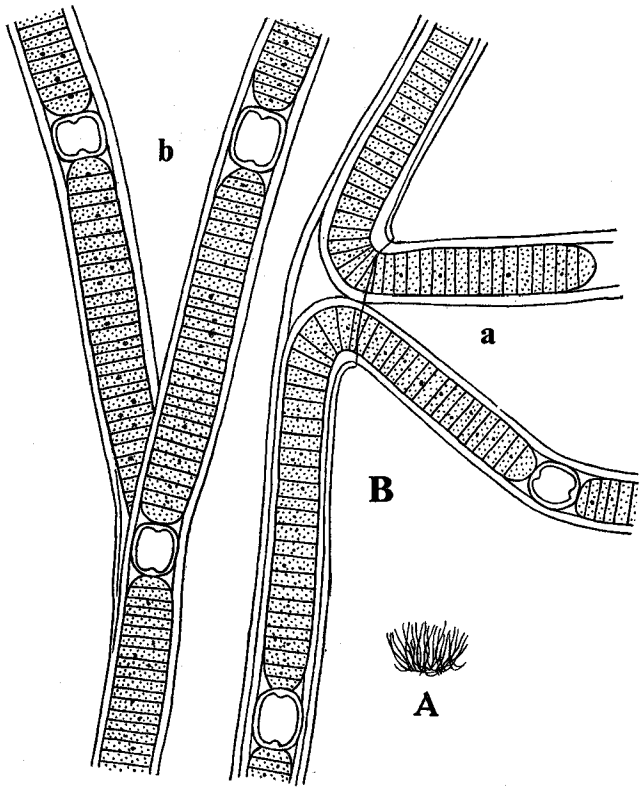

Fig. 4. *Scytonema polycystum* BORNET & FLAHAULT. A, habit of filaments. ×½. B, two portions of filaments showing geminate- (a) and single-branching (b). ×250.

Plant mass 1 cm broad, 1 cm high, grayish green; filaments falsely branched in pairs or single, 16–18 (−22)μ broad; sheaths colourless, up to 3μ thick; trichomes 10–15μ broad; cells 3–6μ long; heterocysts 7–21μ long.

Geogr. Distrib.: Pacific Ocean.

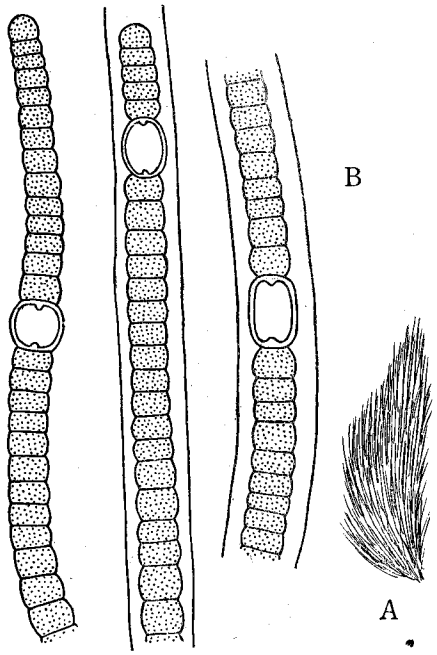

Fig. 5. *Hormothamnin enteromorphoides* GRUNOW.
A, habit of a frond. ×½. B, apical and middle portions of filaments. ×400.

Family Nostocaceae

Hormothamnion enteromorphoides GRUNOW

(Fig. 5)

Koniya: Floating or on *Hypnea cervicornis* and *Sargassum* sp. growing within one meter below low tide level (1757, 1772, 1824 a, 1826).

Plant mass bright blue-green, gelatinous, at first growing on large algae, later floating free; filaments nearly parallel with one another or irregularly arranged; sheaths colourless, diffluent sometimes, thin or sometimes becoming thicker while aging; trichomes blue-green, towards the ends sometimes attenuating slightly; cells nearly spherical or a little shorter than the diameter, 8–9μ broad, 4.5–7.5μ long; heterocysts quadrate or rectangular, 9–10.5μ broad, 10–15.5μ long; spores unknown.

In spite of careful observations from abundant materials the spores could not be found.

Geogr. Distrib.: Pacific Ocean, North America, Southern Asia, West Indies, North Africa.

Family Oscillatoriaceae

Spirulina tenerrima KUETZING

Yamma: In company with *Phormidium epiphyticum* on the sheaths of *Hydrocoleum glutinosum* (1745 b, 1750 b). Ushuku: In company with *Phormidium epiphyticum* on *Hydrocoleum lyngbyaceum* (1855 e).

Geogr. Distrib.: Probably cosmopolitan.

Oscillatoria Bonnemaisonii CROUAN

Koniya: Among the fronds of other Cyanophyceae (1806 e).
Trichomes 20–30 μ broad; cells 4–6.5μ long.
Geogr. Distrib.: Probably cosmopolitan.

Oscillatoria chalybea MERTENS

Koniya: Floating among the filaments of *Scytonema polycystum* and *Hydrocoleum cantharidosmum* (1758 c).

Only a few trichomes having a diameter of 13μ were found among the filaments of other blue-green algae.

Geogr. Distrib.: Cosmopolitan.

Oscillatoria nigro-viridis THWAITES

Asani: On rocks in the upper littoral zone (1704, 1708). Naze: On rocks or on other algae, *Caulacanthus* sp. and *Microdictyon japonicum* (1845, 1847, 1848, 1872). Gusuku: On rocks in the upper littoral zone (1716). Yamma: On other Cyanophycean masses growing on rocks near high tide level (1737 in part).

Geogr. Distrib.: Probably cosmopolitan.

Plectonema terebrans BORNET & FLAHAULT

Asani: In company with *Mastigocoleus testarum* in oyster shells (1712 b). Ushuku: In company with *Mastigocoleus testarum* in a mollusc shell (1876 b).

Geogr. Distrib.: Probably cosmopolitan.

Plectonema norvegicum GOMONT

(Fig. 6 A)

Asani: On *Calothrix crustacea* (1698 b). Gusuku: On *Calothrix crustacea* (1729 b). Yamma: On *Lyngbya semiplena* (1741 b).

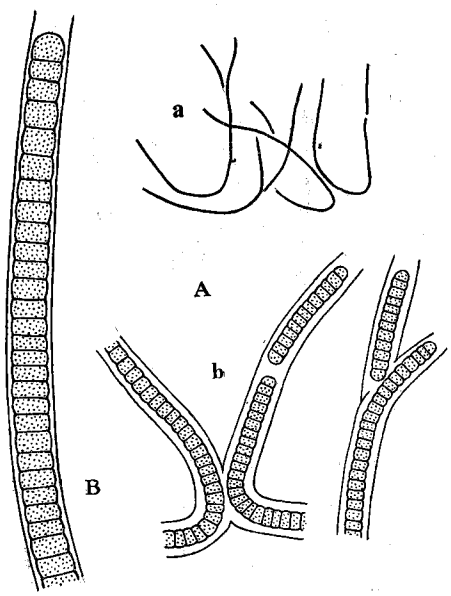

Fig. 6. A. *Plectonoma norvegicum* GOMONT. a, habit of filaments. ×400. b, filament with geminate branching (left) and filament with single (right). ×1,000.
B. *Lyngbya gracilis* RABENHORST. Upper portion of a filament. ×400.

Filaments densely intricated, mostly up to 100 μ long, irregularly curved, 2.5–3.5 μ broad, not attenuating towards the apex; sheaths colourless, thick; trichomes pale blue-green, 1.5–2 μ broad, constricted at the cross walls; cells $\frac{1}{2}$–1 time as long as the diameter; end cells rounded.

Though each local plant from three stations was found epiphytic instead of growing on rocks, they are identical with the characteristics of the species.

Geogr. Distrib.: Australia, Europe.

Plectonema calothrichoides GOMONT

Yamma: On *Gelidium* sp. (1744 in part). Gusuku: On *Nemalion pulvinatum* (1728 in part).

Filaments up to 300 μ long, sometimes branched in pairs, 4–5 μ broad; sheaths colourless; trichomes pale blue-green, 2.5–3.5 μ broad.

Geogr. Distrib.: Japan, North America, Europe.

Plectonema Nostocorum BORNET

(Fig. 7 A)

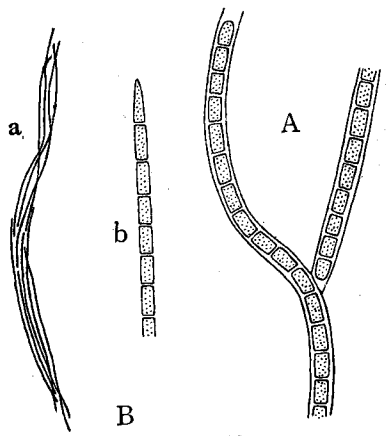

Fig. 7. *Plectonema Nostocorum* BORNET.
Filament with single branching. ×1,000. B. *Microcoleus Voukii* FRÉMY. a, habit of a filament. ×80. b, apical portion of a trichome. ×400.

Yamma: On *Ulva conglobata* (1736 in part).

Filaments intricated, elongate, sparsely branched; false-branches mostly single; sheaths colourless, thin; trichomes pale blue-green, 1–1.3 μ in diam., slightly constricted at the cross walls; dissepiments not granulated, a little pellucid; cells longer than the diameter, 2–2.5 μ in length; end cells rounded.

Geogr. Distrib.: Cosmopolitan.

Phormidium Corium (AGARDH) GOMONT?

Koniya: On rocks in the lower littoral zone, associated with *Hydrocoleum cantharidosmum* (1785 b). Yamma: On concrete near high tide level (1738 in part).

Geogr. Distrib.: Cosmopolitan.

Phormidium epiphyticum GARDNER

Asani: On the sheaths of *Hydrocoleum cantharidosmum* (1706 b). Yamma: In company with *Spirulina tenerrima* on *Hydrocoleum glutinosum* (1745 c, 1750 c).

Ushuku: In company with *Spirulina tenerrima* on *Hydrocoleum lyngbyaceum* (1855 d).
Geogr. Distrib.: Japan, North America, West Indies.

Lyngbya Rivulariarum GOMONT

Koniya: In the fronds of *Rivularia polyotis* (1796 b).
Geogr. Distrib.: Probably cosmopolitan.

Lyngbya infixa FRÉMY

Asani: On *Gelidium* sp. and *Bostrychia binderi* (1701 in part).
Geogr. Distrib.: Japan, West Indies, Europe.

Lyngbya Nordgardhii WILLE

Gusuku: On *Gelidium* sp. (1726 in part).
Geogr. Distrib.: Japan, North America, West Indies, Europe.

Lyngbya gracilis RABENHORST

(Fig. 6 B)

Asani: On *Caulacanthus* sp. (1709 in part). Koniya: On shaded rocks along high tide level (1913 a).

In the local plants the filaments were very short compared with the description by GOMONT. Concerning the diameter and colour of the trichome and the cell-length these seem to be the nearest to this species.

Geogr. Distrib.: Japan, North America, West Indies, Europe.

Lyngbya sordida (ZANARDINI) GOMONT

Koniya: On *Centroceras clavulatum* (1809). Ushuku: With filamentous diatoms on rocks in the upper littoral zone (1860, 1861).

In addition to the filaments having normal diameter, the specimen 1861 contains the filaments having the larger dimension from 52μ to 59μ, which seem to be the f. *maxima* mihi, although the trichome is yellowish-green instead of rose coloured. Such filaments were found in a mixture with those of typical form.

Geogr. Distrib.: Japan, Pacific Ocean, West Indies, Australia, Europe.

Lyngbya majuscula HARVEY

Koniya: Associating with *Jania* sp. on rocks a little below low tide level (1823). Filaments up to 1 cm long, 37–61.4μ broad; sheaths 4.5–9μ thick; trichomes

28–43.5μ broad; cells 2.5–6μ long.

Geogr. Distrib.: Cosmopolitan.

Lyngbya confervoides C. AGARDH

Asani: On rocks in the lower littoral zone (1715). Koniya: Floating on the surface of sea (1765).

Geogr. Distrib.: Cosmopolitan.

Lyngbya semiplena (C. AGARDH) J. AGARDH

Naze: On concrete and rocks near high tide level (1840 a, 1841). Yamma: On rocks near high tide level (1736, 1741 a, 1743). Koniya: On rocks in the upper littoral zone (1760, 1790 c, 1798 a). Akakina: With *Calothrix crustacea* on rocks in the lower littoral zone (1864 c).

Geogr. Distrib.: Cosmopolitan.

Lyngbya lutea (AGARDH) GOMONT

Yamma: On rocks in a rock depression in the upper littoral zone (1749). Koniya: On rocks in a rock depression a little above high tide level (1816 a).

Geogr. Distrib.: Probably cosmopolitan.

Lyngbya aestuarii (MERTENS) LIEBMANN

Koniya: On rocks and on *Bostrychia binderi* growing on rocks in the upper littoral zone (1754 in part, 1756 a, 1763 a, 1764 a, 1784 a, 1806 a, 1816 b, 1822 a, 1883).

Geogr. Distrib.: Cosmopolitan.

Microcoleus tenerrimus GOMONT

Asani: Scattered among small red algae (1711 in part). Yamma: On *Ulva conglobata* (1736 in part); on concrete near high tide level (1738 in part); associating with *Hydrocoleum glutinosum* (1750 d). Koniya: Associating with *Microcoleus chthonoplastes* and *Hydrocoleum lyngbyaceum* (1803 c); with *Lyngbya aestuarii* (1806 c); with *Microcoleus chthonoplastes* on rocks in the upper littoral zone (1815 b). Ushuku: With *Microcoleus chthonoplastes* and *Hydrocoleum lyngbyaceum* (1855 c). Akakina: With *Microcoleus chthonoplastes* on rocks in the upper littoral zone (1866 b, 1870 d).

Geogr. Distrib.: Cosmopolitan.

Microcoleus chthonoplastes THURET

Ushuku: With *Microcoleus tenerrimus* and *Hydrocoleum lyngbyaceum* on rocks

along high tide level (1855 b). Akakina: With *Microcoleus tenerrimus* on rocks in the upper littoral zone (1866 a, 1870 c). Koniya: Among the filaments of *Calothrix pilosa* (1753 b, 1807 b); On rocks and *Bostrychia binderi* growing on rocks along high tide level (1755 in part); among the fronds of *Hydrocoleum lyngbyaceum* (1803 b); with *Lyngbya aestuarii* (1806 b); with *Microcleus tenerrimus* on rocks in the upper littoral zone (1815 a). Naze: On *Bostrychia binderi* (1844). Asani: On shaded rocks in the upper littoral zone (1700 a).

Geogr. Distrib.: Cosmopolitan.

Microcoleus Voukii FRÉMY

(Fig. 7 B)

Gusuku: Among the utricles of *Codium intricatum* (1732).

Filaments endophytic, simple or sparsely branched; sheaths colourless, mostly diffluent; trichomes pale blue-green, 1.6–1.8μ broad, not constricted at the cross walls; dissepiments pellucid, not granulated; cells 3.2–9μ long; protoplast homogeneous; end cells sharply conical.

According to FRÉMY, this species bears the nearest resemblance to *Microcoleus tenerrimus*, from which he distinguished it only by the characteristics that the trichome is purple in colour and not constricted at the cross walls. The trichome of this local plant is pale blue-green and nearly resembling *M. tenerrimus*, although it was found endophytic.

Geogr. Distrib.: Europe.

Hydrocoleum lyngbyaceum KUETZING

Koniya: Associated with *Microcoleus chthonoplastes* and *M. tenerrimus* on rocks a little below high tide level (1803 a); On *Hypnea cervicornis* (1824 b). Ushuku: With *Microcoleus tenerrimus* and *M. chthonoplastes* on rocks along high tide level (1855 a). Akakina: In company with *Microcoleus chthonoplastes* and *M. tenerrimus* (1866 c). Yamma: On rocks in the upper littoral zone (1747 in part).

Geogr. Distrib.: Cosmopolitan.

Hydrocoleum cantharidosmum (MONTAGNE) GOMONT

Asani: On rocks in the upper littoral zone (1706 a). Gusuku: On rocks in the lower littoral zone (1726 in part). Koniya: Among the masses of *Scytonema polycystum* (1758 b); on rocks in the lower or upper littoral zone (1763 b, 1769, 1773, 1783 a, 1789, 1805, 1811, 1820, 1822 b).

Geogr. Distrib.: Japan, Southern Asia, Pacific Ocean, West Indies, Australia.

Hydrocoleum glutinosum (AGARDH) GOMONT

Yamma: On rocks in the upper littoral zone (1745 a, 1750 a). Koniya: On rocks a little above high tide level (1814). Naze: On rocks in the upper littoral zone (1851).

Geogr. Distrib.: Japan, Pacific Ocean, North America, West Indies, Australia, Europe, Indian Ocean.

Hydrocoleum coccineum GOMONT

Asani: Among the utricles of *Codium adhaerens* (1710). Gusuku: Among the utricles of *Codium adhaerens* (1734). Koniya: Among the utricles of *Codium adhaerens* (1835). Ushuku: Among the utricles of *Codium adhaerens* (1878).

All of the alga from Amami-Oshima have the trichomes 3–4.5μ or 5.5μ in diameter, a little more slender than those of the original specimen cited by GOMONT.

Geogr. Distrib.: Japan, Pacific Ocean, North America, Indian Ocean, Europe.

Symploca hydnoides KUETZING

Asani: On rocks in the upper littoral zone (1705). Naze: On rocks in the upper littoral zone (1849). Gusuku: On rocks in the upper littoral zone (1718).

The local specimens are forming fasciculated tufts 1–4 cm high.

Geogr. Distrib.: Cosmopolitan.

VII. Summary

1. This paper deals with the floristic, ecological and phytogeographical studies on the marine Cyanophyceae of Amami-Oshima island.

2. 7 families, 21 genera, 51 species are enumerated, among them 7 species being new to Japan.

3. The stations visited to collect the material are the following seven localities: Naze, Asani, Akakina, Ushuku, Yamma, Gusuku, and Koniya. Among these stations the Koniya coast is best not only in being plentiful in the marine flora but also for the convenience of collecting the material.

4. On the basis of the ecological variation in habit, the species of Amami-Oshima island are classified into the following five forms: (1) planktonic form, (2) lithophytic form, (3) epiphytic form, (4) endophytic form, and (5) shell-perforating form. 5 species belong to the planktonic form, 25 to the lithophytic form, 14 to the epiphytic form, 4 to the endophytic form, and 3 to the shell-perforating form.

5. *Coccochloris stagnina*, *Anacystis dimidiata*, *Agmenellum thermale*, *Calothrix balearica*, *Spirulina tenerrima*, *Oscillatoria chalybea*, *Plectonema Nostocorum*, *Phormidium Corium*, *Lyngbya lutea*, *L. aestuarii*, and *L. Rivulariarum* whose habitats are

generally in fresh water, although they occasionally grow in marine water, are included here.

6. 29 cosmopolitan or probably cosmopolitan species, which grow also on the coast of Honshu, are recqrded.

7. 42 of these species have already been reported from Japan proper, 24 from Hokkaido, 2 from the China coast, 17 from Southeast Asia, 34 from the warmer Pacific Ocean, 37 from the Pacific coast of North America, 37 from the West Indies, 21 from Australia, and 43 from Europe.

8. *Gardnerula corymbosa*, *Fremyella vitiensis*, *Scytonema polycystum*, and *Hormothamnion enteromorphoides* which seem to be of tropical origin, are listed here.

9. From the phytogeographical standpoint, the marine Cyanophycean composition of Amami-Oshima island is considered to be subtropical.

VIII. Acknowledgements

Here the writer wishes to express his sincere thanks to Dr. Y. YONEDA of the Department of Fisheries, Faculty of Agriculture, Kyoto University, who gave him most kind guidance during the course of this study. Thanks are also due to Dr. F. DROUET of the Cryptogamic Herbarium, Chicago Natural History Museum, Chicago, who sent him a number of the specimens of *Symploca hydnoides* and *Gardnerula corymbosa* from various localities in the world and gave him valuable suggestions in determining the present species, and who read this manuscript.

REFERENCES

BATTERS, E. A. 1902. A catalogue of the British marine algae. Journ. of Bot. 40 (supplement 1) : 1–107.

BORNET, E., & C. FLAHAULT. 1886–1888. Révision des Nostocacées hétérocystées contenues dans les principaux herbiers de France. Ann. Sc. Nat. VII, Bot. 3 : 323–380 ; 4 : 343–373 ; 5 : 51–129 ; 7 : 177–268.

DAWSON, E. A. 1954. Marine plants in the vicinity of the Institut Oceanographique de Nha Trang, Viet Nam. Pac. Sci. 8 (4) : 377–469.

DE TONI, J. 1936. Noterelle di nomenclatura algologica. VIII. Terzo elenco di Missoficee omonime. 1–6. Brescia.

DROUET, F. 1936. Myxophyceae of the G. Allan Hancock Expedition of 1934, collected by Wm. R. Taylor. Hancock Pac. Exped. 3 (2) : 15–31, pls. 2–3.

———— 1951. Cyanophyta, in SMITH's Manual of Phycology, 159–166.

DROUET, F., & W. A. DAILY. 1956. Revision of the coccoid Myxophyceae. Butler Univ. Bot. Stud. 12 : 1–218, 377 figs.

FELDMANN, J. 1937. Les algues marines de la côte des Alberes. I. Cyanophyceae. Rev. Algol. 9 (3–4) : 141–172.

FRÉMY, P. 1934. Les Cyanophycées des côtes d'Europe. Mém. Soc. Nat. Sc. nat. et math. de Cherbourg. 41 : 1–234, 66 pls.

———— 1936. Marine algae from the Canary Islands, especially from Teneriffe and Gran Canaria. IV. Cyanophyceae. Kgl. Dansk. Vidensk. Sels. Biol. Meddel. 12 (5) : 4–43.

———— 1939. Cyanophycées marines des anciennes Antilles Danoises, in BOERGESEN's Marine algae of the Danish West Indies. Dansk. Botanik Arkiv. 9 (7) : 5–46.

———— 1941. Cyanophycées des Iles Bonaire, Curacae et Aruba d'aprés les recoltes de M. Wagenaar Hummelink (Utrecht) en 1930. Rev. Algol. 12 (1-2) : 102-152.

GARDNER, N. L. 1918. New Pacific coast marine algae. I-IV. Univ. Calif. Publ. Bot. 6 : 377-416, pls. 31-35 ; 429-454, pls. 36-37 ; 455-486, pls. 38-41 ; 487-496, pl. 42.

———— 1932. The Myxophyceae of Porto Rico and the Virgin Islands. Surv. of Porto Rico and the Virgin Isl. 8 (2) : 249-311, pls. 1-2.

GEITLER, L. 1932. Cyanophyceae, in RABENHORST'S Kryptogamen-Flora von Europa. 14 : 1-1196, 780 figs. Leipzig.

GOMONT, M. 1892. Monographie des Oscillariées (Nostocacées homocystées). Ann. Sc. Nat. VII. Bot. 15 : 263-369, pls. 6-14 ; 16 : 91-264, pls. 1-5.

———— 1899. Sur quelques Oscillariées nouvelles. Bull. Soc. Bot. de France 46 (24) : 25-40, pl. 1.

———— 1901. Myxophyceae hormogoneae, in SCHMIDT'S Flora of Koh Chang. Bot. Tidsskr. 24 : 202-211, pl. 1.

GUILER, E. R. 1952. The marine algae of Tasmania, check list with localities. Pap. & Proc. Roy. Soc. Tasmania 86 : 71-106.

JAO, C.-C. 1948. The marine Myxophyceae in the vicinity of Friday Harbor, Washington. Bot. Bull. Acad. Sinica 2 : 161-176, fig. 1.

LINDSTEDT, A. 1943. Die Flora der marinen Cyanophyceen du schwedischen Westkueste. viii-121, 11 pls.

MAY, V. 1953. Some marine algae from New Caledonia collected by Mrs. R. Catala. Contrib. New South Wales Nat. Herb. 2 (1) : 38-66.

MOELDER, K. 1945. Die Cyanophyceenflora Estlands. Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo. 20 (4) : 1-21.

NEWTON, L. 1931. A handbook of the British seaweeds. xiii-478, 270 figs. London.

NIEL, M. C. 1930. Hawaiian marine algae. Bernice P. Bishop Museum Bulletin 67 : ii-84.

SETCHELL, W. A. 1926. Tahitian algae collected by W. A. Setchell, C. B. Setchell, and H. E. Parks. Univ. Calif. Publ. Bot. 12 (5) : 61-142, pls. 7-22.

SETCHELL, W. A., & N. L. GARDNER. 1903. Algae of Northwestern America. *Ibid.* 1 : 154-418, 21 pls.

———— . ———— 1919. The marine algae of the Pacific coast of North America. Part 1. Myxophyceae. *Ibid.* 8 (1) : 1-138, pls. 1-18.

———— . ———— 1924. New marine algae from the gulf of California. Proc. Calif. Acad. of Sc. Ser. IV. 12 (29) : 659-704, pl. 12.

TAYLOR, WM. R. 1942. Marine algae from Haiti collected by H. H. Bartlett in 1914. Rep. of Michigan Acad. Sc. Arts and Letters, 28 : 143-163, pls. 1-4.

———— 1945. Pacific marine algae of the Allan Hancock Expedition to the Galapagos Island. Allan Hancock Pac. Exped. 12 (1) : iv-528, 100 pls.

———— 1950. Plants of Bikini and other northern islands. 1-227. Ann Arbor.

TSENG, C. K. 1936. On marine algae new to China. Fan Mem. Inst. Biol. Bull. (Bot). 7 (5) : 169-196.

———— 1940. Marine algae of Hong Kong, historical survey and list of recorded species. Journ. Hong Kong Fish Res. Stat. 1 (2) : 194-210.

TILDEN, J. 1910. Minnesota Algae. I. The Myxophyceae of North America and adjacent regions including Central America, Greenland, Bermuda, the West Indies and Hawaii. Rep. Surv. Bot. Ser. 8 : iv-328, 20 pls.

UMEZAKI, I. 1950-1956a. Marine Cyanophyceae from Japan (1-12). Journ. Jap. Bot. 25 (9-12) : 224-228 ; 26 (7) : 203-205 ; 26 (9) : 267-269 ; 27 (4) : 117-120 ; 27 (7) : 219-222 ; 28 (6) : 165-170 ; 28 (7) : 201-203 ; 28 (8) : 236-239 ; 28 (12) : 363-366 ; 29 (6) : 172-176 ; 29 (7) : 217-220 ; 31 (2) : 33-36. [In Japanese]

———— 1955a. Marine Cyanophyceae from the Shima Peninsula (1-2). *Ibid.* 30 (2) : 57-62 ; 30 (7) : 209-214.

———— 1955b. Some marine Cyanophyceae of the Tokara Islands. Bot. Mag. Tokyo 68 (801) : 63-70.

———— 1956b. Marine Cyanophyceae from Hokkaido. Acta Phytotax. Geobot. 16 (3) : 84-90. [In Japanese]

———— 1956c. On a collection of *Gardnerula corymbosa* (Harvey) J. de Toni. Publ. Seto Mar. Biol. Lab. 5 (2) : 291-295.

WEBER-VAN BOSSE, A. 1913. Liste des algues du Siboga. I. Myxophyceae, Chlorophyceae, Phaeophyceae avec le concours de M. Th. Reinbold. Siboga-Exped. Monogr. 59(a) : 1-186, figs. 1-52, pls. 1-5.

———— 1926. Algues de l'expedition danois aux iles Kei. Vidensk. Meddel. Dansk Naturh Foren. 81 : 57-155, 43 figs.

WOMERSLEY, H. B. 1946. Studies on the marine algae of the Southern Australia. Introduction and No. 1. The genera *Isactis* and *Rivularia* (Myxophyceae). Trans. Roy. Soc. S. Aust. 70 (1) : 127-136.

———— 1950. The marine algae of Kangaroo island. III. List of species I. *Ibid.* 73 (2) : 137-197.