瀬戸内海の汚染海域から検出された鞭毛虫類

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The Flagellata Examined from Polluted Water of the Inland Sea, Setonaikai[1]

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Abstract

In the Inland Sea, Hiroshima Bay and its adjacent region is so exceedingly polluted recently with industrial drainage, city sewage and human wastes, that present blooming flagellates differing from ones of the former years have occurred. Also these number has lately become large in sea. *Rhodomonas lacustris* PASCHHER & RÜTTER, *Heterosigma inlandica* HADA and *Hemieutreptia antiqua* n. sp. frequently bloom to cause colored water in present years. Of these, the last new species is the most notiable flagellate causing a terrible damage to the fishery of cultured yellowtails in the Inland Sea. There have been 80 colored species including six new forms and 26 colorless ones of the Class Chromonadea and 21 heterotrophic flagellates of the Class Leucomonadea collected from the sea. The colored flagellates, closely related to colored water have annually increase in number of species, of which the small forms included in the nannoplankton and ones well-known as fresh water species are increasing in recent years.

Introduction

The materials of the present study have been mainly collected since 1956 from Hiroshima Bay and its adjacent sea off the western coast of Hiroshima-Ken and the south-eastern coast of Yamaguchi-Ken in the western district of the Inland Sea. Into the sea are three long rivers, Ota, Oze and Nishiki. Four cities, Kure, Hiroshima and Otake in Hiroshima-Ken and Iwakuni in Yamaguchi-Ken, are distributed on the northern coast of the sea. Excepting Hiroshima City, these cities have many plants draining polluted water, especially at Otake and Iwakuni cities, in which the oil plants pour a great amount of industrial drainage containing dissolved nutriments favorable for reproduction of flagellates into the western region of the sea. Besides this, the main origin of the water pollution in the sea is city sewege and thrown body wastes. Nutrient substances in such polluted water are the source of colored water, so-called *Akashiwo* in Japan, which is caused by blooms of unicellular organisms, carrying chromatophores, which are typically flagellates and diatoms in the seas.

Collections of the materials were made by myself and the research boats of the Hiroshima-Ken Fisheries Experiment Station, and the most of my collections were carried out without an use of a plankton-net in the fishery port of Itsukaichi. Excepting large thecate dinoflagellates, all of examined forms have been studied in a living natural condition.

The classification of the Flagellata agrees to the system of the Society of Protozoologists Committee on Taxonomy and Taxonomic Problems (1961).

[1] 瀬戸内海の汚染海域から検出された鞭毛虫類。
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Table 1. The colored species of the Class Chromonadea examined from the Inland Sea (* Showing the species blooming in polluted water.)

Order Chrysomonadida	
Suborder Euchrysomonadina	
Family Chromuliniidae	
1. *Chromulina ovalis* KLEBS	May—October
2. *C. biconvex* n. sp.	June—September
3. *C. triangula* n. sp.	May, June
4. *Kephyrion spirale* (LACKEY)	June—September
5. *K. mosquense* GUSEWAI?	April—November
6. *K. spinosum* n. sp.	September
7. *Kephyrion* sp.?	September
Family Ochromonadidae	
8. *Ochromonas crenata* KLEBS	May—July
Family Prymnesiidae	
9. *Chrysochromulina parva* LACKEY	June
Suborder Silicoflagellina	
Family Distephaniidae	
10. *Dictyocha fibula* EHRENBERG	May—September
11. *Distephanus speculus* (EHRENBERG)	Summer
12. *Mesocena polymorpha* (EHRENBERG)	May
Order Cocolithophorida	
Family Syracosphaeridae	
13. *Pontosphaera huxleyi* LOHMANN	April—August
14. *Calyptrosphaera oblonga* LOHMANN	June
Family Coccolithiidae	
15. *Coccolithus pelagicus* (WALLISCH)	January—April
Order Heterochlorida	
Family Chloromesonidae	
16. *Olisthodiscus luteus* CARTER	April
Order Cryptomonadida	
Family Cryptochrysididae	
17. *Cryptochrysis polychrysis* PASCHER	August, September
18. *C. gigas* PASCHER	April—July
19. **Rhodomonas baltica* KARSTEN	April—September
20. **R. ovalis* NYGAARD	June—November
21. **R. lacustris* PASCHER & RÜTTER	Throughout the year
22. *R. nannoplanctica* SKUJA	June, July
Family Nephroselmidae	
23. *Protochrysis phaeophycearum* PASCHER	Spring
24. *P. minimum* n. sp.	May—July
Order Dinoflagellida	
Suborder Adinidina	
Family Haplodiniidae	
25. **Haplodinium antijolense* KLEBS	May—June
Family Prorocentridae	
26. *Prorocentrum micans* EHRENBERG	Autumn
27. *P. redifieldi* BURSA	May—August
28. *Exuviaella marina* CIENKO	Throughout the year
29. *E. compressa* (BAILEY)	September
30. *Exuviaella* sp.	May—October
Suborder Diniferina	
Family Heterosigmidae	
31. **Heterosigma inlandica* HADA	May—September

Table 1. continued

Family Dinophysididae	
32. *Pharacroma rotundata* (CLAP. & LACHM.)	Summer
33. *Dinophysis caudatum* SAVILLE-KENT	April—October
34. *D. ovum* SCHÜTT	Spring
Family Gymnodiniidae	
35. *Amphidium turbo* SCHÜTT	Summer
36. **Gymnodinium simplex* LOHMANN	Throughout the year
37. **G. mikimotoi* MIYAKE & KOMINAMI	May—September
38. **G. ostenfeldi* SCHILLEER	Summer
39. *G. catenatum* GRAHAM	September
40. *G. splendens* LEBOUR	Throughout the year
41. *G. paulseni* SCHILLER	Spring
42. *G. japonicum* n. sp.	May—September
43. *G. lunulum* SCHÜTT	Summer
Family Peridiniidae	
44. *Pyrophacus horolongicus* STEIN	July—October
45. *Diplopsalis lenticula* BERGH	Autumn
46. *Gonyaulax polygramma* STEIN	Summer
47. *G. diegensis* KOFOID	Summer
48. *G. spinifera* (CLAP. & LACHM.)	Spring
49. *Peridinium trochoidum* (STEIN)	Throughout the year
50. *P. divergens* EHRENBERG	August
51. **P. quinquecorne* ABE	Summer
52. *P. nipponicum* ABE	Summer
53. *P. cerasum* PAULSEN	May—September
54. *P. orbiculare* var. *temari* ABE	Summer
55. *P. hirobis* ABE	Summer
56. *P. adriaticum* BROCH	February—April
57. *P. oblongum* (AURIVILIUS)	October—February
58. *P. conicum* (GRAN)	Throughout the year
59. *P. pentagonium* (GRAN)	Summer
60. *P. depressum* BAILEY	March—May
61. *Ceratium fusum* (EHRENBERG)	March—October
62. *C. furcum* (EHRENBERG)	Throughout the year
63. *C. lineatum* (EHRENBERG)	May
64. *C. tripos* (MÜLLER)	Throughout the year
65. *C. gibberum* GOURRET	February—August
Order Euglenoida	
Suborder Hemieuglenoina	
Family Hemieutreptiidae	
66. **Hemieutreptia antiqua* n. sp.	July—September
Suborder Euglenoina	
Family Eutreptiidae	
67. *Eutreptiella viridis* PERTY	Summer
68. *E. marina* da CUNHA	April—November
Family Eugleniidae	
69. *Euglena gracilis* KLEBS	April—August
70. *E. pisciformis* KLEBS	July
Order Chloromonadida	
Family Rhaphidomonadidae	
71. *Rhaphidomonas depressum* LAUTERBORN	June
72. *R. semen* STEIN	November

Family Thaumatomastixiidae	
73. *Thaumatomastix setifera* LAUTERBORN	Throughout the year
Order Phytomonadida	
Family Polyblepharididae	
74. **Dunaliella salina* (DUNKERLEY)	June
75. *Pyramimonas* sp.	Throughout the year
Family Chlamydomonanidae	
76. *Chlamydomonas* spp.	April—August
77. *Chlorogonium euchlorum* EHRENBERG	June
78. *C. elongatum* DANGEARD	June
79. *Carteria cordiformis* (CARTER)	April—July
Family Volvocidae	
80. *Pandorina mora* BORY	May

Colored Flagellata

The unicellular organisms with flagella, Superclass Mastigophora, are divided into two autotrophic and heterotrophic groups, Class Chromonadea and Class Leucomonadea. In the autotrophic class many species having no chromatophore are also included. In the present study, therefore, the colored Flagellata include only flagellates of the Class Chromonadea containing one or more chromatophores. The colored Flagellata having a faculity of photosynthesis are not principally related to polluted water of the sea, but they reproduce by making use of sufficient nutrient substances in polluted water, and some of them bloom to be representative organisms of colored water.

From the sea where collections were made, 80 forms of the colored flagellates have been examined, of which six are probably new species as in Table 1. These flagellates belong to eight orders of the Class Chromonadea except the Order Ebriacida consisting only of colorless species. The order of the greatest number of species is the Dinoflagellida, having 21 forms, and the smallest is the Heterochlorida consisting of a single amoeboid species, *Olisthodiscus luteus* CARTER (Fig. 2–3). Of the Order Chroysomonadida, the small species simple in structue annually increase in company with three new species, and a rare flagellate with three flagella, *Chrysochromulina parva* LACKEY (Fig. 2–1). The species of the Order Cryptomonadida also increase year by year. Four forms including a new species have been observed from Hiroshima Bay in 1972 as follows: Changeable *Cryptochrysis gigas* PASCHER (Fig. 3–1), small *Rhodomonas nannoplanctica* SKUJA (Fig. 3–2), curved *Protochrysis phaeophycerum* PASCHER (Fig. 3–3) and small *P. minimum* n. sp. (Fig. 3–4). In the order are included the following species blooming to make brown colored water: elongate *Rhodomonas baltica* KARSTEN and ovoid *R. ovalis* NYGAARD having two chromatophores bloomed until a few years ago, while *R. lacustris* PASCHER & RÜTTER with a single chromatophore blooms in recent years. In the Order Dinoflagellida six species blooming in Hiroshima Bay have been observed. *Haplodinium antijolense* KLEBS carrying an ovoid discal cellulose cover rarely bloom in the early summer in the bay. The primitive unarmored dinoflagellate, *Heterosigma inlandica* HADA, annually bloomed since 1967 everywhere in the Inland Sea and also in Hakata Bay and the Ariake Sea in Kyushu. *Gymnodinium simplex* LOHMANN and *G. mikimotoi* MIYAKE & KOMINAMI often bloom in Hiroshima Bay. In the fall season of 1959, the former bloomed in the bay and numerous brown specimens attached on mantles of the cultured oysters, hung in water, changing the oyster to a brown color. The latter had been first recorded as a blooming flagellate in Japan, and frequently bloomed in

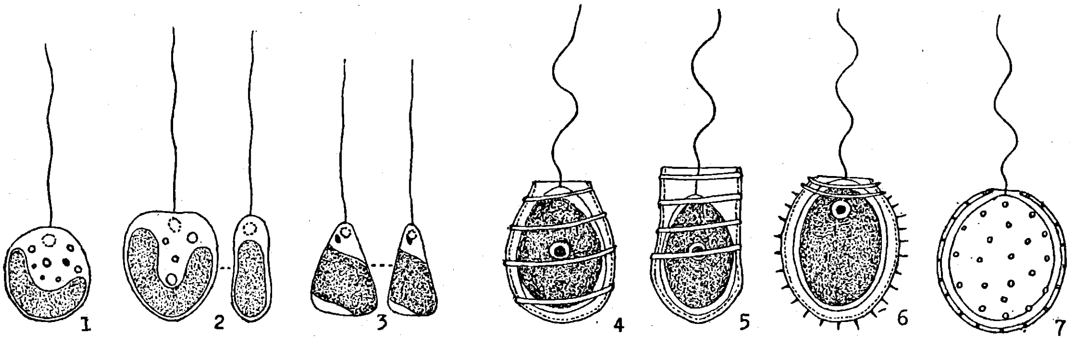

Fig. 1-1. *Chromulina ovalis* KLEBS, 2,000 X.
Fig. 1-2. *Chromulina biconvex* n. sp., 2,000 X.
Fig. 1-3. *Chromulina triangula* n. sp., 2,000 X.
Fig. 1-4. *Kephyrion spirale* (LACKEY), 4,500 X.
Fig. 1-5. *Kephyrion mosquense* GUSEWAI ? 4,000 X.
Fig. 1-6. *Kephyrion spinosum* n. sp., 4,500 X.
Fig. 1-7. *Kephyrion* sp., 4,000 X.

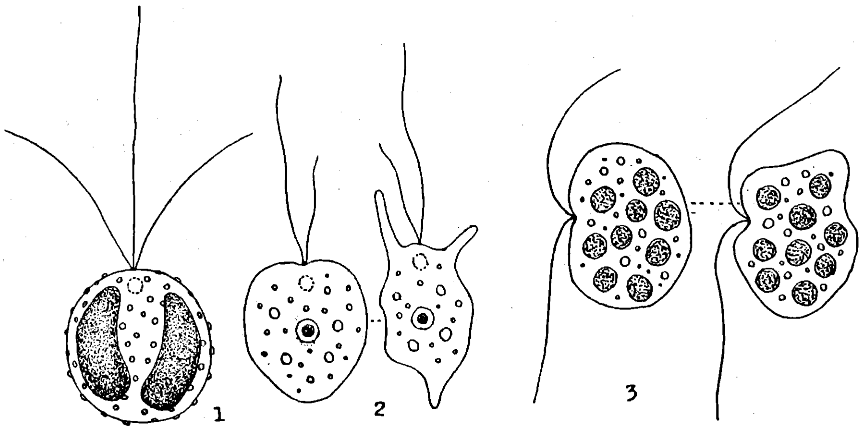

Fig. 2-1. *Chrysochromulina parva* LACKEY, 1,100 X.
Fig. 2-2. *Polypseudopodius bacterioides* PUSCHKAREW, 1,300 X.
Fig. 2-3. *Olisthodiscus luteus* CARTER, 1,400 X.

neritic waters in Japan. *G. ostenfeldi* SCHILLER having a red pulsing vacuole so-called eye-spot annually bloomed until 1964 in Hiroshima Bay, but it has not so afterward. The armored species, *Peridinium quinquecorne* ABE, had bloomed every summer to 1968, but has not bloomed since.

Of the order Euglenoida comparising many forms occurring in polluted water, five species have been found from the Inland Sea. One of them, *Hemieutreptia antiqua* n. sp. is remarkably primitive in structure of the cell and blooms to cause terrible damage to the cultivating fishery of young yellowtails, called *hamachi* in Japan. The most serious injury happened in coastal waters of Hiroshima-Ken in 1970 and also in the eastern region of the Inland Sea, Harimanada, in 1972. The blooming species were first found by myself in summer of 1967 in Hiroshima Bay. Afterwards the primitive flagellate, reproductive in polluted water has spread the whole area of the Inland Sea. This is the most notable species among the blooming colored flagellates in the Inland Sea. Of the Order Chloromonadida, only three forms have been secured from the region where the research was conducted. One of these,

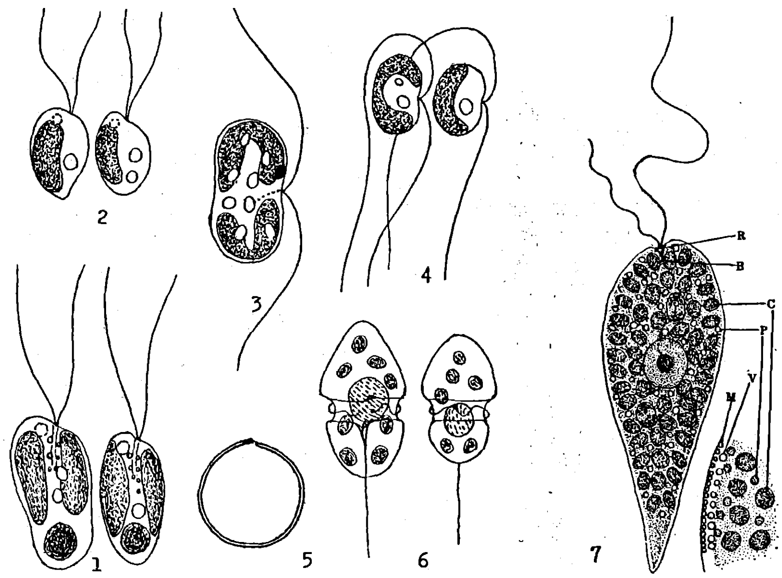

Fig. 3-1. *Cryptochrysis gigas* PASCHER, 1,500 X.
Fig. 3-2. *Rhodomonas nannoplanctica* SKUJA, 2,000 X.
Fig. 3-3. *Protochrysis phaeophycearum* PASCHER, 1,200 X.
Fig. 3-4. *Protochrysis minimum* n. sp., 2,000 X.
Fig. 3-5. *Exuviaella* sp., 1,000 X.
Fig. 3-6. *Gymnodinium japonicum* n. sp., 2,500 X.
Fig. 3-7. *Hemieutreptia antiqua* n. sp., 1,500 X.
B. blepharoplast; C. chromatophore;
M. mucous body; P. paramylon grain;
R. reservoir; V. contractile vacuole.

Thaumatomastix setifera LAUTERBORN, stretching out occationally thread-like pseudopodia, is common in the sea all year found. The colored forms of the Order Phytomonadida examined from the sea are not so many nowadays, but an inclination of increasing numbers is observed in the study of the Flagellata. *Dunaliella salina* (DUNKERLEY) making a pretty reddish bloom was observed once in the port of Itsukaichi in July of 1961.

In Hiroshima Bay and its adjacent sea the colored flagellates blooming to compose collored water are as 11 species in the observations made up to date. Only two of 11 bloom-

Table 2. The colorless species of the Class Chromonadea examined from the Inland Sea

Order Chrysomonadida	
Suborder Euchrysomonadina	
Family Chromuliniidae	
1. *Heterochromulina termo* (EHRENBERG)	Throughout the year
Family Ochromonadidae	
2. *Monas minima* MEYER	Throughout the year
3. *Polypseudopodius bacterioides* PUSCHKAREW	April
Order Cryptomonadida	
Family Chilomonadidae	
4. *Chilomonas paramecium* EHRENBERG	Throughout the year
5. *C. oblongum* PASCHER	April—August
6. *Cyathomonas truncatum*	October
Order Dinoflagellida	
Suborder Diniferia	
Family Entomosigmidae	
7. *Entomosigma peridinoides* SCHILLER	May—September
Family Protonoctilucidae	
8. *Oxyrrhis marina* DUJARDIN	April—October
Family Gymnodiniidae	
9. *Gymnodinium minor* LEBOUR	Throughout the year
10. *G. marinum* KENT	April—October
11. *G. ovulum* KOFOID & SWEZY	April—August
12. *G. arcuatum* KOFOID	July
13. *Gyrodinium flavum* KOFOID	Throughout the year
Family Polykrikiidae	
14. *Polykrikos schwartzi* BÜTSCHLI	Summer
Family Noctilucidae	
15. *Noctiluca scintillans* (MACARTONEY)	Throughout the year
Order Ebriacida	
Family Ebriidae	
16. *Ebria tripartia* (SCHUMANN)	May—October
17. *E. longispina* HADA	November
Order Euglenoida	
Suborder Euglenoina	
Family Astasiidae	
18. *Astasia vacuolata* SKUJA	Summer
Suborder Peranemina	
Family Anisonemidae	
19. *Anisonema ovale* KLEBS	October—January
20. *A. acina* DUJARDIN	June—November
22. *A. prosgeobia* SKUJA	April, November
Suborder Petalomonadina	
Family Petalomonadidae	
23. *Parmidium scutalum* (SKUJA)	November
Order Phytomonadida	
Family Polyblepharididae	
24. *Polytomella agilis* ARAGOA	April
25. *Tussetia polytomoides* PASCHER	April—June

ing forms have given direct bad influences to the coastal fishery: *Gymnodinium simplex* decreased the price of oysters by coloring brown, and *Hemieutreptia antiqua* killed an enormous number of young yellowtails by a respiratory injury of mucous.

Colorless Flagellata

The colorless Flagellata comprise two groups of flagellates different originally each other: one is the colorless forms of the Order Chromonadea which had secondarily lost chromatophores due to living in dull polluted water, and the other is the true heterotrophic colorless flagellates probably developing from the Spirochaeta. Regardless of different courses of the evolution, all of the colorless flagellates generally increase in polluted water. Therefore, they may be called as unicellular organisms of polluted water, and they commonly occur in fresh and sea water. The most of them have a tendency of increase after the disappearance of colored water.

From Hiroshima Bay and its adjacent sea colorless autotrophic flagellates belong to six orders have been found 26. Of the Order Chrysomonadida, *Heterochromulina termo* (EHRENBERG) is one of the common colorless species occurring usually throughout the year. *Polyseudopodius bacterioides* PUSCHKREW (Fig. 2-2) is a rare colorless form producing occasionally pseudopodia. Three colorless species of the Order Cryptomonadida also appear in polluted water. In the Order Dinoflagellida several unarmored species are usually observed in the sea: *Entomosigma peridinoides* SCHILLER, having a single forward flagellum, has increased in recent years and *Oxyrrhis marina* DUJARDIN well known as a primative dinoflagellate of polluted sea water, is commonly found throughout the year. The small *Gymnodinium* species, *G. minor* LEBOUR and *G. marinum* KENT are the commonest colorless flagellates in the sea. The similar large fragile form, *Gyrodinium flavum* KOFOID is also common the year around. The large colonial organism, *Polykrikos schwartzi* BÜTSCHLI, which has been reported long ago as one of blooming flagellates in Japan, rarely occurs in Hiroshima Bay in summer. *Noctiluca scintillans* (MACRTONEY) has not increased in the region as to cause pink colored water. Of the Order Ebriadida, containing many fossile species of the polluted ancient seas, *Ebria tripartia* (SCHUMANN) sometimes remarkably increases after disappearance of the colored water. In the Order Euglenoida consists of the four suborder of which two typically include only colorless forms, several species rarely occur in summer and autumn in Hiroshima Bay. Of the order Phytomonadida, three colorless flagellates have been occasionally secured from the bay.

The species of the Class Leucomonadea originally without a chromatophore, obviously belong to the heterotrophic organisms as the other groups of the Protozoa, such as amoebae and ciliates. They usually take particles of organic matters in their bodies as a food. Therefore, they are group of the important microorganisms decomposing organic substances in polluted water (HADA, 1972c).

From Hiroshima Bay and its adjacent sea (Table 3) have been detected 11 species of the Order Choanoflagellida consisting of the colorless flagellates with a collar composed of protoplasmic membranes, in which the protoplasmic current is easily observed. Most of them (7) have been found from fresh water and one, *Poteriodendropsis setouchi* HADA is a new species secured first from Hiroshima Bay in autumn of 1971. *Dimastigameeba bacillaria*

HADA of the Order Rhizomastigida, a species taking an amoeboid transformation, unexpectedly reproduced after the disappearance of colored water in September of 1969. The nine common species of the Order Kinetoplastida including small forms related closely with the water pollution, have been found from the sea where the research was carried on them, *Bodo globosus* STEIN, *B. edax* KLEBS and *Cercobodo crassicaudus* (LEMMERMANN) are most abundant in deeper layers of the sea and also in polluted water after the diminution of blooming colored flagellates.

Table 3. The species of the Class Leucomonadea found from the Inland Sea

Order Choanoflagellida	
Family Monosigidae	
1. *Monosiga ovata* KENT	Fresh
2. *M. longitenax* HADA	
3. *Desmarella moniliforme* KENT	Fresh
4. *Protospongia haeckeli* KENT	Fresh
Family Salpingoecidae	
5. *Salpingoeca pyxidia* KENT	Fresh
6. *S. vaginicola* STEIN	Fresh
7. *S. sphaericola* STOKES	Fresh
8. *S. longipes* KENT	
9. *S. elegans* LEMMERMANN	
10. *Diplosigopsis francei* LEMMERMANN	
11. *Poteriodendropsis setouchi* HADA	
Order Rhizomastigida	
Family Mastigamoebidae	
12. *Dimastigamoeba bacillaria* HADA	
Order Kinetoplastida	
Suborder Bodonina	
Family Bodonidae	
13. *Bodo globosus* STEIN	Fresh
14. *B. edax* KLEBS	Fresh
15. *B. parvus* (NÄGLER)	
16. *B. compressus* LEMMERMANN	
17. *Cercobodo crassicaudus* (LEMMERMANN)	Fresh
18. *Phyllomitus undulans* STEIN	
Family Amphimonadidae	
19. *Amphimonas globosa* KENT	Fresh
Family Rhynchomonadidae	
20. *Rhynchomonas nasuta* KLEBS	
21. *Phyllomonas contorta* KLEBS	

Injury of Colored Water

Colored water, *Akashiwo*, is typically composed of colored unicellular organisms, but the plankton of colored water seldom directly causes the injury associated with colored water. The injury generally depends upon the rapid decrease of dissolved oxygen and the increase of hydrogen sulfide (H_2S) poisonous for all living things excepting sulfur bacteria.

Colored water of colored flagellates appears in the sea polluted with much nutrient substances supplied from the industrial drainage and the city sewage, and vast quantities of the fatal specimens of blooming flagellates further the sea pollution. In the sea of colored water dissolved oxygen typically increases while the sun shines, and often exceeds the saturated volume because of the active photosynthesis in the surface layers where colored organisms are blooming. However, it begins to decrease rapidly just below the blooming layers, and it vanishes totally in the deeper layers. Inspite of the high oxygen in the surface layer hydrogen sulfide, a poisonous gas, is produced in the deep layers which are an aerobic. The most injury of colored water to fishes and shells including oysters is caused by this gas.

From the end of August to September in 1970, larvae of *Hydroides norvegica* GUNNERUS, which is a lugworm living in a calcareous tube usually attaching in crowds to hard substrata on the bottom of the sea, adhered closely to shells of oysters hung in deep layers, and gave the ill influence to the growth of oysters. The fact explains that the larva of the lugworm crowded to hung shells in the median layers containing no dissolved hydrogen sulfide, because this poisonous gas was present in the bottom layer.

The harmful effect of blooming flagellates has twice occurred on the fishery in the district of the Inland Sea: *Gymnodinium simplex* bloomed to color the hung oysters brown in autumn of 1959, and the market price of the oysters dropped drastically down, and the other is that *Hemieutreptia antiqua* killed vast numbers of young yellowtails by the disturbance of the respiration depending on mucous films.

I have not observed any injury of the plankton-toxin during my long period of studying the Protozoan plankton (about 40 years).

Conclusion

In Hiroshima Bay and its adjacent sea the kinds of the plankton concerning with colored water have varied according to the advance of water pollution during the past ten years. As shown in Table 4, colored water of *Peridinium quinquecorne* and *Gymnodinium ostenfeldi* annually appeared in the former years, but these do not bloom in the present polluted sea: the *Peridinium* bloomed every year until 1968 and the *Gymnodinium* until 1964. The three species of *Rhodomonas*, *Haplodinium antijolense*, *Hetetosigma inlandica*, *Gymnodinium simplex*, *G. mikimotoi*, *Hemieutreptia antiqua* bloom to compose colored water in several years. In these flagellates, *G. simplex* and *G. mikimotoi* rarely bloomed in the past in Hiroshima Bay, and *Rhodomonas* spp. were found as a flagellate of colored water since 1965, *H. inlandica* since 1967 and *Hem. antiqua* since 1969. The species which most frequently composes colored water in the present years, is *H. inlandica*, and the most careful organism is *Hem. antiqua*.

Owing to water pollution small forms of colored flagellates, such as *Chromulina* and *Kephyrion* spp. and *Chrysochromulina parva* belonging to the Order Chrysomonadida, *Olisthodiscus luteus* of the Order Heterochlorida, *Rhodomonas nannoplanctic* and *Protochryis* spp. of the Order Cryptomonadida, and *Pyramimonas* sp. *Chlamydomonas* spp. and *Carteria cordiformis* of the Order Phytomonadida tend to increase year by year in the sea. Furthermore, fresh water forms, such as the follwing flagellates; *Euglena piscifomis* of the Order Euglenoida, *Rhaphidomonas semen* and *R. depressum* of the Order Chloromonadida and *Chlorogonium* *euchlorum*, *C. elongatum* and *Pandorina mora* of the Order Phytomonadida, are frequently found from the sea.

The colorless species of the Class Chromonadea also gradually increased. Therefore, the following forms have been recently observed from the sea *Polypseudopodius bacteriodes* of the Order Chrysomonadida, *Cyathomonas truncata* of the Order Cryptomonadida; *Entomosigma peridinoides* of the Order Dinoflagellida and *Polytomella agilis* and *Tussetia polytomoides* of the Order Phytomonadida.

The original colorless flagellates of the Class Leucomonadea preferring to live in polluted water, are abundant in the sea and the two new species, *Poteriodendropsis setouchi* of the Order Choanoflagellida and *Dimastigamoeba bacillaria* of the Order Rhizomastigida, have been detected from Hiroshima Bay. In accordance with the advance of the water pollution, the number of the species examined from the sea has become annually greater; namely 16 species have been found anew continously in the year of 1972.

Table 4. The colored flagellates blooming in Hiroshima Bay since 1964

Species	1964	1965	1966	1967	1968	1969	1970	1971	1972
Rhodomonas baltica	−	−	+	−	−	+	−	−	−
R. ovalis	−	−	−	−	+	−	−	−	−
R. lacustris	−	+	−	−	−	−	+	+	−
Haplodinium antijolense	−	+	−	−	−	−	−	−	−
Heterosigma inlandica	−	−	−	+	+	+	+	+	+
Gymnodinium simplex	−	−	−	−	−	−	−	+	−
G. mikimotoi	−	−	−	−	−	−	+	−	−
G. ostenfeldi	+	−	−	−	−	−	−	−	−
Peridinium quinquecorne	+	+	+	+	+	−	−	−	−
Hemieutreptia antiqua	−	−	−	−	−	+	+	−	+
Carteria cordiformis	−	−	−	+	−	−	−	−	−

Description on the New Species

The following new species have been described only in Japanese in the special report published hurriedly last summer on the flagellates in colored water occurring in the coastal area of Hiroshima-Ken in the Inland Sea, according to the requirement of the Hiroshima-Ken Fisheries Experiment Station for the purpose of diminishing damage of the fishery caused by blooming plankton. Therefore, I repeat the discription in English on the same species in the present paper.

Class Chromonadea
Order Chrysomonadina
Suborder Euchrysomonadina
Family Chromuliniidae

Chromulina biconvex n. sp. Fig. 1-2

The new species having a single flagellum is a small ovate concave flattened flagellate.

In the body are usually found a large greenish curve chromatophore, a small contractile vacuole and several grains of reserve substances, but a stigma is not observed. Length, 7–10 μ; thickness, 3–4 μ.

The new species is different from *Chromulina ovalis* KLEBS (Fig. 1-1) in being concave in the center of the body and in absence of a stigma. It has been found rarely in surface water taken from Hiroshima Bay in summer.

Chromulina triangula n. sp. Fig. 1-3

The new form is triangular flask-shaped sometimes more or less flattened. A single large chromatophore is ribbon-like in shape and greenish orange in color. A red stigma and a small contractile vacuole are in the anterior conical part of the body, from which is stretched a flagellum as long as twice the length of the body. Length, 7–10 μ.

The new flagellate differs from published species of *Chromulina* in its triangular form. It was first found commonly in surface water obtained from the fishery port of Itsukaichi in Hiroshima Bay on May 11, 1972.

Family Kephyrioniidae

Kephyrion spinosum n. sp. Fig. 1-6

The lorica of the new species is oblong in shape and has two growing spiral turns in the anterior region and numerous short spines on the surface. The diameter of the oral opening is nearly half the largest of the lorica. The nucleus is usually in the anterior half of the body. Length, 5 μ; breadth, 3 μ.

The new form differs from all species of *Kephyrion* in carrying a spinous lorica. It occurs in September together with the other three of the genus in Hiroshima Bay and is rare.

Order Cryptomonadida

Family Nephroselmidae

Protochrysis minimum n. sp. Fig. 3-4

The new species is small and oblong or ovate, and slightly dented at the middle of one side, and from the ventral dent two long flagella stretch: a longer anterior flagellum 4–5 times as long as a body starts ahead and then gradually curves to the dorsal side, at last, stretches posteriorly as does the shorter posterior flagellum, 3–4 times of a body in length. A single green curved chromatophore is along the dorsal side. Being small in size, the nucleus and pharyngeal apparatus are not obviously observed in living specimens, but a few grains of reserved substances are usually seen. The small biflagellate organism typically moves with a counter clockwise rotation which is produced by an anterior flagellum. Length, 3–7 μ.

The new species differs from *Protochrysis phaeophycearum* PASCHER in its small size and absence of an eye spot. It occurs rarely in Hiroshima Bay from May to July, but it is more common than the other large species, *P. phaeophycearum* in the bay.

Order Dinoflagellida

Suborder Diniferina

Family Gymnodiniidae

Gymnodinium japonicum n. sp. Fig. 3-6

The small elongate new species consists of a conical epicone, a wide girdle and a smaller ovoid chromatophores scattering wholly in the body are greenish brown. The nucleus is typically central. Length, 8-12 μ, breadth, 5-7 μ.

The new species differs from *Gymnodinium simplex* LOHMANN, *G. mikimotoi* MIYAKE & KOMINAMI, *G. agiliforme* SCHILLER, *G. agile* KOFOID & SWEZY and *G. lantzschii* UTERMOHL in its elongate form and in constitution of the body concerned with a size and a shape of an epicone and a hypocone. It is one of the common dinoflagellates in Hiroshima Bay during May-September.

Order Euglenoida

Suborder Hemieuglenoina new suborder

The new suborder is distinguished from the other suborders, Euglenoina, Peranemina and Petalomonadina, in primitive structure of the cell. In the species of the new suborder the reservoir is simply V-shaped instead of a bladder in those of the other suborders, and numerous contractile vacuoles which are gathered around a reservoir in the known species, entirely scatter in the whole ectoplasma of the cell.

Family Hemieutreptiidae

Hemieutreptia antiqua n. gen. & n. sp. Fig. 3-7

The new primitive marine euglenoid organism is compressed fusiform and has two flagella different in length: a longer flagellum is nearly twice as long as another shorter one. The ovoid nucleus is comparatively large in the central region, and many discal green chromatophores scatter in the whole body. Paramylon grains, the main characteristic of the Order Euglenoida, are numerous and minute. The reservoir is undeveloped to make a simple V-shaped depression at the anterior end of the body. The two flagella extend forwards from the blephaloplast at the bottom of the primitive reservoir. The cell is typically fragile and the endoplasm containing chromatophores and paramylon grains, is usually yellow, while the ectoplasm composed of an outer layer of numerous minute mucous bodies secreting mucous and an inner one of many small contractile vacuoles, is colorless. Length, 50-130 μ; breadth, 25-23 μ; thickness, 15-22 μ; chromatophore, 3-5 μ; paramylon grain, 1-2 μ; contractile vacuole, about 1 μ; mucous body, 0.5-1.0 μ.

The new form, primitive in structure, differs from all known species of the Order Euglenoida in having an undeveloped V-shaped reservoir and numerous contractile vacuoles scattered in the ectoplasm. In the cell of the new species a surface cuticular layer is not so developed as in the others of the order, that the ectoplasm is easily destroyed. When the flagellate blooms, therefore, a large quantity of mucous is mingled in water and gives a bad influence to the cultured fish, *Seriola quinqueradiata* TEMMINCK & SCHLEGEL. The new species occurs from July to September and often blooms to compose dark violet-brown colored water in the Inland Sea.

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