

The Taxonomy and Ecology of Genus *Oscillatoria* in Tainan Area

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ABSTRACT

Samples were collected widely and randomly from ditches, drainages, channels, streams, fish ponds and the canal in Tainan area, Taiwan, from July 1981 to March 1982.

Twenty-two species of *Oscillatoria* have been identified, five of them belong to the organic pollution species reported by Palmer, they are *O. formosa*, *O. tenuis* var *tenuis*, *O. chalybea*, *O. agadhii*, and *O. ornata*. We have also found that *O. formosa* and *O. tenuis* var *tenuis* are the most common and dominant species that associate with waters of higher organic content, such as urban drainages, Yen-Shui-Chi, country ditches, and Tainan canal. *O. chalybea* is only found dominantly in Yen-Shui-Chi and Tainan canal, but not in the rest of waters. *O. limnetica* is one of the most popular species present in various waters, it associates more abundantly with waters of less organic pollution, such as country streams, channels, and fish ponds in Taiwan area.

The species of *Oscillatoria* in relation to water pollution have been discussed. The key to species of *Oscillatoria* and the pictures are also presented.

INTRODUCTION

The growth of human population and the rapid development of industry generate a wide variety of waste products. Most of the domestic sewage and industrial waste are organic compounds that will pollute the water after being discharged (Salanki and Ponui, 1975). Algae in water are often sensitive to pollutants, therefore, only some species of algae may grow, the rest are eliminated. Algae has been used as indicators for evaluating the degrees of water quality in lakes and streams. A number of algae that are tolerant of organic environments have been reported by Palmer (Palmer, 1959). There are at least forty-seven important species of algae in waters of high organic content, among them the blue-green algae are the most frequently encountered in waters containing organic compounds. There are fifteen species of blue-green algae have been reported as polluted water algae, and eight of them belong to the genus

of *Oscillatoria*. *O. tenuis* and *O. limosa* have been reported by workers more often than any other species as reliable indicators of organic pollution (Palmer, 1969). Blue-green algae always bloom in eutrophic water resource in autumn. Once algae bloom in a water resource, it may effect on the water quality of taste and odor, and also cause problems of water treatment plants by clogging of filter and decreasing the efficiency of sedimentation tanks. *Oscillatoria* has been reported as one of the clogging algae in Cheng-Ching-lake water treatment plant (Wang and Tseng, 1981). The use of fresh water algae as an indicator for the management of water resource is quite important. In addition, algae have received more attention for the past, they are able to play an importance role in sewage treatment. In sewage stabilization ponds or lagoons, algae can be utilized for the production of oxygen essential to the growth of bacteria and other organisms that break

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down the organic waste (Palmer, 1959). With algae it is possible to support large populations of aerobic bacteria, and then the sewage stabilization process may be greatly accelerated. Thus the pollution algae may become useful not only as indicators but also as purifiers.

The information of *Oscillatoria* in Taiwan is scarce, there are 9 species of *Oscillatoria* reported in Taiwan have been mentioned in a review article (Chiang, 1972). The purpose of this study is to investigate the taxonomy and ecology of *Oscillatoria* in ditches, drainages, channels, streams, fish ponds, and the canal of Tainan area.

MATERIALS AND METHODS

Samples were collected widely from ditches, drainages, channels, streams, fish ponds and the canal with sampling jar or net in Tainan area, Taiwan (Fig. 1) from July 1981 to March 1982.

Tainan area includes Tainan City (臺南市) and Tainan Hsien (臺南縣). Tainan Hsien is an agricultural country. Some samples were collected from ditches at Hsin-Hua (新化), Yung-Kang (永康), Jeh-Te (仁德), Ta-Wan (大灣), in Tainan Hsien, which is the neighbourhood of Tainan City. Chu-Chi (竹溪), Chai-Tou-Chiang-Chi (紫頭港溪) and Peh-Kuan-Hsien (北幹線) are

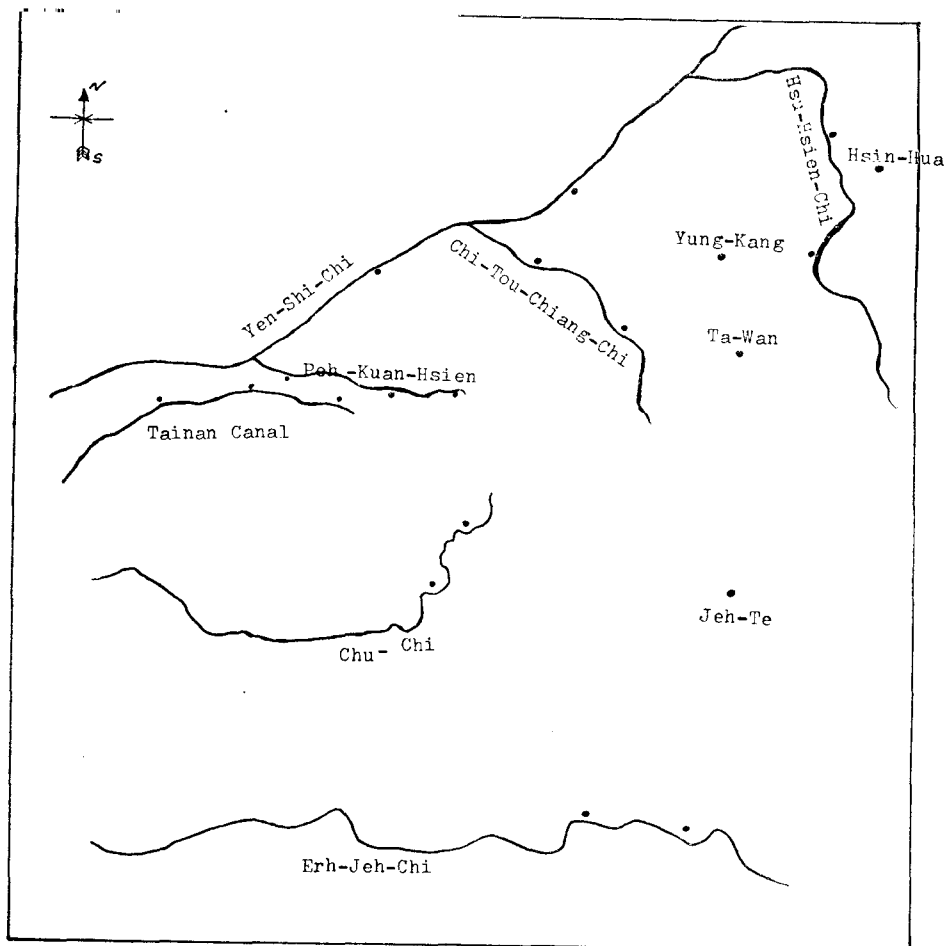


Fig. 1. Figure of sampling place.
(• sampling station)

3 drainages in Tainan City, a part of the city domestic sewage directly discharges into the drainages without any treatment, and then, flows into the Tainan canal (臺南運河) and Yen-Shui-Chi (鹽水溪). Hsu-Hsien-Chi (許縣溪) is the upstream of Yen-Shui-Chi, after it flows into Tainan City is called Yen-Shui-Chi. Hsu-Hsien-Chi and Erh-Jeh-Chi (二仁溪) flow along the agricultural fields. The up stream of Erh-Jeh-Chi has not been polluted and the down stream has been severely polluted (Kao and Wen, 1980). The channels are the ducts for irrigation that flow along fields.

The species were identified according to

Hirose (1977), Mizuno (1974) and Prescott (1975).

RESULTS

There are 20 species and 2 varieties of *Oscillatoria* have been identified from our collection samples in Tainan area, Taiwan (Table 1, 2), (Figs. 2, 3). Nine species of *Oscillatoria* have been reported in Taiwan (Chiang, 1972). Chang (1978) has reported 3 species found in Chia-I area, Wang and Tseng (1981) have reported 2 species found in Cheng-Ching lake.

The dominant species of *Oscillatoria* in Chu-Chi, Chai-Tou-Chiang-Chi and Peh-Kuan-

Table 1. Distribution of *Oscillatoria* in Tainan City

Species	Numbers of sampling station					
	Yen-Shui-Chi**	Tainan Canal	Chi-Tou-Chiang-Chi*	Chu-Chi*	Peh-Kuan-Hsien*	Fish ponds
<i>O. formosa</i>	++	++	+++	+++	+++	+
<i>O. nigra</i>	+++	++	+	-	-	-
<i>O. peronides</i>	+	-	-	-	-	-
<i>O. tenuis</i> var <i>tenuis</i>	++	++	+++	+++	+++	+
<i>O. tenuis</i> var <i>tergestina</i>	+	+	+	+	+	+
<i>O. brevia</i>	-	-	-	-	-	-
<i>O. agardhii</i>	-	-	-	-	-	-
<i>O. articulata</i>	-	+	-	-	-	+
<i>O. sakashitae</i>	-	-	-	-	-	-
<i>O. granulata</i>	+	-	-	-	-	-
<i>O. animalis</i>	-	-	-	-	-	-
<i>O. neglecta</i>	-	-	-	-	-	-
<i>O. quasiperforata</i>	-	-	-	-	-	-
<i>O. anguina</i>	-	-	-	-	-	-
<i>O. chalybea</i>	+++	+++	-	-	-	-
<i>O. oranata</i>	++	+	-	-	-	-
<i>O. sancta</i>	+	-	-	-	-	-
<i>O. limnetica</i>	+	+	+	+	+	+++
<i>O. geminata</i>	+	-	-	-	-	-
<i>O. amoenia</i>	++	-	-	-	-	-
<i>O. limosa</i>	+	-	-	-	-	-
<i>O. amphibia</i>	+	-	-	-	-	-

*: drainage, **: stream.

+++ : dominance ++ : medium + : presence - : none

Table 2. Distribution of *Oscillatoria* in Tainan Hsien

Sampling place	Hsu-Hsien-Chi*	Erh-Jeh-Chi*	Fish ponds	Hsin Hua		Yung Kang		Ta Wan		Jeh Te	
				C	D	C	D	C	D	C	D
	Numbers of sampling station										
Species	2	2	4	3	3	2	2	2	2	2	2
<i>O. formosa</i>	—	—	—	—	+++	—	+++	—	+++	+	+++
<i>O. nigra</i>	—	—	—	+	++	—	++	—	++	—	++
<i>O. peronides</i>	—	—	+	—	++	—	++	—	+	—	+
<i>O. tenuis</i> var <i>tenuis</i>	—	+	++	+	+++	+	+++	+	+++	+	+++
<i>O. tenuis</i> var <i>tergestina</i>	+	+	+	—	++	—	++	—	+	—	++
<i>O. brevis</i>	+	—	+	—	+	—	+	—	—	—	—
<i>O. agardhii</i>	—	—	—	—	+	—	—	—	—	—	—
<i>O. articulata</i>	—	—	+	—	—	—	—	—	—	—	—
<i>O. sakashitae</i>	—	—	—	—	—	—	—	—	—	—	+
<i>O. granulata</i>	—	—	—	—	+	—	+	—	+	—	—
<i>O. animalis</i>	—	+	+	—	—	—	+	—	—	—	—
<i>O. neglecta</i>	+	+	+	—	—	—	—	—	—	—	—
<i>O. quasiperforata</i>	—	+	+	—	+	—	+	—	—	—	+
<i>O. anguina</i>	—	—	+	—	+	—	+	—	+	—	+
<i>O. chalybea</i>	—	—	—	—	—	—	—	—	—	—	—
<i>O. oranata</i>	—	—	—	—	—	—	—	—	—	—	—
<i>O. sancta</i>	—	—	—	—	—	—	—	—	—	—	—
<i>O. limnetica</i>	+++	+++	+++	++	++	++	++	++	++	++	++
<i>O. geminata</i>	+	+	+	—	—	—	—	—	—	—	—
<i>O. amoenia</i>	—	—	+	—	—	—	—	—	—	—	—
<i>O. limosa</i>	—	—	—	—	—	—	—	—	—	—	—
<i>O. amphibia</i>	—	—	—	—	—	—	—	—	—	—	—

*: stream C: channel D: ditch

+++ : dominance ++ : medium + : presence — : none

Explanation of Figs. 2 and 3

1. *O. formosa* (×600).
2. *O. nigra* (×600).
3. *O. peronides* (×600).
4. *O. tenuis* var *tenuis* (×600).
5. *O. tenuis* var *tergestina* (×600).
6. *O. brevis* (×600).
7. *O. agardhii* (×600).
8. *O. articulata* (×600).
9. *O. sakashitae* (×600).
10. *O. granulata* (×600).
11. *O. animalis* (×600).
12. *O. neglecta* (×600).
13. *O. quasiperforata* (×600).
14. *O. anguina* (×600).
15. *O. chalybea* (×600).
16. *O. oranata* (×600).
17. *O. sancta* (×600).
18. *O. limnetica* (×600).
19. *O. geminata* (×600).
20. *O. amoenia* (×600).
21. *O. limosa* (×600).
22. *O. amphibia* (×600).

Hsien were different from those in the Yen-Shui-Chi and the Tainan canal (Table 1, 2). *O. formosa* and *O. tenuis* var *tenuis* were the dominant species in Chu-Chi, Chai-Tou-Chiang-Chi and *O. Chalybea* were the dominant species in Yen-Shui-Chi and Tainan canal. There were more species found in samples collected from Tainan Hsien than from Tainan City. *O. nigra* and *O. tenuis* var *tenuis* were often found in the ditches of Tainan Hsien. *O. limnetica* was the most popular species present in various waters, however, *O. formosa* and *O. tenuis* var *tenuis* were the dominant species in seriously polluted waters, and *O. limnetica* was more dominant in less polluted waters.

There are 3 more species of *Oscillatoria* which have not been completely identified (Fig. 4), they were found only in Yen-Shui-Chi but not in the rest of waters.

**Key to the Genus of *Oscillatoria*
in Tainan Area**

I. Trichome 5 μ or more in diameter.

A. Trichome constricted at cross walls.

a. Trichome tapering at the apex.

1. Cells with prominent granules at both ends of each cell, 4-6 μ in diameter. Cells 0.5-1 times their diameter in length *O. formosa*
2. Cells without prominent granules, 7-10 μ in diameter. Cells 1/2-1/3 times their diameter in length... *O. Chalybea*

b. Trichome not tapering at the apex.

1. Apical cell capitate with a calyptra, 10 μ in diameter. Cells 1/3-1/5 times their diameter in length... *O. sancta*
2. Apical cell not capitate.
 - (1) Cells with rows of granules at both end of each cell.
 - ① Apical cell rounded, 5-10 μ in diameter. Cells 1/3 times their diameter in length.....

- *O. tenuis* var *tenuis*
- ② Apical cell convex, 5-6 μ in diameter. Cells 1/3 times their diameter in length.....

- *O. tenuis* var *tergestina*
- (2) Cells with very few granules at both ends of each cell.

- ① Trichome crook and much twist in apical region, 10 μ in diameter. Cells 1/2-1/5 times their diameter in length.....
- *O. ornata*

- ② Trichome not crook and slightly twist in the apical region, 7.5-9 μ in diameter. Cells $\frac{1}{2}$ -1 times their diameter in length..... *O. nigra*

B. Trichome not constricted at cross wall.

a. Trichome tapering at the apex.

1. Cells with granules at both ends of each cell, 4-6 μ in diameter. Cells 1/2-1/3 times their diameter in length *O. brevis*
2. Cells without granules at both ends of each cell, 3 μ in diameter in length *O. animalis*

b. Trichome not tapering at the apex.

1. Cells with granules at both ends of each cell.
 - (1) Apical cell truncate-conical, with or without a calyptra, 5-6 μ in diameter. Cells 1/2-1/3 times their diameter in length.....

..... *O. agadhii*

- (2) Apical cell rounded, without a calyptra.
 - ① Cells 3-6 μ in diameter, 2/3 times their diameter in length *O. granulata*
 - ② Cells 10-12 μ in diameter, 1/3-1/6 times their diameter in length..... *O. limosa*

2. Cells without granules.

- (1) Cell with a calyptra at the apex, 6-7 μ in diameter. Cells 1/2-1/4 times their diameter in length...
.....*O. sakashitae*
- (2) Cell without a calyptra at the apex, 5.0 μ in diameter. Cells 1-2 times their diameter in length...
.....*O. peronides*

- ① Cells with pseudo vacuoles at both ends of each cell, 2 μ in diameter. cells 3-8 times diameter in length.....
.....*O. quasiperforata*
- ② Cells without pseudo vacuoles, 1.5 μ in diameter. Cells 3-7 times diameter in length.....
.....*O. limnetica*

II. Trichome less than 5 μ in diameter.

A. Cell constricted at cross wall.

1. Cell less than 2 μ in diameter. Cells 1-2 times their diameter in length...
.....*O. neglecta*
2. Cell more than 2 μ in diameter.
- (1) Apical cell capitate, with a cone-shaped calyptra, 3-4 μ in diameter. Cells 2/3-1 times their diameter in length...*O. amoena*
- (2) Apical cell not capitate, without a calyptra.
- ① Cell with thick cross wall without granules at both end of each cell, 3-4 μ in diameter. Cells 1/2-1 times their diameter in length...*O. geminata*
- ② Cells have a single granule on either side of cross walls, 2 μ in diameter. Cells 2-3 times their diameter in length.....
.....*O. amphibia*

B. Cell not constricted at cross walls.

1. Trichome tapering toward the apex, 3 μ in diameter. Cells 1/2-1 times diameter in length.....*O. animalis*
2. Trichome not tapering.
- (1) Cells with a thick gelatinous outer sheath, 2.5-3.5 μ in diameter. Cells 1/2-1 times diameter in length.....*O. articulata*
- (2) Cells without a thick gelatinous sheath.

Order : Nostocales

Suborder: Oscillatoriineae

Family : Oscillatoriaceae

1. *Oscillatoria formosa* Bory (Figs. 2-1, 3-1)

Trichomes straight and rather firm, curved and slightly tapering toward the apex. Apical cell conical, not capitate, without a calyptra. Trichomes constricted at the cross walls, which contained microgranules. Cells 4-6 μ in diameter, 2.5-6 μ long. Trichomes aggregated to form a dark blue-green plant mass.

Collected at: Yen-Shui-Chi, Tainan Canal, Chi-Tou-Chiang-Chi, Chu-Chi, Peh-Kuan-Hsien, fish ponds, Hsu-Hsien-Chi, Erh-Jeh-Chi, Yun Kang, Ta Wan, Jeh Te.

Refs.: Hirose, H. etc. (ed), 1977, p. 102, pl. 44, fig. 33.

Prescott, 1975, p. 487, pl. 109, figs. 10, 11.

Mizuno, 1964, p. 115, pl. 43, fig. 15.

2. *Oscillatoria nigra* Vaucher (Figs. 2-2, 3-2)

Trichomes straight or slightly twist, not tapering toward the apex, straight or curved. Apical cell round, not capitate. Trichomes constricted at the cross walls, which contain microgranules. Cells 7.5-9 μ in diameter, 3.5-7 μ long. Trichomes aggregated to form a mucilaginous bluish-green plant mass.

Collected at: Yen-Shui-Chi, Tainan Canal,

- Chi-Tou-Chiang-Chi, Hsin-Hua, Yung Kang, Ta Wan, Jeh Te.
Refs.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 12.
 Prescott 1975, p. 489, pl. 109, fig. 18.
3. *Oscillatoria peronides Shuja* (Figs. 2-3, 3-3)
 Trichomes straight for most of their length, but bent at the apex, not tapering. Trichomes not constricted at the cross walls, which are not granular, but contained microgranular in cells. Cells 5.0 μ in diameter, 5-10 μ long.
Collected at: Yen-Shui-Chi, Hsin-Hua, Yung Kang, Ta Wan, Jeh-Te, fish ponds.
Ref.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 33.
4. *Oscillatoria tenuis* Agardh var *ten tenuis* (Figs. 2-4, 3-4)
 Trichomes straight or slightly flexuous at the anterior end, which does not taper, homogenous sheath frequently present. Apical cell round, and not capitate. Trichomes only slightly constricted at the cross walls, which are granular. Cells 5-10 μ in diameter, 2.5-4 μ long. Trichomes aggregated to form a blue-green mass.
Collected at: Yeh-Shui-Chi, Tainan Canal, Chi-Tou-Chiang-Chi, Chu-Chi, Peh-Kuan-Hsien, fish ponds, Erh-Jen-Chi, Hsin Hua, Yung-Kang, Ta Wan, Jeh Te.
Ref.: Hirose, H. etc. (ed) 1977, p. 102, pl. 44, fig. 25.
5. *Oscillatoria tenuis* var *tergestina* Robenhorst (Figs. 2-5, 3-5)
 Trichomes are slightly flexuous at the anterior end. Apical cell convex, smooth and not capitate. Trichomes only slightly constricted at the cross walls, which are granular. Cells only 5-6 μ in diameter, 2-3 μ long.
Collected at: Yen-Shui-Chi, Tainan Canal, Chi-Tou-Chiang-Chi, Chu-Chi, Peh-Kuan-Hsien, fish ponds, Hsu-Hsien-Chi, Erh-Jeh-Chi, Hsin-Hua, Yung Kang, Ta Wan, Jeh Te.
Refs.: Hirose, H. etc. (ed) 1977, p. 102, pl. 44, fig. 27.
 Prescott, 1975, p. 492, pl. 110, figs. 12, 13.
6. *Oscillatoria brevis* (KÜTZING) Gomont (Figs. 2-6, 3-6)
 Trichomes are slightly flexuous at the anterior end, which are tapering. Trichomes don't constricted at the cross walls, which are granular. Apical cell convex, not capitate. Cell 4-6 μ in diameter, 1.5-2 μ long. Trichomes aggregated to form a blue-green mass.
Collected at: Hsu-Hsien-Chi, Hsin-Hua, Yung-Kang, fish ponds.
Ref.: Hirose, H. etc. (ed) 1977, p. 102, pl. 44, fig. 34.
7. *Oscillatoria agardhii* Gomont (Figs. 2-7, 3-7)
 Trichomes straight throughout their entire length, or slightly flexuous at the anterior end, briefly tapering at the anterior end, which is usually capitate. Trichomes do not constricted at the cross walls, which are granular. Apical cell truncate-conical, with or without a calyptra. Cells 5-6 μ in diameter and 3-4 μ long, contain pseudovacuoles. Trichomes interwoven to form a blue-green plant mass.
Collected at: Hsin Hua, Ta Wan.
Refs.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 34.
 Prescott, 1975, p. 484, pl. 108, figs. 15, 16.
 Mizuno, 1964, p. 115, pl. 43, figs. 13, 14.

8. *Oscillatoria articulata* (Figs. 2-8, 3-8)
Trichomes with a thickened outer membrane, not tapering at the apices, apical cell rounded not capitate and without a calyptra. Cells 2.5-3.5 μ in diameter, 1.2-3.5 μ long, not constricted at the cross walls.
Collected at: Tainan Canal, fish ponds.
Ref.: Prescott, p. 486, pl. 107, fig. 22.
9. *Oscillatoria sakashitae* Yoneda (Figs. 2-9, 3-9)
Trichomes straight, slightly twist at the apex and with a calyptra. Trichomes not constricted at the cross walls which are not granular and only slightly tapering at apex. Cells 6-7 μ in diameter, 1.5-3 μ long.
Collected at: Jeh Te.
Ref.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 19.
10. *Oscillatoria granulata* (Figs. 2-10, 3-10)
Trichomes straight and slightly curved at the apex. Apical cell not capitate and without a calyptra. Cells 3-6 μ in diameter, 2-4 μ long, not constricted at the cross wall, which are granular.
Collected at: Yen-Shui-Chi, Hsin-Hua, Yung Kang, Ta Wan, Jeh Te.
Ref.: Prescott, 1975, p. 487, pl. 109, figs. 12, 13.
11. *Oscillatoria animalis* Agardh (Figs. 2-11, 3-11)
Trichomes straight but bent and twist in the apical region, tapering toward the apex. Cells not constricted at the cross walls and not granular, 3 μ in diameter, 2-3 μ long, blue-green in color.
Collected at: Erh-Jeh-Chi, Yung Kang, fish ponds.
Ref.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 16.
12. *Oscillatoria neglecta* Lemmermann (Figs. 2-12, 3-12).
Trichomes straight or flexuous, constricted at the cross wall. Cells blue-green in color, 1.5 μ in diameter, 1.5-3.5 μ long.
Collected at: Hsu-Hsien-Chi, Erh-Jeh-Chi, fish ponds.
Ref.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 16.
13. *Oscillatoria quasiperforata* (Figs. 2-13, 3-13)
Trichomes straight or slightly flexuous, not constricted at the cross walls, which are not marked by granules but with pseudovacuoles. Cells light blue-green in color, 2 μ in diameter, 6-16 μ in length.
Collected at: Erh-Jeh-Chi, Hsin-Hua, Yung Kang, Ta Wan, Jeh Te, fish ponds.
Ref.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 25.
14. *Oscillatoria anguina* (Bory) Gomont. (Figs. 2-14, 3-14)
Trichomes straight for most of their length but bent and sometimes twist in the apical regions, slightly tapering toward the apex. Apical cell with capitata. Cells not constricted at the cross walls, which are granular, 7.5 μ in diameter, 1.2 μ long, blue-green in color.
Collected at: Hsin Hua, Ta Wan, Yung Kang, Jeh Te, fish ponds.
Ref.: Hirose, H. etc. (ed) 1977, p. 102, pl. 44, fig. 28.
15. *Oscillatoria chalybea* Mertens (Figs. 2-15, 3-15)
Trichomes tapering toward the apex, straight for a portion of their length but spirally twisted toward the apex, apical cell conical. Cells 7-10 μ in diameter, 4-5 μ long, constricted at the cross walls, which are not granular.
Collected at: Yen-Shui-Chi, Tainan Canal.

- Ref.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 2.
16. *Oscillatoria ornata* KÜTZING
(Figs. 2-16, 3-16)
Trichomes crooked and much twisted, not tapering toward the apex. Apical cell broadly rounded, not capitate and without a calyptra. Cells $10\ \mu$ in diameter, $2-5\ \mu$ long, constricted at the cross walls with microgranules, blue-green in color.
Collected at: Yen-Shui-Chi.
Refs.: Hirose, H. etc. (ed) 1977, p. 102, pl. 44, fig. 17.
Prescotte, 1975, p. 489.
17. *Oscillatoria sancta* (KÜTZING) Gomont
(Figs. 2-17, 3-17)
Trichomes straight, not tapering at the apex. Apical cell somewhat capitate with a calyptra. Cells slightly constricted at the cross walls, which are granular, $10\ \mu$ in diameter, $2-3\ \mu$ long, dark yellow-green in color.
Collected at: Yen-Shui-Chi.
Refs.: Hirose, H. etc. (ed) 1977, p. 102, pl. 44, fig. 11.
Prescotte, 1975, p. 490, pl. 110, fig. 4.
Mizuno, 1964, p. 114, pl. 43, fig. 8.
18. *O. limnetica* Lemmermunn (Figs. 2-18, 3-18)
Trichomes straight or flexuous, not tapering toward the apex. Cells not constricted at the cross walls, light blue-green in color, $1.5\ \mu$ in diameter, $4.5\ \mu-10\ \mu$ in length.
Collected at: Yen-Shui-Chi, Tainan Canal, Chi-Tou-Chiang-Chi, Chu-Chi, Peh-Kuan-Hsien, Hsu-Hsien-Chi, Erh-Jeh-Chi, Hsin-Hua, Yung-Kang, Ta Wan, Jeh Te.
Refs.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 15.
- Prescotte, 1975, p. 488, pl. 109, fig. 16.
19. *Oscillatoria geminata* Maneghini
(Figs. 2-19, 3-19)
Trichome straight and slightly twist at the apex. Apical cell taper. Cells, $3-4\ \mu$ in diameter, $2.5-4\ \mu$ in length, slightly constricted at the cross walls which are thick without granular, but cells contain granules.
Collected at: Yen-Shui-Chi, Hsu-Hsien-Chi, Erh-Jen-Chi, fish ponds.
Ref.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 17.
20. *Oscillatoria amoena* Gomont
(Figs. 2-20, 3-20)
Trichomes straight, slightly tapering toward the apex. Apical cell broad, capitate, with a cone-shaped calyptra. Cells slightly constricted at the cross walls, which are granular. Cells $3-4\ \mu$ in diameter, $2.5-4\ \mu$ long.
Collected at: Yen-Shui-Chi, fish ponds.
Refs.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 7.
Prescotte, 1975, p. 484, pl. 109, fig. 2-4.
21. *Oscillatoria limosa* Agardh (Figs. 2-21, 3-21)
Trichomes straight, not constricted at the cross walls which are granular. Apical cell round, cells $10-12\ \mu$ in diameter, $2-4\ \mu$ long, dark blue-green in color.
Collected at: Yen-Shui-Chi.
Refs.: Hirose, H. etc. (ed) 1977, p. 102, pl. 44, fig. 15.
Prescott, 1975, p. 489, pl. 109, fig. 17.
Mizuno, 1964, p. 113, pl. 43, fig. 3.
22. *Oscillatoria amphibia*, Agardh
(Figs. 2-22, 3-22)

Trichomes straight, not tapering toward the apex. Cells not constricted at the cross walls, which have a single granule on either side. Cells $2\ \mu$ in diameter, $6\ \mu$ long.

Collected at: Yen-Shui-Chi.

Refs.: Hirose, H. etc. (ed) 1977, p. 110, pl. 45, fig. 18.

Prescotte, 1975, p. 485, pl. 109, fig. 6.

23. *Oscillatoria* sp. (Figs. 4-1, 4-4)

Trichome straight for most of their length, but bent not twist at the apex, not tapering. Trichomes constricted at the cross walls, which are granular. Cells $7.5\text{--}7.5\ \mu$ long, grey blue-green in color. Cells $2/3\text{--}1$ times diameter in their length.

Collected at: Yen-Shui-Chi.

24. *Oscillatoria* sp. (Figs. 4-2, 4-5)

Trichome straight for most of their length, but bent at the apex, tapering toward the apex. Trichomes constricted at the cross walls, which contained microgranules. Cells $7.5\text{--}10\ \mu$ in diameter, $2.5\text{--}5\ \mu$ long, grey blue-green in color. Cells $1/3\text{--}2/3$ times diameter in their length.

Collected at: Yen-Shui-Chi.

25. *Oscillatoria* sp. (Figs. 4-3, 4-6)

Trichome straight and taper toward the apex. Trichome constricted at the cross wall which are not granular. Cell $2.5\ \mu$ in diameter, $2.5\ \mu$ long, blue-green in color.

Collected at: Yen-Shui-Chi.

DISCUSSION

Kolkwitz and Marsson (1908) have proposed a classification of organisms associated with various degrees of pollution in rivers receiving organic sewage. *Oscillatoria* has been placed in the second higher degree of pollution zone—the α -mesosaprobic zone (Kolkwitz and Marsson, 1908) and the second high genus of the 60 most

tolerant genera of algae reported by 165 authorities (Palmer, 1969). *Oscillatoria* are extremely resistant to organic pollutants, however, various species of *Oscillatoria* react widely different to organic pollutants. There are 20 species and 2 varieties of *Oscillatoria* have been found in Tainan area, five of them belong to the most organic tolerant species reported by Palmer (1969), they are *O. formosa*, *O. tenuis* var *tenuis*, *O. chalybea*, *O. agadhii* and *O. ornata*.

According to the species of *Oscillatoria* revealed in the water samples collected from various water sources in Tainan area, we have found that *O. formosa* and *O. tenuis* var *tenuis* are the most common and dominant species that associate with waters of higher organic pollution, such as country ditches, urban drainages, urban stream and the Tainan canal. *O. chalybea* has only been found dominant in Yen-Shui-Chi (鹽水溪) and Tainan Canal, but not in the rest of waters. *O. limnetica* is one of the most popular species present in various waters, however, it associates more abundantly with waters of less organic pollution, such as country streams, fish ponds and channels in Tainan area.

It is found that the larger diameter species of *Oscillatoria*, such as *O. limosa*, *O. formosa*, *O. tenuis* and *O. chalybea* are more dominantly present in waters of higher organic content, and the species with smaller diameter, such as *O. limnetica*, *O. neglecta*, and *O. geminata*, are abundant in waters of lower organic pollution. *O. limosa* is the highest organic tolerant species of the 12 most tolerant species in genus *Oscillatoria* (Palmer, 1959). It is seldom found in Tainan area, but it has been found in Chia-I area (Chang, 1978) and Taichung area (authors' observation data).

In our conclusion, *Oscillatoria* is a blue-green algae commonly present in waters polluted by organic sewage in Tainan area, the size and species of the *Oscillatoria* are somewhat related

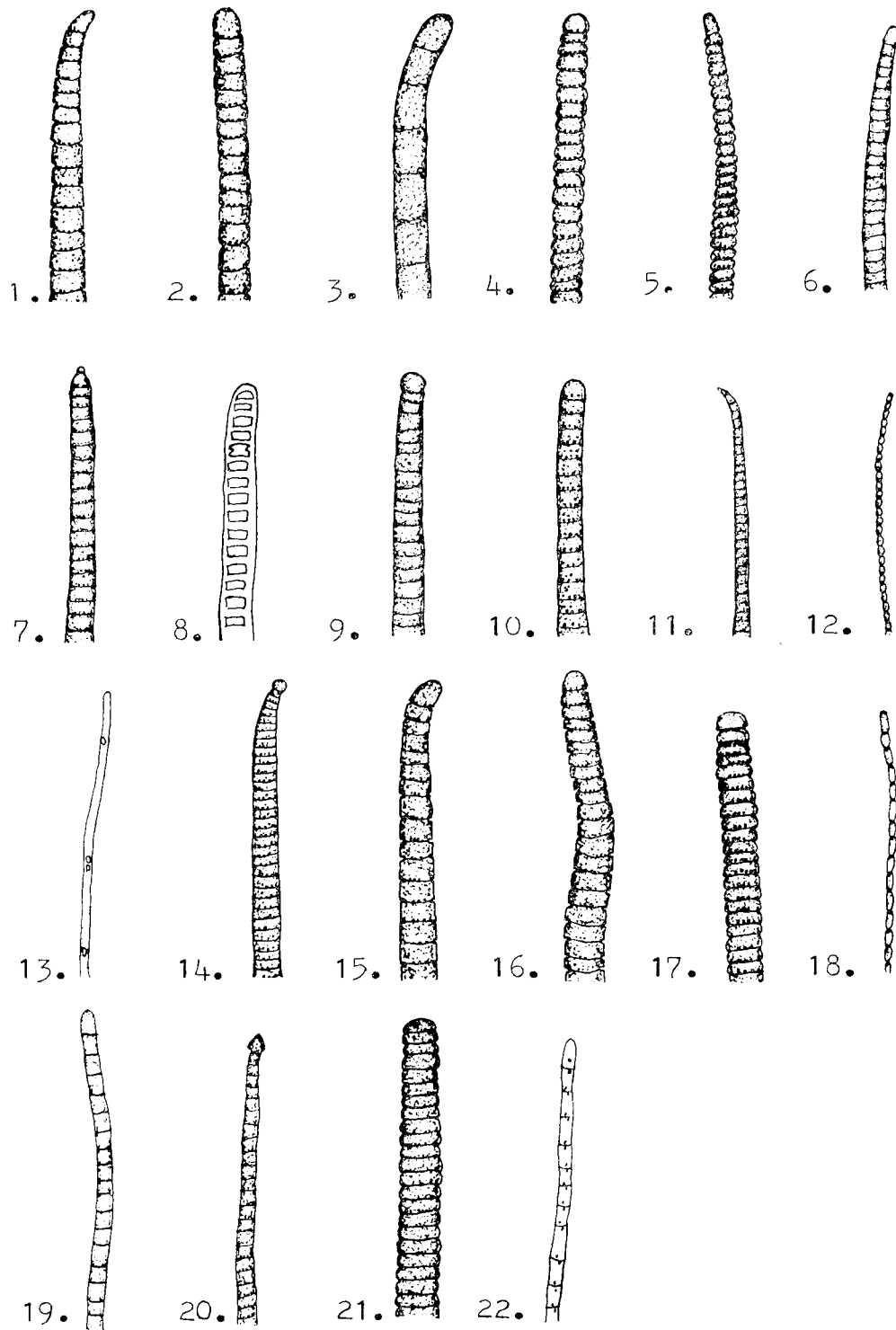


Fig. 2. Drawings of Oscillatoria found in Tainan Area.

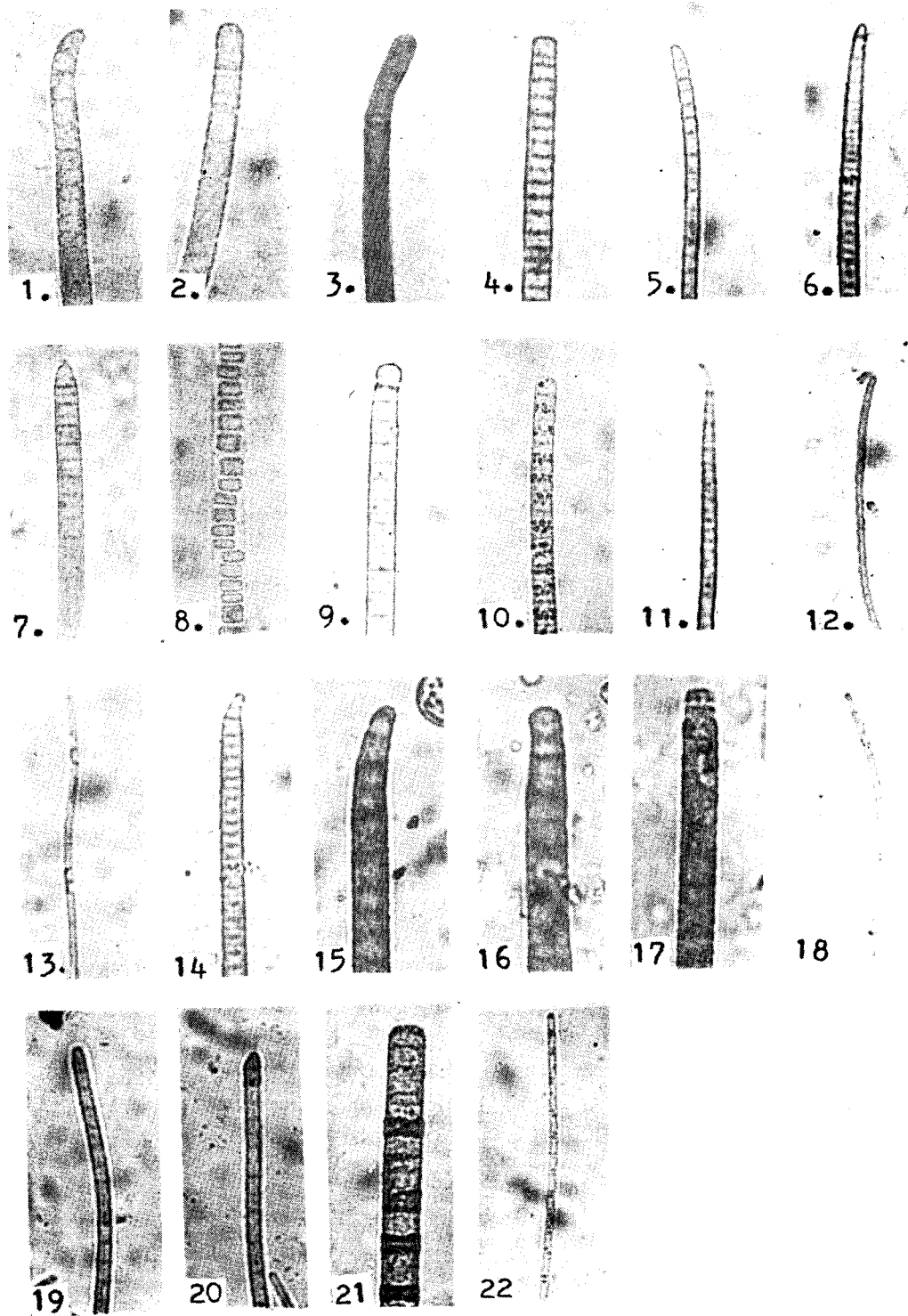


Fig. 3. Photomicrographs of Oscillatoria found in Tainan Area.

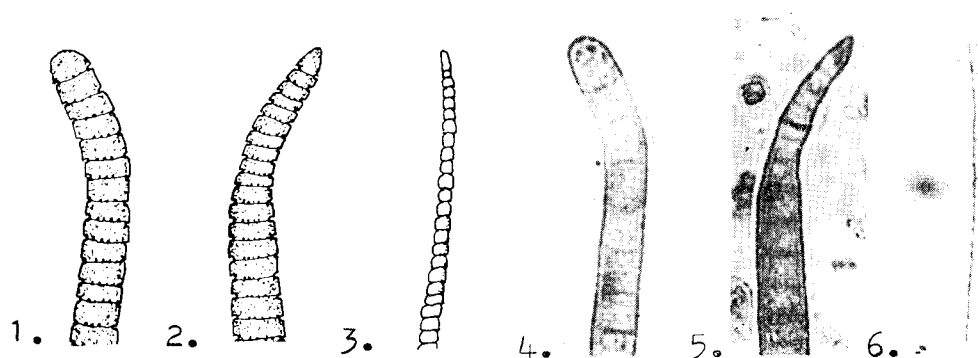


Fig. 4. Species of *Oscillatoria* have not been identified.

to the degree of organic pollution, *O. formosa*, *O. tenuis* var *tenuis*, *O. chalybea* and *O. limnetica* are good indicators in organic pollution assesment (Table 1, 2).

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臺南地區顛藻屬的分類與生態之研究

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摘 要

自民國 70 年 7 月至 71 年 3 月間，從臺南市與臺南縣之鄉間溝渠，城市排水溝，圳道，河川，魚池及臺南運河等處採集水樣調查並鑑定。

在臺南市地區採集到 25 種顛藻，其中 5 種乃屬於 Palmer 指標的有機污染性品種，如 *O. formosa*, *O. tenuis* var *tenuis*, *O. chalybea*, *O. agadhii*, *O. ornata*。我們發現 *O. formosa* 與 *O. tenuis* var *tenuis* 在有機污染性高之水域中，最常出現且佔最優勢，如鄉間溝渠，都市排水溝，嚴重污染之河川，及臺南運河。*O. chalybea* 只在嚴重污染的鹽水溪與臺南運河的上游出現，其他水域中都未發現。*O. limnetica* 在各種水域中出現，但以低污染水域中佔優勢，如臺南縣河川圳道及魚池等。

本論文對顛藻與水污染之關係，曾加以討論。臺南地區顛藻屬之檢索表與 25 種顛藻的照片與繪圖均在論文中發表。