

## Seasonal fluctuation of *Spiniferomonas* (Chrysophyceae, Synuraceae) in two ponds on Mt. Rokko, Japan

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The seasonal fluctuation of the genus *Spiniferomonas* was investigated from April 1975 to April 1977 in two ponds, Doro-ike and Hoshino-ike, situated 800 meters above sea level on Mt. Rokko in Kobe City, Japan. Six species and two unidentified taxa were found in both ponds. Among them, *S. bourrellii*, *S. trioralis* and *S. bilacunosa* were dominant. All taxa were from an oligotrophic pond, Doro-ike. The three dominant species appeared all year round and the five other taxa were observed on a few occasions. The maximum density of the *Spiniferomonas* population each year was observed from March to May. Four species and one unidentified taxon were found in an eutrophic pond, Hoshino-ike. They appeared from October to April, when the pH was below 7.1. The maximum density was about a quarter of that in the Doro-ike pond.

*Key Index Words:* Chrysophyceae; seasonal fluctuation; *Spiniferomonas*; Synuraceae.

Since the genus *Spiniferomonas*, including seven species, was established in 1973 by one of the authors (TAKAHASHI 1973), three species and one forma have been described as new taxa by BALONOV (1978) and NICHOLLS (1981). The worldwide distribution of this genus has been proved by many workers (ANDERSON and GREEN 1976, ASMUND 1973 1977, BALONOV 1977 1978, DÜRRSCHMIDT 1980, GREEN 1979, KRISTIANSEN 1975 1976, 1979 1980, NICHOLLS 1981, ROIJACKERS 1981, ROIJACKERS and KESSELS 1981, STOERMER and SICKO-GOAD 1977, TAKAHASHI 1973 1978, TAKAHASHI and HAYAKAWA 1979, WUJEK *et al.* 1975, WUJEK and VAN DER VEER 1976). However, investigations from an ecological point of view are very few. Several brief observations on some species have been reported (BALONOV 1978, DÜRRSCHMIDT 1980, TAKAHASHI 1978).

This is the first report about the quantitative seasonal fluctuation of *Spiniferomonas*.

### Materials and Methods

Water samples were collected from two ponds, Doro-ike and Hoshino-ike, situated 800 meters above sea level on Mt. Rokko in Kobe City from April 1975 to April 1977. Every month from April 1975 to October 1976, 0.5 l of each water sample was collected from the surface layer at a distance of one meter from the shore in both ponds, and fixed immediately with Lugol's solution and subsequently with formalin. From November 1976 to April 1977, two samples (each 0.5 l) were collected every other week from each pond and one of them was fixed immediately. The fixed sample was settled for a week and then concentrated to 10 ml. The concentrated fixed sample was used for qualitative and quantitative studies with optical and electron microscopes. The unfixed sample was centrifuged at 3,000 r.p.m for 10 min. and then concentrated to 1 ml. The concentrated unfixed sample was used to make

a clear detailed examination of each species. For transmission electron microscopy (JEM-100B), 5  $\mu$ l of each concentrated sample was mounted on collodion-carbon coated grids, desiccated in an oven, and then shadowed at about 20 degrees with chromium or Pt-Pd alloy.

The cell number of each species of *Spiniferomonas* was estimated as follows. First, the number per ml of other phytoplankton cells excluding *Spiniferomonas* at each sampling time was estimated with the optical microscope by counting the number of whole cells in 1/1,000 ml of the fixed water sample which has been concentrated to 10 ml. Second, by using the transmission electron microscope, the cell number of each species of *Spiniferomonas* and that of other phytoplankton cells on the whole visible field of grids was counted under a magnification of  $\times 10,000$ , and then the cell ratio of each species of *Spiniferomonas* to other phytoplankton cells at each sampling time was calculated. Finally, the cell number per ml of each species of *Spiniferomonas* was estimated by multiplying the number per ml of other phytoplankton cells, which was calculated first, by the ratio obtained.

## Results and Discussion

Six species and two unidentified taxa of *Spiniferomonas* were found in two ponds, Doro-ike and Hoshino-ike. All taxa collected were found in Doro-ike Pond and five taxa in Hoshino-ike Pond (Table 1).

In Doro-ike Pond, *Spiniferomonas* appeared throughout the year studied, showing four yearly peaks. The maximum peak in each year was observed in May 1975, in March 1976 and April 1977 (Fig. 1). The density of each peak was 429 cells per ml, 633 and 767 respectively and the frequency of each to the total number of phytoplankton was 26.6%, 9.4% and 19.8% respectively. The maximum peak in 1975 was caused by increases of *S. bourrellii* (Fig. 4), *S. trioralis* (Fig. 5) and *S. cornutus* (Fig. 7), and that in 1976 by increases of *S. bourrellii*, *S. trioralis*,

Table 1. *Spiniferomonas* collected from two ponds, Doro-ike and Hoshino-ike on Mt. Rokko in Kobe City during April 1975 and April 1977.

|                                 | Pond<br>Doro-ike | Pond<br>Hoshino-ike |
|---------------------------------|------------------|---------------------|
| <i>S. bourrellii</i>            | ●                | ●                   |
| <i>S. trioralis</i>             | ●                | ●                   |
| <i>S. bilacunosa</i>            | ●                | ●                   |
| <i>S. cornutus</i>              | ●                |                     |
| <i>S. crucigera</i>             | ●                |                     |
| <i>S. abei</i>                  | ●                | ○                   |
| <i>Spiniferomonas</i> sp. no. 5 | ●                | ○                   |
| <i>Spiniferomonas</i> sp. no. 6 | ●                |                     |

○ showing only scales and spines collected

*S. bilacunosa* (Fig. 6), Sp. no. 5 (Fig. 10) and Sp. no. 6 (Fig. 11), and that in 1977 by increases of *S. bourrellii*, *S. bilacunosa* and *S. cornutus* (Fig. 2). The *Spiniferomonas* population was dominant in May 1975. It was subdominant in March 1976 and in April 1977.

Three other low peaks, ranging from 71 to 168 cells per ml in density and from 2.6 to 24.7% in frequency, in each year sampled were observed in July, October and December 1975 and in June, September and December 1976. The density of one of these low peaks which was observed in July 1975 was only 77 cells per ml but its frequency formed 24.7% of total phytoplankton. It was dominant.

In Hoshino-ike Pond, the *Spiniferomonas* population appeared during seven months from October to April, when the pH was below 7.1, although it appeared throughout the year studied in Doro-ike Pond, where the pH ranged from 5.8 to 6.7. The maximum cell number of *Spiniferomonas* was about a quarter of that in Doro-ike Pond.

As regards the species of *Spiniferomonas* (Fig. 2), *S. bourrellii*, *S. trioralis* and *S. bilacunosa*, which were found in both ponds, appeared throughout the year studied in Doro-ike Pond, whereas, they appeared only on a few occasions, from October to April, in Hoshino-ike Pond. The maximum density of each species in Doro-ike Pond was 467

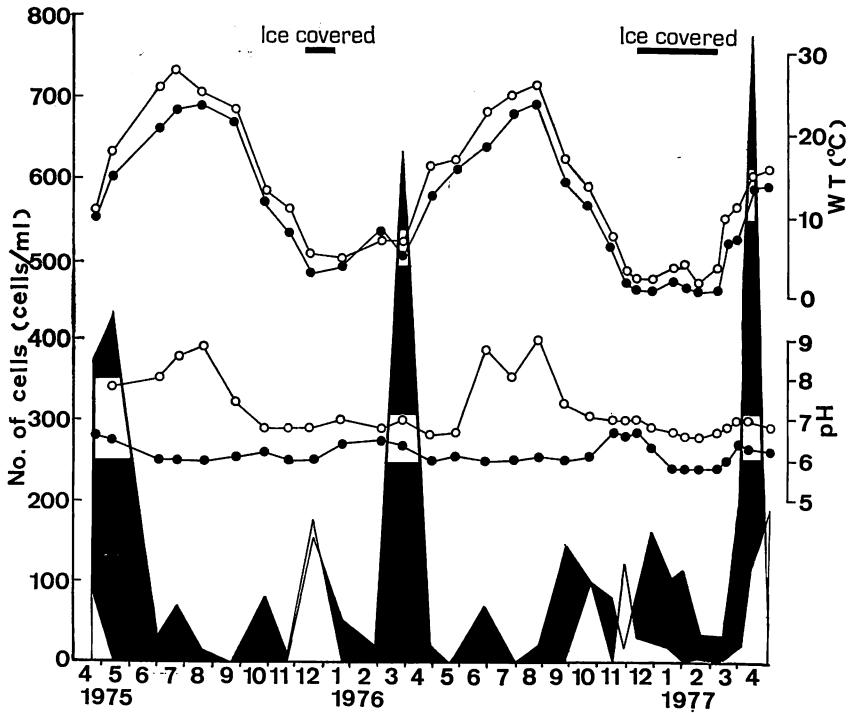


Fig. 1. Seasonal fluctuation in the quantity of *Spiniferomonas* in Doro-ike Pond (black column) and Hoshino-ike Pond (white column); graph showing annual changes of water temperature (WT) and pH values in Doro-ike Pond (—●—) and Hoshino-ike Pond (—○—).

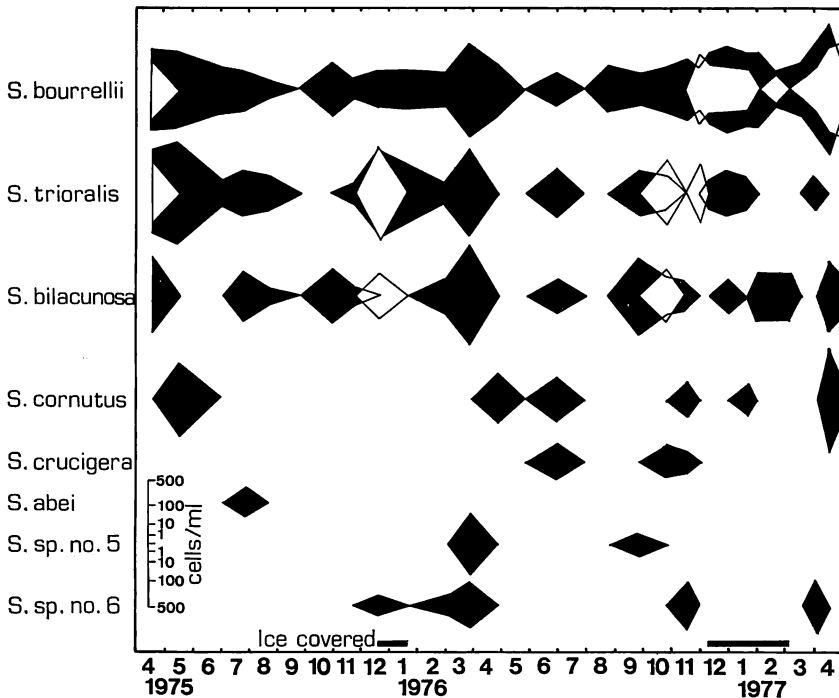


Fig. 2. Seasonal fluctuation in the quantity of eight taxa of *Spiniferomonas* in Doro-ike Pond (black column) and Hoshino-ike Pond (white column).

cells per ml in April 1977 of *S. bourrellii*, 231 in May 1975 of *S. trioralis* and 217 in March 1976 of *S. bilacunosa*, and in Hoshino-ike Pond the density was 190 cells per ml in April 1977 of *S. bourrellii*, 150 in December 1975 of *S. trioralis* and 33 in October 1976 of *S. bilacunosa* respectively. Other species collected from Doro-ike Pond, *S. cornutus*, *S. crucigera* (Fig. 8), *S. abei* (Fig. 9) appeared in small numbers, up to 60 cells on a few occasions.

In both ponds, *Spiniferomonas* species appeared in the range of less than pH 7.1 (Fig. 3). These species are, therefore, classified as acidophilous. Recently, *S. bourrellii*, *S. trioralis*, *S. cornutus* and *S. alata* have been collected from alkaline waters in Russia (BALONOV 1978) and Canada (NICHOLLS 1981). This suggests they can tolerate alkaline waters and may be indifferent to pH.

*S. bourrellii*, *S. trioralis*, *S. bilacunosa*, *S. cornutus* and *S. crucigera* appeared in a wide temperature range showing their maximum densities in the range below 15°C (Fig. 3). These species are, therefore, classified as eurythermal.

Seven species of *Spiniferomonas* have been found mainly in oligotrophic and dystrophic ponds, lakes and swampy bogs located in mountainous districts in Japan (TAKAHASHI 1973, 1978). Doro-ike Pond can be classified as oligotrophic type and Hoshino-ike Pond as eutrophic type on the basis of pH, chloro-

phyll-*a* concentrations, and the constitution and densities of phytoplankton populations of the two ponds.

As previously stated, the *Spiniferomonas* population of the oligotrophic pond, Doro-ike, has numerous species with high densities, and appeared throughout the year studied. However, populations in the eutrophic pond, Hoshino-ike, contain a reduced number of species, with a lower density, and species appeared only on a few occasions even during the period of most favourable water conditions.

BOURRELLY (1957) and HUTCHINSON (1967) have pointed out that chrysophycean plankton in general occurs commonly in humic waters and is the representative plankton of oligotrophic waters.

It is concluded from the present study that *Spiniferomonas*, as well as other chrysophytes, is represented in the plankton of oligotrophic waters in Japan.

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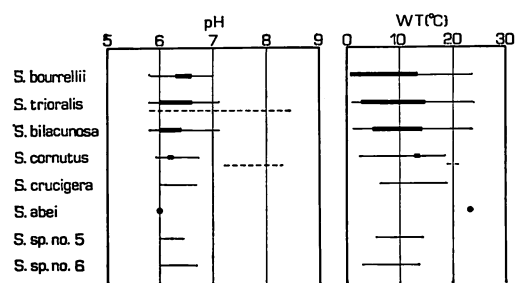
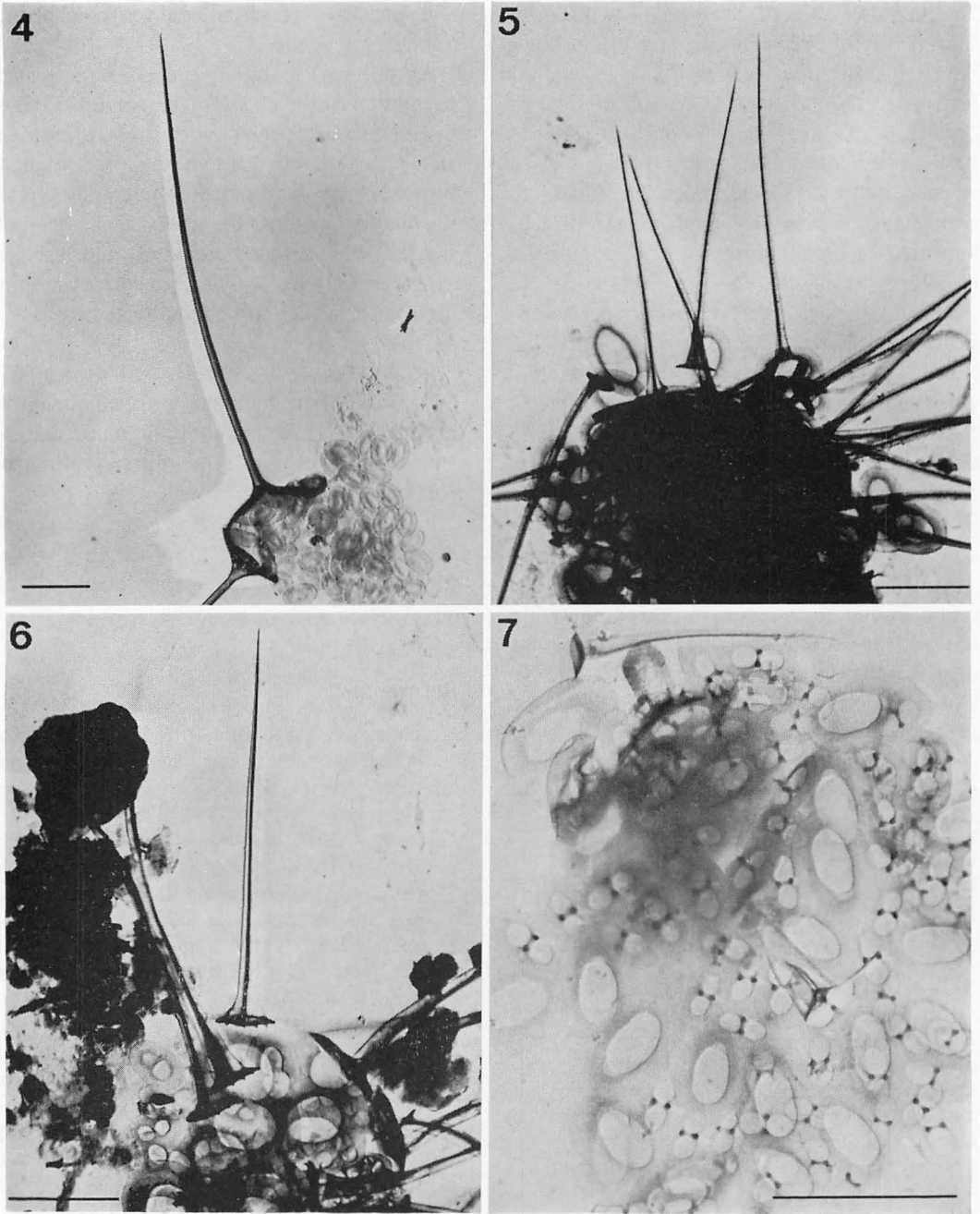
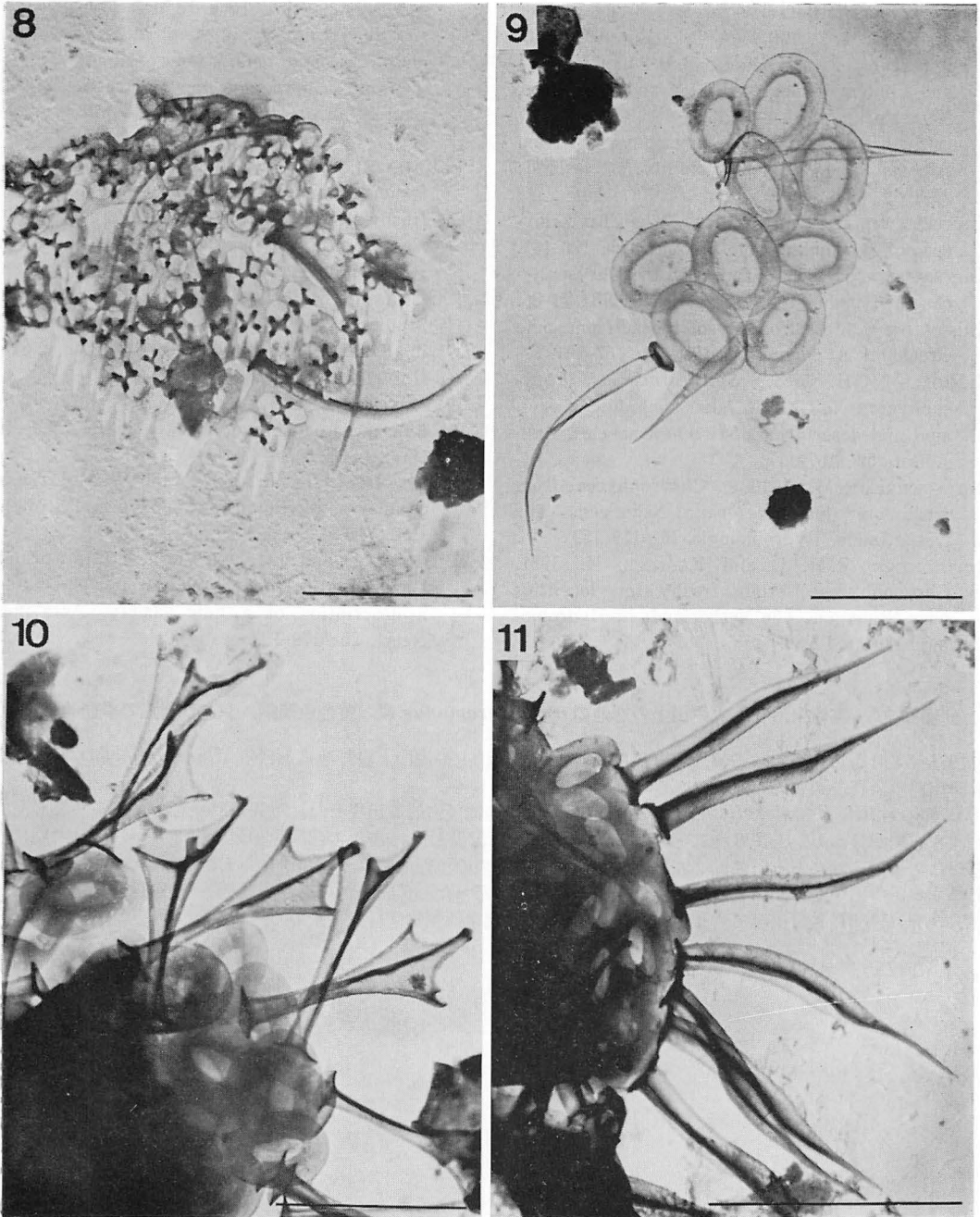


Fig. 3. Ranges in pH values and water temperature (WT) where eight taxa of *Spiniferomonas* were collected from two ponds, Doro-ike and Hoshino-ike. —■— showing the species with more than one hundred cells per ml. ..... referred from BALONOV (1978).



Figs. 4-7. Scales and spines of *Spiniferomonas* collected from two ponds, Doro-ike and Hoshino-ike. 4. *S. bourrellii*; 5. *S. trioralis*; 6. *S. bilacunosa*; 7. *S. cornutus*. (Scales bar 3  $\mu$ m).



Figs. 8-11. Scales and spines of *Spiniferomonas* collected from two ponds, Doro-ike and Hoshino-ike. 8. *S. crucigera*; 9. *S. abei*; 10. *Spiniferomonas* sp. no. 5; 11. *Spiniferomonas* sp. no. 6. (Scales bar 3  $\mu\text{m}$ ).

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伊藤裕之\*・高橋永治\*\*：六甲山上の2池の *Spiniferomonas* 属 (黄金色藻綱, シヌラ科) の季節的消長

1975年4月から1977年4月までの2年間、神戸市六甲山上の泥池と星野池における *Spiniferomonas* 属6種2未同定種の消長を調査した。

*S. bourrellii*, *S. trioralis* と *S. bilacunosa* は両池に優占的に出現した。年間弱酸性を示す貧栄養型の泥池には8種類が分布し、上記3種は周年、他は不連続的に出現した。各年の出現量の最大は3月から5月の間にみられた。一方5月から9月の間アルカリ性を示す富栄養型の星野池には5種類が分布し、池水が酸性になった期間のみ本属が出現した。出現量の最大は泥池の約1/4であった。(\*652 神戸市兵庫区楠谷町37-1 神戸市水道局水質試験所, \*\*657 神戸市灘区六甲台町 1-1 神戸大学理学部生物学科)