**BOTANY HONOURS**

**PHYCOLOGY PROJECT**

# AN ECOLOGICAL INVESTIGATION OF THE FRESHWATER MACROALGAE OF THE MOLENAARS RIVER.

**Submitted as partial requirement for the B. Sc. (Hons.) Degree.**

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**Abstract:**

Macroalgae were studied from ten sites on the Molenaars River during March, April, July and September. Eighteen species were found. Patterns were obtained using canonical correspondence analysis (CANOCO) showing that there are three seasonal groups of macroalgae. The first group consisted of mainly of Zygnemataceae and *Palmella* and was present in high conductivity, warm temperatures and low pH values during summer and autumn. The third group consisted of a species of *Ulothrix* and 'green' mucilaginous unicells which were present during winter in higher pH and water speeds, but lower conductivity and temperatures. The third group consisted of 'orange' mucilaginous unicells, a different species of *Ulothrix* and three as yet unidentified Chlorophyta, which were also present in higher pH and water speeds and lower conductivity and temperatures, but distinct from group 2 and present in during spring. Trout farms along the river were found to have an effect on the macroalgae growth in the river. One species *Stigeoclonium tenue* Rabenh. was found to be specifically associated with the outlets of trout farms. No noticeable effect was found on macroalgal communities as a result of the construction of two bridges over the Molenaars River. There did not appear to be a macroalgal problem in the Molenaars River.

## Introduction:

For more than 25 years, very little scientific work has been conducted on freshwater macroalgae in South Africa. Most work before this has tended to be of a taxonomic nature with little ecological work being conducted. Fritsch (1918), Fritsch & Stephens (1921) Fritsch & Rich (1929) and Hodgetts (1926) have published taxonomic work on South African freshwater algae. Pocock (1966) produced a manuscript on "Fresh water algae in Southern Africa" and although it was never published, it has remained the one of the few substantial works done on South African freshwater algae.

In recent times inland water systems have come to the forefront of scientific and popular attention. This was particularly so during several severe droughts that have plagued South Africa. The importance of wetlands and river systems is now being realised and much effort is now being chanelled into the study and conservation of them (Davis & Day, 1986).

Although there has been a recent increase in ecological studies on freshwater macroalgae in other parts of the world such as Entwisle (1988), Sheath (1992) and Necchi et al. (1991), no ecological studies have been conducted in the South Western Cape region of South Africa.

Biological monitoring of the Molenaars River by Ractliffe (1992) has assessed the impact activities by the construction of the National road at Du Toit's Kloof on fauna communities, but no work has been conducted on the macroalgal communities, other than monitoring of epilithic periphyton. Epilithon refers to the layers of matter, both organic and inorganic, that coats the upper surfaces of rocks and cobbles comprising the riverbed. Ractliffe (1992) found that there was a

general increase in epilithon levels at all her sites on the Molenaars River from February to June 1992, which she attributed to higher winter stocks of trout in trout farms along the river, which are usually heavier than in summer.

The effects of fish farm effluents in rivers in Europe have been shown to be quite substantial, with many reports show that fish-farm effluents cause increases in the phosphorus and nitrogen concentration in recipient rivers, affecting the macroalgae found in them (Carr & Goulder, 1989). A study of the effects of severel trout farms is underway in the Elands River, a tributary of the Molenaars River, (Brown pers comm.) but no work has assessed the effects of the two trout farms situated on the Molenaars River on macroalgal communities.

Lembi et al. (1988), have noted that althuogh macroalgae play an essential and beneficial role in maintaining the health of aquatic systems, there are 'problem' or 'weedy' algae which arise from excessive growth, and have detrimental effects on both indigenous organisims and potential human uses of the systems. In the molenaars River there is a need to assess if algae is a problem and whether the problem is caused as a result of human-caused disturbances on the river.

This project looks at aspects of the ecology of freshwater macroalgae in the upper reaches of the Molenaars River. This section of the Molenaars River is suitable because of its transition from mountain stream to middle reaches and because the Molenaars River is subject to various disturbances due to human impacts, such as the presence of two trout farms along the river and the construction of two bridges by CONCOR for the new section of the National road. Many questions then arise concerning the macroalgal communities and are addressed in this project. Does the effluent released into the Molenaars River from trout farms have an effect on the macroalgal communities and on macroalgal growth? Does the construction of two bridges over the Molenaars river have a significant effect on the macroalgal communities and on macroalgal growth? Are macroalgal species represented

throughout the year or is there a seasonal effect, with macroalgae appearing and disappearing at certain times of the year? Is there a macroalgal problem in the Molenaars River?

In order to investigate the ecology and community structures of the freshwater macroalgae in this river it is necessary to identify those that are present. As there is little readily available literature on the taxonomy of South African freshwater macroalgae it was necessary to create a guide by photographing and noting details of algal species encountered to serve as a reference after each visit to the river.

## Methods and Materials:

### Study Area:

The study area is situated along the upper Molenaars River from the Huguenot Tunnel to just below the Molenaars Bridge (33½44'S, 19½10'E) in which ten sample sites of 10 x 10m were chosen along the length of the upper Molenaars River. The study area and sample site locations are shown in figure 1.

### Site Positions and Descriptions:

Site 1A: Located below the Huguenot tunnel, approximately 50m upstream of first bridge site. This site is situated at the top of a large pool and includes steep gradient riffles and deeper water

Site 1B: Approximately 50m downstream of first bridge site. This site is situated in the middle of a long shallow pool with numerous exposed rocks.

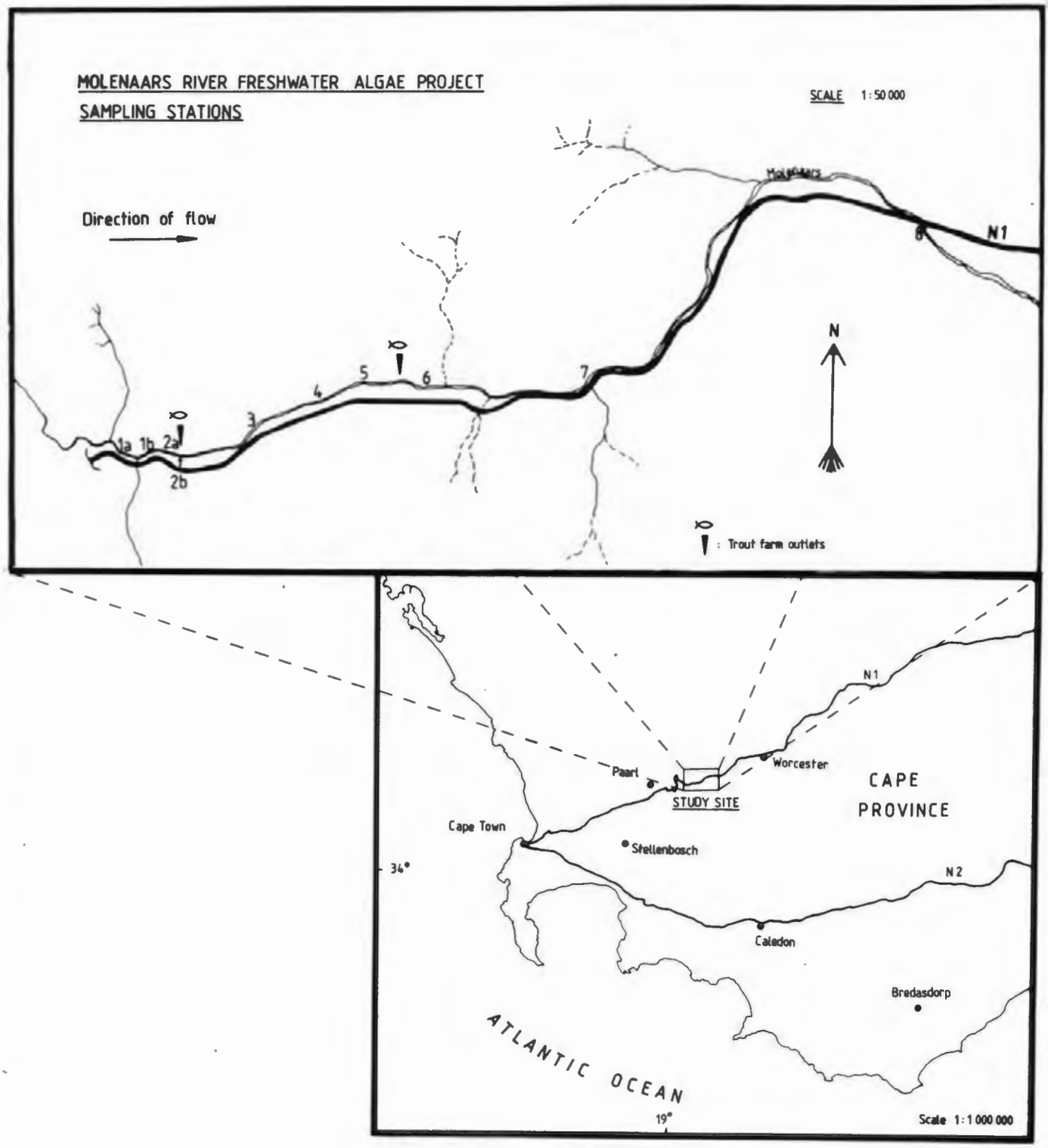


Figure 1: Maps showing the location of the study site and the sampling sites on the Molenaars River.

July and 19 September 1992. Although a visit was made on 15 June, the river level was too high to allow for sampling of algae.

Method of Algal Sampling:

At each site samples of algae were collected in an area of 10m x 10m and usually at depths of less than 0.5m. Mostly those plants forming macroscopically visible thalli that were attached to the substratum were collected. At each site collections were made of the algae that appeared to be different to the naked eye. The algae were removed by hand or using a pen-knife, put into glass vials and transported to the laboratory. For each of these algae their percentage cover for the 10m x 10m area was estimated. Usually this method was sufficient although some overlap was experienced between when samples that appeared visually different contained the same algae. Percentage cover was estimated according to the following modified Braun-Blanquet cover scale (Sheath & Burkholder, 1985): 0 = absent, 1 = <1%, 2 = 1 - 10%, 3 = 11 - 25%, 4 = 26 - 50%, 5 = 51 - 75%, 6 = 76 - 100%.

Environmental Data:

The following environmental data was collected:

1. Temperature.
2. Conductivity.
3. pH.
4. Water Speed.
5. Canopy Cover.
6. Rock Size.

Temperature was measured with an alcohol thermometer at the upstream section of the site in the fast flowing upper column of water, as temperatures were found to be homogenous when taken at different levels. Conductivity was measured with a Chrison conductivy meter at the upstream section of the site in the fast flowing upper column of water. The pH was measured with a Chrison pH meter at the upstream section of the site in the fast flowing upper column of water. Water speeds were measured with a hydrological flow meter made by Scientific Instruments Incorporated at four points in each site. The water speeds were taken at 6/10ths of the water column and the four readings were averaged to give a single figure. Canopy cover above the river was estimated as a percentage. Rock size was estimated according to diameter size for the following scale: 0 = <1cm, 1 = 1 - 4.9cm, 2 = 5 - 9.9cm, 3 = 10 - 49.9cm, 4 = 50 - 99cm, 5 = >100cm.

Laboratory work:

The macroalgae algae identified with the use of a key in Prescott (1954) and descriptions from Bold & Wynne (1985). Samples were never fetile, thus no species determinations could be made, but the macroalgae were identified to genus level where possible. Where more than one species in a gewnus was recorded, these species were labelled differently and their diagnostic features noted. Each different species was photographed with a Zeiss photomicroscope using ILFORD 400 DELTA fine grain, fast black and white film. Measurements of cell lengths and widths were taken and notes made on the chloroplast appearance, the number of pyrenoids and other distinguishing features.

## Analysis of Community Structure with CANOCO

Species and environmental data were analysed by canonical correspondence analysis or CANOCO - a FORTRAN programme for canonical community ordination (Ter Braak, 1987). This is a direct ordination technique that constrains the axes to be linear combinations of environmental variables and maximises the dispersion of species scores by the method of reciprocal averaging using iterative multiple regression of site scores on environmental variables.

For the analysis 37 samples (see table 1), eighteen species (see table 2) and 6 environmental variables (Temperature, conductivity, pH, water speed, canopy cover, rock size) were used. The Braun-Blanquet cover values for each species were entered into CANOCO, while the actual values for temperature, pH, conductivity and water speed were entered. Rock size was entered according to the scale given above and canopy cover was entered as percentages. These percentages had been estimated for each site. All data was entered in Cornell condensed format.

**Results:**

Eighteen species were found of which 12 were placed into genera, while five species were not identified to genus level. All were identified as Chlorophyta and are labelled as Species A, Species B, Species C, 'Green' Unicells and 'Orange' Unicells for use in the ordination. The species are given in the table 3:

**Table 3: A list of species from the Molenaars River:**
(The number of species found in the Molenaars River for each genus is given after the genus name.)

**DIVISION CHLOROPHYTA**

**Order:** Zygnematales
**Family:** Zygnemataceae
**Genus:** *Spirogyra* Link (1 species)
**Genus:** *Mougeotia* C.A. Agardh (3 species)
**Genus:** *Zygnema* C.A. Agardh (1 species)

**Order:** Tetrasporales/Volvocales
**Family:** Palmellaceae
**Genus:** *Palmella* Lyngbye (1 species)

**Order:** Chaetophorales
**Family:** Chaetophoraceae
**Genus:** *Stigeoclonium* Kützing (1 species)

**Order:** Ulotrichales
**Family:** Ulotrichaceae
**Genus:** *Ulothrix* Kützing (3 species)

**DIVISION RHODOPHYTA**

**Order:** Batrachospermales
**Family:** Batrachospermaceae
**Genus:** *Batrachospermum* Roth (1 species)

**DIVISION CYANOPHYTA**

**Order:** Oscillatoriales
**Family:** Oscillatoriaceae
**Genus:** *Lyngbya* Agardh (1 species)
**Genus:** *Oscillatoria* Vaucher (1 species)

## DESCRIPTIONS OF TAXA

## 1. DIVISION CHLOROPHYTA

**A. Order:** Zygnematales

**Family:** Zygnemataceae

**Genus:** *Spirogyra* Link

**General Information and Description:**

This genus is described as one of the commonest South African freshwater algae. *Spirogyra* form unbranched mucilaginous filaments which are thus free from epiphytes. They are common in standing water such as vleis (Pocock, 1966). The cells contain a large central vacuole, a nonspherical nucleus that is suspended by threads of cytoplasm and have one or more parietal chloroplasts spirally arranged with ribbon or band like appearance (Bold & Wynne, 1985). Chloroplasts are scalloped and contain numerous, prominent pyrenoids.

**Species 1:**

**Species Description:**

A large light green species. It is easily recognised, with cells that have 3-4 spirally arranged chloroplasts making 1 - 1 3/4 turns around the cell wall.

**Chloroplast description:** The ribbon-like chloroplast often twist on their own axis. Chloroplasts have an average of 9 pyrenoids.

**Cell length:** 98 -115 µm, average 76.32µm.

**Cell diameter:** 15-27µm, average 17.76µm.

This species was found in March (Sites 1A, 1B, 2A, 2B and 3), April (Sites 1A, 1B, 2A, 2B, 3, 4, 5 and 6), July (Site 1A) and September (Sites 1A, 1B,2A and 5).

**Species 2:**

**Species Description:** This species is characterised by long narrow cells that are 10-15 time as long as broad. On ocassions it seems that younger cells are shorter in length and may be less than half the length of the long cells, but the cell diameters remain faily constant.

**Chloroplast description:** One long thin and flat chloroplast fills the entire length of the cell. The chloroplasts contains an average of 7 pyrenoids

**Cell length:** 35 - 112µm, average 92.4µm

**Cell diameter:** 7 - 8µm, average 7.6µm

This species has characteristics similar to *Mougeotia gracillima* Hass. (Fritsch, 1918). It was found in the Molenaars river in March (Sites 1A, 6 and 8), April (Sites 1A, 3, 4, 5 6 and 7) and September (Sites 1A, 3 and 6). This species was often found in small quantities with *Mougeotia* species 1.

**Species 3:**

**Species Description:** A medium sized species that is smaller than *Mougeotia* species 1 and has a cell diameter greater than *Mougeotia* species 2.

**Chloroplast description:** A flat ribbon like chloroplast that has 3 - 5 pyrenoids.

**Cell length:** 65 -69 μm

**Cell diameter:** 17 - 20 μm

This species was only detected in September at site 1A.

**Genus** *Zygnema* C.A. Agardh

**General Information and Description:**

*Zygnema* are unbranched mucilaginous filamentous macroalgae. Each cell, which is short and cylindrical, has two diagnostic star-shaped chloroplasts each containing a central pyrenoid (Belcher & Swale, 1978). The nucleus is situated between the chloroplasts.

**Species 1:**

**Species Description:** The filaments of this species have a light green appearance, but the star-shaped chloroplasts are clearly distinguishable even under a low-power microscope.

**Chloroplast description:** The distinctly stellate chloroplasts are a result of having protuberances which radiate outwards in all directions. Each chloroplast contains one pyrenoid.

**Cell length:** 41 - 88μm, average 75.1μm.

**Cell diameter:**24 - 28μm, average 22.6μm.

**Zygospore diameter:** 26.4 - 28.8μm

Although cell widths are not a good character in *Zygnema* specimens collected in March became fertile in October and measurements of the zygospores could be made. On the grounds of the zygospore diameter this species then seems to be very similar to *Zygnema spirale* Fritsch (Fritsch, 1918).

This particular species was found in the Molenaars River in March (Sites 1A, 1B, 3 and 6) and April (Sites 4, and 6).

**Order:** Tetrasporales

**Family:** Palmellaceae

**Genus:** *Palmella* Lyngbye

**General Information and Description:**

An irregular gelatinous mass containing numerous cells, often grouped in sets of four. The cells are embedded in a common matrix.

**Species 1:**

**Species Description:** Tiny bright green unicells. This species formed

**Chloroplast description:** A single chloroplast fills most of the cell.

**Cell diameter:** 4 - 9 μm.

Recorded in the Molenaars River in March (Sites 1B, 2A and 8) and in April (Sites 1A, 1B, 2A, 2B, 4, 5 and 8).

C. **Order:** Chaetophorales

**Family:** Chaetophoraceae

**Genus:** *Stigeoclonium* Kützing

**General Information and Description:**

*Stigeoclonium* are bright green in colour with a thallus that consists of a prostrate system and an erect system. The prostrate system attatches the algae to the substratum and may be pseudo-parenchymatous. The erect system has many branched axes that are mostly uniseriate, that arise from the prostrate system

(Pocock, 1966). The distal cells are attenuated and sometimes bear a long multicellular hair. The chloroplasts of the larger cells are parietal cylindrical with several pyrenoids, while in smaller cells they are parietal with 1 - 3 pyrenoids (Entwisle, 1989). Common in running or standing water, especially in Spring (Belcher & Swale, 1978).

**Species:** *Stigeoclonium tenue* Rabenh.

Specimens of similar vegetative morphology from Paarl were sent to Holland where the prostrate thallus was cultured and was positively identified as *Stigeoclonium tenue* Rabenh.

**Species Description:** Easily recognised as *Stigeoclonium*, this species appears as bright green tufts of 0.5 - 1.0 cm in height which consist of many branched filaments.

**Chloroplast description:** Chloroplasts are parietal and in the larger cells cylindrical. There are 3-7 pyrenoids per chloroplast.

**Cell length:** 2 - 22µm, average 16.7µm.

**Cell diameter:** 3.5 - 11µm, average 8.5µm.

This species can tolerate an extremely wide range of eutrophication (Entwisle, 1989). It appears to be a good indicator species for monitoring nitrate levels as it was regularly found at the outlets of trout farms into the Molenaars River. This species was found in the Molenaars river in March (Site 2B), April (Site 2B), July (Site 2B) and September (Site 1B, 2B, 3, 4, 5, 6 and 7).

**D. Order:** Ulotrichales

**Family:** Ulotrichaceae

**Genus:** *Ulothrix* Kützing

**General Information and Description:**

The species in this genus have unbranched filaments. Each cell has one parietal chloroplast which forms an incomplete band around the cell (Pocock, 1966) It is a common genus found in all types of flowing water where it forms bright green attached masses. It is particularly common in spring and autumn (Fritch, 1948).

**Species 1:**

**Species Description:** A bright green species with parietal chloroplasts that appear to be able to move to different positions in the cell.

**Chloroplast description:** Chloroplasts are parietal with 1 - 3 pyrenoids.

**Cell length:** 8 - 11µm, average 10.3µm.

**Cell diameter:** 5 - 6µm, average 5.7µm.

This species was recorded in the Molenaars River in July (Sites 1A, 4, 5, 6 and 8) and September (Sites 1a, 5 and 7).

**Species 2:**

**Species Description:** This species has irregular cell shapes, ranging from circular to rectangular. It is has a light green appearance.

**Chloroplast description:** Chloroplasts are parietal with 1 pyrenoid.

**Cell length:** 4 - 6.5µm, average 5.9µm.

**Cell diameter:** 3.8 - 5µm, average 4.2µm.

This species was recorded in the Molenaars River in September (Sites 1A, 1B, 2A, 4, 5 and 6).

**Species 3:**

**Species Description:** This species is distinguishable from *Ulothrix* species 1 and 2 by its longer cells.

**Chloroplast description:** This species has one long parietal, ribbon-like chloroplast. The chloroplasts have 2 - 3 pyrenoids.

**Cell length:** 8.5 - 12.2µm, average 10µm.

**Cell diameter:** 1.9 - 2.7µm, average 2.2µm.

This species was recorded in the Molenaars River in September (Sites 4, 5 and 6).

**E. Unidentified Chlorophyta:**

**Species A:**

**Species Description:** Bright green unbranched filaments.

**Chloroplast description:** Chloroplasts Parietal, shaped in the like the figure eight.

**Cell length:** 9.5 - 13µm, average 11µm.

**Cell diameter:** 5.8 - 6.7µm, average 6.3µm.

Recorded in the Molenaars River in July (Site 1B)

**Species B:**

**Species Description:** This species has irregularly branched green filaments.

**Chloroplast description:** Chloroplasts are difficult to distinguish, but are parietal.

**Cell length:** 7 - 10µm, average 9µm.

**Cell diameter:** 4 - 6µm, average 4.3µm.

Recorded in the Molenaars River in July (Site 1B)

**Species C:**

**Species Description:** This species has bright green unbranched filaments.

**Chloroplast description:** Chloroplasts are parietal.

**Cell length:** 5 - 7µm, average 6µm.

**Cell diameter:** 5 - 6µm, average 5.8µm.

Recorded in the Molenaars River in July (Site 6)

**'Green' unicells:**

**Species Description:** This species has multitudes of circular bright green unicells, that are embedded in mucilage and form dense slimy layers on the surface of rocks.

**Cell diameter:** 7µm.

This species formed dense gelatious layers on the rocks and was present in greater quantities in July. This life form was found in July (Sites 1A, 1B, 2A, 2B, 3, 4, 5, 7 and 8) and in September (Sites 1A, 1B, 2A, 3 and 5).

**'Orange' Unicells:**

**Species Description:** This species occurs as masses of spherical green unicells which were embedded in mucilage and formed dense slimy layers on the rock surface. This species had an orange colour when viewed with the naked eye.

**Cell diameter:** $>6\mu m$.

'Orange' unicells were only found in July (Sites 1A, 1B, 2A, 3, 4 and 5).

## 2. DIVISION RHODOPHYTA

**A. Order:** Batrachospermales

**Family:** Batrachospermaceae

**Genus:** *Batrachospermum* Roth.
(Frog-spawn alga)

**General Information and Description:**

This genus contains species which have thalli that are branched. Main axes of the thallus consist of axial rows of elongated cells that are often corticated and bear whorls of lateral uniseriate branches. These branches are placed at intervals, giving the thallus a bearded and bushy appearance (Pocock, 1966). The plants are usually a bluish-green or brown colour. They are widely distributed and favour well-aerated water of slow flowing streams (Fritsch, 1954).
One of the phases in the life history of Batrachospermum is the branched filamentous or '*Chantransia*' phase. This phase begins with the germination of a carpospore (Chapman & Chapman, 1983).

**Species 1:**

**Species Description:** This species displayed both the branched filamentous '*Chantransia*' stage and the adult *Batrachospremum* stage of its life history. Both were of a dark brownish-green colour.

**Chloroplast description:** Chloroplasts appear parietal.

**Cell length:** 6 - 11μm, average 8.4μm.

**Cell diameter:** 5.5 - 12μm, average 9.1μm.

The '*Chantransia*' stage was observed in March (Site 2B), April (Sites 2B and 8) and July (Site 2B), while the adult stage was recorded in small amounts among the '*Chantransia*' stage only in March (Site 2B).

## 3. DIVISION CYANOPHYTA

**A. Order:** Oscillatoriales

**Family:** Oscillatoriaceae

**Genus:** *Lyngbya* Agardh

**General Information and Description:**

An unbranched 'blue-green' with filaments that occur either singly or sometimes in dense mats. They have a characteristic smell and are distinguished from *Oscillatoria* by their firm sheath and their absence of movement (Pocock, 1966).

**Species 1:**

**Species Description:**

**Chloroplast description:**

**Cell length:** 4 - 5.7μm, average 4.6μm.

**Cell diameter:** 5 - 7μm, average 6.1μm.

The diameter seems to fit that for *Lyngbya aerugineo-coerulea* Gomont. (Fritsch, 1918)

**Genus:** *Oscillatoria* Vaucher

**General Information and Description:**

Filamentous 'Blue-greens' that are distinguished from *Lyngbya* by their ability to 'creep slowly'. They do not have a sheath, but the outer walls are mucilaginous (Pocock, 1966).

**Species 1:**

This species seems to fit the *Oscillatoria tenuis* Agardh. (Fritsch, 1918).

**Species Description:**

**Cell length:** 2µm.

**Cell diameter:** 6µm.

Found only in Site 6 in July.

**Environmental Data:**

The environmental data is given in graph form in figures 2.1, 2.2, 2.3, 2.4 and 2.5. Temperatures in the Molenaars River dropped from between 15 to 21 degrees in the months of March and April to between 8 and 13 degrees for the months July and September. also there is a general drop in conductivity at each site from March and April to September. Althuogh there is no clear pattern in the range of water speeds over the months, there is a general increase in pH as one travels down the river from readings of just more than 5 to 6.6. Canopy cover and rock size, although different for each site, remained constant from month to month.

Species scores, sample scores and biplot scores of environmental variables were each determined for four axes. The eigenvalues and percentage variance accounted for by the axes are given in table 2. As axes 1, 2 & 3 accounted for most of the variance and because axis 4 had such a low eigenvalue, canonical correspodence analysis (CCA) ordination diagrams of species environment scores from the analysis were plotted for axes 1 & 2 and 1 & 3 only. These diagrams are given in figures 3.1

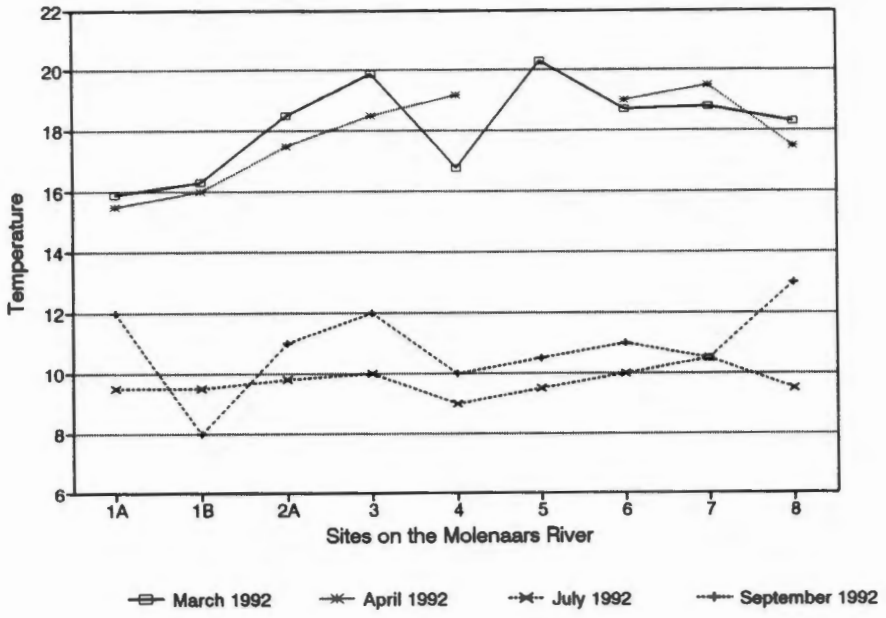


**Figure 2.1:** The range of water temperatures recorded for each site on the Molenaars River for March, April, July and September.

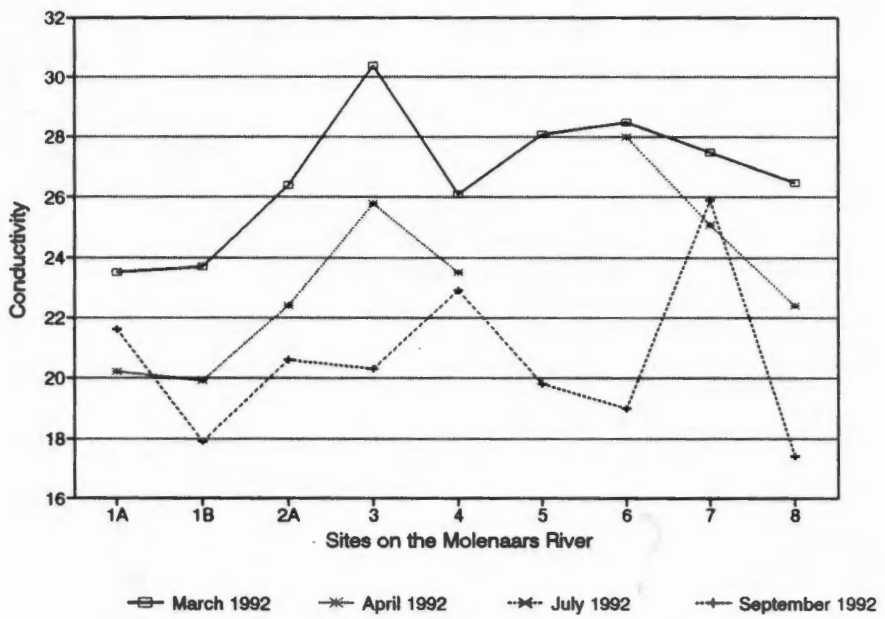


**Figure 2.2:** The range of water conductivity recorded for each site on the Molenaars River for March, April and September.

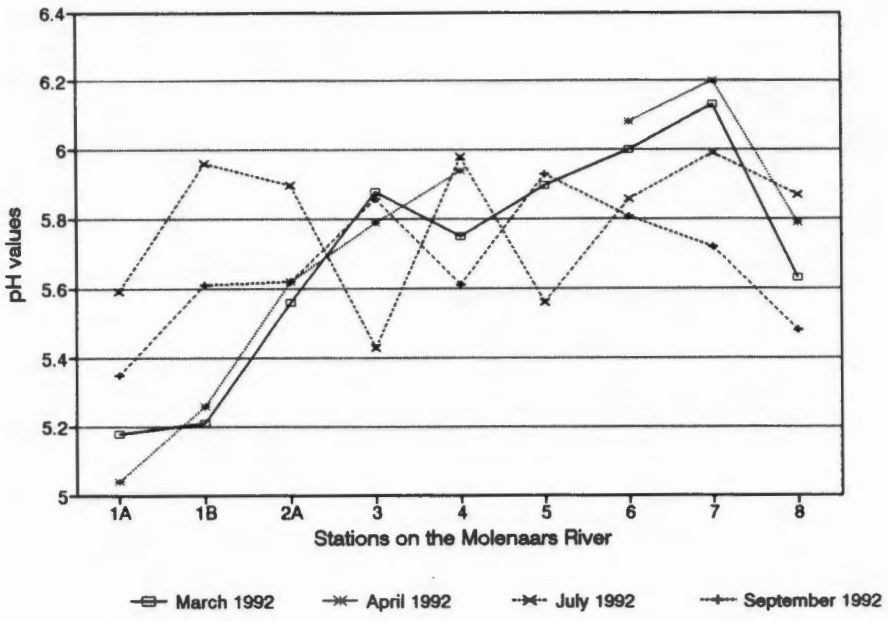


**Figure 2.3:** The range of water pH values recorded for each site on the Molenaars River for March, April, July and September.

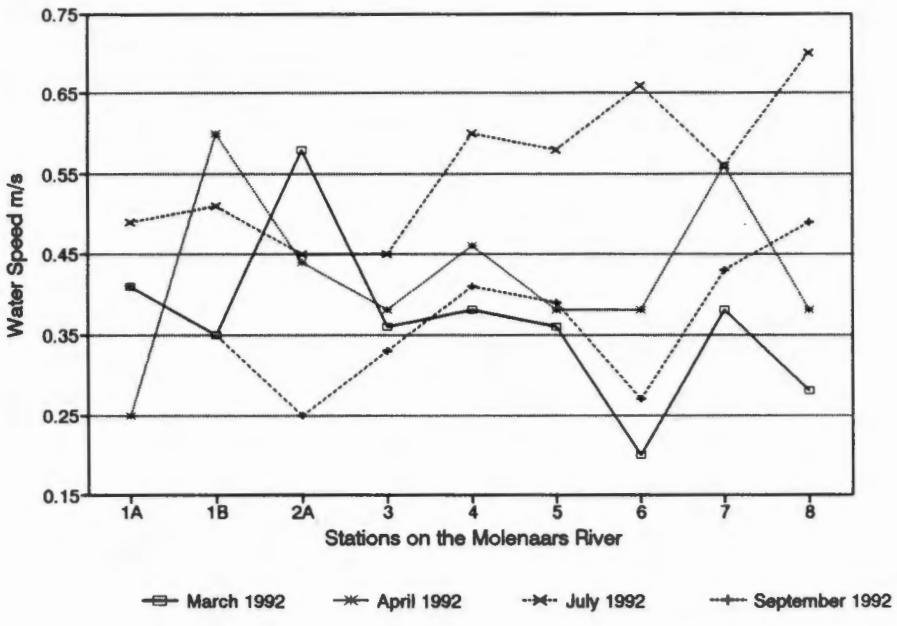


**Figure 2.4:** The range of water speeds recorded for each site on the Molenaars River for March, April, July and September.

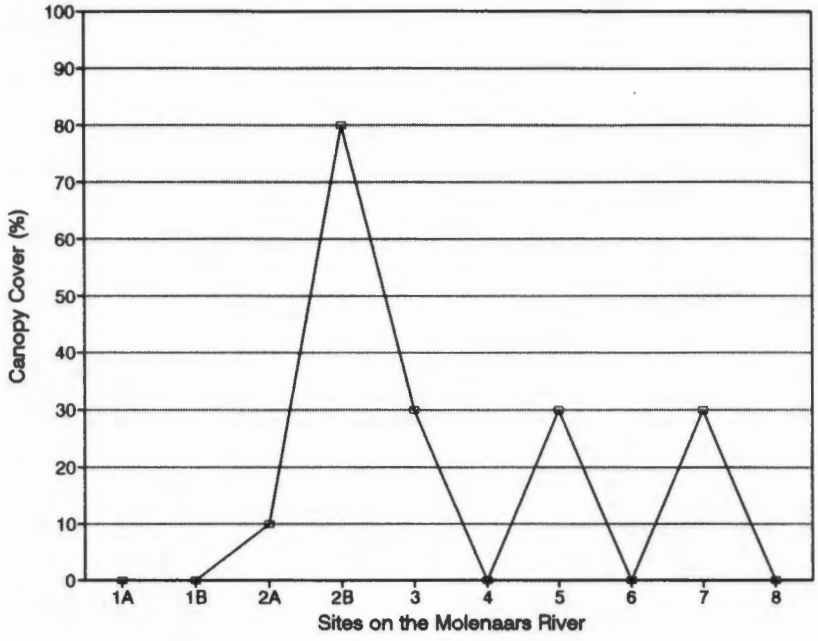


**Figure 2.5:** Graph of estimated canopy cover recorded for each site on the Molenaars River.

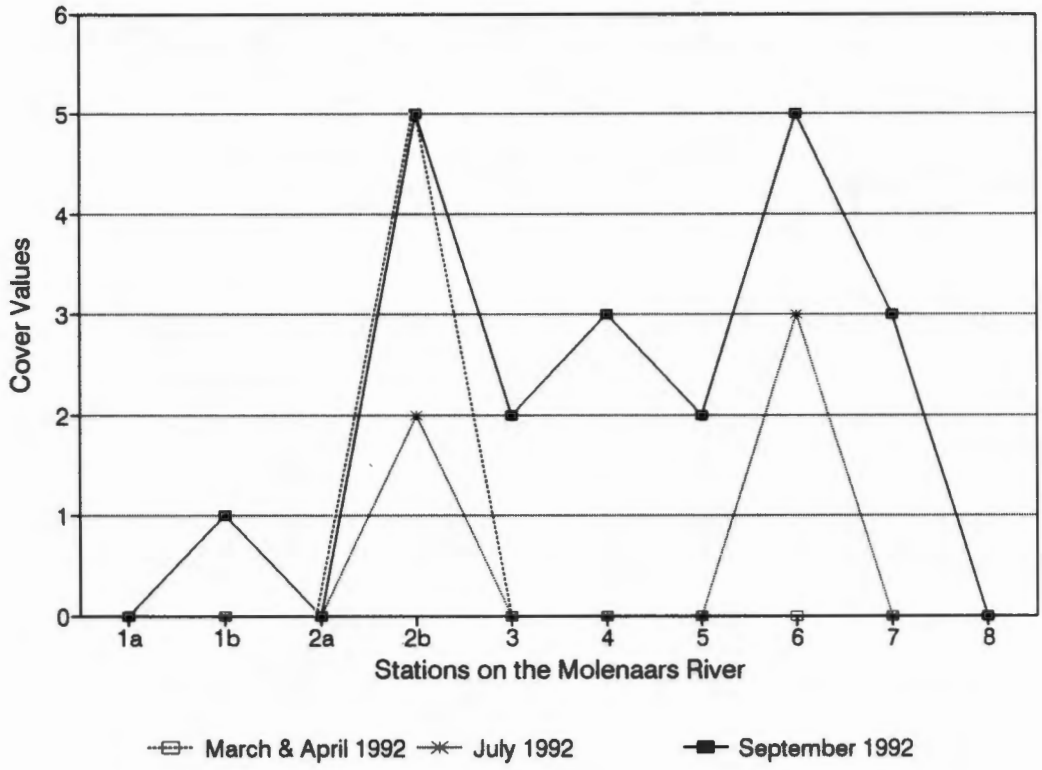


**Figure 2.6:** Graph of cover recorded for *Stigeoclonium tenue* Rabenh. for each site on the Molenaars River for March, April, July and September.

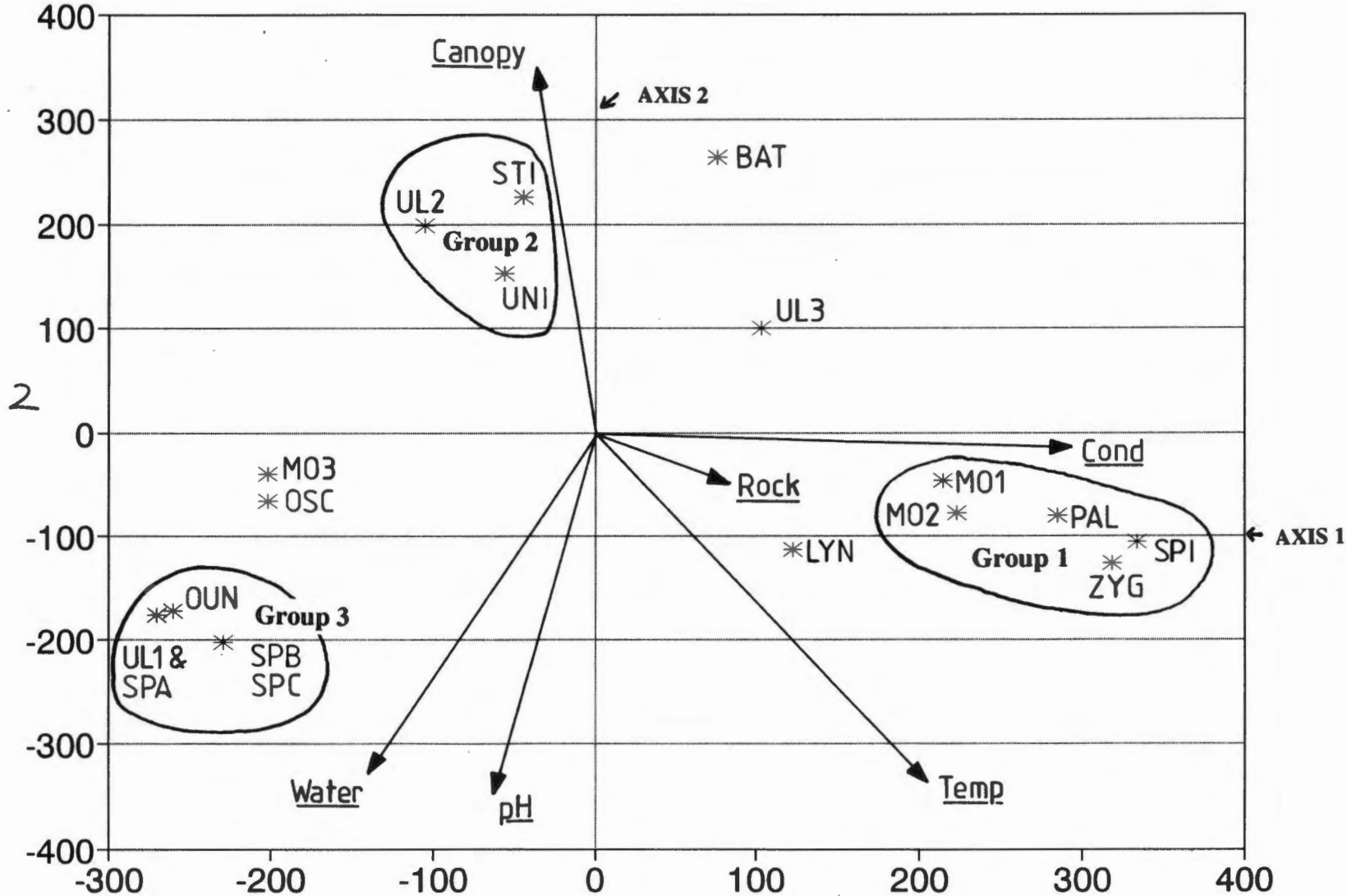


**Figure 3.1:** A Canonical Correspondence Analysis ordination diagram of species and environmental biplot scores for axes 1 & 2 (Species codes explained in Table 3).

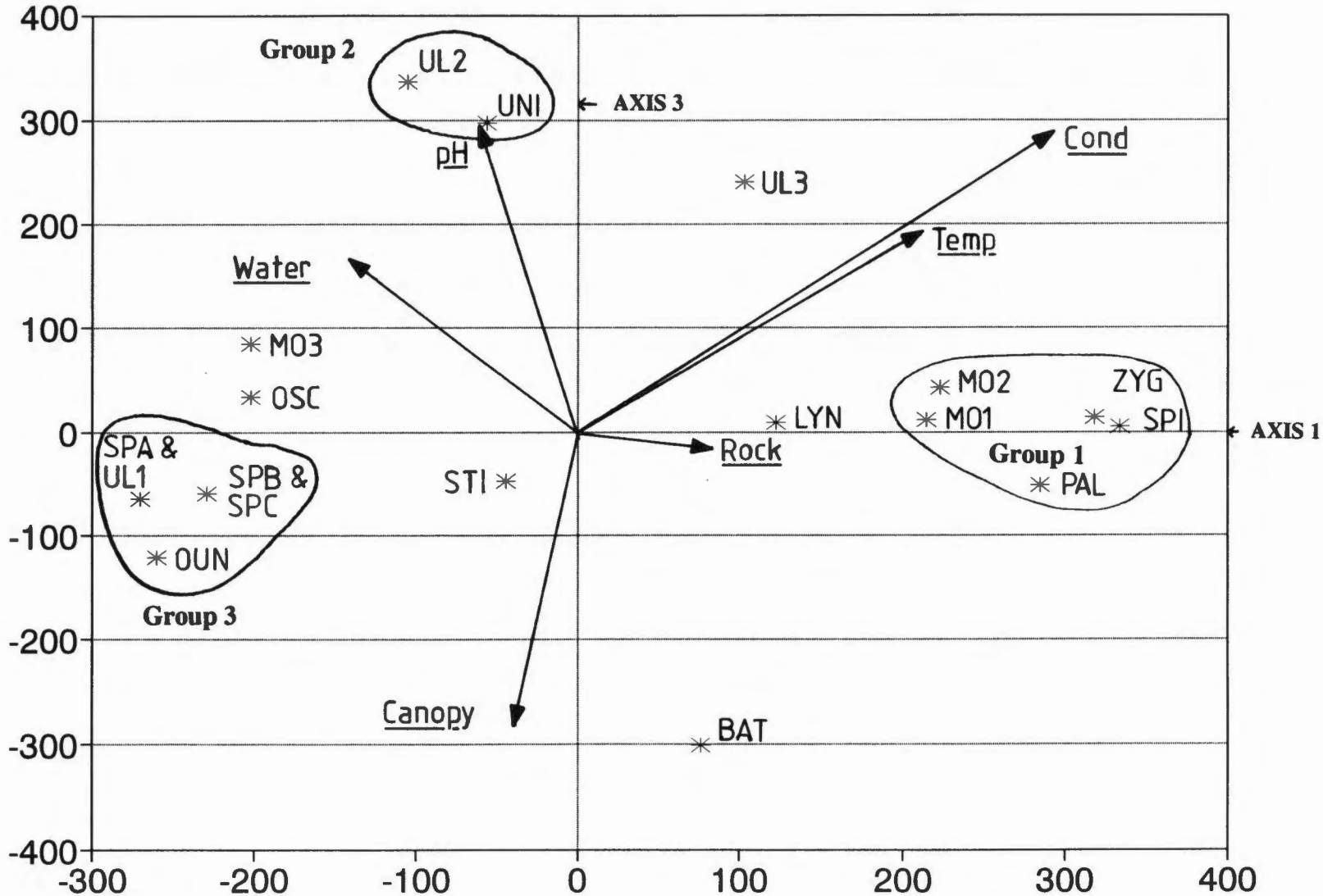


**Figure 3.2:** A Canonical Correspondence Analysis ordination diagram of species and environmental biplot scores for axes 1 & 3 (Species codes explained in Table 3).

and 3.2 respectively. The CCA ordination diagrams for the sample scores, also for axes 1 & 2 and 1 & 3, are given in figure 3.3 and 3.4 respectively.

**Table 1:** **Eigenvalues for each axis and percentage variance accounted for by the axes.**

| Axis (S) | Eigenvalue | % Variance accounted for by the first S axes. |
|---|---|---|
| 1 | 0.75621 | 43.0 |
| 2 | 0.52654 | 72.9 |
| 3 | 0.30527 | 90.3 |
| 4 | 0.08705 | 95.2 |

**Table 4:** **Species Codes and Names.**

| CODE | SPECIES NAME |
|---|---|
| BAT | *Batrachospermum* species 1. |
| LYN | *Lynbgbya* species 1. |
| MO1 | *Mougeotia* species 1. |
| MO2 | *Mougeotia* species 2. |
| M03 | *Mougeotia* species 3. |
| OSC | *Oscillatoria* species 1. |
| OUN | 'Orange' Unicells. |
| PAL | *Palmella* species 1. |
| SPA | Species A |
| SPB | Species B. |
| SPC | Species C. |
| SPI | *Spirogyra* species 1. |
| STI | *Stigeoclonium tenue* Rabenh. |
| UL1 | *Ulothrix* species 1. |
| UL2 | *Ulothrix* species 2. |
| UL3 | *Ulothrix* species 3. |
| UNI | 'Green' Unicells. |
| ZYG | *Zygnema* species 1. |

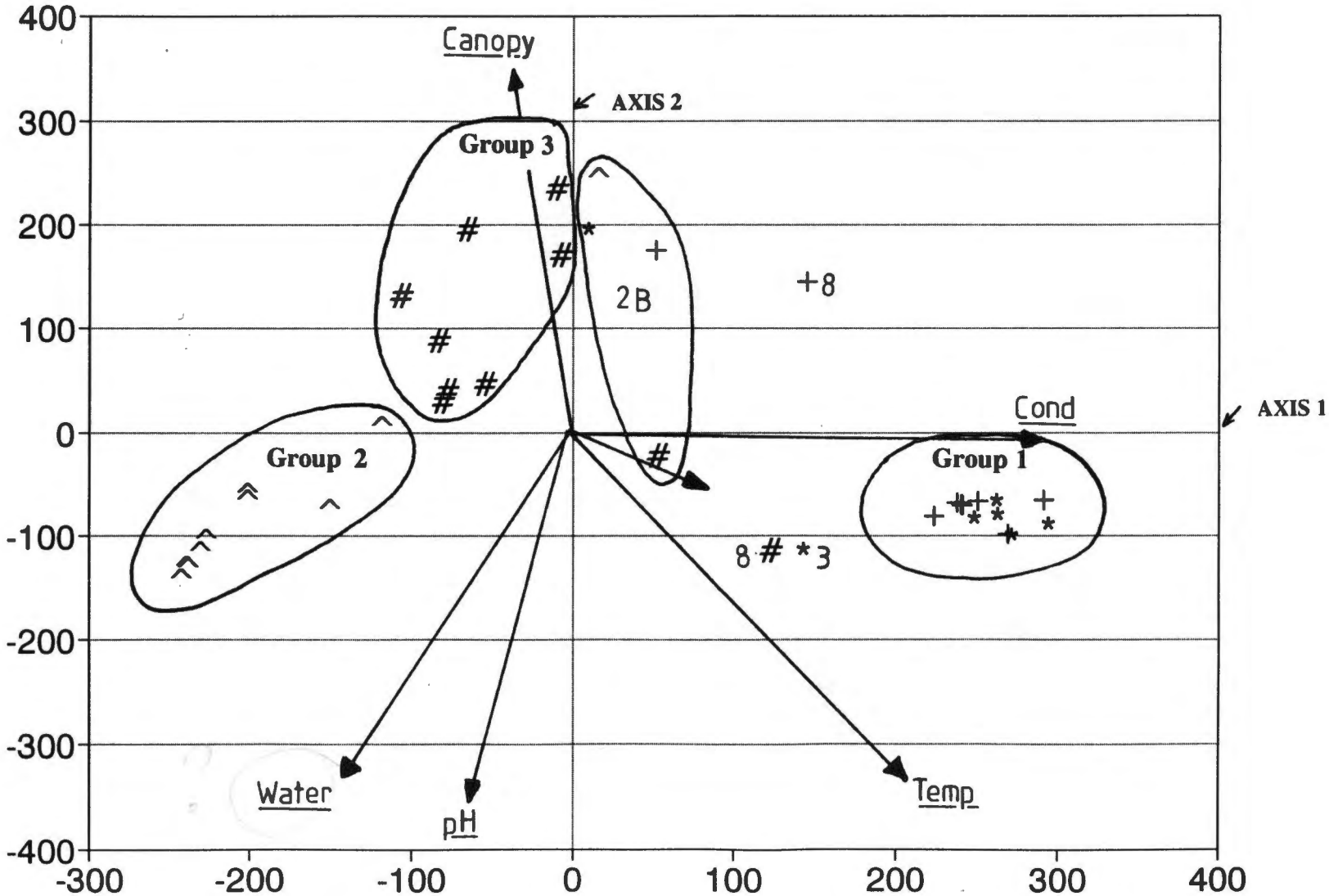


**Figure 3.3** A Canonical Correspondence Analysis ordination diagram of sample and environmental biplot scores for axes 1 & 2 (* = March samples, + = April samples, ^ = July samples, # = September samples)

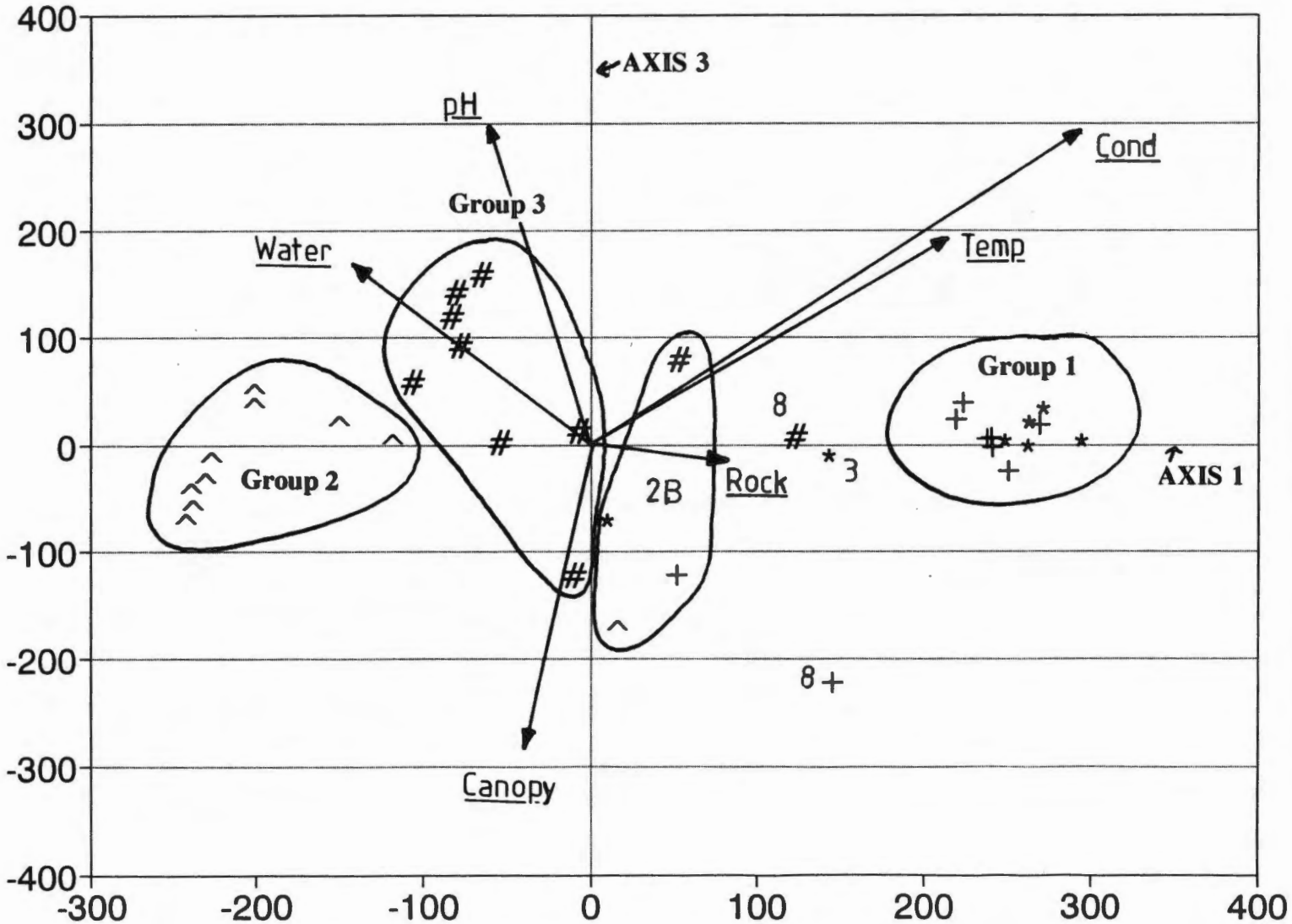


**Figure 3.4** A Canonical Correspondence Analysis ordination diagram of sample and environmental biplot scores for axes 1 & 3 (* = March samples, + = April samples, ^ = July samples, # = September samples)

**Discussion:**

Although the sampling period of this project only covered the period from March to September 1992, thus leaving out most of the spring and summer months, valuable information about macroalgae in the Molenaars River has been obtained.

The question whether the effluent released into the Molenaars River from the trout farms has an effect on the macroalgal communities seems to be answered. If one considers the distribution and abundance of the species *Stigeoclonium tenue* in the Molenaars River (see figure 2.6) it becomes clear that the presence of this species is linked to the the trout farms. *Stigeoclonium tenue* is recorded primarily at the outlets of the trout farms (sites 2B and 6) and has persisted in the Molenaars River throughout the study period. In September *Stigeoclonium tenue* is present in large amounts at site 2B and tapers off at sites 3, 4 and 5 again at site 6 it is present in large amounts and tapers off at sites 7 and 8. Entwisle (1989) has shown that this species can tolerate extremely wide range of eutrophication. Thus this species appears to be a good indicator species for monitoring nitrogen levels in the Molenaars River. This correlates well with Ractliffe's (1992) observation that trout stocks are heavier in the winter than in summer as increased numbers of trout will cause an increase in the amount of effluent being released into the river. This inturn then causes increased amounts of *Stigeoclonium tunue*.

Three main groupings of species becomes apparent in the canonical correspondence ananlysis ordination diagrams in figure 3.1 and 3.2. These are given the following names:

Group 1: Zygnemataceae/*Palmella* group.
Group 2: *Ulothrix* 2/ 'Green' Unicells group.
Group 3: 'Orange' Unicells/*Ulothrix* 1/Species A, B & C group.

Some species are linked to the disturbances on the river. For example the presence of *Stigeoclonium tenue* is related to the presence of trout farms on the Molenaars River which release effluent into the river.

This seasonal effect is also evident in the ordination diagrams for sample and environmental biplot scores (Figures 3.3 and 3.4). Most of the samples for the different months cluster together into three groups:

Group 1 contains sites 1A, 1B, 2A and 6 for March and sites 1A. 1B, 2A, 3, 4, 5, 6 and 7 for April.
Group 2 contains sites 1A, 1B, 2A, 3, 4, 5, 6, 7 and 8 for July.
Group 3 contains sites 1A, 1B, 2A, 3, 4, 5, 6 and 7 for September.

The site ' 2B' clusters together regardless of what date the site was visited and this is due to the high canopy cover over the site and the distinctness of species found in it. Three other sites have not clustered with the other sites for that month. These are site 3 for March and site 8 for April and September.

When assessing whether the construction of two bridges over the Molenaars River has an effect on the macroalgal communities or on macroalgal growth it seems that there is no significant effect. Although there are slight differences between the sites above and below the two bridges, these are not significant enough to show that the bridges are having an impact on the macroalgae.

At this stage there does not seem to be an algal problem in the Molenaars river. Perhaps the fact that the river is in a mountainous area where rain tends to flush out macroalgae on a regular basis has meant that the molenaars River has remained 'clean'.

## Conclusion:

There are clear seasonal patterns in the occurrence of macroalgae in the Molenaars river. This project has shown that there are three main groups of macroalgae that were present in the study period. These are a summer/autumn group, a winter group and a spring group. These groupings were shown for both species and sample ordinations. While the Molenaars River does not seem to be affected by the construction of two bridges over it, it is affected by the effluent released from the trout farms. *Stigeoclonium tenue* has been shown to be an indicator species for the monitoring of trout effluent.

Further study during the spring and summer periods is require to give a more complete appreciation of macroalgae in the Molenaars River.

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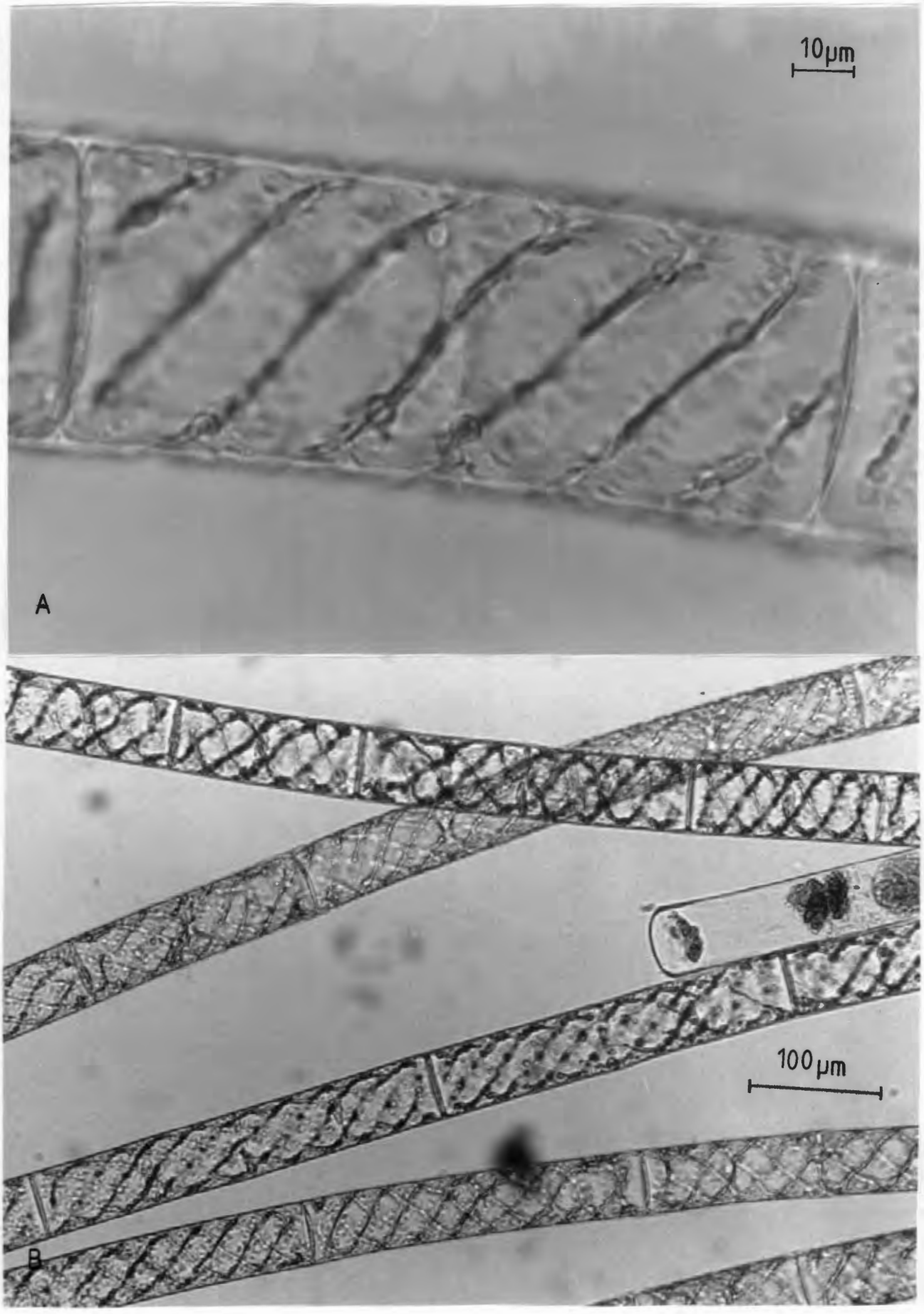


**Plate 1:** **A & B:** Spirogyra **species 1.**

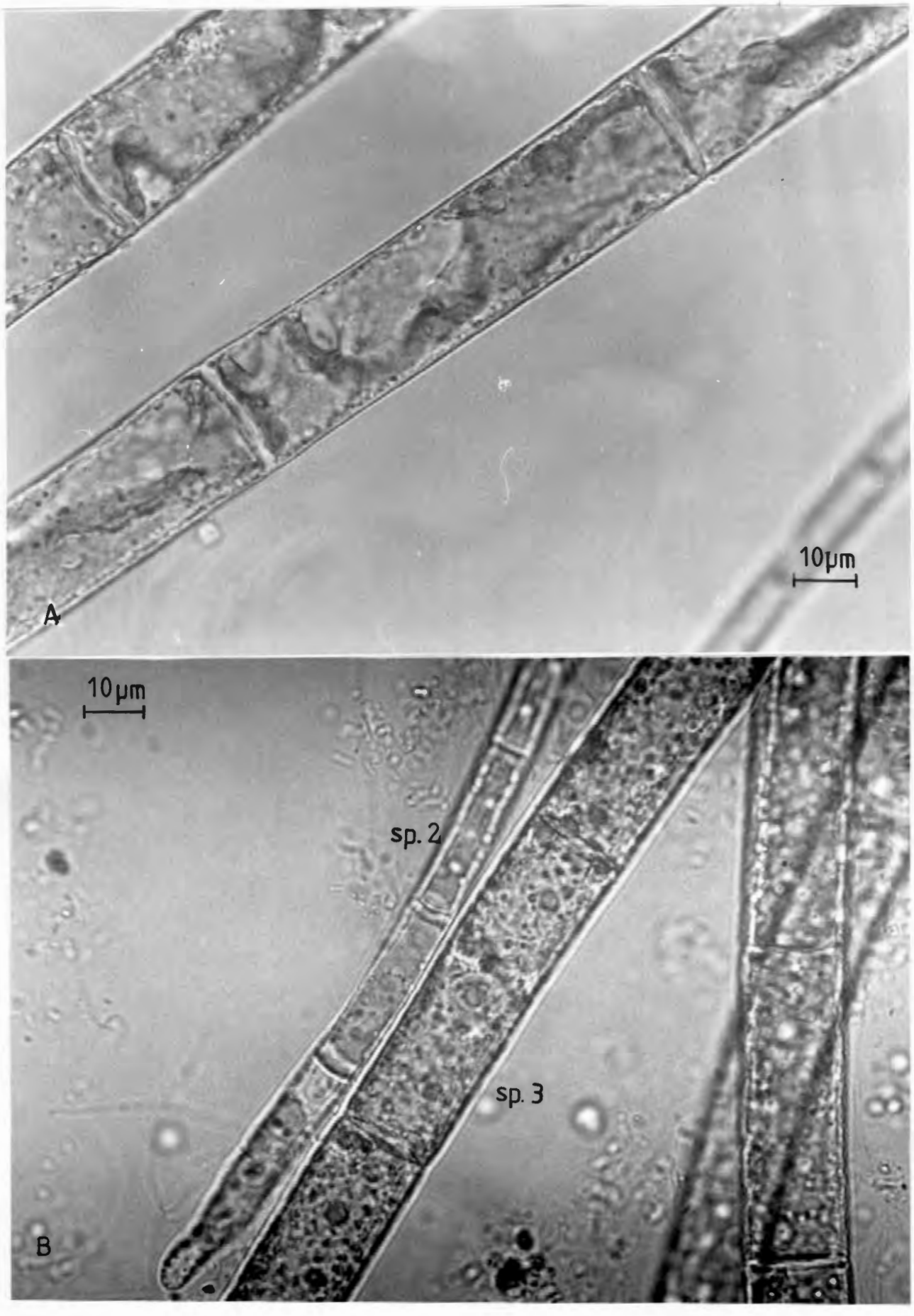


**Plate 2:** **A:** Mougeotia **species 1, B:** Mougeotia **species 3 and species 2.**

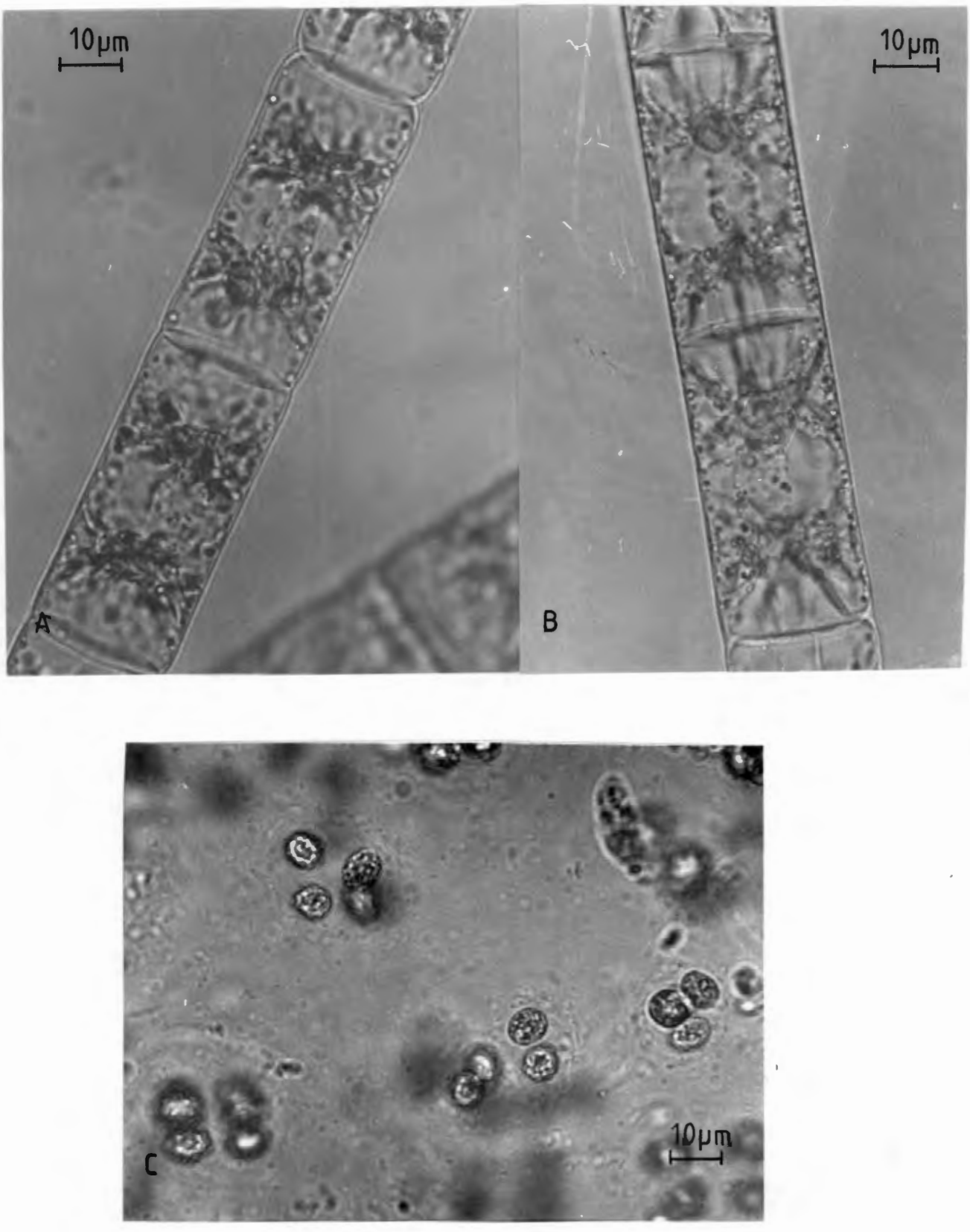


**Plate 3:** **A & B:** Zygnema **species 1, C:** Palmella **species 1.**

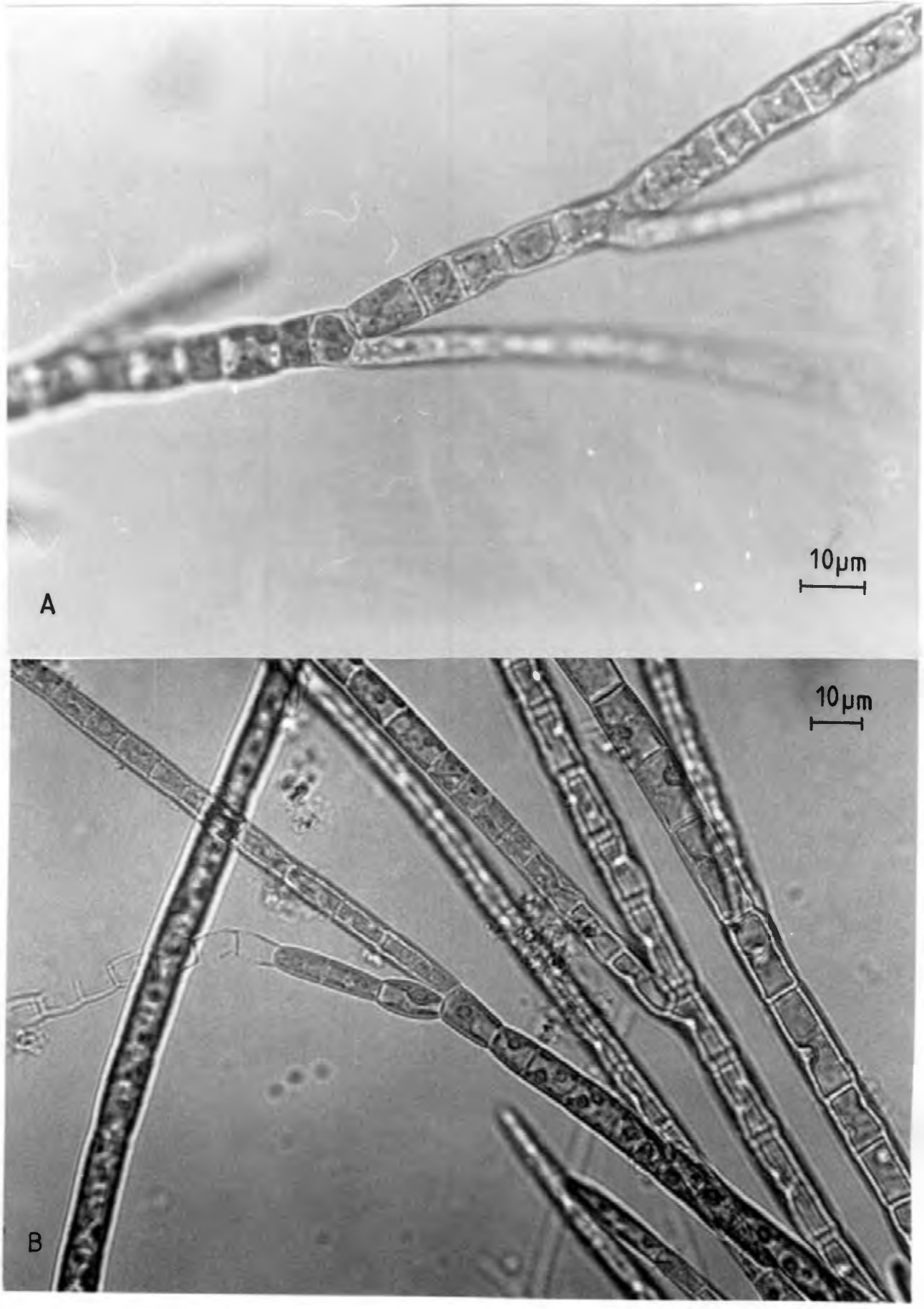


**Plate 4:** **A:** Stigeoclonium tenue **Rahbenh.** B = A

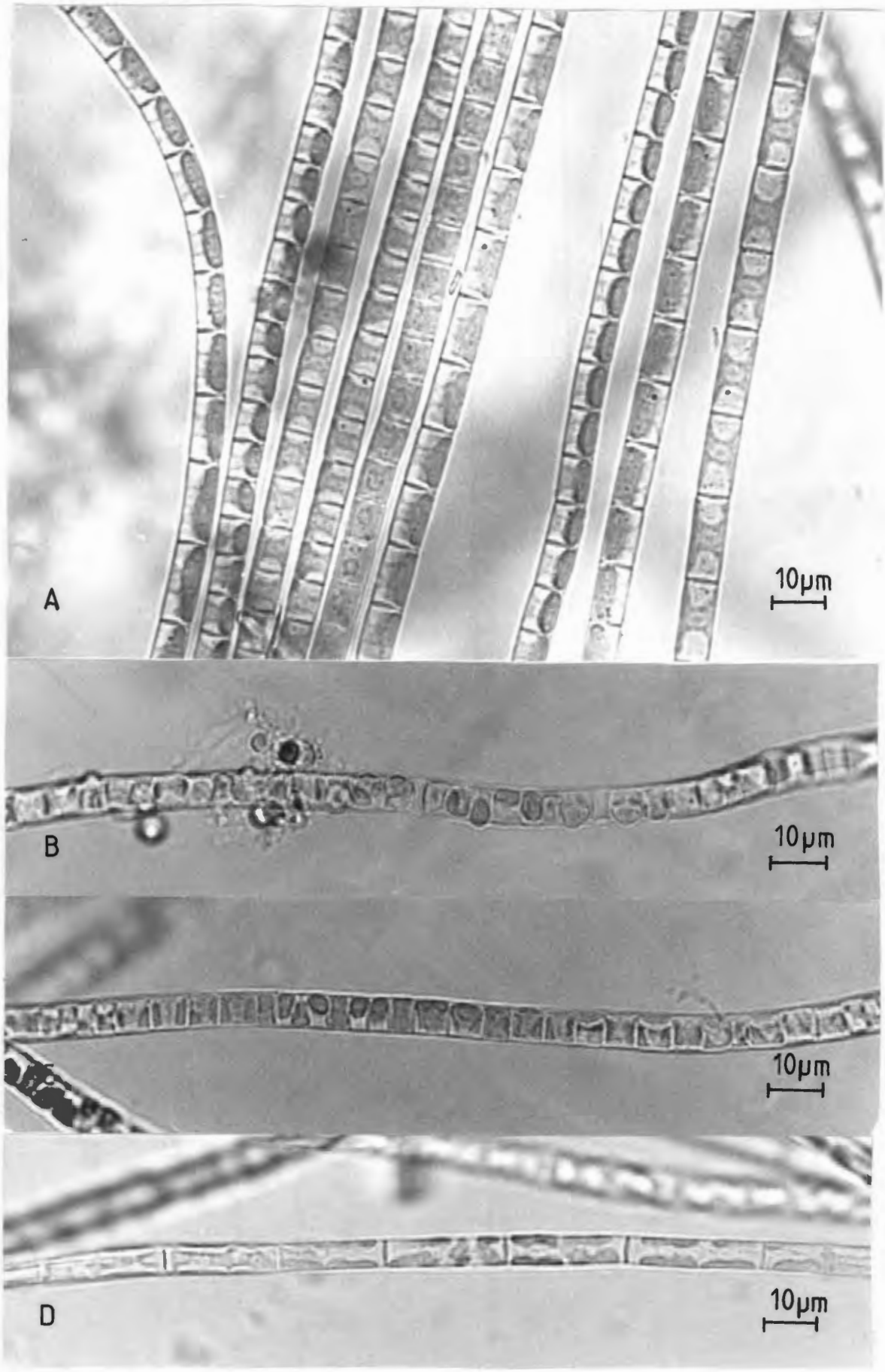


**Plate 5:** **A:** Ulothrix **species 1, B & C:** Ulothrix **species 2, D:** Ulothrix **species 3**

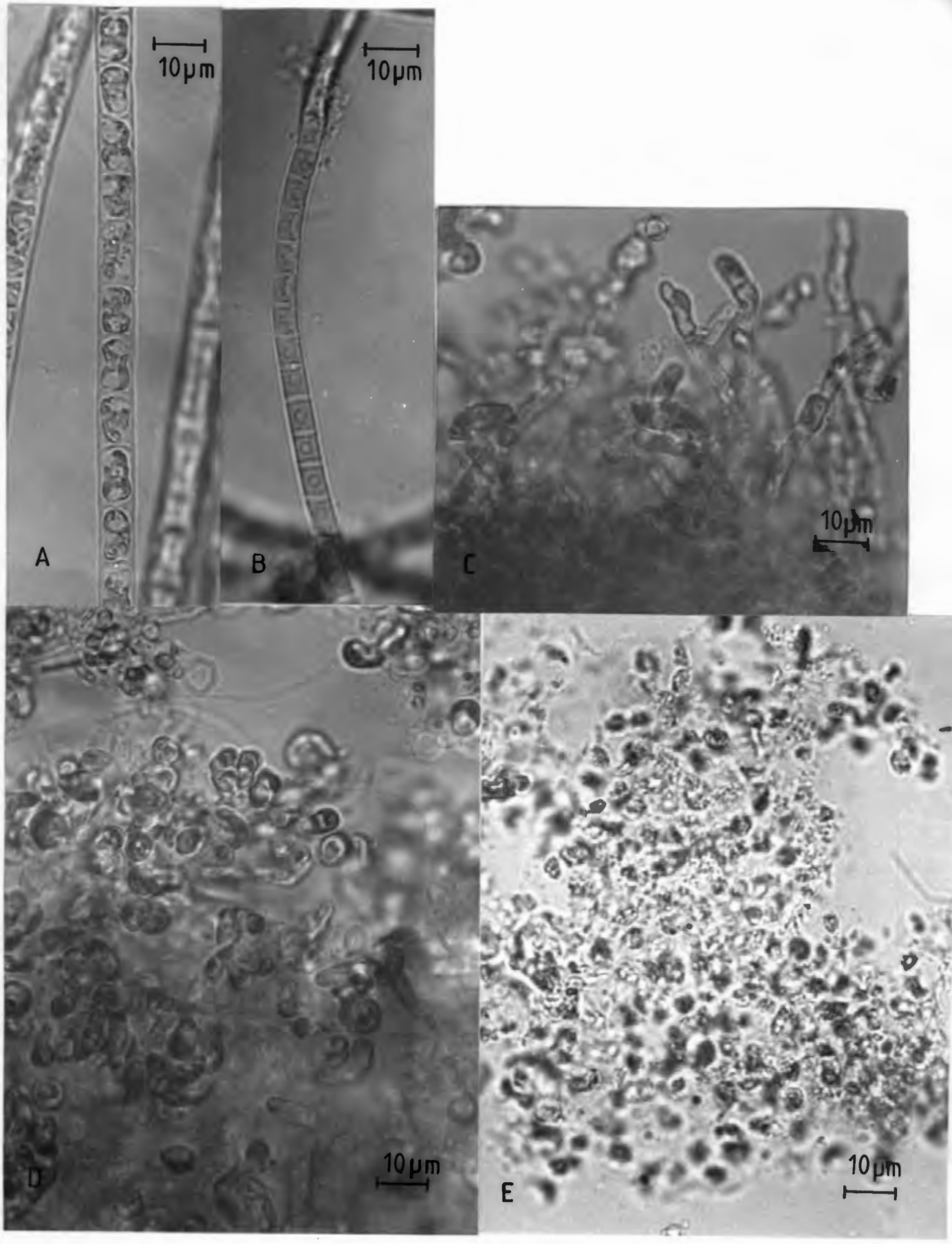


**Plate 6:** **A: Species A, B: Species C, C: Species B, D: 'Green Unicells, E: 'Orange Unicells.**

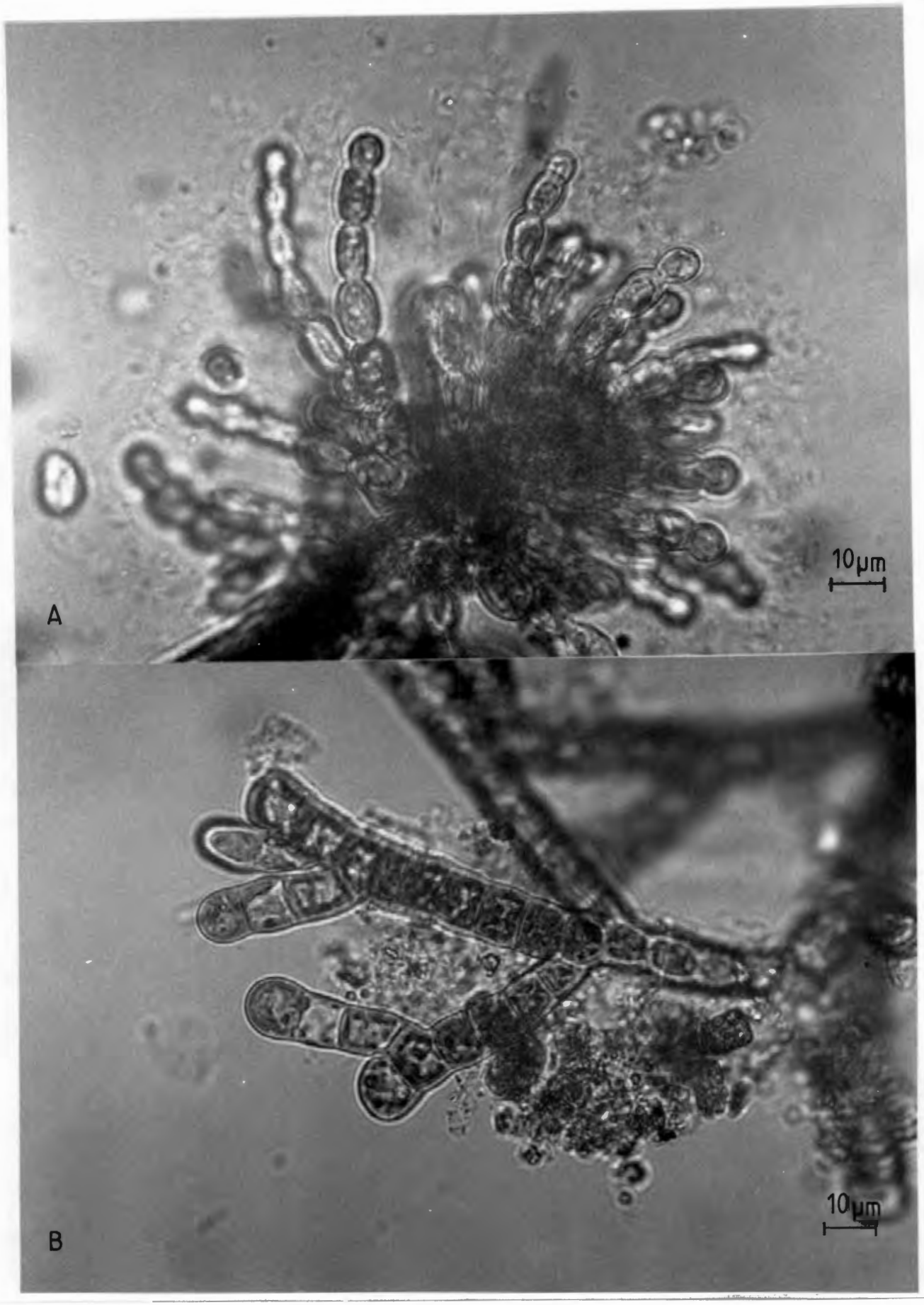


**Plate 7:** **A:** Batrachospermum **species 1 adult stage, B: Batrachospermum species 1 'Chantransia' stage.**

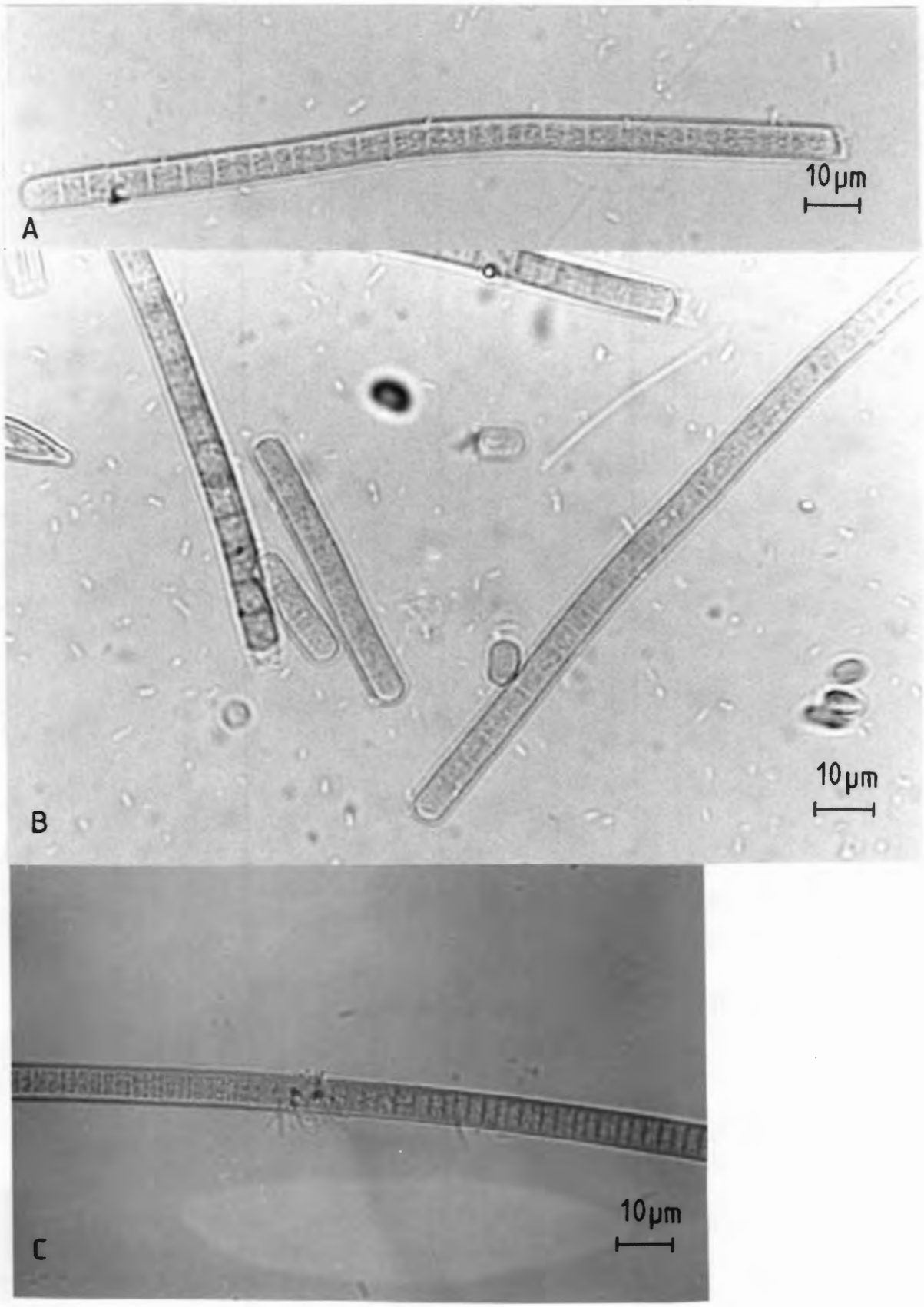


**Plate 8:** **A & B:** Lyngbya **species 1, C:** Oscillatoria **species 1.**

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