ALGAL DIVERSITY OF FRESHWATER STREAMS OF SCHIRMACHER OASIS, ANTARCTICA

By

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The Antarctic flora has evolved millions of years ago on the supercontinent of Gondwana and originally consisted of warmer and wetter, forests of podocarps and southern beech. The separation of South America from Antarctica 30-35 million years ago allowed the Antarctic Circumpolar Current to form, which isolated Antarctica climatically and caused it to become much colder. The Antarctic flora subsequently died out in Antarctica, but is still an important component of the flora of southern Neotropic (South America) and Australasia, which were also former parts of Gondwana.

Antarctica provides most harsh environment for growth and survival of organisms. The terrestrial and aquatic organisms are encountered in restricted areas and it has been presumed that they have special physiological features enabling them to survive at low temperatures and prolonged period of darkness.

Several investigations have been conducted to study the patterns of distribution and taxonomy of aquatic algae in continental Antarctica. A great variety of fresh-water planktonic and Aufwuchs algae from small melt pools and year-round ponds at various places in Antarctica are described.

In Schirmacher Oasis area, fresh-water habitats exhibit the complete range of trophic levels from extreme oligotrophy with a paucity of species and low organic production to hypereutrophy with blooms of a single or a few species.
The Schimacher Oasis has a width of 3 km and a length of about 20 km and is oriented in east-west direction (70°46′04″-70°44′21″S; 11°49′54″-11°26′03″E).

During the polar summer, ice melts and water flows in the stream forming lakes.

A schematic representation of vertical profile of a stream originating from a glacier and entering a lake. The numbers represent place of water sampling from glacier (1), pond (2), proper stream (3), lower stream (4) and lake (5).

Two types of streams were observed: one derived from glaciers and second from snow. Diagrammatic representation of different habitats of algae and cyanobacteria.
We examined the algae and cyanobacteria from three streams of glacier origin (WN, SEM, ST) which were about 500-1000 m in length and the three short (ca 200-400 m) snow drift melt water streams (EGF, EM, NS) were also examined.

Algal samples were scraped from rocks and sediments into sterile plastic bags and specimen tubes using clean implements. Algal and cyanobacterial samples collected during the expeditions were brought to the field station and examined microscopically within 24h of collection. Identification was made using Bourelly, Geitler, and Desikachary.

### Alpha diversity

\[
\lambda = \sum_{i=1}^{R} p_i^2
\]

\[
H' = -\sum_{i=1}^{s} \pi_i \log_2 \pi_i
\]

### Species Richness

\[
SR = S - 1 / \ln (n)
\]

\[
SR = S/\sqrt{n}
\]

\[
SR = S(n)^{1/2}
\]

### Evenness or Equitability

\[
E = S / \log N_i - \log N_s
\]

\[
E_1 = D - D_{\text{min}} / D_{\text{max}} - D_{\text{min}}
\]

\[
E_2 = D / D_{\text{max}}
\]

\[
E_3 = H' / H'_{\text{max}} = H' / \ln (S) = 1_n (N_i) / 1_n (N_0)
\]

### Beta diversity

\[
\beta_w = S / \sqrt{\lambda} - 1
\]

### Shannon Wiener index

\[
\gamma = \alpha \times \beta \times Q
\]

### Gamma diversity

\[
E_4 = e^{H'} / S = N1 / N0
\]

### Cluster analysis

It was done on the basis of species [+nce/ -nce] composition using Euclidean distance measure.
The algal and cyanobacterial species which have been encountered in different streams of Oasis have been presented in (Table).

It is evident that various streams situated at different locations varied in flora composition.

The glacier bound stream SEM near Maitri Lake shows maximum abundance of cyanobacteria whereas the number of species encountered was minimum in Hill top snow drift bound stream EGF near German Station (extreme west of Oasis).

Among the Cyanobacteria more than half of species were nitrogen fixers and Oscillatoria limosa, Phormidium frigidum and Nostoc commune were present in all the six streams studied.
Results and discussion: Diversity Indices

- On the basis of relative frequency and density of species in six freshwater streams, the diversity indices were calculated to determine the richness, diversity and evenness.
- The value of Menhinck index (R2) of richness indicated that species richness of algae and Cyanobacteria was highest in stream SEM followed by stream NS. The lower species richness was recorded in stream EGF whereas the values of Margalef’s index of richness (E1) are higher than R2. It also followed the same trend.
- The species richness in different streams was in the order of SEM>NS>ST>EM>WN>EGF. The diversity indices revealed that maximum diversity exists in stream DEM and minimum in EGF.

The species diversity (NI) decreases in order of SEM>NS>ST>EM>WN>EGF whereas value of Λ increases with increase in diversity indices (NI). The species diversity indices of different streams studied followed the same trend and not much difference was recorded in the indices of ST & NS, but a very high diversity in SEM stream. The evenness indices E1, E2 and E3 of various streams between 0.3 to 0.96 the higher value seems to be related to the dominance of several species.

There is not much difference in the value of β-diversity of the streams studied and these ranged from 29.0 to 29.188 whereas the γ-diversity is highest in stream SEM and lowest in EGF. Evidently, it shows the comparison of stream diversity and gives an idea about how and which stream is different with the other stream as in the present study we have recorded that minimum γ-diversity is found in stream EGF and maximum in SEM thus we can say that both are much different in comparison to other streams.

<table>
<thead>
<tr>
<th>Diversity Indices</th>
<th>WN</th>
<th>SEM</th>
<th>ST</th>
<th>EGF</th>
<th>EM</th>
<th>NS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unified Indices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Simpson’s index (λ)</td>
<td>0.09</td>
<td>0.5</td>
<td>0.07</td>
<td>0.11</td>
<td>0.09</td>
<td>0.06</td>
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<tr>
<td>Shannon Wiener index (H')</td>
<td>2.50</td>
<td>2.98</td>
<td>2.83</td>
<td>2.30</td>
<td>2.50</td>
<td>-2.78</td>
</tr>
<tr>
<td>Species Richness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Menhinck index (R₂)</td>
<td>3.05</td>
<td>5.00</td>
<td>4.42</td>
<td>2.39</td>
<td>3.13</td>
<td>3.91</td>
</tr>
<tr>
<td>Margalef index (E1)</td>
<td>1.51</td>
<td>2.41</td>
<td>2.02</td>
<td>1.20</td>
<td>1.60</td>
<td>1.90</td>
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<tr>
<td>Evenness Indices</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Species Evenness (E₁)</td>
<td>0.92</td>
<td>0.94</td>
<td>0.97</td>
<td>0.93</td>
<td>0.97</td>
<td>0.95</td>
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<tr>
<td>Species Evenness (E₂)</td>
<td>0.81</td>
<td>0.82</td>
<td>0.77</td>
<td>0.83</td>
<td>0.81</td>
<td>0.85</td>
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<tr>
<td>Species Evenness (E₃)</td>
<td>0.80</td>
<td>0.81</td>
<td>0.76</td>
<td>0.82</td>
<td>0.80</td>
<td>0.84</td>
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<tr>
<td>Evenness Indices</td>
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<tr>
<td>Hill Ratio (E₄)</td>
<td>0.93</td>
<td>0.97</td>
<td>0.90</td>
<td>0.93</td>
<td>0.94</td>
<td>0.98</td>
</tr>
<tr>
<td>Modified Hill ratio (E₅)</td>
<td>0.93</td>
<td>0.97</td>
<td>0.90</td>
<td>0.92</td>
<td>0.93</td>
<td>0.98</td>
</tr>
<tr>
<td>Beta Diversity</td>
<td>β-diversity (βw)</td>
<td>29.0</td>
<td>29.188</td>
<td>29.158</td>
<td>29.0</td>
<td>29.188</td>
</tr>
<tr>
<td>Gamma Diversity</td>
<td>γ-diversity</td>
<td>435</td>
<td>518.5</td>
<td>496.88</td>
<td>400.2</td>
<td>437.82</td>
</tr>
</tbody>
</table>

Various Diversity Indices of Algae and Cyanobacteria
To illustrate the results we have used a cut off distance of 0.06 (shown as horizontal dash line in).

At this level of resemblance there are two distinct clusters.

In one cluster stream WN and EGF, and in second cluster stream SEM, ST, NS & EM, has been categorized.

This shows the similarities between the streams of the clusters in terms of the algal composition.
Some field photographs

Cyanobacteria growing on exposed part

Expedition vessel

Rocky area of the Schirmacher Oasis (inset a helicopter flying over the Maitri station and the continental ice is also seen).

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