Unseen worlds: microscopic lake plankton fuel food chains and befriend algae

Dr Bettina Sonntag
Ciliate plankton play essential roles in the environment

Ciliates are tiny unicellular organisms invisible to the naked eye, present in almost all freshwater environments. ‘Ciliates are named for their cilia – short hair-like appendages used for movement and eating. Ciliates are not animals, plants, or fungi!’ Dr Sonntag explains. ‘Unlike single-celled bacteria and archaea, ciliates’ organelles, Dr Sonntag explains. ‘Unlike single-celled Ciliates are not animals, plants, or fungi.’appendages used for movement and eating. Ciliates are not animals, plants, or fungi!’

Happy together: symbiosis between ciliates and green algae promotes survival

Ciliates and green algae thrive as a pair, and Dr Sonntag’s work has investigated how living together benefits both species. Their relationship is most probably not essential, as both ciliates and the algae can survive independently, but symbiosis protects both against mortality amidst harsh lake environments. As part of this work, the team looked at the ciliate species Phacus viridis and studied its close relationship with green algae. The pair helps each other survive in harsh environments with little available food, and protect each other against starvation in nutrient-poor lakes.

Still waters in the Limnology Institute in Mondsee, Austria, Dr Sonntag’s work has investigated how living together benefits both species. Their relationship is most probably not essential, as both ciliates and the algae can survive independently, but symbiosis protects both against mortality amidst harsh lake environments. As part of this work, the team looked at the ciliate species Phacus viridis and studied its close relationship with green algae. The pair helps each other survive in harsh environments with little available food, and protect each other against starvation in nutrient-poor lakes.

When living in symbiosis with algae, ciliates are mixotrophic organisms, meaning that they can continue to engulf food as heterotrophs, but also consume photosynthetic energy from autotrophic algae. With enough light and ciliate-produced CO₂, algae perform photosynthesis. This cycle produces oxygen by-products that the ciliates can benefit from in turn. As nutrient and sunlight levels are always in flux in oligotrophic lakes as the weather shifts and the seasons change, this exchange between ciliates and green algae increases the survival rates of both species in these harsh habitats.

Stress responses: algae act as a ciliate sunscreen

Plankton are highly sensitive to light, and life in lakes is often oriented around avoiding sun exposure. In clear lakes, many plankton travel downward at around midday when the sun is at its peak. Although sun exposure may damage ciliates, Dr Sonntag did not observe such midday migration behaviour in ciliate species from a high mountain lake. Instead, some ciliate species may rely instead on the sunscreening properties of their algal friends.

Both shortwave ultraviolet radiation (UVR) and photosynthetically active radiation (PAR) can cause ciliates harm. UVR passes through cell membranes, causing potentially fatal DNA and protein damage, and ciliates exposed to UVR appear deformed under a microscope. Movement and growth slow, with exposure proving fatal for some ciliates. If a freshwater ciliate population is decimated by excessive sun exposure, aquatic food webs can be thrown into disarray. Furthermore, if a particular ciliate species dies out, the bacterial groups they prey on can rise in number, disrupting ecological balance. The imbalance can have massive implications for the entire habitat.

Dr Sonntag and her colleagues investigated how algal act as a ciliate sunscreen by exposing two groups of a ciliate species - those living in symbiosis with green algae and those living independently from their symbionts – to artificial UVR and

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**UNSEEN WORLDS: MICROSCOPIC LAKE PLANKTON FUEL FOOD CHAINS AND BEFRIEND ALGAE**

Dr Bettina Sonntag investigates ciliates – microscopic organisms living in freshwater lakes. As a senior scientist at the Research Institute for Limnology in Mondsee, Austria, Dr Sonntag leads a research team exploring how these single-celled protists interact with their environments. Their studies are documenting ciliate diversity and elucidating ciliates’ roles in microbial food webs, including their mutually-beneficial partnership with green algae.

Aquatic food webs are a major driving force behind ecosystem functioning. Dr Sonntag and her fellow ecology researchers seek to understand the complex relationships between members of the food chain. She tells us that ‘a major component in aquatic food webs are microscopic organisms, including viruses, bacteria, protists and small metazoans.’ Ciliates and algae are among these microscopic organisms that make up the base of the food web. Despite their size, ciliates are integral to microbial food webs. By preserving environmental balance, ciliates promote the efficient recycling of chemical substances essential to life. For example, by exchanging carbon and oxygen gases with green algae, they help power essential carbon cycles. Ciliates are prey for microbes in higher positions along the food chain, who in turn feed crustaceans and fish.

Understanding ciliates’ contributions to lake ecology must begin at the species level. Dr Sonntag tells us how her work helps advance researchers’ understanding of aquatic food webs: ‘In the past, “protists” were more or less neglected in such studies or lumped into “black boxes” such as “ciliates” or “heterotrophic flagellates”. However, to reveal the complex patterns and interactions in aquatic food webs, the identification of individual species and their ecological traits and specific biotic-abiotic interactions are a prerequisite.’ Dr Sonntag and her colleagues are identifying and investigating specific ciliate species, observing their close relationships with green algae, and advancing the use of state of the art technology to genetically categorise plankton species.

“We are building a basic database from morphology up to molecular sequences which can be used by any researcher who investigates lake ecosystems”

Dr Sonntag’s work has investigated how living together benefits both species. Their relationship is most probably not essential, as both ciliates and the algae can survive independently, but symbiosis protects both against mortality amidst harsh lake environments. As part of this work, the team studied ciliates in lakes all over the world including lakes on islands in the Pacific Oceans, soda lakes in Kenya and of course freshwater lakes in Europe.”

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**Metopus**

**Coleps**

**Urocentrum**

**Metaflagella**

**Stichococcus**

**Ciliophora**

**Stichococcus**

**Urocentrum**

**Metaflagella**

**Stichococcus**

**Ciliophora**
In our studies, we determine the respective food organisms for a set of planktonic ciliate species, which may then provide an explanatory variable for seasonally changing ciliate diversity patterns.