***Cosmarium woronichinii*: Record of a Rare Species in Strathcona Provincial Park, New to the Americas** [i]

-in memoriam Dr. Taylor Steeves (1926-2011)

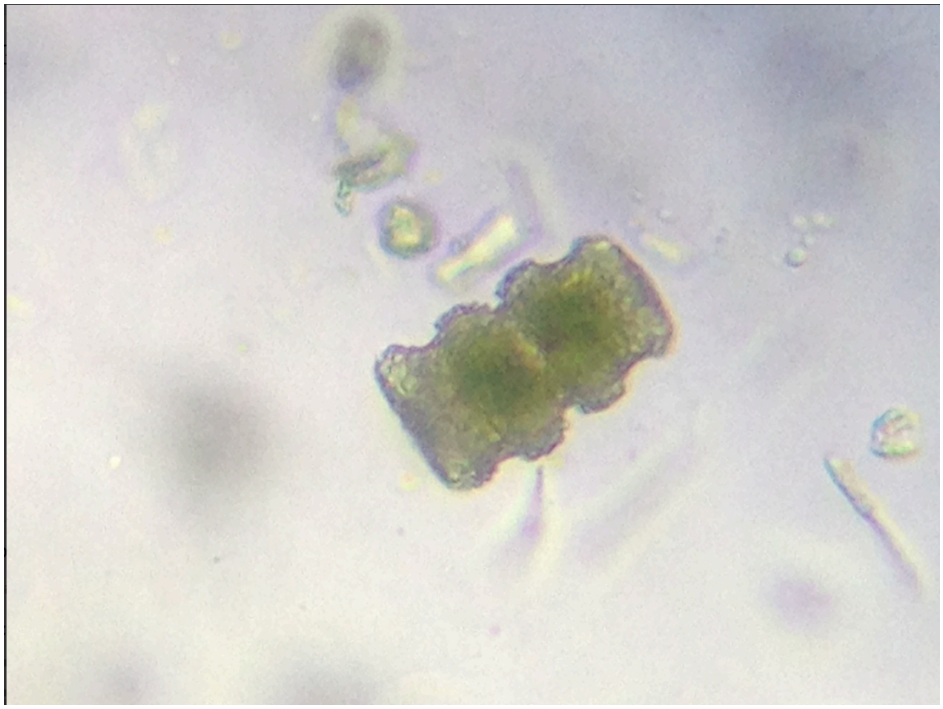

Figure 1 *Cosmarium woronichinii* (~ 90 microns at 1,000X magnification) Note the polysaccharide semi-cells and the 2 chloroplasts surrounding the darker nuclei.

Not all the gold in the Price Creek Valley is mineralogical, or fool's gold. Though no cairn stands to commemorate, as it should, the dedication, vision and valour of the mine protestors of 1988-9 who were socially berated, arrested and sentenced, as are the protestors of Fairy Creek today, and none were ever given the Orders of BC or Canada, they are to be commended and remembered for saving a public treasure of unique invaluable biological gold for future generations. This is confirmed by the discovery May 20 2022, in the Price Creek Valley of an extremely rare algal species which is not listed in any known species data banks routinely consulted by phycologists such as the Integrated Taxonomic Information System.[ii] It is however a taxonomically recognized species in "AlgaeBase" for which there is only a single entry from 1936.[iii] Had the mine development proposed by the mining company in the 1980s succeeded we would have lost not only the beauty of Cream lake, but yet untold other species to the growing biodiversity emergency that is currently driving climate change, as increasingly urgent IPCC and IPBES reports tell us.[iv]

In the great chain of being, every species count. Every species is essential to the fabric of life. Aquatic species probably count a little bit more on the scale of life

because they control water quality, quantity and availability, essential to life itself, and are evolutionary predecessors that remind us that terrestrial angiosperms are just descendents of obscure algae who mastered the arts of water transport and condensation. Without humble little algae there are no towering old growth forests to marvel at. No wonder, E.O Wilson often quipped that: *"It is the little things that run the world."*[v]

That this algae could not initially be identified would normally have suggested that this is a new addition to science. Fortunately, thanks to iNaturalist, it was identified Dr. Roman Romanow of the Komarov Botanical Institute in St. Petersburg, whose reaction was: *"Amazing record of really rare species!!! Cosmarium woronichinii described from wet mosses from Yakutia (North West Siberia)"*[vi] Just how rare? My understanding is that it was found once, and was never found again in spite of dedicated surveys. So this would appear to be the second global observation of this species, and the first in the Americas. I say the "Americas" because *Cosmarium woronichinii* was found in conjunction with another "rare" or "rarely found" algae, *Spirotaenia endospira,* (**Figure** 2). In the Southern hemisphere *Spirotaenia endospira* is found without any *Cosmarium* in Bromeliads which are known to be home to some unique epiphytic aquatic species.[vii] Unfortunately, to the best of my knowledge Canada has no native Bromeliads.

Figure 2: *Spirotaenia endospira* (25 microns at 4000x magnification) Note the spiral chloroplast, 2 nuclei and the beginning of a cell wall dividing the cell into 2)

The Price Creek Valley trail is important geologically, historically and biologically. Geologically the valley rests on a mantle of Sicker and Buttle Lake volcanic rocks, rich in gold which has made it a target for mining interests which are well represented in the BC Geological Survey map of 1995 (**Figure 3).** As noted by Phil Stone, historically before 1920 mining interests made the Price Valley the pioneer trail between Port Alberni and Buttle Lake.[viii] Historically this is the area that the 1988-9 protest over the proposed expansion of the "Cream Silver mine at Cream Lake saved from destruction. The protest resulted in the aberrant ceding of a central part of the park to Westmin mines and the limitation of mining in the park, as the Strathcona-Westmin Provincial Park on the recommendation of *The Larsen Report*, which condemned commercial development in the park.

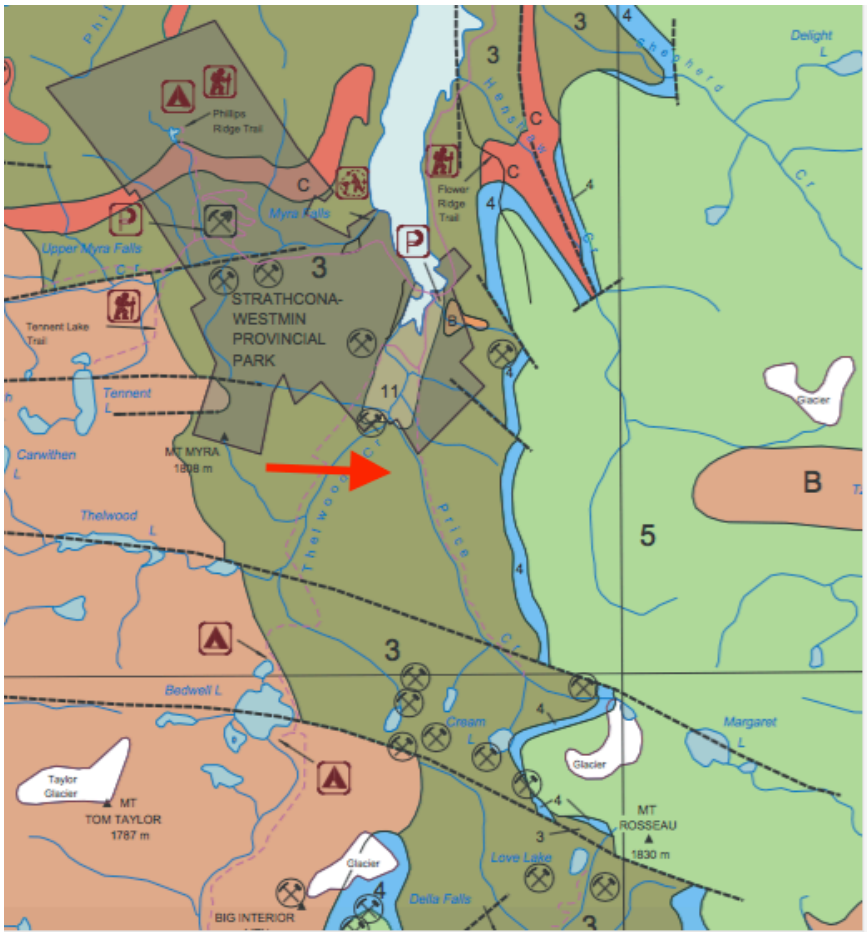

Figure 3: Geological map of the Price Creek and Thelwood Creek Valleys reproduced from the BC Geological Survey map of 1995.[ix]

Most of the trail is now overgrown and reduced to a narrow footpath. Sections of the trail engineered, There are drained roads out of Great Central Lake to Della Falls and from Buttle lake into the current Strathcona Provincial Park boundary. What makes the Price Creek Valley both biologically and geologically distinct from the more frequented and better-known Thelwood Valley that regularly provides access to thousands of tourists to the Bedwell Valley, is the narrow karst intrusion shown

in blue below Flower Ridge which lines almost the entire drainage of the valley from Buttle lake to Mount Rosseau. This means that the water chemistry of surface streams draining into Price Creek is higher in calcium than the Thelwood and most streams in the park. That this affects the floral species composition of Price Creek is evident from the fact that Dr. Randal Mindell, found the calcium-loving moss, *Cratoneuron flicinum* in the Price Creek drainage. This moss is endangered and listed in some parts of the world.[x]

The Strathcona Wilderness Institute "Lakes Project" collects small 10-50ml water samples from rills, streams and lake outlets, for microscopic species composition analysis. This is the same water that thousands of hikers collect by the litre in water bottles and then treat with UV to kill all waterborne organisms. Freshwater micro-algal and plankton species composition is one of the most sensitive indices of water quality and climate change. A majority of these unheralded micro-organisms which play key role in shaping entire ecosystems are sensitive to changes in pH, temperature, oxygen and carbon dioxide. At a time when we do not know very much about our freshwater ecosystems, there is growing concern about the impacts of climate change on freshwater ecosystems.[xi] The SWI Lakes Project is an unfunded modest attempt to collect data to characterize and model the park's freshwater systems and provide a baseline for future comparisons as climate change proceeds.

Given the particular conditions of the Price Creek drainage, it is therefore not entirely surprising that it has been found to be home to an "extremely rare algae." It had previously been collected with mosses in Siberia. At Price Creek it was collected from water and gel debris dripping from a large forest boulder covered with mosses. The gel debris may be a key to understanding the distribution of this species. It was not found floating independendently from the gel debris in open water, as so often happens with other species of *Cosmarium*. It appears to have only been present in association with the gel which was the mucilage of a large colony of *Spirotaenium endospira*. The bryophyte and lichen environment within which these two microalgae were found is largely controlled by the physics of water on byrophytes covering a vertical rock face. On the one hand, in the West Coast's torrential rains these organisms have to eke an existence in the shearing forces of laminar flow through bryophyte foliage. On the other hand, they are subject to surges of electrostatic water movement on bryophyte foliage. At scale, the environment of these microalgae is similar to that of barnacles on an ocean rockface. What may seem to the passing observers to be a passive existence to the naked eye is in fact a violent world that requires physiological adaptations to extremes.

To understand the evolutionary significance of these two algae in association with mosses on a rockface, it helps to know that both of these algae are "placoderm desmids." As all Desmidaceae they consist of 2 semicells with a median connection joined by a connection zone ("isthmus"), and ornamented porous cell walls. Desmids can be solitary, or form filamentous or amorphous colonies. Most significantly, desmids are members of the "Zygnematales." These unique

chlorophytes reproduce by isogamous conjugation. That makes them the direct forerunners of our land plants. Conjugation involves the creation of a zygote which forms a cell wall, rests and germinates meiotically. **Figure 4** captures the meiotic development of a zygote between parents in *Cosmarium woronichinii*.

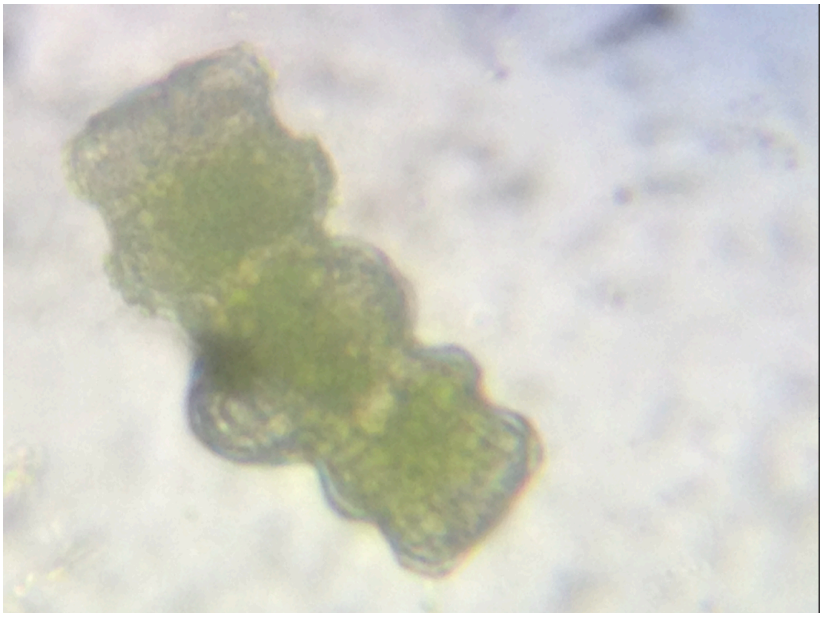

Figure 4: Conjugation and zygote development in *Cosmarium woronichinii*.

The Zygnematales are the algae that moved onto land. They did not just wash up onto land. Most Zygnematales that we still have today are capable of self-directed movement. They move by the excretion of a mucilage, that is "a gel". Interestingly enough, algal movement is activated by light which activates chloroplast energy, but it is not a response to the direction of light.[xii] Light provides autotrophic energy, but the algal colony determines the direction of its movement. In that respect when autotrophic algae like *Spirotaenium endospira* form an amorphous colony directional movement by mucilage production is a variant on cytoplasmic streaming which we find in heterotrophic amoeboid organisms like *Fuligo septica*. Given the current growing in interest in "plant behaviourism" and the neuroscience of angiosperms as argued by Suzanne Simard and others, the extent to which Zygnemetales' movement is not simply a phototactic reaction but a display of sentient intention is open to consideration.

The presence of *Cosmarium woronichinii* in the mucilage of a large amorphous colony of *Spirotaenium endospira* is not , as standard texts argue, a simple question of these algae being somehow loosely associated with bryophytes. It appears to form a symbiotic "coenobium," that is, a loose association of single-celled organisms acting independently as a colony. The mucilage serves at least four purposes for the

host organism (the one that produces the mucilage): physiological water regulation, colony movement, solar orientation and bacterial exclusion. In many ways this symbiosis recapitulates the evolution of land plants from single-celled algae. Algal mucilage serves to regulate osmosis. It creates a stable cellular environment for algae emerging from water. As countless studies have demonstrated, algal mucilage not only maintains a relatively constant chemical environment for cells immersed in water, it also regulates water potential around single-celled algae through drying periods and prevents cell lysis from rapid dehydration. Additionally, the mucilage may limit bacterial activity. Various medical studies of algal mucilage have focused on the antibacterial properties of algal and plant mucilage.

Spirotaenium endospira is a producer of copious amounts of mucilage visible to the naked eye as a large mass of gel. It is therefore able to regulate its internal physiological environment, displace itself as a colony on a vertical rockface and orient itself for light. We can therefore speculate that the observed presence of *Cosmarium woronichinii* within the gel itself rather than independently in boundary water at the surface of the *Spirotaenium endospira,* or in the surrounding water may present certain obvious advantages for both organisms. *Cosmarium woronichinii* is two to three times bigger than individual *Spirotaenium endospira* cells. It therefore adds to the photosynthetic power of the coenobium. Additionally, it is likely to respond to a different though complementary light activation spectrum. *Cosmarium woronichinii* itself gains from bacterial protection and the shelter of the coenobium's mass and movement.

Finding a organism new to the North American flora should not be just an addition to a catalogue. It should be an invitation to add to our understanding of evolution and the factors that made the survival of life on this fragile planet at a time when it is increasingly threatened. To have the good fortune to find a tiny algae in a place that has been nearly devastated by man's lust for gold invites one to reflect on the fortune that lies in finding a lost Zygnematales at a time of conflict and climate change. This is the lineage that gave us one of the greatest marvels in the evolution of life, "the seed," which is best defined as a spore that packed its lunch for the long migratory journeys out of water. Without the Zynematales, no seed, without the seed, no agriculture, no civilization. And civilization may still have a lot to learn from the lowly unimportant algae that knew interspecies cooperation, how to save energy to survive and how to conserve water. All elemental lessons of biodiversity, still valid, and yet to be learnt by mankind.

Loys Maingon
(28 May 2022)
Rifflewoods.

[i] -*Special thanks are owed to Dr. Roman Romanow for identification of the species. All and any errors are entirely mine.*

[ii] https://www.itis.gov

[iii] https://www.algaebase.org/search/species/detail/?species_id=156840

[iv] https://www.ipcc.ch/site/assets/uploads/2021/07/IPBES_IPCC_WR_12_2020.pdfhttps://www.ipcc.ch/site/assets/uploads/2021/07/IPBES_IPCC_WR_12_2020.pdf

[v] https://faculty.washington.edu/timbillo/Readings%20and%20documents/ABRIDGED%20READINGS%20for%20PERU/Wilson_1987_Little_things_that_run.pdf

[vi] (personal communication) https://www.inaturalist.org/observations/118291262

[vii] https://www.biotaxa.org/Phytotaxa/article/view/phytotaxa.309.3.8

[viii] Philip Stone (2018). *Exploring Strathcona Park: A Guide to British Columbia's First Provincial Park.* Wild Isle Publications.

[ix] https://www.biotaxa.org/Phytotaxa/article/view/phytotaxa.309.3.8 http://cmscontent.nrs.gov.bc.ca/geoscience/PublicationCatalogue/InformationCircular/BCGS_IC1995-07.pdf

[x] https://www.inaturalist.org/observations/117950493

[xi] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2880135/

[xii] Robert Edward Lee. (1995) *Phycology.I Cambridge, 205-26.*