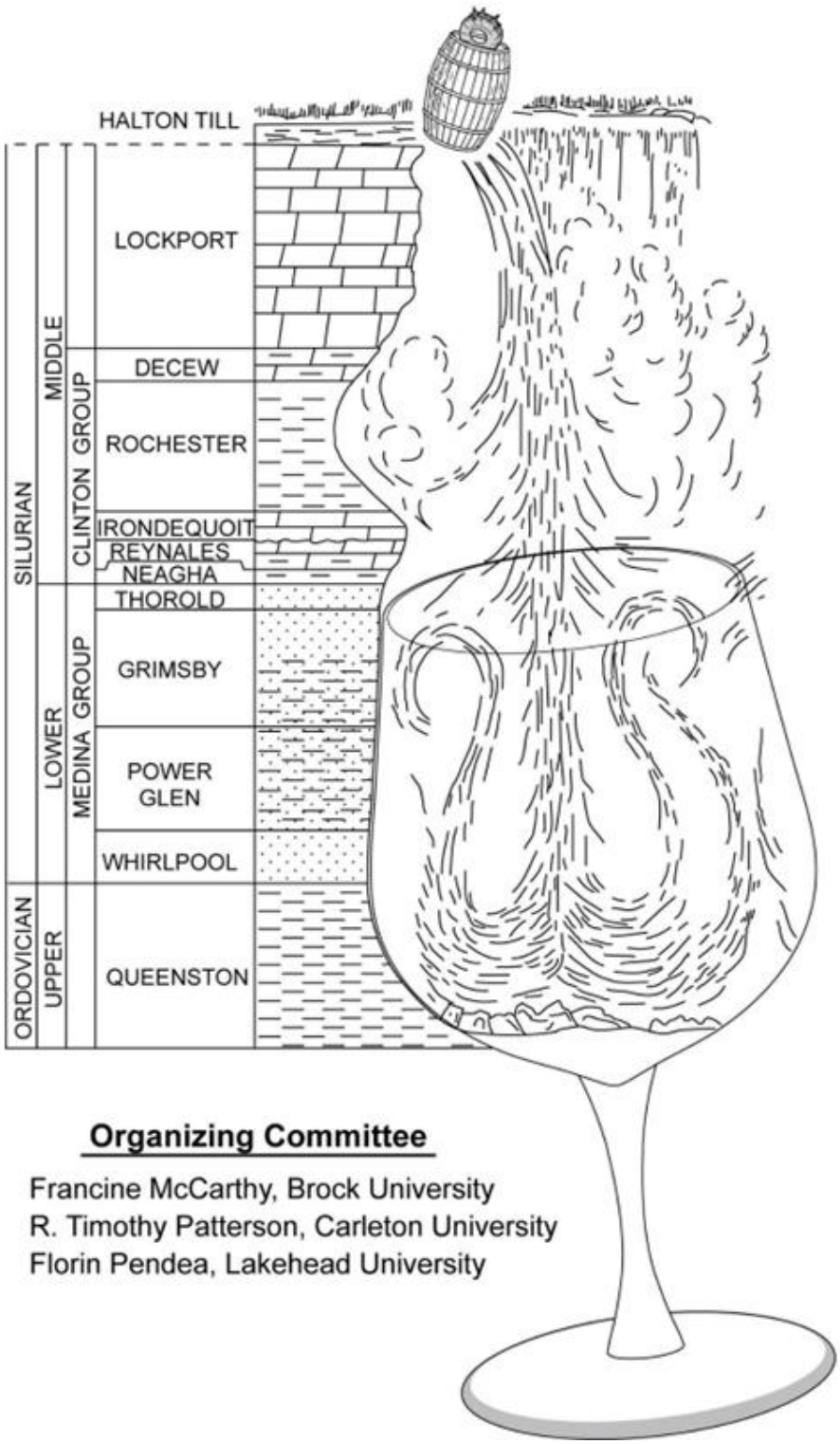
ISTA - CAP 2025

June 22-27, 2025



Organizing Committee

Francine McCarthy, Brock University
R. Timothy Patterson, Carleton University
Florin Pendea, Lakehead University

WELCOME MESSAGE

Dear colleagues, friends and fellow testate amoebae and palynomorph enthusiasts,

It is with great pleasure that we welcome you to the 11th International Symposium on Testate Amoebae, a joint meeting of the International Society for Testate Amoebae Research (ISTAR) and the Canadian Association of Palynologists (CAP). Set against the scenic backdrop of Ontario's Niagara region—where natural beauty, cultural heritage, and scientific discovery converge—this location provides the ideal setting for convening researchers studying testate amoebae, as well as pollen and non-pollen palynomorphs (NPP) across diverse environments, including lakes, peatlands, soils, and saltmarshes. Through thematic sessions and discussions, the conference aims to strengthen connections within this dynamic research community, including ecologists, paleoecologists, molecular ecologists, and functional ecologists. We are particularly excited to celebrate and support the contributions of students, early-career scientists, and established researchers from both ISTAR and CAP, fostering lively discussions and broadening participation at all levels of experience.

Brock University is situated within a UNESCO World Biosphere Reserve, with the northern boundary of its campus resting against the Niagara Escarpment. The region is renowned not only for its natural landscapes, including Niagara Falls, but also for its rich cultural and historical significance. It offers an ideal location for a scientific meeting, combining beautiful natural surroundings with vibrant local festivals, concerts, and events such as the Niagara Grape and Wine Festival. Niagara's fertile soil and favorable climate have made it famous for wine production, particularly ice wine, while its deep agricultural roots are reflected in farm-to-table dining, local markets, and seasonal harvests. Historically, Niagara played a central role during the War of 1812 and is closely tied to the Underground Railroad, with its rich history preserved in museums, heritage sites, and architectural landmarks. The area also boasts a strong outdoor culture, with activities such as hiking, cycling, boating, and winery tours drawing visitors from around the world. Furthermore, Niagara's diverse immigrant population enriches its cultural fabric, reflected in its culinary scene, festivals, and events.

We thus encourage you to explore the rich culture, history, and natural beauty of the Niagara region, drawing inspiration not only from tiny microbes and big data but also from our shared human pursuit of knowledge.

Welcome to ISTA 11. Let's make this a meeting to remember!

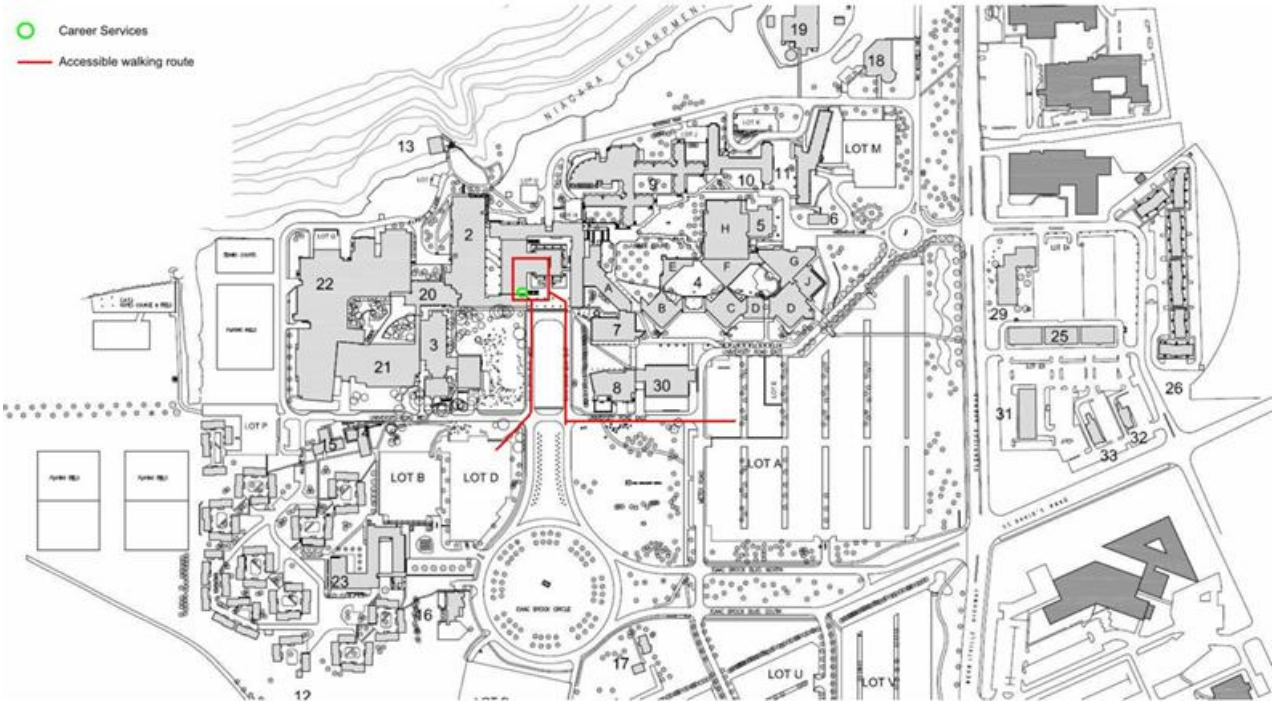
Warm regards, the ISTA 11 Organizing Committee

Francine McCarthy, Brock University

Tim Patterson, Carleton University

Florin Pendea, Lakehead University

Brock University Campus Map



Important Information

- The **conference registration desk/ general inquiries** will be available on Sunday, June 22, from **1:30 to 4:30 PM in Room RFP 216**, located in the Rankin Family Pavilion at the base of Brock Tower (marked as a red rectangle on the Campus Map above).
- **Residence 8 guest check-in (24/7)** https://brocku.ca/housing/residence8/ (**#11** on the Campus Map above) **is at the East Service Desk** (eastdesk@brocku.ca) in the same building.
- The **Ice Breaker Mixer** (appetizers, non-alcoholic beverages) on Sunday, June 22nd will begin at **5PM in the Residence 8 banquet space** (where many delegates are staying) and we will have a **registration/ information table available there until 8PM**
- **Oral sessions will take place in South Block** (**#21** on the Campus Map), in room STH 202 (STH 203 for the 1-day CAP session).
- **Posters will be displayed in the South Block Atrium** (**#21**), **with breaks (and lunches on Monday and Thursday) also held in the Atrium and adjacent Courtyard**. Additional indoor seating is available in the NW South Block in case of inclement weather. **Poster board dimensions are 1.19 X 1.19 m** accommodating both portrait and landscape formats
- **A concurrent CAP session will run in STH 203 on Monday**; NOTE: Room STH 203 will be available to all for presentation uploading and preview until 10:45 AM that day

We will take advantage of our location and offer you several excursions/ experiences:

Monday evening: Port Dalhousie Pub Night. This lakeside neighbourhood, once a bustling Lake Ontario port and is now a major recreational area hosting international regattas, has a beach with a view of Toronto across this Great Lake and historic **Lakeside Park Carousel - St. Catharines** (5 cents/ride!). It is home to many pubs, bistros and restaurants, including The Kilt & Clover, Lock Street Brewing Co – Lock Street Brewing Co, PORTSIDE Social Bar & Kitchen - Restaurant - Port Dalhousie, Ontario, The Twisted Pig | Home. Accessible by public transit Niagara Transit - Niagara Region Transit, rideshare, etc.

Tuesday afternoon: Niagara Falls with Dinner at Skylon Tower Restaurant. Also accessible via public transit (although ridesharing is much easier!) Niagara Falls needs no introduction. I will offer **walking tours** of their (geological and human) history, leaving from the meeting point where we will have an early group dinner: the Skylon Tower (5200 Robinson St., Niagara Falls) – two options, either at **2 or 3PM** to keep the group size manageable but you can also discover the Falls on your own and take part in myriad activities including my favourite ('Journey Behind the Falls') and boat tours. **Meet at the entrance to the Skylon Tower no later than 4:40 PM so we can ride up the tower as a group, with a buffet dinner 5-6:30 PM.**

Wednesday afternoon: Tour through Wine Country with lunch. Enjoy the scenery of wine country and two quaint historic settlements, Niagara-on-the-Lake and Jordan Village, and learn about the distinct terroirs that result from the glacial history of the region and its geographic setting. **An optional tour of Peller Estates Winery** (Greatest Winery Tour | My Wine Country) is available (**cost $45**) and **optional tastings** will be available at Cave Spring Vineyard - offering an incredible local Niagara wine selection! (**contact me as soon as possible to book these – fmccarthy@brocku.ca**). A tour bus will depart from the front of the Brock Tower at 1PM, returning around 6PM, with a group lunch at 1:30PM at *Old Winery Restaurant*.

Thursday evening: ISTA Awards Dinner Banquet, 6:30–9PM. Awards will be presented at the end-of-conference banquet at Rockway Vineyards Come Enjoy Some of Our Events - Rockway Vineyards, one of several wineries within St. Catharines city limits. In addition to fixed salad and dessert courses, three main course options are available, so please **contact me with your choice – fmccarthy@brocku.ca** and alert me to any food allergies or dietary constraints:

1) Chef's Signature Sweet Potato Curry, **2)** Chicken Supreme, thyme jus, roasted fingerling potatoes, fresh seasonal vegetables, **3)** Ale Braised Short Rib with Syrah Jus, with garlic mashed potatoes and seasonal vegetables

Friday: optional visit to Crawford Lake - Conservation Halton. A site whose rich archeological heritage was discovered during pollen analysis in the early 1970s and became world famous when it was selected as the proposed golden spike record to define the Anthropocene as a geological epoch (with an associated Crawfordian Age). Visit reconstructed longhouses illustrating life during the 15th century CE and the boardwalk around this unique meromictic lake that occupies a sinkhole in the Niagara Escarpment – a UNESCO World Biosphere Reserve. For those who can provide their own transportation to this site (ca. 90 km. north of Brock U.) **the cost (covering park entry fee and lunch) is $35 and for those requiring transportation it is an additional $35, i.e. $70.**

We hope you enjoy the conference and your stay in Niagara!

DAY 1, Monday June 23
8:00 AM **Registration** (South Block Atrium)
Upload PPT presentations, Day 1

8:50 AM South Block ROOM STH 202: ***Welcome – Local Organizing Committee***
ISTA Session 1: Session Chair: Florin Pendea – *When things fall apart*
(Bioindicators of Anthropogenic Disturbance – Degraded, Contaminated and Stressed Landscapes)
9:00 AM Nawaf NASSER, *KEYNOTE PRESENTATION:*
Canaries in Contaminated Mud:
Testate Amoebae as Bioindicators of Heavy Metal Contamination in Mining-Impacted Lakes
9:40-10:10 AM Break/
Poster Set-up
10:10 AM Samantha MITCHELL
Tiny microbes for big problems: testate amoebae communities as tracers of industrial pollution in heavily degraded peatlands of the Greater Sudbury Area
10:30 AM R. Timothy PATTERSON
Arcellinida (Testate Lobose Amoebae) as Bioindicators of Road Salt Contamination and Nutrient Loading in Eastern North American Lakes
10:50 AM Daria WOCHAL
From Fen to Fiction: How Drainage and Peat Extraction Redefined Bagno Chlebowo.
11:10 AM Jean Claude NDAYISHIMIYE
Biodiversity conservation challenges in urban blue-green infrastructure under climate extremes:
Insights from testate amoeba communities.
11:30 AM Eduard REINHARDT
Closure of Khor Al Balid and Khor Rori harbours/estuary with coastal uplift and aridity in the 12th–15th c.CE: implications for ancient port sites in southern Oman

12-2:00PM
Lunch (South Block Atrium/ Courtyard)
Poster Session (South Block Atrium)- see list of posters and presenters at the end of DAY 1 Program

ISTA Session 2: *Live Long and Sequence (Molecular, Genomic and Computational Approaches)*
Session Chair Bob Booth
2 PM Laura KATZ
Rethinking large scale phylogenomics with EukPhylo, a flexible toolkit to enable phylogeny-informed data, Curation and analyses of diverse eukaryote lineages
2:30 PM David SINGER
Diving into Arcellinida Diversity in Oromocto Lake (Canada):
A Metabarcoding Approach to Explore Undocumented Microeukaryotes
2:50 PM Jun YANG
Phenotypic and genetic diversification of Asian endemic *Netzelia tuberspinifera* metapopulation.
3:10 PM Giulia RIBEIRO
Revealing Hidden Testate Amoebae Diversity using an intragrative 'Omics' Approach.
3:30 PM Camille VOGELI
Developing a deep learning model to identify peatland-specific testate amoebae
Posters in South Block Atrium; refreshments available

Monday June 23

CAP Session South Block STH 203

Chair: Martin Head

11:00 AM Arun KUMAR

Palynology of the recent sediments of various southern Red Sea coastal environments of Saudi Arabia

11:20 AM Anne de Vernal *KEYNOTE PRESENTATION:*

A palynological overview of the late Pleistocene in the southeastern Lomonosov Ridge area

12-2PM

Lunch (South Block Atrium/ Courtyard)

Poster Session (South Block Atrium)- see list of posters and presenters at the end of DAY 1 Program

2:00 PM Tribute to Dr. Anne de Vernal

2:10 PM Francine McCARTHY

Dinoflagellate cyst transfer functions: a game-changer

2:30 PM Petra MUDIE

Dinoflagellate and other NPP indicators of Arctic Ocean multiyear ice

2:50 PM Saif AL SILWADI

Marine palynology across the Pliocene–Pleistocene transition in the northern South China Sea

3:10 PM Helen ROE

Understanding long-term forest responses to climate change in the Northwest Territories, Canada: insights from multiproxy (palaeo)ecological data

3:30 PM Sarah FINKELSTEIN

Reconstructing Holocene and Late Pleistocene paleo-wetland dynamics and carbon cycling using pollen and other microfossil proxies

CAP Board Meeting, 4-6PM

POSTERS (South Block Atrium)

Presenters in attendance Monday during lunch & afternoon break, & Tuesday during coffee break; other times by special request

Aaron ALDERSON: Algal palynomorphs as Anthropocene markers

Erica COWPER: Herbarium moss specimens as a source of information on testate amoeba ecology: a case study from the New Jersey Pine Barrens

Arnaud DANO: Biotic and Abiotic Drivers of Forest Soil Testate Amoebae Communities Along an Elevation Gradient

Laura KATZ: Describing an previously-undocumented interaction between Arcellinida and a flagellate using transcriptomics

Dominika ŁUCÓW: Testate Amoebae Response to *Alnus* Decline During the Dark Ages: Insights from the paleoecological record

Katarzyna MARCISZ & Mariusz LAMENTOWICZ: "We play it coal" - testate amoebae as the Anthropocene markers

Francine McCARTHY: Thecamoebian and NPP proxies of remediation in the Athabasca Oil Sands

Ben MICHALCHUK: Post-colonial sediment horizons in Lake Ontario coastal lagoons – soil erosion, eutrophication, and pollution impact through historic land-use change

Rheanna PATTERSON: Testate amoeba diversity and community composition in epiphytic bryophytes of a temperate rainforest

Giulia RIBEIRO: Unlocking Testate Amoebae Sex: A Genomic and Cytological Approach to Encystment

Alexis STANSFIELD: Changes in Testate Amoeba Communities and Morpho-Functional Traits Over the Last Century on the North Slope of Alaska

Daria WOCHAL: Unlocking the Past: A New Transfer Function Model for Norwegian Peatlands Using Testate Amoebae

Port Dalhousie Pub Night

DAY 2, Tuesday June 24
8:30 AM STH 202 Upload PPT presentations

ISTA Session 3: Help Me, Testate Amoeba - Testate Amoebae as Paleoecological & Climate Proxies
Session Chair Ed Reinhardt

9:00 AM Robert BOOTH
The no-modern analogue problem in testate amoeba paleoecology:
insights from comparison of surface samples and stratigraphic records in the Neotoma Paleoecology Database

9:30 AM Paula ECHEVERRIA-GALINDO
Neotropical lakes under the microscope: testate amoebae as tracers of ecological turnover over the last millennium.

9:50 AM Katarzyna MARCISZ
Testate Amoebae Boogie Oggie

10:10-10:50AM Break
Poster Session - see list of posters and presenters at the send of DAY 1 Program

10:50 AM Lucie RINQUET (recorded/ online)
Integration of hydrogeologically relevant variables in the potential distribution model of *Hyalosphenia papilio*

11:10 AM Kaelin PLATT
Thecamoebians and Foraminifera as Tracers of Paleohydrologic Shifts in the Yax Chen Cave System, Quintana Roo, Mexico.

11:30 AM Anne NGUYEN
Reconstructing paleoenvironmental changes in the Mackenzie R. Basin, NWT, Canada, using plant macrofossils and testate amoebae.

11:50 AM Dominika ŁUCÓW:
Ecological drivers of testate amoebae diversity and distribution in 50 lakes in coastal areas from the Burin Peninsula, Newfoundland

12:10 PM Arun KUMAR
Palynological preparations of soft sediments and hard sedimentary rocks are a possible source of thecamoebian assemblages

Afternoon in Niagara Falls

DAY 3, Wednesday June 25
8:30 STH 202
Upload PPT presentations

ISTA Session 4: *For Peat's Sake!* - Testate Amoebae in Wetland Settings
Session Chairs Laura Katz & Giulia Ribeiro

9:00 AM Mariusz LAMENTOWICZ
Testate amoebae inform about ecological baselines and critical thresholds in European ombrotrophic peatlands

9:30 AM Robin CALISTI
Testate amoebae as bioindicators of Sphagnum peatland CO2 and CH4 fluxes

9:50 AM Xyza PENA
Methodological Advances to Trace Past CH4 (MATCH4)

10:10-10:40AM Break

10:40 AM Christian QUINTANA
Holocene testate amoeba reconstruction in a Norwegian mountain peatland and its relationship with climate and carbon budget

11:00 AM Andrey TSYGANOV
Development of a transfer function for paleohydrological reconstructions in subarctic and boreal permafrost mires in the western part of the Central Siberian Plateau.

11:20 AM Caroline PLANCHE
Ecology of Testate Amoebae in Icelandic Peatlands and Their Response to Past Tephra and Historical Increases in Dust Deposition

11:40 AM Edward MITCHELL
Sorting the wheat from the chaff in bioindication – Selecting a minimum list of useful testate amoeba indicators

Wine Country Excursion
1-6PM

DAY 4, Thursday June 26
8:30 AM
Upload PPT presentations, Day 4
ISTA Session 5: Nature or Nurture? (Functional Traits, Morphology, and Behaviour)
Session Chair: Edward Mitchell
9:00 AM Enrique LARA, *KEYNOTE PRESENTATION:*
Of testate amoebae and molecules: a journey through the ecology and evolution of our favourite micropredators

9:40-10:10AM Break

10:10 AM Marina HENNION
Microhabitat-Driven Patterns of Testate Amoebae Diversity in Belgian Peatlands.
10:30 AM Aleksandr IVANOVSKII
Multi-scale and multi-source variation of community composition: a case study of testate amoebae from a Sphagnum bog in Swiss Jura region
10:50 AM Jiahui SU
Ecoregional drivers of diversity, functional traits and assembly processes of testate amoebae from mineral vs. organic soils in Northern Eurasia
11:10 AM Norihiko KAMAYA
Food-Dependent Behavioral Changes and Pseudopodial Dynamics in *Lesquereusia spiralis*
11:30 AM Michelle MCKEOWN
Island Biogeography and Ecological Patterns of Testate Amoebae in the Peatlands of La Réunion.
11:50 AM Jasmine PURUSHOTHAMAN
Diversity and Distribution of moss inhabiting Testate amoebae along the altitudinal gradients of selected protected areas of NE India

12:30-2:30PM BBQ Lunch/ Microscopy- Keyence Demonstration

2:30 PM Yuri MAZEI
Deterministic and stochastic processes shaping testate amoeba assemblages
3:00 PM Qihan ZHU
Testate amoeba metacommunity patterns: a case study from Yakushima Island, Japan
3:20 Kirill BABESHKO
Testate amoeba assemblages of the Arctic tundra of the Yamal Peninsula

4-5:30 PM ISTAR Board Meeting

ISTA Awards Banquet
6:30-9PM

Abstracts

Marine palynology across the Pliocene–Pleistocene transition in the northern South China Sea

Saif Al-Silwadi[1], Martin J. Head[2]

(1) Department of Earth Sciences, University of Toronto, Toronto, ON Canada, (2) Department of Earth Sciences, Brock University, St. Catharines, ON Canada

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CAP Session 1, 2:50 PM

The Pliocene–Pleistocene transition is marked by the intensification of Northern Hemisphere glaciation (iNHG), one of the most important climatic shifts in Earth's history. Although many mechanisms have been proposed for the intensification, research has mainly focused around the North Atlantic. With the widespread effect of iNHG, evidence should be found in the North Pacific. The South China Sea (SCS) is frequently used for paleoclimatic reconstruction and is ideal for understanding the response of the Western Pacific across this transition. Dinoflagellate cysts, acritarchs and other palynomorphs are here used to assess the hydrographic evolution of Ocean Drilling Program (ODP) Site 1148, northern SCS, during the Pliocene–Pleistocene transition. This analysis covers approximately 111 samples from 2.85–2.41 Ma with an average spacing of ~4 kyr. An age model was developed using the oxygen isotope stratigraphy of Jian et al. (2003), tuned to the LR04 stack of Lisiecki & Raymo (2005). Results show 60 marine palynomorph taxa, with fair to good preservation. Warm water dinoflagellates (such as *Polysphaeridium zoharyii*) appear frequently, along with *Spiniferites bentorii* and several *Impagidinium* species. This indicates a temperate to tropical, open ocean environment with a significant neritic component, and low temperature variation for most of the study interval. Notable dinocyst species include *Atlanticodinium janduchenei, Dapsilidinium pastielsii, Edwardsiella sexispinosa, Invertocysta tabulata* and *Operculodinium bahamense*; and the a*critarchs Cymatiosphaera? invaginata, C.? icenorum* and *Nannobarbophora walldalei*. Despite the observed stability, fluctuations in the assemblages are evident, particularly in the abundance of the cyst of *Protoceratium reticulatum*, a species used as an indicator for subarctic waters in the North Pacific. A marked increase in this species is observed between 2.724–2.610 Ma, coinciding with iNHG, suggesting the development of unstable and cooler hydrographic conditions. By ~2.540 Ma, assemblage changes are more concordant with global sea level fluctuations, suggesting the influence of global climate on the environment after iNHG.

Algal palynomorphs as Anthropocene markers

Aaron Alderson[1], Francine M.G. McCarthy[1], Paul Michael Pilkington[1], Olena Volik[2], Nicholas L. Riddick[1] & Joshua M. Moraal[1]

(1) Earth Sciences, Brock University, St. Catharines, ON L2S 3A1, Canada, (2) Severn Sound Environmental Association, Port McNicoll, ON L0K 1R0

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Poster

Lake sediments processed for palynological analysis without strong oxidants are commonly rich in the remains of primary producers and consumers, including testate amoebae, as well as microcharcoal and SCPs (spheroidal carbonaceous particles/ microscopic fly ash) that record combustion of biomass and fossil fuels, respectively. Ecosystems respond to both natural and anthropogenic stressors, but human activities have exerted the greatest impact on lake biospheres since prehistoric times, primarily via an increase in nutrient-rich runoff. Sharply higher concentrations of algal palynomorphs (e.g., dinoflagellate cysts, desmid half-cells, *Botryococcus* colonies, *Pediastrum* and *Coelastrum* coenobia) and the acid-resistant remains of their consumers record cultural eutrophication and biochemical oxygen demand associated with all human disturbance in lake catchments. There is a distinct palynological signature of an Anthropocene biosphere, with sediments deposited since the mid-20th century showing a sharp increase in green algae as well as chrysophytes – whose remains were first identified in pollen slides from Crawford Lake. Since these algal groups rely on passive diffusion of CO_2 for photosynthesis (unlike the more commonly studied diatoms and dinoflagellates), this appears to reflect increased concentrations of atmospheric CO_2 through the Great Acceleration or human industry that marks the post-WWII period.

Testate amoeba assemblages of the Arctic tundra of the Yamal Peninsula

Kirill Babeshko[1], Yiwen Xu[1], Yuri A. Mazei[2]

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ISTA Session 5, 3:20 PM

Studying testate amoebae in the Arctic is essential for understanding both current ecological processes and long-term climate changes. Research into their composition and distribution allows us to reconstruct past climatic conditions, which helps us understand long-term changes in the Arctic's climate. The aim of this study is to investigate the distribution patterns of testate amoebae and their response to environmental factors in the Arctic tundra. Fieldwork was conducted in July 2023 in the tundra zone of the Yamal Peninsula, covering 24 sampling points. Moss samples were separated on living and dead parts, which were analyzed for substrate water content, organic matter content, dissolved organic carbon, and dissolved organic nitrogen. Microscopy revealed 65 testate amoebae taxa from 33 genera, with *Trinema lineare* (27.5% of total counts), *Meisterfieldia chibisovi* (14.9%), *Assulina muscorum* (7.9%) being the most abundant taxa. Taxa with the highest occurrence were *A. muscorum* (97.2%), *Euglypha rotunda* (97.2%), *T. lineare* (97.2%). Eight testate amoeba taxa were counted only in one sample. The data suggests a relationship between testate amoeba assemblage composition from living and dead moss parts and major environmental variables. Redundancy Analysis of the environmental variables in the upper moss layer collectively explained 17.15% of the community composition. In contrast, environmental variables in the lower moss layer explained only 9.17% of the community composition. Statistical significance tests (permutation test, n=999) revealed in living mosses part only permafrost depth and DON exhibited significant effects ($P < 0.05$), whereas in the dead mosses part, SWC was the sole significant variable ($P < 0.05$). The data obtained emphasize the complexity of the interactions between testate amoebae and environmental factors in Arctic ecosystems. They also show that different moss layers respond to environmental changes in various ways, which is significant to take into account when monitoring and reconstructing the effects of climate change in the Arctic region.

The no-modern analogue problem in testate amoeba paleoecology: insights from comparison of surface samples and stratigraphic records in the Neotoma Paleoecology Database

Robert Booth[1]

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ISTA Session 3, 9:00 AM

There has not been a systematic assessment of the quality of modern analogues for testate amoeba paleoecological work, like there has been for other biological proxies (e.g., pollen). Although it has been known for some time that testate amoebae with weakly idiosomic tests do not preserve well in many acidic peatlands, other differences between modern and subfossil testate amoeba communities have also been observed. Direct comparison of stratigraphic and modern datasets can more fully assess and describe the similarity of modern and subfossil communities, and large datasets are needed to identify broad patterns and extend our knowledge beyond site-specific observations. I directly compared subfossil and modern testate amoeba communities in the Neotoma Paleoecological Database, using over 4500 surface samples from the northern hemisphere and more than 2000 stratigraphic samples from over 28 sites. Results indicate that many subfossil communities have few good modern analogues; for example, using the typical thresholds of similarity that have been employed for other paleoindicator groups, less than 50% of the subfossil samples have more than 20 good or very good modern analogues. Potential causes include differential preservation in response to decomposition, peatland acidity, past environmental conditions outside the range of modern calibration datasets, and/or other ecological dynamics. Many subfossil samples contain high abundances and unusual combinations of taxa that are not well represented in modern datasets (e.g., *Difflugia pulex, Galeripora discoides*-type along with abundant *Hyalosphenia subflava*), and the causes and implications these poor-analogue communities deserve greater attention. More experimental and observational work is needed, including taphonomic investigations and ecological studies in unusual or under-sampled peatland settings. The analysis of large subfossil and modern datasets, like that contained in the Neotoma Paleoecology Database, will be an important component to this work, allowing generalization of widely observed subfossil-modern community differences.

Testate amoebae as bioindicators of Sphagnum peatland CO_2 and CH_4 fluxes

Robin Calisti[1], Laure Gandois[2], Adrien Jacotot[3], Camille Voegeli[1] & Edward A.D. Mitchell[1]

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ISTA Session 4, 9:30 AM

Boreal peatlands are increasingly threatened by climate change and anthropogenic disturbances, such as drainage, which lead to a decline in their water table, promoting peat decomposition and turning these C-sinks into sources of carbon dioxide (CO_2). Conversely, peatlands with higher water tables (natural or restored) tend to release methane (CH_4). Developing effective yet simple methods for monitoring water table (WT) and associated greenhouse gas (GHG) fluxes is crucial for quantifying the contribution of peatlands to climate change, informing restoration strategies and providing reliable data for carbon credits assessments. By raising the water table, peatland restoration aims both at restoring biodiversity and minimizing C loss or ideally fixing C, but concomitant releases of CH_4 also need to be quantified. Testate amoebae (TA) are commonly used as bioindicators of water table depth in peatlands through the application of transfer functions. This modelling approach relies on extensive datasets of TA community and associated environmental variables, from which species-specific preferences and tolerances are derived. By applying these transfer functions, TA can be utilized to infer past and present hydrological conditions in peatlands. As water table depth is a key driver of GHG fluxes we developed a transfer function using TA as bioindicators of greenhouse gas fluxes (CO_2 and CH_4) in peatland ecosystems. We collected GHG flux data from four peatlands in the Jura Mountains from chamber measurements and correlated these fluxes with TA communities to build transfer functions. The transfer function for CH_4 shows better performance than the one for CO_2 for which more data will be needed. This approach offers a cost-effective and time-efficient alternative to direct GHG flux measurements, providing a valuable tool for assessing peatland C dynamics and optimizing renaturation strategies.

Herbarium moss specimens as a source of information on testate amoeba ecology: a case study from the New Jersey Pine Barrens

Erica Cowper[1], Maura Sullivan[2], Stephen Peters[1], Robert Booth[1]

(1) Department of Earth and Environmental Sciences, Lehigh University, Bethlehem, PA. USA, (2) Finger Lakes Community College, Canandaigua, NY, USA

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Poster

Collections of *Sphagnum* moss spanning the last several centuries are well represented in herbaria and potentially serve as an underutilized source of information on testate amoeba communities. We conducted a study to 1) assess the preservation and potential use of testate amoebae recovered from herbarium Sphagnum, 2) investigate testate amoeba ecology in the New Jersey Pine Barrens, including relationships between the ecology of *Sphagnum* host species and testate amoebae, and 3) assess changes in testate amoeba community composition that may have occurred in response to heavy metal deposition and disturbance. Very little investigation of testate amoebae has occurred in the New Jersey Pine Barrens since the pioneering work of Joseph Leidy, and the industrial and environmental history of the region makes it particularly suitable for investigating pollution impacts on testate amoebae. Testate amoebae were extracted and quantified from over 200 herbarium *Sphagnum* samples collected between 1800-2023 CE, and community composition was compared with the moisture ecology of Sphagnum species, concentrations of ragweed pollen, and heavy metals (Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb). Results indicated good preservation of testate amoebae in herbarium mosses, including the preservation of siliceous tests that generally do not preserve well in bog stratigraphy. Results also confirmed the primary importance of substrate moisture in controlling the composition of testate amoeba communities, but suggested that landscape disturbance, as indicated by the concentration of ragweed pollen, was a secondary influence on the structure of testate amoeba communities. Interestingly, within drier habitats the composition of testate amoeba communities was correlated with the concentration of zinc, with higher zinc concentrations associated with a higher abundance of mixotrophic testate amoebae. Herbarium mosses contain a valuable record of testate amoebae, providing an underutilized source of information for examining ecological changes of the last several hundred years

Biotic and Abiotic Drivers of Forest Soil Testate Amoebae Communities Along an Elevation Gradient

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Poster

While biodiversity patterns along elevation gradients are well studied for plants and animals, soil microorganisms, particularly protists, have only recently received attention. Due to their short generation times, microbial communities respond rapidly to environmental changes. However, seasonal fluctuations appear to have relatively minor effects compared to the pronounced contrasts observed across elevation gradients. Testate amoebae are a diverse and abundant group of shelled unicellular protists found in soil and freshwater. As microbial predators, they play a key role in soil food webs and nutrient cycling. Their community composition is known to respond to abiotic factors such as soil moisture, pH, and nutrient availability, but the relative influence of abiotic vs. biotic drivers (e.g. litter type), especially in the context of elevation, remains unclear. We conducted observational and experimental studies to assess how litter type and climate influence testate amoeba communities. In the observational study, we sampled forest litter from three dominant tree species (beech, spruce and oak) along an elevation gradient (370-1447 m a.s.l.) from Lake Geneva to the Jura Mountains. In the experimental study, sterilized litter of each species was incubated in mesocosms filled with a mixed inoculum of non-sterilized forest litter from all sites and exposed to four climate treatments (hot/cold × wet/dry), mimicking the extremes of the gradient. In the field, community composition clustered by site and litter type, with elevation, moisture, soil carbon, and pH as the strongest predictors. Although litter type did not directly correlate with physicochemical variables, it explained ~20% of the variation in community structure. In the experiment, climate treatment was the main driver of community differences, followed by litter type. These findings demonstrate how abiotic and biotic factors jointly shape testate amoeba communities. Elevation-driven variation in climate, vegetation and soil properties, along with distinct litter and moisture dynamics, explains observed community patterns.

A palynological overview of the late Pleistocene in the southeastern Lomonosov Ridge area

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(*Keynote Speaker*) CAP Session, 11:20 AM

Palynological analyses of Holocene sediment cores from circum-Arctic seas revealed abundant dinocysts, which permitted the reconstruction of variations in seasonal sea ice cover. Back in time, at the scale of the Pleistocene, the paleoecology and palaeoclimatology of the Arctic Ocean are more challenging to assess because they had to be documented from sedimentary records of deep sites of the central basin, where dating issues and the rarity of biogenic proxies related to surface waters and primary productivity prevent unequivocal interpretations. Nevertheless, sites close to the shelf edge might permit inferences of surface ocean conditions before the Holocene. This is the case of sites PS8770, PS8779 and PS2757 in the southeastern Arctic Ocean close to the Lomonosov Ridge and the Laptev Sea shelf (see de Vernal et al. *PNAS*, 2020). At the three sites, the analyses at 1-cm intervals of the multicores have shown the occurrence of dinocyst assemblages dominated by *Operculodinium centrocarpum* in early and middle Holocene sediments, leading to the documentation of primary productivity and seasonal sea-ice-free conditions, at least episodically, in the area. In opposition, the barren assemblages of the late Holocene sediments point to the development of perennial sea-ice cover. At these sites, sedimentation rates of the order of a few cm/ky could be estimated, at least for the uppermost part of the sequence where some biogenic carbonates are still preserved and provide ^{14}C ages. The 6 to 8 meters-long cores from the three sites should thus encompass several glacial-interglacial cycles of the Pleistocene. Palynological analyses were performed at 4-cm intervals in cores PS8779-1, PS8770-1, and PS2757-8. Most samples below the Holocene sediments were barren, except for a few discrete layers containing rare dinocysts in addition to some pollen grains and reworked palynomorphs. A resilient perennial sea ice may thus be inferred throughout most of the studied Pleistocene interval. However, an organic-rich layer has been found between 5.5 and 6 m in core PS8770-1, and between 6.5 and 7.1 m in core PS2757-8. It was not recovered in core PS8779-1, representing a shorter time interval. This layer contains freshwater chlorophytes, thousands of pollen grains (*Pinus*, *Picea*, *Betula*, *Alnus*, Ericacea, Poaceae, Cyperaceae, etc.) and spores (Polypodiaceae, *Sphagnum*, etc.), some dinocysts and reworked material. The layer reflects a major paleogeographic event, marked by significant inputs from an environment occupied by peatland and shrub tundra, possibly related to an ice advance over northern Eurasia. This episode could date from the mid-Pleistocene, with an age older than that of marine isotope stage (MIS) 8 according to ^{230}Th measurements in core PS2757-8 (Purcell et al. *Mar. Geo.* 2022). Further

analyses are underway to secure the correlation between cores PS2757-8 and PS87070-1 and to better anchor the chronology of both sequences.

Neotropical lakes under the microscope: testate amoebae as tracers of ecological turnover over the last millennium

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ISTA Session 3, 9:30 AM

Biodiversity changes and ecological turnover over the last 1000 years CE were analyzed in Lakes Nahá and Amarillo (~830 m a.s.l.), located in the karst mountains of the Lacandon forest, Chiapas, Mexico. Despite their close proximity (<500 m apart), differences in trophic status, depth, and area, along with surrounding vegetation, influence their limnology and testate amoebae communities. Lake Nahá (mesotrophic, max. depth 50 m, surface area 569 m²) and Lake Amarillo (hypereutrophic, max. depth 10 m, surface area 20 m²) were recently cored for micropaleontological and geochemical analyses. In Lake Nahá, 17 strains of testate amoebae were identified, with *Centropyxis aculeata* strain "*aculeata*" and *C. constricta* strain "*spinosa*" dominating (>50% relative abundance). Beta diversity analysis indicates a major shift around 1760 CE, marking the highest species dissimilarity. Detrended Correspondence Analysis (DCA) shows that testate amoebae dynamics are primarily driven by oxygen availability in the water column (45%) and sedimentary organic matter content (15%). Before 1800 CE, the rate of ecological change remained relatively stable. Afterward, it declined from 1.8 standard deviation (SD) at 1300 CE to approximately 0.5 SD by 2000 CE. In Lake Amarillo, six strains were identified, with *Arcella discoides* being the most abundant. The highest community dissimilarities occurred around 550–50 BCE and 1450 CE. Water conductivity (DCA1: 49%) and sedimentary organic matter content (DCA2: 14%) were key environmental drivers of the observed community dissimilarities. The most pronounced ecological change occurred between 1350–1450 CE, coinciding with a

steady decline in conductivity after 1350 CE, suggesting a shift in the lake hydrology that influenced testate amoebae community composition. The contrasting trophic conditions of the two adjacent lakes enable us to compare the response of testate amoebae to environmental and climatic changes, providing insight into their sensitivity to stressors across different trophic settings in Neotropical ecosystems.

Reconstructing Holocene and Late Pleistocene paleo-wetland dynamics and carbon cycling using pollen and other microfossil proxies

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CAP Session 1, 3:30 PM

Wetlands are critical to maintaining global biodiversity, water quality, nutrient cycling and carbon sequestration, yet they are highly vulnerable to human impact with recent global estimates suggesting more than 21% of global wetland area has been completely lost since 1700 CE. The impacts of these losses on Earth's present and future climate, and on carbon cycling, are not fully quantified in part due to poor understanding of the extent and types of paleo-wetlands. Unlike tree pollen assemblages, wetland and aquatic pollen types are more rarely aggregated for biome identification or quantitative reconstructions. Inspired by the work of several of our group members over recent years and the innovative and highly distinguished contributions of paleoecologist Dr Anne de Vernal, we present here recent progress on identifying wetland types from paleoecological proxy assemblages using classical and machine learning classifiers. We also discuss the utility of wetland microfossil proxies to open questions on wetland carbon cycling in the Late Quaternary including magnitudes of CH_4 fluxes from boreal and middle latitude wetlands during the deglacial and Holocene, and the strength of boreal peatland carbon sinks during ice-free intervals prior to the Last Glacial Maximum.

Microhabitat-Driven Patterns of Testate Amoebae Diversity in Belgian Peatlands

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ISTA Session 5, 10:10 AM

The role of environmental factors in shaping the protists distribution remains underexplored. The distribution of peat-dwelling testate amoebae is used to establish the influence of various microhabitats. Thanks to their sensitivity to ecological conditions and their good preservation in the sedimentary record, they are used as proxies for climate changes in given regions. Testate amoebae studies are under progress in Belgium and is currently improved to enhance Western European database. This research contributes to Holocene environmental reconstructions as part of the ANTHROPEAT project. Abundance data were analysed from surface samples collected throughout the Grand-Passage peat bog in Belgium (Houffalize, Ardenne-Wallonia). This peat bog was selected for its ombrotrophic character and the limited anthropogenic influence. The evolution of the species richness, abundance and community of testate amoebae was examined in a series of terrestrial habitats (including ponds) along different transects through the peat bog. Preliminary results indicate a significant contribution of a local environmental heterogeneity on the distribution patterns of the testate amoebae. This ecological study revealed a distinctive repartition regarding the presence and number of taxa across the different ecosystems. Given the diversity observed within the testate amoebae community, the study aims to identify specific correlations between the substrates sampled and environmental parameters likely to influence the spatial distribution of taxa within local ecological niches. The main environmental parameters are pH (ranging from 5.6 to 2.7) and Normalized Difference Vegetation Index (NDVI) which reflects surface vegetation patterns. The NDVI index derived from remote sensing data identified five distinct levels reflecting both vegetation density and potential vegetation stress in the study area. This comparative approach provides a robust dataset to decipher the dynamic and distribution of testate amoebae in response to microenvironmental variations. The same investigation will be further conducted onto microfossils, sampled along 4 meter-long core, at the same locality.

Multi-scale and multi-source variation of community composition: a case study of testate amoebae from a Sphagnum bog in Swiss Jura region

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ISTA Session 5, 10:30 AM

On the testate amoeba communities from Burtigniere bog (Switzerland), we aimed to distinguish the effects of three sources of community composition variation: selection by environmental filters of different spatial scale, inter-species interactions, and the stochastic processes. A simple ordination with subsequent post-hoc testing of environmental factors revealed that the water table depth and the nutrient supply demonstrated significant correlations with site scores. The gradient position – from the open bog towards the forest – with its changes in vegetation composition was also the significant factor. In the most parsimonious model, that explained a half of the total variance in community composition, we distinguished effects of environmental filters which acted at different scales. Namely, the gradient position was the spatially broadest factor; microrelief and humidity were the spatially narrowest ones, and the nutrient supply acted as the factor of a mesoscale. In spite of the importance of deterministic environmental forces, including the vegetation gradient, the contribution of stochastic processes in shaping community composition was sufficient: from 40 % to 70 % (depending on a chosen null-model). In the co-occurrence analysis, almost all species were involved in non-random links with each other. Two out of four species clusters were organized around seven *Nebela* species, which, in turn, organized 5 rather isolated species groups. Previously, it was stated that the distribution of *Nebela* species within a single bog is driven by the main environmental factors: humidity, nutrients, microrelief. In our results, some species of *Nebela* were separated across microhabitats, even after removing the effect of the main environmental factors. Perhaps, *Nebela* species are driven by the distribution of their prey, which, in turn, can be shaped by environmental factors. The study was funded by Shenzhen Municipal Government, Shenzhen First Class Discipline Construction Fund, and the Shenzhen MSU-BIT University, P.R. of China.

Food-Dependent Behavioral Changes and Pseudopodial Dynamics in *Lesquereusia spiralis*

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ISTA Session 5, 11:10 AM

The behavior of testate amoebae plays a significant role in nutrient cycling within their environment. However, their behavioral characteristics, especially those related to environmental cues and foraging strategies, are still poorly understood. *Lesquereusia spiralis* is a freshwater testate amoeba commonly found in nutrient-rich environments, where it feeds on filamentous algae such as *Spirogyra*. Previous studies have suggested that it may also consume small metazoans like nematodes, indicating a broader and more varied range of foraging strategies. In this study, we investigated the movement and pseudopodial activity of *L. spiralis* under two different experimental conditions. One condition featured a conditioned URO medium where *Spirogyra* had grown, while the other condition used a fresh URO medium. We observed the behavior of the *L. spiralis* in each medium. In the conditioned medium, *L. spiralis* frequently extended multiple pseudopodia in various directions and often remained stationary while actively exploring the area around the cell. These pseudopodia were short-lived and dynamically adjusted. In contrast, in the flesh medium, the amoebae extended fewer pseudopodia, maintained them for longer periods, and moved more steadily along linear paths. Overall, locomotion was faster and covered greater distances in the flesh medium. These results suggest that food-derived substances influence the movement patterns and the number of pseudopodia in *L. spiralis*, potentially promoting more efficient foraging in this species.

Describing an previously-undocumented interaction between Arcellinida and a flagellate using transcriptomics

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Poster

Here, we investigate a previously-undocumented relationship between two microbes - a testate amoeba (Arcellinida) and an unknown flagellate. Arcellinida are single-celled amoeba enclosed in a simple test and, because of their importance in geology, molecular dating, and overall beauty, they have been extensively studied since the 1800s. Several symbiotic associations between Arcellinida and other groups of organisms have been identified, but there has been no record of any relationship with a flagellate. However, Arcellinida collected from Acadia National Park, Maine, USA have been observed with the microscope to serve as hosts for some flagellates. In this study, we analyzed 128 single-cell transcriptomes from Arcellinida cells of which 10 had a flagellate living inside the shells to shed light on this association, and to compare the transcriptomes between those with and without a flagellate in them at the time of sequencing. Using rDNA and multiple protein coding genes with EukPhylo, our in-house taxon-rich phylogenomic pipeline, I am working to identify the symbiont and provide insights to this association through gene tree reconstruction. By combining microscopy observations, molecular analyses, and bioinformatic methods, I plan to identify the flagellate symbiont(s) in the amoeba cells. These analyses aim to characterize a novel relationship between shelled amoeba—which are uncultivable and densely populated *Sphagnum* mosses in low-pH bogs and fens— and flagellates, which are understudied in these habitats.

Rethinking large scale phylogenomics with EukPhylo, a flexible toolkit to enable phylogeny-informed data curation and analyses of diverse eukaryotic lineages

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ISTA Session 2, 2:00 PM

Eukaryotic diversity is largely microbial, with macroscopic lineages (plant, animals and fungi) nesting among a plethora of diverse protists. Understanding the evolutionary relationships among eukaryotes is rapidly advancing through 'omics analyses, but phylogenomics are challenging for microeukaryotes, particularly uncultivable lineages, as single-cell sequencing approaches generate a mixture of sequences from hosts, associated microbiomes, and contaminants. Moreover, many analyses of eukaryotic gene families and phylogenies rely on boutique datasets and methods that are challenging for other research groups to replicate. To address these challenges, we present EukPhylo v1.0, a modular, user-friendly pipeline that enables effective data curation through phylogeny-informed contamination removal, estimation of homologous gene families (GFs), and generation of both multisequence alignments and gene trees. For GF assignment, we provide the 'Hook Database' of ~15,000 ancient GFs, which users can easily replace with a set of gene families of interest. We demonstrate the power of EukPhylo, including a suite of stand-alone utilities, through phylogenomic analyses of 500 conserved GFs sampled from 1,000 diverse species of eukaryotes, bacteria and archaea. We show improvements in estimates of the eukaryotic tree of life, recovering clades that are well established in the literature, through successive rounds of curation using the EukPhylo contamination loop. The final trees corroborate numerous hypotheses in the literature (e.g. Opisthokonta, Rhizaria, Amoebozoa) while challenging others (e.g. CRuMs, Obazoa, Diaphoretickes). The flexibility and transparency of EukPhylo sets new standards for curation of 'omics data for future studies.

Palynological preparations of soft sediments and hard sedimentary rocks are a possible source of thecamoebian assemblages: examples from Permian sediments of Himalayas and recent lacustrine sediments of the Ganga-Yamuna Plains of North India

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ISTA Session 3, 12:10 PM

Thecamoebian tests are autogenous, are proteinaceous and acid-resistant, occur in palynological preparations of recent and fossil sediments. However, harsh palynological preparation techniques may destroy few species. Earliest thecamoebians are from Neoproterozoic, but their pre-Holocene occurrences are rare and patchy. The lacustrine and peat samples containing thecamoebians are unconsolidated, thus only water is used to disaggregate by laboratory shaker. Pre-Holocene sediments are consolidated and hard rocks. Thus, method used to isolate thecamoebians from Holocene sediments cannot be used. Bulk sediment samples of Cretaceous clay-silt were soaked in warm water forming slurry for wet sieving. It was sieved on a screen of 45 μm openings, and the residue was examined using a light stereomicroscope followed by scanning electron microscopy (SEM). Neoproterozoic samples of carbonate nodules within black shales were either thin sectioned and viewed with a compound light microscope or macerated in 15 % acetic acid. Macerated specimens of Vase-shaped microfossils were mounted on slides with Euparaly and viewed with a compound light microscope. Diverse and well preserved thecamoebian assemblages were obtained from the Permian sediments of Himalaya and recent lake sediments from India. Permian shale/slate sampl were treated with hydrochloric acid, followed by washing, the samples were sieved through 600 mesh (> 15 μm) and the residue of the larger fraction was mounted on glass slides in glycerol for microscopy. Thecamoebians from lake sediments were isolated by disaggregating using laboratory shaker. Initial examination revealed dark specimens covered under clay and organic particles. Alternatively, palynological preparation method was used. Sediment sample was boiled with 5 % KOH mixed with distilled water for 10 minutes, sieved through 150 mesh size (~105 μm) sieve, followed by acetolysis and centrifuged at 1000 rpm for 5 minutes. Opaque specimens became transparent, free from clay, and organic particles. However, living thecamoebians (with protoplasm) were lost.

Palynology of the recent sediments of various southern Red Sea coastal environments of Saudi Arabia

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CAP Session, 11:00 AM

Palynomorph assemblages and mineral microfossils (Ascidian and sponge spicules and phytoliths) from twenty-five mainly surface samples from tidal flats (7), mangrove swamps (7), middle Holocene paleochannel section (7), algal mat (2), and Sabia Island coral reef environments (2), were studied to establish a baseline data set. This defines the present health of the coastal ecosystem, creating a benchmark to be used for future environmental monitoring. Samples are mud, clay and fine sand that yielded low numbers but high diversity of palynomorphs divided into five groups: (A) pollen and spores; (B) dinoflagellate cysts and algal remains; (C) fungal spores, hyphae and fruit bodies; (D) protists and invertebrate remains; and (E) miscellaneous and unidentified forms. The protists and invertebrate remains are a diverse group that includes microforaminifera, thecamoebians, tintinnomorphs, crustacean and annelid palynomorphs. Charcoal fragments occur in almost all samples. These palynomorphs belong to both marine and terrestrial environments and are of autochthonous and allochthonous origins. All groups of palynomorphs occur in all these environments; however, their relative abundances vary. Intertidal environment is characterized by mostly rare occurrences of pollen, spores, dinoflagellate cysts and algal remains, fungal fruit bodies and few indeterminate fungal forms are common. Protist and invertebrate palynomorphs dominate the assemblage. Mangrove swamps have a higher diversity and numerical abundance of palynomorphs where protists and invertebrates are common. Crustacean and annelid remains are common to abundant as well. The palynomorph assemblages in the paleochannel section and algal mat are impoverished. Algal mat samples are characterized by the presence of abundant green filamentous, branched alga. The Sabia Island coral reef has rare pollen, spores, fungal remains, dinoflagellate cysts and algal remains. Protists and invertebrates dominate this assemblage. Ascidian and sponge spicules occur only in this environment along with a few specimens of phytoliths.

Testate amoebae inform about ecological baselines and critical thresholds in European ombrotrophic peatlands

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ISTA Session 4, 9:00 AM

Our study examines benchmarks and restoration strategies for ombrotrophic peatland ecosystems spanning the nemoral zone in Europe, from Western (Netherlands, Northwest Germany) to Eastern (Poland) and Northern (Southern Sweden) to Southern (Austria) regions. These sites have endured degradation due to drainage, climate change, intensive land use, and diverse management practices, with restoration efforts currently underway. We employed paleoecological indicators and historical data to analyze six representative peatland sites. Our focus was on testate amoebae and plant macrofossils from peat samples to reconstruct past water table levels and detect shifts in plant community composition using broken-line regression models. Additionally, threshold indicator taxa analyses were conducted to assess plant species patterns along hydrological gradients across all sites. Our findings revealed distinct disturbances experienced by these ecosystems due to anthropogenic pressures, leading to alterations in vegetation and water table levels during drainage and peat extraction. Moreover, our study uncovered the pre-disturbance states and varying resilience potentials of these peatlands, which are crucial for setting efficient restoration goals. Notably, we identified a tipping point at a depth to water table (DWT) of 8.5 cm, suggesting an optimal wetness range for peatland health across different climates. These findings serve as essential baselines for future rewetting scenarios in Sphagnum-dominated European peatlands, guiding conservation efforts.

Of testate amoebae and molecules: a journey through the ecology and evolution of our favourite micropredators

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(*Keynote Speaker*) ISTA Session 5, 9:00 AM

Testate amoebae have colonized (almost) all continental biomes on Earth. Their beautiful shapes are known since more than 200 years, and they are commonly used as witnesses of present and past environments. Yet, fundamental questions have remained untouched until recently. The application of molecular phylogenetic –omic approaches reshuffled the systematics of testate amoebae, revealing the importance of convergent evolution rather than morphological stasis. Metabarcoding, an approach based on sequencing of the specific amplification and sequencing of environmental DNA extractions, permitted the retrieval of large amounts of data necessary to explore species evolution and ecology. We investigated lesser-known environments such as karstic caves in Croatia, and showed that bats maintained distinct and probably endemic communities through their guano input. We focussed on ecological transitions, with a special emphasis on the salinity barrier, showing how it influenced cladogenesis in genus *Cyphoderia*. Within Arcellinida, inland lakes in Spain and Chile are particularly diverse, while there is no convincing evidence yet that the group managed to conquer marine systems. Water availability is of great importance in testate amoebae, and we showed that transitions between aquatic and terrestrial ecosystems has most likely influenced diversification in Arcellinida evolutionary history; we also showed that wetter climates influence Arcellinida diversity in the cedar forests of Lebanon.

Getting to know testate amoebae diversity and ecology better permitted us to develop a bioindication prototocol based on Arcellinida metabarcoding. A case study in two great river basins located in the South of Spain showed that land use is the most important parameter that influences community composition. Our protocol allows therefore quick, precise and relatively cheap diagnostics of environmental health in freshwater systems that can be easily transferred to other regions of the world.

Ecological drivers of testate amoebae diversity and distribution in 50 lakes in coastal areas from the Burin Peninsula, Newfoundland

Dominika Łuców[1,2], Karina Apolinarska[3], Cyprian Kowalczyk[4], Mariusz Lamentowicz[5], Krzysztof Pleskot[3], Michała Słowiński[6], R. Timothy Patterson

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ISTA Session 3, 11:50 AM

Climate models project that coastal lakes will be severely impacted in a warming world. For example, these lakes, located near mean sea level, may face increasing inundation from storm surges. Additionally, rising sea surface temperatures are expected to shift tropical cyclone tracks, leading to more frequent cyclone strikes in Atlantic Canada. These and other climatic influences will have a significant impact on coastal lakes ecosystems. Testate amoebae are key intermediary components of lake food webs. Therefore, monitoring changes in their assemblage dynamics, along with understanding the ecological requirements of individual species based on observations of contemporary communities, is essential for assessing both the current state and resilience of lakes to disturbances (e.g., storms, marine incursions), and for reconstructing past environmental conditions. The study aims to assess modern testate amoebae assemblages from 50 lakes in coastal areas on the Burin Peninsula of Newfoundland, a region that has not yet been thoroughly studied in terms of testate amoebae ecology. Our research revealed moderate species diversity and varying concentrations of testate amoebae, with most ponds exhibiting low concentrations. To date, we have identified approximately 32 species and strains. The most abundant taxa were *Centropyxis aculeata "aculeata", Difflugia oblonga "oblonga", Pontigulasia compressa, Difflugia oblonga "tenuis"*, and *Difflugia glans "glans"*. Less abundant species included *Centropyxis aculeata "discoides", Centropyxis constricta "constricta", Difflugia glans "distenda", Lagenodifflugia vas, and Difflugia globulosa. Difflugia corona, Difflugia difficilis,* and *Cyclopyxis impressa* were recorded rarely. The ecological preferences of testate amoabe taxa and assemblages will be determined through statistical analysis of water chemistry data, reservoir morphometric traits such as pond depth and distance of ponds from the ocean, sediment grain size distributions using end member modeling analysis, and ITRAX-XRF elemental analysis of lake bottom sediments. The research was funded by a project financed by the Bekker NAVA programme (BPN/BEK/2023/1/00254) and National Science Center (2020/37/B/ST10/02614).

Testate Amoebae Response to *Alnus* Decline During the Dark Ages: Insights from the paleoecological record

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Poster

The final centuries of the first millennium AD saw a sharp decline in the presence of Alnus (alder), most likely triggered by significant climatic shifts in Central Europe and the Baltic region. One or more extreme climatic events likely triggered the collapse of alder forests. The associated spread of a pathogen resulted in a deadly alder disease outbreak that ultimately caused a rapid decline in Alnus populations across Europe. Despite considerable research to understand this episode, testate amoebae have not yet been used to investigate the associated hydrological changes. These organisms could provide valuable new insights into this ecological shift. We traced the hydrological response during the decline of *Alnus* in the first millennium AD. To achieve this, we employed a multi-proxy approach, analyzing testate amoebae, pollen, charcoal, and plant macrofossils from a peat core collected from the Gorodziecky Moch ombrotrophic peatland, located in the East European Plain (Russian Federation). Our results reveal a shift towards drier hydrological conditions in the peatland during the *Alnus* decline, indicated primarily by the disappearance of *Amphitrema wrightianum*. This study highlights the utility of testate amoebae in palaeoecology, highlighting their value in understanding short-term environmental changes that are possibly related to climate change. The research was funded by a National Science Center (2019/35/N/ST10/03492).

Testate Amoebae Boogie Oggie

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ISTA Session 3, 9:50 AM

Climate change is affecting ecosystems worldwide, driving increases in surface temperatures and altering precipitation patterns. These changes are projected to be greatest in the higher latitudes of the Northern Hemisphere, where the majority of the world's peatlands occur. The vulnerability of the vast carbon stores contained within these formerly stable ecosystems under a changing climate makes them an important area of research. In the Arctic, warmer conditions trigger glacier melting, permafrost thawing, as well as tundra greening and browning. Yet, the speed of these processes and the effects they will have on permafrost peatlands are unclear. One of regions in the Arctic in which the response of peatlands to climate change is highly understudied is Disko Island, located in western Greenland. So far, no peatland palaeoecological study has been conducted there, and investigations of testate amoebae were limited to surface sampling of soil and mosses. Aiming to provide first estimates of climate change impacts on peatlands in Disko, we sampled two permafrost peatlands near the town of Qeqertarsuaq at the peak of the thawing season in the summer of 2024. We were able to collect surface moss samples as well as peat cores from an active permafrost layer. The analysis of surface moss samples explores taxonomic diversity of testate amoeba communities in several microhabitats present on the thawing permafrost peatlands. Our palaeoecological reconstructions focus on peat and carbon accumulation rates, hydrological dynamics, local and extra-local vegetation and fire histories to uncover past dynamics of peatland ecosystems in the Greenlandic Arctic. This talk will introduce preliminary results of our study focusing on testate amoebae and their ecology and palaeoecology in the far north.

We acknowledge GREENFIRE project financed by INTERACT, National Science Centre, Poland (2021/41/B/ST10/00060), and the Arctic Station in Qeqertarsuaq (University of Copenhagen) for on-site support.

“We play it coal” – testate amoebae as the Anthropocene markers

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Poster

Paleoecology has played a critical role in recent years to define the stratigraphic Anthropocene. In this poster presentation, we will show how the presence of testate amoebae in the peat record helped distinguish the proposed epoch. Our study is based on the subalpine Śnieżka peatland located in the Polish part of the Sudetes Mountains. The site was selected as a Standard Auxiliary Boundary Stratotype (SABS) for the proposed Global Boundary Stratotype Section and Point (GSSP) of the Anthropocene (Fiałkiewicz-Kozieł et al., 2023). Among many critical markers – i.e., Pu isotopes, ^{137}Cs, ^{14}C, fly ash particles, rare earth elements (REE), Hg and stable C and N isotopes and others – testate amoebae also turned out to be important anthropogenic indicators. We found that fossil testate amoebae had technofossils built into their tests – spheroidal aluminosilicates fly ash particles (SAP) in particular. The corresponding decline of several sensitive hydroclimatic indicators in the late 1950s corresponded with the proposed 1952 as the year marking the beginning of the Anthropocene. The study was supported by IGCP 732 - LANGUAGE of Anthropocene.

References: Fiałkiewicz-Kozieł B., Łokas E., Smieja-Król B., Turner S., De Vleeschouwer F., Woszczyk M., Marcisz K., Gałka M., Lamentowicz M., Kołaczek P., Hajdas I., Karpińska-Kołaczek M., Kołtonik K., Mróz T., Roberts S., Rose N., Krzykawski T., Boom A., Yang H., 2023. The Śnieżka peatland as a candidate for the Global Boundary Stratotype Section and Point for the Anthropocene series. The Anthropocene Review 10, 288-315.

Deterministic and stochastic processes shaping testate amoeba assemblages

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ISTA Session 5, 2:30 PM

Neutral and niche-based theories in a multi-scale framework provide complementary ways to understand community assembly mechanisms. Community composition is shaped by a balance between "deterministic" (related to interspecies interactions and environmental filtering) and "stochastic" (driven by random dispersal and accidental mortality) mechanisms. Assembly processes have mostly been studied on macro-organisms. Testate amoebae (TA) are useful model to address these questions for soil microbes. The study of soil inhabiting TA in taiga forests along an elevation gradient in the Northern Urals revealed two major mechanisms of community assembly related to the heterogeneity of habitats. Species segregation was observed within the different typical microbiotopes from each vegetation type at each elevation, in agreement with the predictions of the species sorting paradigm. Within a specific type of microbiotope occurring across the gradient (sub-crown litter of *Picea obovata*) the revealed random association of species agrees with the mass effect paradigm. The study of TA assemblages in mineral soils and peatlands across latitudinal gradient of Western Siberia and longitudinal gradient within forest-steppe zone across Eurasia revealed that mineral soil communities are assembled by environmental filtering, whereas, biotic interactions are the leading driver of organic soil community assembly. The study of TA assemblages in different biotopes (tree holes, tree trunk mosses, soil litter, and pond sediments) in the urban parks from temperate (Moscow) and subtropical (Xiamen) climate zones revealed that stochastic processes predominate in shaping TA assemblages among the set of all types of biotopes. However, higher importance of deterministic processes was detected in moss and soil habitats comparing with other habitats. Understanding the differences in dominant assembly processes between environments and scales is crucial for predicting their responses to disturbances and climate change. The work was supported by Russian Science Foundation (24-14-00065, 24-44-0096), National Natural Science Foundation of China (32361133557) and Asahi Glass Foundation.

Dinoflagellate cyst transfer functions: a game-changer

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CAP Session, 2:10 PM

The readily fossilizable organic-walled cysts whose dinoflagellate affinity was recognised only in the 1960s have become important proxies in sediments of Mesozoic-Cenozoic age, particularly from high-latitude and neritic marine environments where mineralised microfossils are rare. They have long been useful biostratigraphy markers and important investigations improved our understanding of the morphological link between living dinoflagellates and fossilized cysts, continuously improving cyst taxonomy. Arguably the most important application of dinocysts is as paleoenvironmental proxies, with studies demonstrating relationships between cyst assemblages in modern sediments and present-day environmental factors controlling their distribution allowing dinocyst transfer functions to be developed. Without question, the work of Anne de Vernal and her students and colleagues has been pivotal in providing quantitative reconstructions of paleoenvironmental conditions, particularly at high northern latitudes where conditions are changing more rapidly than the global average. This information is essential to adapting to future climate change and associated ecological and socioeconomic repercussions. Less well-known is the record of cysts produced by freshwater dinoflagellates, although they are known from Late Mesozoic through modern sediments. Taking inspiration from the work of de Vernal and others, we have started taken the first steps toward developing dinocyst-based paleolimnological transfer functions by relating the cyst distribution in surface sediments from 32 boreal lakes in the Experimental Lakes Area of NW Ontario with varying physical and chemical characteristics.

Thecamoebian and NPP proxies of remediation in the Athabasca Oil Sands

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Poster

Microfossils record anthropogenic impact, from siltation and eutrophication to the increase in chemicals associated with industrialization. Assessing the effectiveness of strategies to speed up natural reclamation requires a biomonitor that is sensitive to- but tolerant of- the environmental stressor. Testate amoeba assemblages correlate well with concentrations of the by-products of oil sands extraction and they respond quickly (within one year) to variations in the flux of oil sands process-affected water (OSPW). Sites in the Suncor Constructed Wetlands Facility (SCWF) exposed to high volumes of OSPW are dominated by hardy bacteriophage centropyxid amoebae, whereas sites with lower concentrations of naphthenic acids and lower conductivity are dominated by more sensitive herbivorous difflugiid species. Analysis of non-pollen palynomorphs/ NPP (acid-resistant organic walled microfossils common in pollen slides) in two nearly identical engineered ponds identified a NPP assemblage in the difflugiid-dominated Sustainable Lake South (Pond 15) but a sparse, low-diversity assemblage in the centropyxid-dominated Sustainable Lake North (Pond 14). Not only are algal palynomorphs ~13X more abundant and more diverse in than in sediments from Pond 15 than Pond 14, but the assemblage also contains the fossil remains of animals and protozoans. The more complex ecosystem in Pond 15 is attributed to amendment by nutrients in Sustainable Lake South for several years following construction in 1992. Testate amoebae and NPP are thus useful biomonitors of reclamation success, and the more diverse and abundant communities of primary producers as well as consumers in the pond that received phosphorus suggests that nutrient-loading is a useful reclamation strategy.

Island Biogeography and Ecological Patterns of Testate Amoebae in the Peatlands of La Réunion

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ISTA Session 5, 11:30 AM

La Réunion's high-altitude peatlands represent some of the most ecologically distinctive peatland systems in the tropical Indian Ocean. Despite their importance, the microbial communities inhabiting these environments remain largely undocumented. This study explores the biogeography and ecological patterns of testate amoebae across three unique peatland complexes on La Réunion. The study aims to investigate how factors such as moisture availability, vegetation structure, and elevation influence testate amoebae community composition on La Réunion. This work will provide foundational knowledge on La Réunion's peatlands and highlight the importance of conserving these unique but threatened ecosystems.

Post-colonial sediment horizons in Lake Ontario coastal lagoons - soil erosion, eutrophication, and pollution impact through historic land-use changes title

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Poster

This study evaluates differential impacts of recent and historical anthropogenic land use changes on sediment and water quality in two coastal lagoons in the eastern Greater Toronto Area: Lynde Creek (LC) and Frenchman's Bay (FMB). Sediment cores (0.5-1.6m, n=4x2) were collected along shoreline perpendicular transects to determine the thickness and distribution of contaminated sediments using environmental proxies in ITRAX micro-XRF, magnetic susceptibility, thecamoebian taxa, loss-on-ignition, AMS ^{14}C, and ^{210}Pb chronology. Principal component and cluster analyses of elemental data identified 12 lithochemofacies (all cores) and Q-mode clustering of thecamoebian assemblages (2 index cores) distinguish 3 biofacies in each core. Facies analyses discriminate and help define the European Settlement Layer (ESL) boundary: a chemically, physically, and biologically distinct sediment unit initiating deposition ~1840AD. It is composed of ~1-1.4m thick detrital gyttjas and interbedded sands; distinct from underlying, organic-rich Late Holocene sands, peats, and gyttjas (~2500-200 14C YBP). This transition marks a key environmental threshold in both lagoons, linking anthropogenic watershed disturbance with a persistent shift in sediment composition and aquatic ecosystem structure. The ESL boundary is characterized by rapid increase in magnetic susceptibility, silica (Si), titanium (Ti) and iron (Fe) alongside a sharp decrease in LOI organics (from 50-75% to 5-20%); signaling land clearance, enhanced soil erosion, and wetland degradation. The boundary also coincides with a sharp then sustained increase in eutrophication indicator species: *Cucurbitella tricuspis* (from 5-25% to 30-70%). Within the ESL in FMB, urbanization (mid-20th century) is indicated by higher concentrations of heavy metals (Zn, Pb); calcium (Ca) and chlorine (Cl); and *C. tricuspis*. Rising Cl in FMB likely records sodium chloride inputs from road de-icing. LC shows similar elemental trends but with a lower relative abundance of heavy metals and more diverse thecamoebian assemblages, indicating lower overall environmental stress, though increasing *C. tricuspis* may indicate emerging eutrophication in LC.

Tiny microbes for big problems: testate amoebae communities as tracers of industrial pollution in heavily degraded peatlands of the Greater Sudbury Area (Canada)

Samantha Mitchell[1], Nathan Basiliko[2], Colin McCarter[3], Ellie Goud[4], Pete Whittington[5], Peter Beckett[6], Florin Pendea[1]

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ISTA Session 1, 10:10 AM

Testate amoebae (TA) are documented to be reliable bioindicators of various environmental conditions due to their high sensitivity, short life cycles, and cosmopolitan distribution. In peatlands, research shows that TA are good indicators of water table depth, pH, trophic states, and various pollutants. As increasing ecological restoration efforts worldwide necessitate a spectrum of biomonitoring tools, TA offer a relatively fast and inexpensive way to measure restorative success. Sudbury (ON), a former mining and Cu-Ni smelting centre, was North America's largest point source pollutant of sulfur and some toxic metals and metalloids (TMMs) during mid 20th century, which left a substantial pollution legacy on extant ecosystems in the region. In this study, we conducted a causal-comparative analysis of sub-fossil TA community structure and composition in three peatlands along a disturbance gradient from the smelter loci to areas that were minimally impacted. Our preliminary results suggest that TA assemblages within peat deposited during the industrial isochron (1885-1975) show a dramatic reorganization at sites proximal to the smelters while at distal sites they are broadly similar to pre-disturbance communities. The TA communities from peats with high sulfur and TMMs (particularly Cu, Ni, Pb, As) are dominated by *Cyclopyxis arcelloides* and *Phryganella* acropodia, while those from a minimally impacted site were led by *Nebela militaris* and *Difflugia pulex*, alongside several minor taxa. These results suggest that TA assemblages can discriminate between degrees of pollutant loading, although the causality involved is likely complex. In some cases, species-pollutant relationships are more direct (e.g., the Cu affinity of *C. arcelloides*), while in others indirect and/or multifaceted relationships can be inferred (e.g., *P. acropodia's* association with disturbed habitats via trophic webs alterations). This work informs our current peatland restoration efforts in the region but may be applicable to other restoration contexts.

Sorting the wheat from the chaff in bioindication –

Selecting a minimum list of useful testate amoeba indicators for building transfer functions for water table depth, pH and gas fluxes in peatlands

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ISTA Session 4, 11:40 AM

Bioindication, the use of species to inform about the ecological status of the environment is a useful tool for to monitor current (e.g. pollution, restoration) and past (palaeoecology) environmental conditions. To develop such tool the ecological preferences (optimum and tolerance) of species are determined for factors of interest (e.g. temperature, pH, pollution, ecosystem process) based on observational or experimental studies. Based on this transfer functions are developed. The performances of these models are assessed using indicators such as the correlation (r2) between observed and predicted values, the root mean squared error of prediction. (RMESP). Outlier samples (with high error) or species (usually only very rare taxa) are removed to improve model performance. This approach results in including in each model many species, which need to be identified. A model with fewer species would simplify and potentially speed-up analysis. Furthermore, species' identification is challenging for some species resulting in possible bias among analysts, which represents a possible limitation for meta-analyses. This bias could potentially be overcome by automatic identification using IA. However, training such models requires a high number of images for each species. Our goal was therefore to select a reduced number of optimally selected species that 1) have well-defined ecological preference, 2) together cover the whole ecological gradient, 3) together represent a minimum proportion of the community in a large majority of sample and 4) have well-defined morphologies that allow reliable automatic identification. Using several published and unpublished data sets we tested the performances of transfer functions based on different number of species. For each combination we assessed the performance of transfer function models and the distribution of percentage of total community accounted for the selected species across all samples in the data set. Results show that with ca. 1/3 of the total number of species the performance of transfer function models is close to that of the full model.

Dinoflagellate and other NPP indicators of Arctic Ocean multiyear ice

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CAP Session, 2:30 PM

The semi-enclosed Arctic Ocean is unique in being the smallest, coldest and freshest of the global oceans, and having multiyear sea-ice (MYI) >2 m thick. Ships cannot access perennial sea-ice. Therefore, the MYI dinoflagellates and other NPP microbiota are little-known, limiting interpretation of Arctic paleosea-ice records. For example, the GEOTOP 1968-site reference database lacks samples for MYI. New morpho-taxonomic and seasonal data were obtained for dinophytes, ciliates and foraminifers from MYI on the Canadian Polar Margin (80oN) 1985–1989, and over Gakkel Ridge 86oN, 1987, at the start of global warming and irreversible thinning of MYI, to compare with archives of Meunier (1910) at 72°N. Five years of data from Canadian Ice Island sea-ice, plankton tows and sediment traps reveal a succession of sympagic and cryophilic biota. Winter traps have abundant chrysophytes, diatoms, juvenile forams, a thecamoeban, ice nematodes, radiolaria and silicoflagellates, but no dinoflagellates. Spring samples contain snowalgae and cysts of *Polarella (Echium) glacialis, Echium spp., Becheleria, cf. Boreadinium breve, Peridiniella catenata* and *Dinophysis arctica*. July-August has a succession from predominantly *suessioid dinocysts* and occasional *Diplopsalis sphaerica* to an August bloom of *Peridiniella catenata*. The sympagic August flora from Gakkel Ridge is similarly dominated by suessioids with rare *Diplopsalis, Polykrikos, Caracomia, Actiniscus pentasterias*, and acritarchs not seen in Canadian ice. Meunier's Kara Sea samples were mainly *Polarella glacialis, Echinum sphericum* and *Biecheleria*. Notably, surface sediments under the pack ice contain a disjunct protoperidinioid flora dominated by *Islandinium minutum, Brigantedinium, Echinidinium, Multispinula quanta*, and *Impagidinium pallidum*. The disjunction between sympagic and seabed assemblages suggest that most of the traditional Arctic dinocyst indicators are advected pelagic biota, indicated by low dinocyst/foram lining ratios. To fill the gap between sympagic and bottom assemblages, we can apply biomolecular or stable isotope analysis that trace *Polarella glacialis* and ice-algae to the last interglacial.

Canaries in Contaminated Mud: Testate Amoebae as Bioindicators of Heavy Metal Contamination in Mining-Impacted Lakes

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(Keynote Speaker) ISTA Session 1, 9:00 AM

In lake ecosystems, testate amoebae have emerged as reliable bioindicators of various anthropogenic disturbances, including those linked to mining activities. Despite its profitability, the mining sector is often associated with the release of heavy metals into vulnerable ecosystems, some of which are highly toxic (e.g., arsenic). Lakes are particularly prone to the adverse impact of such contaminants because they can act as either sinks or sources of contamination under certain redox conditions. With climatic warming expected to exacerbate the release of heavy metals from lake sediments, understanding the ecological response of lakes to contamination across time and space is essential for assessing the long-term ecological impact of evolving contamination. Over the past decade, I have conducted several studies exploring the dynamics between mine-induced heavy metal contamination and testate amoebae in impacted lakes across Canada. In this presentation, I will discuss the insights gained from three interdisciplinary studies designed to quantify the ecological response of Arcellinida to legacy mining contamination. Specifically, I will present evidence of the sensitivity and tolerance of testate amoebae assemblages and individual taxa to spatial and temporal variability in gold-mining-induced arsenic contamination in the subarctic Canada. The response of the group to arsenic contamination from two distinct historical gold mines, and the potential variation in arsenic mineralogy, will be discussed in the context of the same region. I will also present insights into the temporal sensitivity of testate amoebae to variations in the levels of several heavy metals in lake sediment cores from the Cobalt area in Ontario, Canada.

Biodiversity conservation challenges in urban blue-green infrastructure under climate extremes: Insights from testate amoeba communities

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ISTA Session 1, 11:10 AM

Urban blue-green infrastructure is essential for addressing the challenges posed by urbanization. However, the full extent of its ability to provide ecosystem services, including biodiversity conservation under predominantly anthropogenic climate change, remains unclear. This study evaluates the biodiversity conservation challenges associated with urban blue-green infrastructure under climate extreme scenarios, such as heatwaves, droughts, typhoons, and floods, using highly sensitive and decay-resistant microorganisms, testate amoebae, as indicators of ecosystem health. The studied urban blue-green infrastructure comprises 0.67 km² of forested hills and 3,668 m² of ponds, located within a 55,800 km² city cluster in the Pearl River Delta, South China. The analysis is based on testate amoeba records from 27 soil samples, 30 pond water samples, and pond sediment samples, along with 27 microspatial factors, all collected during consecutive periods of peak warmth or climate extremes in 2021 and 2022. The biodiversity conservation challenges faced by urban blue-green infrastructure in four studied climate extreme scenarios, along with associated water quality concerns resulting from interactions between harmful urban emissions and aquatic ecosystems, are highlighted through the following key findings: Biotope connectivity enabled the redistribution of soil-specific testate amoebae (6 out of 42 species) along hillslopes (moisture gradient) and pond lengths (hydrological gradient). Testate amoebae exhibited strong biotope adaptation, with stochastic processes explaining 69.3% of community variation in water and 78.8% in sediment. Urban blue-green infrastructure became ineffective in mitigating urban emissions, such as CO and NH_3, particularly when testate amoebae were negatively impacted by climate extreme-induced weather conditions and when water quality was further degraded by poor air quality.

Reconstructing paleoenvironmental changes in the Mackenzie River Basin, Northwest Territories, Canada, using plant macrofossils and testate amoebae

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ISTA Session 3, 11:30 AM

Northern watersheds, such as the Mackenzie River Basin (MRB), are particularly sensitive to climate change, with surface air temperatures in the western Canadian Arctic increasing twice as fast as the global average since the beginning of the 20th century. The MRB is one of the largest drainage basins in Canada, and one of the largest permafrost peatland areas in the world. The largest community within the northern part of the MRB is Inuvik, Northwest Territories, where residents have reported decreased water levels and flows, warmer and drier conditions, and thinning ice. The aims of this research are to: 1) reconstruct the paleoenvironment and fire history in the Gwich'in Settlement Area (GSA; northern MRB) using biological proxies; 2) assess hydrological trends in the peatlands from generated water table profiles; and 3) compare these observations to known ocean-atmosphere interactions (e.g., solar cycles, Pacific Decadal Oscillation) that have influenced the paleoclimate of North America through the late Holocene. This project represents the first time an integrated, high-resolution (decadal to centennial) reconstruction of past climate and paleohydrology is produced for the MRB. As part of this project plant macrofossils and testate amoebae were used to reconstruct paleoenvironmental changes in the GSA. We present a 2000-year, high-resolution record from six peat cores collected between 2016 and 2020. Among the cores, one was identified as ombrotrophic. Using stratigraphically constrained cluster analysis, we have identified biostratigraphic paleoenvironmental zones based on plant macrofossil and testate amoebae distributional data for each of the cores. Water table depth reconstructions were generated using established paleoecological transfer functions from testate amoebae assemblages. Despite shifts between wet and dry phases, all cores reveal an overarching trend toward drying.

Testate amoeba diversity and community composition in epiphytic bryophytes of a temperate rainforest

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Poster

Information on the ecology and diversity of testate amoebae has greatly expanded in the last several decades, with much of this work focusing on lakes and peatlands because of their use as paleoenvironmental indicators in these systems. However, other habitats have been relatively understudied. For example, testate amoebae inhabiting epiphytic, forest bryophytes have only been described in a few regions, and even less work has identified factors influencing community structure within this unique, aerial habitat. We quantified testate amoebae in 45 samples from four widely distributed species of epiphytic bryophytes along a height gradient from near the ground to the canopy in the Hoh Rainforest of Olympic National Park, Washington, USA. Communities were characterized by abundant *Assulina muscorum, Euglypha spp., Galeripora arenaria, Porosia bigibbosa, Trinema spp., Nebela tincta*, and *Padaungiella wailesi*. With the exception of *Porosia bigibbosa*, these are widely distributed taxa common in moss-dominated habitats. However, the high abundance (2%-70%, average 38%) and frequency (70% of samples) of *Porosia bigibbosa* was surprising given that previous studies suggested it is indicative of forest litter, particularly in deciduous forests dominated by beech. Our data clearly indicate that canopy bryophytes are also an important biotope for the species. Testate amoeba diversity and community composition differed among epiphytic species, but unlike studies in tropical and boreal forests we found no relationship to height in the canopy. Communities inhabiting *Metaneckera menziesii* were less diverse than those of I*sothecium myosuroides, Hylocomium splendens*, and *Porella navicularis*. Percent moisture measurements on our samples were consistently drier in *Metaneckera menziesii* compared to the other bryophyte species, suggesting that water-holding capacity and/or other characteristics of the microenvironment created by epiphytic mosses influence the composition of testate amoeba communities. Results highlight how little we know about testate amoebae and microbial biodiversity in general within understudied habitats.

Arcellinida (Testate Lobose Amoebae) as Bioindicators of Road Salt Contamination and Nutrient Loading in Eastern North American Lakes

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ISTA Session 1, 10:10 AM

The rapidly growing Golden Horseshoe (GH)/Greater Toronto Area (GTA) conurbation, with a population of >10 million, flanks the western end of Lake Ontario. Lakes in this region face increasing pressure principally from road salt contamination and nutrient loading. Winter de-icing salts (up to 220 tons per kilometer on major highways) contribute significantly to environmental stress throughout this region and the greater North American "salt belt." Rock salt (NaCl) is commonly used due to its cost-effectiveness and regional climate suitability (effective to -18°C). However, road salt damage is cumulative, impacting aquatic systems up to 2 km from roadways. As salinity increases, aquatic species diversity and abundance decline, potentially leading to ecological collapse. Despite these effects, NaCl remains in use due to its role in reducing road accidents by 88%. Urban and suburban growth has also intensified eutrophication in GHGTA lakes, primarily through increased nutrient inputs of phosphorus and nitrogen from runoff, sewage, and industrial discharge. This study uses Arcellinida assemblages from lake bottom substrates and core records from the GHGTA-Ottawa (eastern Ontario) corridor to assess the impacts of road salt and nutrient loading, while considering other stressors (e.g. substrate particle size, geochemistry, dissolved oxygen). Focusing on Haynes Lake, an environmentally sensitive lake in the GTA, this presentation demonstrates intra-lake Arcellinida assemblage variability linked to nutrient loading (up to 350 OP ppm; *Difflugia*-dominated) and road salt contamination (up to 3500 µS cm-1, 3 ppt; *Centropyxis*-dominated). Haynes Lake also preserves a record of ecological change, from a pre-settlement forested catchment to 19th-century agricultural land clearance, followed by post-WWII nutrient and road salt impacts. These changes became particularly evident with surrounding urbanization, including the construction of an adjacent golf course, in the late 20th century.

Methodological Advances to Trace Past CH4 (MATCH4)

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ISTA Session 4, 9:50 AM

Although peatlands are well-known as carbon sinks, their influence on atmospheric methane (CH_4) concentrations remains poorly understood on long-term timescales. As CH_4 is a potent greenhouse gas, with a warming capacity 28–36 times that of carbon dioxide, it is a significant contributor to climate change (IPCC, 2023; Neubauer, 2021). While there has been notable progress in our understanding of net ecosystem exchange of GHG from peatlands (Hambley et al., 2019; Lees et al., 2019; Premrov et al., 2021), knowledge gaps still exist in our understanding of long-term CH_4 emissions. Palaeo-methane reconstructions are regionally poorly constrained outside of the well-known and globally important ice core records (Blunier et al., 1995). Although attempts have been made internationally to improve our understanding of long-term CH_4 emissions, through building transfer functions using peatland vegetation assemblages (Mathijssen et al., 2017) and lipid biomarkers from microbial communities involved in methanogenesis (Zheng et al., 2019), they have been met with various challenges. Testate amoebae have been used to infer palaeo-CH_4 by applying a linear regression models derived from contemporary growing season methane fluxes and WTDs (Davies et al., 2021). Frésard et al. (2023) further highlights the promising potential of testate amoebae for inferring northern hemisphere peatland methane through direct measurements with this gas. Our study builds on this pioneering work and aims to develop a TA-based inference model to directly reconstruct long-term CH_4 fluxes in Clara Bog in Ireland and test the validity of the inference model by applying it to sub-fossil testate amoebae assemblages extracted from a 2-metre core. Preliminary results show promising potential of testate amoebae to infer palaeo-methane reconstructions in Ireland.

Ecology of Testate Amoebae in Icelandic Peatlands and Their Response to Past Tephra and Historical Increases in Dust Deposition

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ISTA Session 4, 11:20 AM

Since human settlement, Icelandic peatlands have been subject to recurrent deposition of both volcanic tephra and aeolian dust due to soil erosion. These inputs, often associated with acid rain, are suspected to alter peatland chemistry, particularly pH, and to influence microbial communities, including testate amoebae (TA). This study aims to assess the impact of such deposits on TA assemblages by combining modern surface sampling and peat core analysis from Icelandic peatlands. Surface samples were collected across four sites to develop a transfer function enabling the inference of key environmental variables, such as depth to water table (DWT) and pH, from fossil TA assemblages. The peat core was analyzed to detect potential shifts in TA communities associated with tephra or dust layers. Preliminary results suggest that TA assemblages in the peat core resemble those typically found in studies using TA as proxies for sea-level reconstruction. These findings challenge initial expectations and raise new questions not only about the ecological stability of TA in Icelandic peatlands despite environmental perturbations, but also about the nature of past Icelandic landscapes, suggesting that the historical hydrological and ecological context of the studied peatland may differ from present-day assumptions.

Thecamoebians and Foraminifera as Tracers of Paleohydrologic Shifts in the Yax Chen Cave System, Quintana Roo, Mexico

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ISTA Session 3, 11:10 AM

Sediments sourced from cenotes (sinkholes) and coastal caves in Mexico's Yucatan Peninsula contain records of paleohydrology and sedimentation within these cave systems. Due to their sensitivity to environmental conditions, microfossils preserved in these sediments serve as valuable indicators of paleoclimate parameters, reflected in species abundance and diversity. The flooded Yax Chen cave system, a 2.7 km NE-SW trending section of the Ox Bel Ha cave system in Quintana Roo, includes terrain transitioning from upland forest to mangrove wetlands and eight cenotes of variable size. Flowing coastward, groundwater is stratified, with a meteorological water mass overlying a denser marine water mass, separated by a halocline that responds to seasonal and climatic variability. Sediment traps (n=51) were placed in seventeen stations throughout the cave system and collected every ~6 months from May 2013-May 2024, alongside instrumental records of salinity, temperature and precipitation. Previous studies on sediment cores collected from Yax Chen displayed a combination of freshwater thecamoebians and brackish foraminifera, suggesting potential transport of microfossils via groundwater flow. This preliminary study examines the abundance of these taxa in sediment trap samples (n=15) from three stations collected annually from December 2019-December 2024 (excluding 2020). Results indicate a correlation between precipitation and species diversity, with the short-term dominance of brackish/marine taxa following synoptic rainfall- likely reflecting temporary mixing of the stratified marine and meteorological water masses.

Diversity and Distribution of moss inhabiting Testate amoebae (Protista) along the altitudinal gradients of selected protected areas of North eastern India

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ISTA Session 5, 11:50 AM

The structure of moss inhabiting testate amoebae communities along the altitudinal gradients of Nameri National Park, Assam and Talley valley WLS, Arunachal Pradesh, India were investigated. The moss dominated microenvironments were exhibiting substantial difference in the diversity of their testate communities. A total of 33 testate amoebae species belonging to 12 genera were identified from Nameri NP, Assam whereas a total 62 species belonging to 12 families and 24 genera were identified from Talley Valley WLS. The dominant species observed in the moist moss habitats were Euglypha ciliata, E. rotunda, *T.lineare, Cyclopyxis arcelloides*, and *Arcella vulgaris*, whereas the species observed in the regions of Nameri NP were inhabited with *Assulina muscorum, A.seminulum, Trinema enchelys, Euglypha laevis, Corythion dubium* etc. The relative abundance of species was higher in the wet habitat of moss dominated high altitudinal regions of Talley Valley compared to the dry moss habitats of Nameri forest. In Talley Valley, Highest number of species belongs to the family Centropyxidae followed by Hyalospheniidae and Difflugidae. The abundance and composition of the dominant testate amoebae complex have close dependence on the moisture content. Some species like *Galeripora arenaria* and *Hyalosphenia* were dominated under wet conditions of the WLS. The relative abundance of species was higher in the wet moss habitat compared to the dry moss habitats of the forest. Multivariate analysis suggested a significant difference in assemblage patterns of testate amoebae between the two habitats of Protected areas. The temperature, moisture content and pH of the substratum influence on testate amoebae distribution patterns. In conclusion, the study suggests that the total diversity of testate amoebae is determined by the differences between the microhabitat environment along with the altitudinal gradients within the North eastern forest biotopes of India.

Holocene testate amoeba reconstruction in a Norwegian mountain peatland and its relationship with climate and carbon budget

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ISTA Session 4, 10:40 AM

There is extensive literature on temporal carbon accumulation changes in arctic and boreal peatlands in northern peatlands, but little has been achieved in comparing mountain peatlands carbon sinks capacities in wet regions such as Norway. Projections in Norway show a rise in temperature and annual rainfall with more intense seasonal events in western, eastern, and northern parts. In this context, this study hypothesizes that temporal variability of temperature and precipitation during the Holocene led to weaker and stronger evapotranspiration and moisture signals affecting local and regional vegetation in peatland ecosystems, water-table changes, and carbon accumulation capacity. This study aims to use Testate amoebae remains to reconstruct fluctuations of water table in a mountain peatland in the south of Norway during the last 10 000 years, in order to compare the changes of species with its temporal carbon sink capacity. Methods involve a multiproxy approach to reconstruct carbon accumulation rate, local vegetation changes, %C and % N and testate amoebae linked to water table variabilities, to investigate the relationship between the proxies and Holocene carbon changes.

Closure of Khor Al Balid and Khor Rori harbours/estuary with coastal uplift and aridity in the 12th – 15th c. CE: implications for ancient port sites in southern Oman

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ISTA Session 1, 11:30 AM

Ancient maritime trading ports along the southern coast of Oman have been the target of archaeological excavations for several decades. Though historical chronologies are well-researched, information from a paleoenvironmental perspective is lacking and can provide a more complete understanding of site development. This study investigates the timing of coastal sand barrier accumulation in the natural harbours at Khor Al Balid and Khor Rori, which had considerable effects on the populations at the ancient cities of al–Balīd and Sumhuram, respectively. Six cores from Khor Al Balid and four cores from Khor Rori were analyzed using sedimentological, microfossil (foraminifera and testate amoebae), geochemical (microXRF), and radiocarbon dating methods. Marine proxies (e.g., *Amphistegina spp., C. pseudolobatulus, E. lebatum*, Sr, Ca/Si) and lagoon proxies (e.g., *T. macrescens, T. inflata, C. constricta* and *C. aculeata*, Ti/Ca, Fe/Ca) were used to identify Marine Sand, Brackish Lagoon/Marsh, and Freshwater facies. Results indicate that the eastern arm of Khor Al Balid closed off from the sea around the 12th century CE and that the western arm closed around the 15th century CE. Siltation of harbours and the formation of sand barriers may have contributed towards site abandonment. Previous archaeological findings suggest that al-Balīd was able to continue with maritime trade activities along the southern seaside edge of the city for several centuries after siltation of Khor Al Balid, possibly with the help of dredging. An extreme overwash event was recorded in almost all cores across both sampling sites, suggesting that a very large cyclone or a tsunami hit the southern Oman coast sometime around the 18th–19th century CE. This event, as well as continuous coastal sand accumulation, may have contributed to the decline and abandonment of Khor Al Balid and highlights the impacts that large storm/wave events have on archaeological site preservation.

Revealing Hidden Testate Amoebae Diversity using an integrative 'Omics' Approach

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ISTA Session 2, 3:10 PM

Testate amoebae (Arcellinida: Amoebozoa) are bioindicators in freshwater and peatland ecosystems, yet unresolved taxonomy limits our ability to use them as sentinels of environmental quality. The presence of a microbiome within each individual, cryptic diversity, phenotypic plasticity, and the presence of numerous uncultivable lineages are only a few of the obstacles to species determination in testate amoebae. Despite being the norm for identifying species historically, traditional morphological classifications frequently fail to capture the entire range of genetic variability within this group. This restriction is especially noticeable in the very diverse testate amoebae clade, Arcellinida, where genetic research has shown a great deal of genetic variation and phenotypic plasticity that morphology-based taxonomic frameworks do not capture. How can we reconcile traditional species classification with the extent of modern complex genetic variation found in this group? Our research combines morphological characterization with novel molecular techniques (including 18S metabarcoding, single-cell omics), and development of a fluorescence in situ hybridization (FISH) procedure to uncover the unknown biodiversity within Arcellinida. We collected samples across diverse peatland habitats in the United States, selecting sites that represent pH and water temperature gradients enabling the characterization of community assemblages and phylogenetic relationships. By integrating high-throughput sequencing with classical microscopy, we aim to provide a more robust framework for studying microbial eukaryotic diversity and their response to environmental fluctuations. Ultimately, our work advances testate amoebae classification, while also providing a genomics monitoring protocol for the conservation of endangered places, such as peatland ecosystems.

Unlocking Testate Amoebae Sex: A Genomic and Cytological Approach to Encystment

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Poster

Testate amoebae (Arcellinida: Amoebozoa) have long challenged the assumption that microbial eukaryotes are strictly asexual, but critical gaps need to be filled to fully understand their life cycle. Raikov and Mignot's (1992) discovery of a putative synaptonemal complex in Arcella vulgaris set the stage for the hypothesis that meiosis (sex) occurs during encystment in Arcellinida. Also, molecular studies showed the presence of a well-developed meiotic toolkit in Arcellinida, suggesting the presence of meiosis and sex at some lifestage. However, in which condition meiosis occurs is still unknown. Although the hypothesis that meiosis occurs during encystment is up to today well accepted, this early hypothesis still lacks the confirmation using modern imaging technologies. Here, we use *Hyalosphenia papilio* to confirm whether DNA structure modifications and meiosis occur during encystment in Arcellinida. To address that, we induced encystment in *H. papilio* cells through starvation, and employed confocal microscopy to analyze chromatin structure and estimate DNA content to infer ploidy levels, and to compare nuclear states between vegetative and encysted cells. Additionally, we examine whole transcriptomes from these two cell types, seeking evidence of meiosis by differential expression of gene families known to play a role in meiosis. Preliminary imaging revealed distinct chromatin compaction in encysted cells, suggesting ploidy reduction. We show here the novel molecular and cytological evidence produced using modern technologies supporting the DNA modification process in *H. papilio* cysts. By building a bridge between the classical Raikov experiment and modern technologies, this work reinforces the potential existence of sexual strategies in Arcellinida. Insights like this show that diversity is much broader than traditionally recognized and investigating understudied lineages of eukaryotes unveils new mechanisms in eukaryotes.

Understanding long-term forest responses to climate change in the Northwest Territories, Canada: insights from multiproxy (palaeo)ecological data

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CAP Session, 3:10 PM

Palaeolimnological studies from sites above the modern treeline in the -Northwest Territories, Canada, have revealed the dynamic nature of the response of the boreal ecozone to inferred climate warming during the mid-Holocene. However, the character of landscape evolution during the first few millennia after deglaciation remains poorly understood. This period was characterised by complex environmental changes as glacial meltwaters drained from the region and boreal forest communities migrated northwards in response to climate amelioration. This paper will draw upon peatland and lake sediment records from a transect of sites (n=9) extending from the central Great Slave Lowlands to the tundra ecozone approximately 200 km to the northeast. It aims to: (i) provide new insights into rates of peatland initiation, vegetation colonisation and treeline mobility in the early to mid Holocene; and (ii) appraise the utility of a range of proxies (pollen; stomata; chironomids; diatoms; charcoal) for understanding climate-environment interactions during this period. These insights could provide valuable context for understanding the impacts of future potential climate change in the region. Quantitative temperature reconstructions derived from fossil chironomid assemblages in three study lakes show that during the early Holocene (prior to ~8000 cal yr BP) temperatures exceeded present conditions by ~1-2°C, whilst palynological data reveal a more dynamic treeline in the mid Holocene than previously documented. Surficial pollen data from a transect of modern lakes (n=57) in the region helps to better contextualise some of the inferred changes in Holocene forest dynamics, while also highlighting some of the challenges of using arboreal pollen data to reconstruct treeline position. Together, the records provide a basis for re-assessing the character, timing and impacts of regional climate fluctuations in this sensitive northern region, highlighting the benefits of integrating long-term palaeoecological records with a knowledge of modern vegetation dynamics.

Diving into Arcellinida Diversity in Oromocto Lake (Canada): A Metabarcoding Approach to Explore Undocumented Microeukaryotes

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ISTA Session 2, 2:30 PM

Arcellinida testate amoebae are efficient bioindicators of environmental conditions in freshwater ecosystems. Despite existing morphological surveys in New Brunswick freshwater systems, the molecular diversity of Arcellinida remains unexplored. In this study, we addressed this gap by investigating the spatial variability of Arcellinida communities and their associations with specific aquatic plants in sediments from several New Brunswick lakes, including Oromocto and Frog Lake. Sediment samples were collected via scuba diving, with four to sixteen replicates per site to capture maximum variability. Environmental DNA was extracted from each sample, and Arcellinida-specific primers targeting the cytochrome c oxidase I (COI) gene were used for high-throughput sequencing on the Illumina MiSeq platform. Plant associations were recorded in the field and examined in relation to Arcellinida community composition. Preliminary results revealed high haplotype diversity within Arcellinida, with a substantial proportion of sequences corresponding to unclassified or potentially novel environmental lineages. Among the identified taxa, several operational taxonomic units (OTUs) showed high similarity to *Centropyxis blatta*, a species recently described from Spanish ponds. These OTUs were among the most abundant and widely distributed across samples. These findings uncover a previously undocumented microbial eukaryote diversity in oligotrophic lake sediments and suggest a possible link between specific aquatic plants and Arcellinida assemblages. Our study underscores the need to expand reference databases to improve taxonomic resolution in metabarcoding studies and highlights the potential of COI-based approaches for fine-scale monitoring of benthic microbial biodiversity.

Changes in Testate Amoeba Communities and Morpho-Functional Traits Over the Last Century on the North Slope of Alaska

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Poster

High-latitude warming has driven significant ecological changes in Arctic ecosystems, including shrubification and peatland expansion, yet microbial responses remain poorly understood. In the Brooks Range foothills of northern Alaska, Sphagnum peat patches, measuring a few meters in diameter and 20-50 cm deep, have become abundant within the matrix of tussock tundra over the past century. Paleoecological records indicate that these patches began forming in the mid-20th century, their expansion accelerated after the 1970s, and increasingly oligotrophic conditions established by the 1990s and 2000s. We examined how testate amoeba community composition and morpho-functional traits have responded to these changes by quantifying community composition, the relative use of phototrophy by mixotrophic testate amoebae, and test size in both heterotrophic and mixotrophic taxa in peat core stratigraphic records from across the North Slope. The difference in $\delta^{13}C$ measurements on *Archerella flavum* and *Sphagnum* from the same depths was used to estimate relative changes in the use of phototrophy through time. Results indicated increasing percentages of mixotrophic taxa in recent decades at most study sites, particularly *Archerella flavum* and *Hyalosphenia papilio*. $\delta^{13}C$ measurements revealed an increase in their use of phototrophy shortly before this community transition. Test size in both mixotrophic and heterotrophic species decreased at the time of the community transition, likely due to increasingly oligotrophic conditions. Comparison with instrumental records revealed that the relative use of phototrophy corresponded to the length of the snow-free season, as measured near Toolik Lake since 2007. Our findings highlight the influence of warming-related ecological change on both the structure and function of microbial communities, with potential implications on carbon cycling processes.

Ecoregional drivers of diversity, functional traits and assembly processes of testate amoebae from mineral vs. organic soils in Northern Eurasia

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ISTA Session 5, 10:50 AM

Soil microbial communities are fundamental to terrestrial ecosystem processes. Anticipated shifts in climate and land management practices are projected to substantially modify these communities, with uncertain repercussions for ecological functions. Although variations in microbial functional characteristics and taxonomic diversity across soil types and climatic conditions are documented, systematic investigations of community assembly processes across contrasting environments remain scarce. To address this knowledge gap, we compared the community composition, diversity, functional traits and assembly mechanisms of testate amoebae from organic to mineral soils in six biogeographic regions spanning Central-North Eurasia. We observed clear contrasts in all diversity metrics: Organic soils in arid ecoregions exhibited higher taxonomic and functional richness as compared to mineral soils, whereas the trend was reversed in humid regions, suggesting that the higher moisture content was favourable to microbial diversity in dry areas but detrimental in moister regions. The patterns of traits varied in contrasted way depending on regional climate: in the dry forest-steppe zones, organic soils hosted amoebae with elongated shells and reduced apertures, while moist taiga and tundra environments were dominated by compact forms with larger apertures. Community assembly mechanisms diverged between soil types: mineral soils were governed primarily by environmental filtering, whereas organic soils showed stronger signatures of biotic interactions. This integrative investigation elucidates how abiotic constraints and biological processes collectively structure microbial communities, with the soil moisture regime emerging as a pivotal factor.

Development of a transfer function for paleohydrological reconstructions in subarctic and boreal permafrost mires in the western part of the Central Siberian Plateau

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ISTA Session 4, 11:00 AM

Permafrost mires are important carbon stocks that are very sensitive to variation in local hydrological regime, which in turn, might be strongly controlled by climate. We use testate amoebae to investigate their indicator value to water table depth (WTD) and substrate water content (SWC) and to develop transfer functions for quantitative reconstructions of these environmental characteristics in the permafrost mires on the Central Siberian Plateau. Surface samples for the training set were collected in regions located in the spatial range of 60.3 – 69.6° N and 86.7 – 102.3 E. In total 26 mire ecosystems were sampled and 330 samples were collected. The WTDs varied in the range from -3 to 87 cm with the mean value of 15.5 ±13.8 cm, whereas SWC ranged from 55 to 99% with the mean value of 92.7 ±5.59%. The permafrost sites were characterized by a narrower range (86–94%) and lower mean values of SWC (86 ± 4.34% SD) that might indicate water shortage for testate amoebae in these locations. The results indicate that testate amoebae form diverse assemblages with the species structure strongly controlled by WTD and SWC. For each environmental characteristics transfer functions were developed based on Modern Analogue Technique which were assessed using leave-one-out and bootstrap cross-validation. We find that both transfer functions have good predictive power (for WTD: RMSEP = 6.8 – 7.6 cm, R2 = 0.54, for SWC: RMSEP = 2.0-2.3 %, R2 = 0.74-0.76). The ecological preferences of the majority of testate amoebae were similar to those reported by the studies in lower-latitudes, although some hydrophilic taxa were observed in the drier end of the surface wetness gradient. These data represent an important source for improvement of quantitative reconstructions based on subfossil testate amoebae in permafrost mires. The work was supported by the Russian Science Foundation (grant No 24-14-00065).

Developing a deep learning model to identify peatland-specific testate amoebae

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ISTA Session 2, 3:30 PM

Testate Amoebae (TA) are commonly used as paleoenvironmental bioindicators in lakes and peatlands. However, their morphological identification remains challenging and time-consuming, often relying heavily on observer expertise and subjectivity. A tool is needed to optimize the morphological identification of testate amoeba and reduce potential inter-study bias. In an initial project, we trained a deep learning model to detect two species frequently found in commercial peat products, used for gardening and horticulture—*Archerella flavum* and *Amphitrema wrightianum*. These species were targeted to create a decision-support tool aimed at assessing peat presence in soil substrates, based on the occurrence of TA species characteristic of peatlands. We trained YOLOv8 object detection models using images of TA extracted from commercial peat samples. The system outputs cropped images of potential TA individuals, which are then reviewed by an expert for confirmation, significantly reducing the time required for community analysis. The model successfully detected 96% of *Archerella* individuals and 79% of *Amphitrema* individuals present in the samples. To our knowledge, this is the first automated system developed for the detection of testate amoebae using deep learning. Building on these results, we are currently expanding the system to recognize a broader set of ten TA species commonly found in peatlands and frequently used as ecological indicators. The new generation of models, trained with YOLOv11, is demonstrating high performance in preliminary tests. These results pave the way for broader applications, including the development of new transfer functions and more efficient paleoecological reconstructions.

Unlocking the past: a new transfer function model for Norwegian peatlands using testate amoebae

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Poster

Peatlands, although covering only 3% of Earth's land surface, are vital ecosystems that store approximately 25% of global soil carbon (600 GtC). They play a critical role in regulating local and global carbon and water cycles. These ecosystems host diverse organisms, including testate amoebae—single-celled organisms with protective shells—that serve as sensitive bioindicators. The composition of testate amoebae communities responds strongly to environmental changes, such as fluctuations in groundwater levels and pH, making them invaluable tools for reconstructing past hydrological conditions in peatlands. Despite their ecological and paleoecological significance, knowledge of testate amoebae communities is limited in many regions, including Norway. This gap hampers efforts to reconstruct historical changes in Norwegian peatlands and assess their responses to human activities and climate change. To address this issue, we developed a new transfer function model for Norwegian peatlands based on testate amoebae. Surface samples were collected from three sites spanning a north-south transect: Midtfjellmosen and Øvre Forra nature reserves in southern Norway, and Suossjavri, a palsa peatland above the Arctic Circle. These samples were used to build a dataset, further validated with peat cores extracted from Midtfjellmosen and Øvre Forra. In addition to testate amoebae analysis, palynological analysis was conducted on these cores, providing complementary insights into vegetation changes and regional environmental conditions over time. Initial findings reveal hydrological shifts during the development of these peatlands, providing insights into the interplay of natural processes, human activity, and global warming. Beyond its local importance, this study contributes a valuable open-access dataset for paleoecological research across Fennoscandia. By addressing a critical knowledge gap, the dataset and transfer function enable reconstructions of hydrological histories across diverse peatland types in the region. This knowledge is essential for informing sustainable peatland conservation and management strategies, particularly in the face of climate change and increasing anthropogenic pressures.

From Fen to Fiction: How Drainage and Peat Extraction Redefined Bagno Chlebowo

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ISTA Session 1, 10:40 AM

Peatlands are among the most threatened ecosystems globally, with their degradation accelerating over the past two centuries due to increasing human activity. These ecosystems have often been drained to support agriculture, forestry, and peat extraction. Bagno Chlebowo is one of the most severely impacted peatlands in western Poland. Although a small portion has been protected as a raised bog since 1959, historical and ongoing drainage and peat mining—initiated in the 19th century—have continued to undermine the peatland ecological state. This study aims to reconstruct the long-term effects of human activity on Bagno Chlebowo over the past 600 years. Using palaeoecological methods (testate amoebae and plant macrofossils), we examined historical changes in water table levels, trophic status (pH), and local vegetation. Additionally, historical maps were analyzed to track changes in land use and land cover over time. Our findings show that drainage and peat extraction have significantly altered the site's hydrology and chemistry, particularly by increasing acidity. This shift has promoted the spread of *Sphagnum* species, altering the peatland's vegetation composition. These transformations complicate the current classification of the site as a raised bog by various administrative units responsible for the protection of the site. Instead, palaeoecological evidence suggests that Bagno Chlebowo functioned predominantly as a fen throughout much of its history. This research highlights the value of long-term ecological reconstructions for peatland conservation. Understanding historical baselines is essential not only for accurately assessing ecosystem condition but also for developing effective restoration and management strategies adapted to sites with a complex history. The study was supported by National Science Centre, Poland (grants 2020/39/D/ST10/00641, 2023/07/X/ST10/00536) and Research University-Excellence Initiative AMU (grant 034/34/UAM/0027 and 172/06/POB1/0007).

Phenotypic and genetic diversification of Asian endemic Netzelia tuberspinifera metapopulation

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ISTA Session 2, 2:50 PM

Netzelia tuberspinifera (basionym *Difflugia tuberspinifera*) is an endemic testate amoeba species of East Asia. We found that its distribution was significantly related to latitude, elevation and temperature based on the datasets of 88 lakes and reservoirs in China, and this microorganism was mainly distributed in subtropical and tropical lakes and reservoirs. We investigated its spatial-temporal distribution based on a high-frequency time series sampling in Tingxi Reservoir (Xiamen, China), combined with spatial samples from 28 reservoirs in southern China. The results showed that water temperature and foods (phytoplankton) exhibited significant effects on seasonal patterns of population density, with a higher correlation coefficient for water temperature than for food. On the spatial scale, the population density was mainly limited by geographical factors and decreased with an increase in latitude and longitude, respectively. Meanwhile, foods (phytoplankton), electrical conductivity and nitrate nitrogen also had significant effects on the population density. Interestingly, the variation in aperture diameter of *N. tuberspinifera* was the major contributing factor in explaining the temporal-spatial differences of population morphological characteristics. Furthermore, we found that foods (phytoplankton) play a key role in the difference of aperture diameter between different seasons in Tingxi Reservoir. The difference in aperture diameter between the Yangtze River and other watersheds was mainly affected by foods (phytoplankton), total carbon and water turbidity. Importantly, based on COI gene of more than 1000 *N. tuberspinifera* cells (individuals), the genetic diversity exhibited a significant negative relationship with latitude. Geographical distribution patterns of genetic diversity in *N. tuberspinifera* were more influenced by climatic condition (the lowest temperature) than by spatial and water environment factors. Meanwhile, the connectivity of gene flow results suggest that the Pearl River and Nanliujiang River watershed may serve as the genetic exchange hub for populations of *N. tuberspinifera* in China.

Testate amoeba metacommunity patterns: a case study from Yakushima Island, Japan

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ISTA Session 5, 3:00 PM

Understanding how communities are structured across space remains a central question in community ecology. Traditionally, metacommunity studies have focused on quantifying the relative importance of environmental and spatial factors, guided by the main difference among four metacommunity paradigms, focused on the mechanisms of metacommunity assembly. As a complementary approach, the Elements of Metacommunity Structure (EMS) framework offers a pattern-based method for diagnosing the most characteristic structure of a metacommunity. It assesses three aspects of metacommunity structure: coherence, species turnover, and boundary clumping of species range. Despite its conceptual value, the application of EMS remains limited, especially on the ecologically important testate amoebae. Using the EMS framework, the present study aims to identify the idealized pattern that best describes soil testate amoeba metacommunities sampled along an elevation gradient on Yakushima Island, Japan. The results, based on a fixed-fixed null model, revealed positive coherence, high species turnover, and clumped species boundaries. Positive coherence implies a uniform response of all species to a leading environmental gradient (in our case, elevation). Species turnover, opposed to nestedness, rejects a hypothetical pattern of subsequent impoverishment of local species richness along the elevation gradient. Clumped species ranges implies the existence of sharp boundaries between adjacent communities. Together, these results pointed to a Clementsian structure, in which species respond to environmental gradients as distinct communities. This pattern suggests that environmental filtering was a strong force shaping testate amoeba metacommunity on Yakushima Island. Future analyses could incorporate species co-occurrence and functional trait data analyses to evaluate whether clumped species groups are organized by species interactions and share similar traits. The study was funded by Shenzhen Municipal Government, Shenzhen First Class Discipline Construction Fund, and the Shenzhen MSU-BIT University, P.R. of China (for QZ and AAI). The research was supported by research funds of the Asahi Glass Foundation for SS.