

SHALLOW LAKES 2021

BOOK OF ABSTRACTS

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10th International Shallow Lakes Conference

Towards a landscape ecology of shallow lakes

Shallow lakes are important freshwater ecosystems worldwide, contributing in important ways to biodiversity and ecosystem services locally as well as at the landscape scale. In addition to the traditional topics addressed on previous shallow lakes conferences, we take the opportunity of this 10th meeting to devote special attention to landscape ecology and its importance to understand the structure and function of shallow lakes. Shallow lakes are embedded in heterogeneous landscapes, and their density and surface area are important determinants of landscape connectivity that influence metapopulation, metacommunity and metaecosystem dynamics. Landscape ecology focuses on the relationships between spatial pattern and ecological processes, and considers spatial scales that extend well beyond the individual system traditionally studied by ecologists. From a landscape perspective, conceptual frameworks have been proposed to emphasize the importance of ecosystem boundaries, including their permeability and resistance to flows of energy and materials and to dispersal of organisms, and the challenges of managing systems to maintain biodiversity and ecosystem services at the landscape scale. This fosters a view of land-water interactions that encompasses the integrated sets of lakes, streams and wetlands that occur in a landscape. Understanding the implications of the dynamic landscape mosaic for ecosystem processes remains a frontier in both ecosystem and landscape ecology, and is actualized also in the ongoing global change perspective. Despite the great advances in shallow lake ecology over the last decades, we do not yet sufficiently grasp all consequences of regional processes for the structure and function of shallow lakes. We think there is great opportunity to integrate ecological theories that address both the role of local and spatial processes for population, community and ecosystems dynamics in such lakes, and to consider the implications for their management. Thus, we invite shallow lake ecologists to join the 10th International Shallow Lakes Conference, to present their recent work on shallow lake ecology and discuss current challenges and opportunities toward a landscape ecology of shallow lakes.

In this book, you will find all the abstracts submitted to the conference and some video links to the work whose authors allowed us to include them in this book. Due to the covid-19 pandemic, the conference that would occur in June 2020 in Natal, Brazil, became a virtual (online) conference to guarantee the safety of all participants and democratize access to the conference. We hope you enjoy this first virtual shallow lakes conference from 1st to 5th March 2021 and thank you for your interest and participation in the conference.

José Luiz Attayde
President of the Organizing Committee

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PLENARY LECTURES

VIEWING SHALLOW LAKES FROM A LANDSCAPE PERSPECTIVE



Kendra Spence Cheruvelil
(Data-intensive Landscape Limnology Laboratory, Department of Fisheries and Wildlife, Michigan State University, USA)

The long history of shallow lake research has contributed important theory to the discipline of ecology as well as to lake management. This research has led to important understanding of fine-scale mechanisms affecting ecosystem stable states, primary productivity, and foodweb interactions. However, much of this research has been conducted on a relatively small number of lakes relative to the total population of lakes at the continental or global scale. Recent increases in data availability and computational advances now allow limnologists to take a broader perspective and study populations of shallow lakes across large scales of space and time. Such studies provide limnologists the opportunity to identify emergent properties, identify areas of rapid change and novel areas for conservation, and to forecast and extrapolate understanding from finer-scaled mechanistic studies. This lecture will share what the Continental Limnology research group has learned by studying shallow lakes at broad scales, including case studies based on LAGOS - a lake and landscape database in the United States, and will share lessons learned about the challenges and opportunities faced when conducting data-intensive research on shallow lakes.

QUANTIFYING AND INTERPRETING THE 'INTERNAL STRUCTURE' OF DIVERSE LAKE METACOMMUNITIES IN COMPLEX LANDSCAPES



Mathew A. Leibold
(Department of Biology, University of Florida, USA)

The metacommunity concept is a way to think about the feedback between regional and local ecological dynamics and has provided useful insights about landscape scale variation in community and ecosystem structure. Describing and quantifying this variation however remains a challenge and linking this structure to processes is even more elusive. Here I argue that progress can be made by looking at the 'internal structure' of metacommunities that dissects the contributions of individual species and of individual sites (e.g. lakes) to this landscape-level variation. I will outline methods that can accomplish this dissection of variation and apply it to lakes in the continental U.S.A to illustrate the insights that can come from this. Although this can now be done using existing methods, the interpretation of the results can be more complex than it seems. Resolving this issue will require more work but I will present results of ongoing research that highlights the difficulties and identifies a partial solution involving the statistical properties of interactions rather than descriptive ones.

WHAT CONTROLS WHICH SPECIES WHERE? CONCEPTUAL AND ANALYTICAL FRAMEWORKS FOR STUDYING BIODIVERSITY PATTERNS ACROSS LAKE LANDSCAPES



Pedro Peres-Neto
(Department of Biology of Concordia University, Canada)

Determining the relative importance of the processes underlying complex spatial patterns of biodiversity has been one of the most popular, vibrant and challenging areas of research in ecology. Although the processes are many, and they interact with each other, there are four essential elements to consider: [1] species differences associated to how they perform across different environments and other species; [2] local processes that regulate the success of species following either their own arrival or the arrival of other species (e.g., niche differentiation, local environment, microhabitat heterogeneity); [3] regional processes that regulate the arrival of species into the various local communities (e.g., environmental heterogeneity, landscape connectivity, dispersal limitation); and [4] the interactions of these three elements vary across different spatial (and temporal) scales .One key challenge today is that current models and analyses attempting to explain and predict variation in species distributions across landscapes (beta-diversity) are generally weak. The inadequacy of current models and analyses are likely the result of either: [a] we are not identifying the correct trait, environmental and dispersal predictors; or [b] current model specification are just too simple to allow representing how different processes and species distributions are connected; or [c] processes are just too complex and interactive, thus generating species distributions across local communities that are just too idiosyncratic to serve useful as analytical targets for community ecology. In this talk, I will provide a critical discussion on the challenges and potential solutions to these three issues aiming at increasing our understanding of the complex patterns of biodiversity underlying lake landscapes.

METACOMMUNITY NETWORK STRUCTURE ON BIODIVERSITY PATTERNS



Ana Inés Borthagaray
(Universidad de la República/Centro Universitario Regional Este – UDeLaR, Uruguay)

Increasingly theoretical and empirical evidence have demonstrated that the metacommunity network structure is a main determinant of biodiversity patterns. Furthermore, when is considered, metacommunity effects are typically large and comparable to classical local determinants of diversity, such as productivity, ecosystem size and heterogeneity. Herein, I would like to discuss three issues on the interplay between metacommunity structure and biodiversity patterns: 1) quantification of metacommunity structure and local communities isolation, 2) the observed role of isolation on community structure and 3) the potential of lottery models for the theoretical and empirical evaluation of metacommunity mechanisms. I hope this talk contribute to advance on our understanding of shallow lakes ecology.

ECO-EVOLUTIONARY DYNAMICS IN LANDSCAPES



Luc De Meester
(University of Leuven, Belgium)

Rapid evolutionary change is receiving increasing attention because it may feedback on ecological dynamics. If evolutionary tracking of environmental change is sufficiently effective, this may strongly influence how communities respond to environmental gradients and change, and thus alter the distribution of species, traits and genes in landscapes. Drawing on our own data using the water flea Daphnia magna and ponds in heterogeneous landscapes as models I will first briefly provide examples of rapid evolution in response to global change and then develop its feedback on the structure of communities and ecosystems. I will then focus on some limitations of our current perspective on eco-evolutionary dynamics and will introduce ideas and approaches to further develop the field of eco-evolutionary dynamics so as to increase its power to inform the contribution of evolutionary trait change to ecological dynamics in nature. I will emphasize and illustrate multi-species approaches and the quantification of eco-evolutionary dynamics in landscapes. Ponds and shallow lakes offer an ideal model system for the further development of the evolving metacommunity framework, which – as I hope to illustrate – offers important added insights into how communities and metacommunities respond to global change.

CONSERVATION OF AQUATIC BIODIVERSITY IN THE LANDSCAPE: UNDERSTANDING THE ROLE OF CONNECTIVITY



Zsófia Horváth
(Balaton Limnological Institute, Centre for Ecological Research, Hungary)

Habitat loss and fragmentation are among the most significant drivers of biodiversity loss in the Athropocene. At the same time, there is still not only substantial disagreement regarding the actual processes leading to the loss of species, but lakes and ponds in general receive little attention. It is very easy to overlook the role of connectivity in the case of these insular type of ecosystems compared to more continuous terrestrial or even riverine habitats. In my talk, I will show why it is crucial to understand the role of dispersal agents and the drivers of beta diversity in a pond landscape, together with an example from a longitudinal study on pond loss leading to connectivity loss among the remaining habitats, which eventually translates into a loss in both alpha and gamma diversity.

PROPAGULE PRESSURE AND ENVIRONMENTAL FILTERS RELATED TO NON-NATIVE SPECIES SUCCESS IN HIGHLY CONNECTED HABITATS OF RIVER-FLOODPLAIN ECOSYSTEMS



Sidinei Magela Thomaz
(Center for Research in Limnology, Ichthyology and Aquaculture, Maringá State University,Brazil))

In this review I conducted a literature survey to discuss some patterns related to the performance of non-native species (NNSs) in river floodplain ecosystems. First, floods connect the floodplain habitats and spread NNSs propagules, causing ‘propagule pulses’ in these ecosystems. A single annual propagule pulse is a unique feature of floodplains with seasonal predictable flooding. After NNSs establishment, floodplains may function as steppingstones for future invasions, because the propagule pulses generated inside the floodplain enhances invasions in nearby landscapes. Second, the flood pulse changes environmental filters, with consequences for invasion success. Flooding decreases the success of some NNSs, but flooding also represents a disturbance which enhances the success of other NNSs by reducing the biotic resistance and changing the resources availability. The drought enhances the invasion success of NNSs that colonize the aquatic-terrestrial transition zone and of some aquatic NNSs too. The changes promoted by the flood pulse sometimes affect differently native and NNSs, improving the chances of coexistence. Third, impacts caused by river regulation and global changes alter the flood pulse, what in turn affect the invasion success through changes in environmental filters and in habitat connectivity. There is a great degree of idiosyncrasy in these patterns, but they pose a broad perspective that help managing NNSs in floodplains.

IMPLICATIONS OF IMBALANCED NUTRIENT SUPPLY RATES: ECOLOGICAL STOICHIOMETRY IN A SPATIAL CONTEXT



Steven Declerck
(Netherlands Institute of Ecology, NIOO – KNAW, Netherlands)

Due to anthropogenic activities, absolute and relative supply rates of key elements to lakes, such as carbon (C), nitrogen (N), phosphorus (P) and silicon (Si) are being altered dramatically in many places of the world. Along with modifications in water column light climate, such altered supply rates result in important shifts in the elemental composition of autotrophs and the degree of stoichiometric mismatch with consumers. Such changes often have important implications not only for the population performance of consumers, but also for the structure and dynamics of the entire food web, including trophic energy transfer efficiency, the strength of top-down control and a variety of other ecosystem functions and services. Lakes should not be considered as isolated entities but form part of a larger meta-ecosystem, where flows of matter and energy take place simultaneously with movements of organisms. Lakes are strongly integrated with the landscape in their catchment. Lakes receive nutrients and energy from a variety of sources and may act as source themselves for other lakes. Concurrently, lakes form interconnected patches within metacommunities and exchange with each other a variety of aquatic organisms. While representing a flow of material and energy themselves, these organisms also impact community dynamics and ecosystem functioning. The balance of energy and matter in lakes has received considerable attention and is often well understood. In addition, numerous metacommunity studies have focused on lakes as study system. The potential interactions between flows of matter and organisms remain, nevertheless, relatively unexplored. In this talk, I will introduce lakes as part of larger meta-ecosystems and review the literature that has focused on the potential interactions between flows of matter and energy between lakes at one hand and the exchange of organisms at the other hand. I will discuss the potential impact of such interactions on nutrient supply rates and stoichiometric mismatch between primary producers and consumers. Finally, I will share recent insights regarding ecological and evolutionary consequences of such mismatch from recent research in my group.

RURAL AND URBAN WATERS AS CARBON HUBS



Sarian Kosten
(Aquatic Ecology & Environmental Biology Department, Institute for Water and Wetland Research, Radboud University, Netherlands)

Although lakes and ponds only cover a small area of the Earth's land area they play a disproportionally large role in the global carbon cycle due to the large amount of C they process, store, and transport. They are true carbon 'hubs' in the sense that they receive large amounts of carbon originating from their drainage basin, take up CO2 through primary production, bury carbon in their sediment, pass on carbon downstream and also emit significant amounts of CO2 and CH4 to the atmosphere. Although often not incorporated in landscape-wide greenhouse gas assessments the contribution of aquatic greenhouse gas emissions can be substantial. Recent work has highlighted that global change, particularly temperature, drought, eutrophication and salinization as well as changes in plant and fish communities, can have a strong impact on aquatic greenhouse gas emission. In my talk, I will give various examples and focus on the different ecological processes involved. Within the scientific community working on this topic we are working to obtain a mechanistic understanding of greenhouse gas production, consumption and transport processes to better quantify aquatic greenhouse gas emissions for individual systems, for aquatic systems on a landscape or even the global level. For human-made and heavily managed aquatic systems - including rural and urban waters - we ultimately aim to develop climate-smart water management tools that will not only contribute to improve water quality but will also decrease greenhouse gas emissions. Although this remains a challenge, I will present some first steps in this direction.


SESSIONS

SMALL LAKES AND PONDS AS MODEL SYSTEMS FOR THE ANALYSIS OF SPATIAL PROCESSES

SESSION 01

Robert Ptacnik
(Wasser Cluster Lunz – Biologische Station GmbH, Austria)
Zsófia Horváth
(Balaton Limnological Institute, Centre for Ecological Research, Hungary)

Spatial processes have traditionally been addresses separately from local dynamics of communities. However, local community dynamics are directly linked to the interaction of the local species pool with potential invaders from the region. The interplay between local and regional dynamics are particularly relevant for understanding and forecasting the ability of communities in terms of tracking environmental changes in times of global change. This session invites studies address the interplay of local and regional dynamics in small lakes and ponds. Time series analysis at the regional scale are particularly relevant for understanding the coupling of local with regional species pools. We invite presentations on observational studies, experiments (micro- or mesocosms) and modeling studies in order to stimulate exciting discussions.

METACOMMUNITY RESILIENCE AGAINST SIMULATED GRADIENTS OF WILDFIRE: DISTURBANCE INTENSITY AND SPECIES DISPERSAL ABILITY DETERMINE LANDSCAPE RECOVER CAPACITY



LINK TO THE STUDY VIDEO

David Cunillera-Montcusí (WasserCluster Lunz & GRECO, Institute of Aquatic Ecology, University of Girona, Girona, Spain); **Ana Inés Borthagaray** (Centro Universitario Regional Este (CURE). Univ. de la República, Uruguay); **Dani Boix** (GRECO, Institute of Aquatic Ecology, University of Girona, Girona, Spain); **Stéphanie Gascón** (GRECO, Institute of Aquatic Ecology, University of Girona, Girona, Spain); **Jordi Sala** (GRECO, Institute of Aquatic Ecology, University of Girona, Girona, Spain); **Irene Tornero** (GRECO, Institute of Aquatic Ecology, University of Girona, Girona, Spain); **Xavier D. Quintana** (GRECO, Institute of Aquatic Ecology, University of Girona, Girona, Spain); **Matías Arim** (Centro Universitario Regional Este (CURE). Univ. de la República, Uruguay)

Disturbances are the main drivers of biodiversity dynamics and ecosystem functioning at regional scales. Wildfires are natural disturbances, but their frequency and intensity are expected to increase. Biodiversity resilience to such increase in disturbance regimes and the metacommunity role in this response are not yet evident. Wildfires generate a mosaic of disturbed and undisturbed patches, changing the regional network structure. In 2012, a wildfire burned a cluster of ponds in NE Iberian Peninsula. Despite the wildfire impacts, the system was strongly resilient in recovering local biodiversity patterns after one year. Based on these findings, we hypothesized that metacommunity network structure was playing a main role in biodiversity resilience, being determined by wildfire landscape alteration and species dispersal. To better comprehend system resilience and its response to future scenarios, we created a lottery model that considered landscape structure and species dispersal ability evaluating metacommunity recovery across gradients of wildfire size and intensity. We analysed system resilience determinants and limits to increased wildfire regimes. We reported a highly resilient system, but our model identified that resilience gradually declined with increased wildfire size and collapsed when fire intensity affected more than half of the landscape. At this point, the network becomes fragmented, breaking the recolonization dynamics for some dispersal groups and compromising recolonization. So, although high system resilience was previously reported, the theoretical analysis indicated that biodiversity resilience could sharply collapse with an increase in disturbance regimes. These findings highlight not only the importance of using theoretical approaches rooted in empirical data to comprehend metacommunity dynamics it highlights the imperious need to preserve and build connected and heterogenous landscapes to face future catastrophic scenarios.

Lottery model; Landscape perception; Dispersal ability; Pondscape; Disturbance; Climate change

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VARIATION PARTITIONING OF LOCAL AND GEOGRAPHIC FACTORS IN STRUCTURING BACTERIOPLANKTON METACOMMUNITY USING HIGH THROUGHPUT SEQUENCING



Erick Mateus-Barros (Universidade Federal de São Carlos (UFSCar), Departamento de Hidrobiologia, Laboratory of Microbial Processes and Biodiversity, São Carlos, SP 13565-905, Brazil); **Adriano Caliman** (Universidade Federal do Rio Grande do Norte, Departamento de Ecologia, Natal, RN 59078-900, Brazil); **Hugo Sarmento** (Universidade Federal de São Carlos (UFSCar), Departamento de Hidrobiologia, Laboratory of Microbial Processes and Biodiversity, São Carlos, SP 13565-905, Brazil)

LINK TO THE STUDY VIDEO

Determining the relative weight of space and environmental selection in structuring species abundance and community composition is a central question in metacommunity ecology, especially for microorganisms that have a high dispersion capacity, challenging the concept of dispersal limitation. We collected water samples from 60 shallow lakes distributed over a wide landscape (>3000 km perimeter) to obtain data on bacterioplankton biodiversity using 16S rRNA Illumina MiSeq amplicon sequencing, and determined the variation partitioning to address the influence of environment and geography on amplicon sequence variants (ASVs). We tested three hypotheses on this metacommunity: (1) dissimilarity between-sites should be high and reflect a large influence of spatial turnover; (2) both environment and geography affect dissimilarity, firstly by pure environment, followed by spatially structured environmental factors, and finally by pure spatial factors; finally (3) these processes should be better observed considering ASV abundance, rather than presence/absence. Variation partitioning showed that geography explained better the dissimilarity observed, followed by the environment spatially structured (geography and environment interaction), and to a less extend by the environmental fraction. The partitioning of environmental factors showed that pH alone explained one third of variation. Finally, the partitioning of geographical factors showed that the region (weigh geographical isolation by natural barriers) explained the major part of observed dissimilarity, after, the neighborhood (weigh gradual isolation increment by increasing distances) and space (strait distances). Moreover, we found higher dissimilarity using relative abundance rather than ASV presence/absence. We demonstrated that geography may overcome the environment selection determining shallow lake bacterioplankton metacommunities, as far as spatial scale is sufficiently large.

betadiversity partition, environmental filtering, spatial dynamics

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METACOMMUNITY DIVERSITY AND BODY SIZE: BEYOND THE SCALING IN DISPERSAL

SESSION 01

Esteban Ortiz (Centro Universitario Regional Este - Universidad de la República); **Ana Borthagaray** (Centro Universitario Regional Este - Universidad de la República); **Matías Arim** (Centro Universitario Regional Este - Universidad de la República)

LINK TO THE STUDY VIDEO

Metacommunity theory highlights the importance that dispersal among communities, diversity of the regional pool and community size have on determining diversity patterns. Notably, these three elements are closely associated with body size. However, the focus of most studies has been on species dispersal ability, with seldom attention put on the other scaling relationships. If the scaling in dispersal ability with mass is considered in isolation, larger taxa, which disperse more, should present more diversity at a local scale than smaller taxa. However, empirical patterns do not fit this trend suggesting that the scaling in local density and regional pool size with mass must play a significant role in shaping diversity. We hypothesize that the combined effect of these three elements determines a reduction in taxa alpha, beta, gamma diversity along a gradient in taxa body size. These relationships are determined by the negative scaling in local density and species pool size and, the positive scaling in dispersal ability with mass. To evaluate our hypotheses, first we used a coalescent-based metacommunity model to predict the trends of diversity with body size. Then, we empirically evaluated how taxa diversity scales with body size in an animal metacommunity of temporary ponds. As expected, both theoretical and empirical results showed a negative effect of taxa body size on alpha, beta and gamma diversity. We showed that: (i) the relationships between diversity and mass are mainly driven by the combined effect of the scaling in local density and regional pool size with mass; and (ii) the positive scaling in dispersal with body size attenuates this trend by enabling the coexistence of larger species. Considering the scaling of dispersal with body size is necessary but not sufficient in order to explain diversity patterns, evidencing that a broader view of how body size determines metacommunity diversity in needed.

Metacommunity theory, Body size, Diversity patterns, Dispersal ability, Regional pool, Local density, Temporary ponds

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ZOOPLANKTON FUNCTIONAL COMPLEMENTARITY BETWEEN TEMPORARY AND PERMANENT ENVIRONMENTS

Rayanne Barros Setubal (Universidade Federal do Rio de Janeiro); **Reinaldo Luiz Bozelli** (Universidade Federal do Rio de Janeiro)

SESSION 01

LINK TO THE STUDY VIDEO

Among continental aquatic environments, small wetlands are the most commonly neglected. Given the threats imposed to aquatic environments, such as pollution and destruction of habitats, the complementarity between different environments is an important feature for biodiversity maintenance. An analysis of the community functional complementarity in light of their potential different responses to environmental variability allows a better understanding of ecosystem dynamics. This study aims to evaluate the functional complementarity of the zooplankton community between temporary ponds and permanent lagoons. We hypothesize that temporary environments will be functionally more diverse than permanent environments and will have different functional composition. Five temporary ponds and five permanent lagoons were compared regarding their limnological characteristics, species richness, functional diversity indices and functional trait composition. No differences between ponds and lagoons were found regarding mean species richness and functional diversity. However, a larger number of species was found in the set of temporary environments i.e., although the mean richness was the same, the species' identity varied from one pond to another. Ponds showed greater variability in functional trait composition, resulting in significant differences in functional dispersion. Ponds also presented a greater range of limnological characteristics. Temporary and permanent environments present high limnological and functional complementarity, which make them important for maintaining biodiversity on a regional scale. Temporary environments seem to be refugees for species that do not settle in more stable environments because these species are more likely to colonize environments that periodically restart their successional trajectory. Therefore, actions that seek to preserve complementary environments are essential and urgent, especially those related to small and temporary environments.

Functional dispersion, hydroperiod, ponds, coastal lagoons

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INTERPRETING PRIORITY EFFECTS IN ARIDLAND SHALLOW WATERS



Patrick Brown (University of Texas at El Paso); **Robert L. Wallace** (Ripon College); **Elizabeth J. Walsh** (University of Texas at El Paso)

The importance of founder and other priority effects relative to other community structuring factors, such as the local edaphic conditions and biogeography, remains uncertain for many systems including shallow waters. Connections through dispersal among temporary, shallow waters in aridlands (rock pools, playas) are only intermittent. Thus, they are expected to be subject to strong priority effects. To investigate this, we compared species composition at 60 rock pools and 16 playa sites in the Chihuahuan Desert using three approaches. First we explored how geographic distance at several spatial scales was related to community composition using Mantel tests. Second, we tested for a correlation of species richness with habitat area. Finally, we looked at three important environmental variables (hydroperiod, salinity, chlorophyll a). We found that distance between meta-sites is important at smaller spatial scales, but its importance declines after the number of sampled sites increases at higher scales. Community composition of rock pools was significantly impacted by distance only when pools were assessed individually. However, once we combined pools, this relationship disappeared. In contrast to rock pools, playas maintained the same relationship between diversity and distance over a large range of sampled areas. Thus, for rock pools priority effects seem to play a role in structuring community composition, however this relationship is less clear for playas. Additional analyses on environmental variables and habitat size are underway. Through our studies we hope to elucidate the importance of priority effects in aridland shallow waters and then to continue by expanding it to other systems.

temporary ponds desert species composition

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EFFECT OF NATURAL SUBSTRATE, ENVIRONMENTAL AND SPATIAL FACTORS ON ALPHA AND BETA FUNCTIONAL DIVERSITY OF EPIPHYTIC ALGAE

SESSION 01

Irma Carvalho e Silva (PPGEco, UFRN); **Cihelio Alves Amorim** (PPGB, UFRPE); **Ênio Wocyli Dantas** (UEPB); **Juliana Déo Dias** (UFRN)

LINK TO THE STUDY VIDEO

The epiphytic algae and submerged macrophytes are directly associated, therefore the local interactions between both communities could be increased by competition processes, reflecting changes in the patterns of diversity and functioning of aquatic ecosystems. We analyzed spatial trends in epiphyton alpha (functional richness-FRic, evennes-FEve and divergence-FDiv) and beta functional diversities and the relationships with environmental and submerge macrophytes data in 19 tropical shallow lakes (7 with Chara presence, 7 with Nitella, and 5 with both genera). We tested the hypotheses that substrate type (Chara or Nitella) could provide different microhabitats to epiphytic algae, increased alpha and beta functional diversities, explaining better modifications on patterns of epiphytic diversity than spatial and environmental variables. We used two factors: lakes (with substrate isolated and occurring together) and substrate (separating lakes with Chara, Nitella and both of them). FRic differed significantly between lakes and increased in lakes that both macrophytes co-occur. The components FEve and FDiv demonstrated a tendency similar in all lakes and substrate type and FDiv was influenced by dissolved oxygen, pH and total phosphorus. The functional beta diversity of epiphyton have not showed variations among substrate type. These results demonstrate that morphological differences of substrate were not important to explain the patterns of epiphyton alpha and beta functional; however, the alpha functional diversity were mainly explained by limnological variables. The enhance the epiphytic functional rich in lakes with Chara and Nitella co-occuring in the same stands suggest a complementarity effect, whereas the Characeae and epiphytic algae have same strategies for recourse demand this explained the coexistence of both communities. Thus, the environmental filtering effect was mostly processes to explain the functional structure of epiphyton in tropical shallow lakes.

periphyton functional traits macrophyte shallow lakes.

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THE ROLE OF CONNECTIVITY IN THE STRUCTURE AND FUNCTION OF SHALLOW LAKES



Linda May
(UK Centre for Ecology & Hydrology)
Laurence Carvalho
(UK Centre for Ecology & Hydrology)
Nigel Willby
(University of Stirling, UK)

Connectivity is a quintessential property of aquatic systems because it is the means by which energy, materials and genetic resources move within and between hydrological landscapes ('hydroscapes'). However, connectivity also exposes fresh waters to threats from multiple stressors that act over a range of spatial and temporal scales. To manage our shallow lakes sustainably into the future, we need a better understanding of how changes in connectivity affect their resilience to stressors such as climate change, pollution and invasion by non-native species. Interactions between connectivity, stressors and ecological response determine the structure, function and biodiversity of shallow lakes. In hydrologically connected systems, changes in connectivity occur when new waterways are created, or barriers are added or removed. In hydrologically unconnected systems, they occur as a result of changes in passive (biological vectors) or active (self generated movement) dispersal. Whatever the process, changes in connectivity affect the resilience of shallow lakes to change, for example by altering their links to the source material required to support recolonization and ecosystem recovery. For this session, we invite contributions that can help us address the following key questions in relation to the sustainable management and protection of our shallow lakes: (i) how can connectivity be measured? (ii) how does connectivity affect the transport of organisms, nutrients and energy across hydroscapes? (ii) how are these relationships altered by different stressors? (iii) how does connectivity influence the way that shallow lakes function and respond to environmental change and/or management interventions? (iv) how should we prioritise reductions in stressors and changes in connectivity to restore or protect biodiversity and ecosystem function?

RAINFALL LEADS TO HABITAT HOMOGENIZATION AND FACILITATES PLANKTON DISPERSAL IN TROPICAL SEMIARID LAKES

Jandeson Brasil (Universidade Federal do Rio de Janeiro, Brazil);); **Juliana O. Santos** (Universidade Federal do Rio de Janeiro, Brazil); **Wanessa Sousa** (Universidade Federal do Rio Grande do Norte, Brazil); **Rosemberg F. Meneze** (Universidade Federal da Paraiba, Brazil; **Vera L.M. Huszar** (Universidade Federal do Rio de Janeiro, Brazil); **José Luiz Attayde** (Universidade Federal do Rio Grande do Norte, Brazil)



LINK TO THE STUDY VIDEO

Although some efforts have been made to understand the role of hydrology in structuring aquatic systems, little is known about how rainfall affects the relative roles of local environmental and spatial processes in structuring plankton metacommunities in tropical drylands. We hypothesize that the role played by spatial variables is more important in the dry than in the rainy season, because drought increases lakes isolation in semiarid regions. To test our hypothesis, we compared the variation in plankton structure between seasons attributable to local and spatial predictors by using variation-partitioning techniques. We used data for phytoplankton and zooplankton communities as a whole and separately by their size groups (nanoplankton, microplankton and mesoplankton) from 40 man-made lakes in northeastern Brazil. Our results showed that rainfall homogenized limnological variables and reduced total phytoplankton and nanophytoplankton beta diversity, but no effect of season was observed for microphytoplankton and zooplankton communities. Overall, in the dry season, both environmental and spatial variables were important structuring factors for the total phytoplankton, total zooplankton and microzooplankton communities, concurring with both niche- and neutral-based models. In the rainy season, spatial variables were neither important for shaping the phytoplankton nor the zooplankton metacommunities, confirming our hypothesis. The main ecological implication of our findings is that both niche- and neutral-based processes might play an important role on phytoplankton and zooplankton metacommunities

Water-level fluctuation; Habitat connectivity; Community composition; Body size; Local and regional processes; Drylands; Variation partitioning

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DEMERSAL FISH ASSEMBLAGE IN THE PATOS-MIRIM LACUSTRINE LANDSCAPE USING THE BOTTOM TRAWL

SESSION 02

Marcelo Dias de Mattos Burns (Universidade Federal de Pelotas); **Gonzalo Velasco** (Universidade Federal do Rio Grande); **Leonardo Furlanetto** (Universidade Federal do Rio Grande); **Cleber Palma Silva** (Universidade Federal do Rio Grande); **Morevy Moreira Cheffe** (Grupo Especial de Estudo e Proteção do Rio Grande do Sul); **Juvêncio Luís Osório Fernandes Poeuy** (Universidade Federal de Pelotas)

The objective of the research was to describe the structure of the fish assemblage in deep waters and its temporal tendency in different continental aquatic habitats. Four seasonal samplings were carried out, covering about 60 km of the São Gonçalo channel and 20 km in a bay of the Mirim lagoon. A total of 156 samples were taken along the longitudinal extension of these aquatic landscapes using bottom trawling, distributed in the three habitats: mid-channel (n=80), shoreline (n=6), and mid-bay (n=52). The PCA retains the variation of 69.1% demonstrated the spatial distribution of environmental samples indicates the influence season about the habitats. A total of 18.674 individuals were captured, distributed in 37 species, with total length between 15 and 613 mm. Among the habitats 10 species were important in abundance and/or biomass: Pimelodus pintado, Rineloricaria strigilata, Parapimelodus nigribarbis, Pimelodella straminea, Rhamdia aff. quelen, Bunocephalus erondinae, Loricariichthys anus, Pachyurus bonariensis, Hypostomus spiniger and Hoplias aff. malabaricus. Richness and total abundance factors showed significant differences between habitats and seasons, especially during Autumn, when there was an increase in all habitats. The structure in the assemblage of fishes in the PCO retains the variation of 53.5%, showing a significant difference in spatial segregation within the Permanova model, where the factor habitat and its interaction with sazonality explain 44% of the variability. SIMPER indicates that the patterns of dominance were different between habitats and seasons, with the highest average similarity (61.47) in Autumn. Given the condition of the directional flow of water towards the Patos lagoon, and the partial opening of the floodgates of the sluice dam, it is possible that the effect of the closed gates during the autumn sampling had a homogenizing effect on the spatial structure of the assemblage, especially in the portion of the São Gonçalo.

Habitat, Fish Assemblage, Coastal Lagoon, Subtropical.

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A HYDROSCAPE APPROACH TO ASSESSING THE LIKELIHOOD OF RESTORING LOST AQUATIC MACROPHYTE SPECIES

Helen Bennion (University College London); **Ambroise Baker** (Teesside University); **Carl Sayer** (University College London); **Simon Turner** (University College London); **Viv Jones** (University College London); **Neil Rose** (University College London)

SESSION 02

LINK TO THE STUDY VIDEO

The likelihood of a species returning to a site is contingent on a multitude of factors including dispersal capabilities and opportunities via hydrological connectivity or birds, nature of seed production and viability of seedbanks, and proximity to source populations. The questions around whether a species can return and what restoration strategies are appropriate are important not only for aquatic systems but for restoration ecology more widely. Shallow lowland lake restoration has typically focussed on the re-establishment of submerged plant species with a central goal being promotion of clear water conditions conducive to supporting diverse aquatic plant communities. Here we explore the potential of palaeoecological records in combination with contemporary plant distribution maps to assess the likelihood of restoring lost aquatic macrophyte species to a set of shallow lakes in the UK under current conditions. Aquatic plant macrofossils preserved in sediment cores are used to determine which aquatic plant species of conservation interest have been lost from the lakes, while the maps are employed to locate refuges in the surrounding landscape for these lost species. Based on our data and knowledge of life history traits, we ask whether the species in question could recolonise if water quality is restored, where the plants would come from, and consider the implications of restoring sites which are spatially separated from source populations of desirable colonists. We demonstrate how this novel time-space integrated approach can be employed to understand the restoration ecology of rare macrophyte species and to practically guide lake restoration decisions.

connectivity dispersal lakes plants recolonization recovery

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THE POTENTIAL IMPACT OF INSTALLING A FISH PASS ON THE OUTFLOW FROM LOCH LEVEN, SCOTLAND, UK – IS IT BETTER TO BE CONNECTED?

Linda May (UK Centre for Ecology & Hydrology, Scotland, UK); **Stephen Ives** (Marine Scotland Science, UK); **Justyna Olszewska** (UK Centre for Ecology & Hydrology, Scotland, UK); **Bryan Spears** (UK Centre for Ecology & Hydrology, Scotland, UK); **Jan Janse** (Netherlands Institute of Ecology, Wageningen, The Netherlands); **Jan Kuiper** (Stockholm University, Sweden); **Wolf Mooij** (Netherlands Institute of Ecology, Wageningen, The Netherlands)



LINK TO THE STUDY VIDEO

Loch Leven is an internationally important shallow lake in Scotland, UK. In the mid 1830s, sluice gates were installed on the outflow from the lake to provide a reliable water supply to downstream industry. These gates prevented migratory fish from entering or leaving the lake via its outflow, and fish such as Salmon and arctic char were lost from the system. By the late 1970s and early 1980s, the lake had become very eutrophic and algal blooms were common. In the 1990s, restoration targets were set and phosphorus inputs were reduced from 20 t per year in 1985 to about 8 t per year by 1995. After a long period of recovery, the site showed significant improvements in water quality, biodiversity and ecosystem service provision, and algal blooms were much less frequent. To comply with the requirements of the EU Water Framework Directive, it has now been proposed that a fish pass should be installed on the outflow to enable migratory fish to enter the lake, again. However, concerns have been raised about the possible impacts of this on lake water quality. Using the computer model PCLake, we manipulated the fish migration and reproductive parameters in the model to assess the potential impact of allowing planktivorous fish, such as roach, to enter the lake. Our results suggested that this would decrease the level of zooplankton, and thus zooplankton grazing, allowing algal blooms to reappear. We concluded that changing the connectivity of the system in this way could reverse any improvements in water quality that had been achieved by reducing phosphorus inputs.

phosphorus, eutrophication, restoration, PCLake, fish

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IMPACT OF CONNECTIVITY, SPECIES INVASION, AND EUTROPHICATION ON AQUATIC BIODIVERSITY: LESSONS FROM A FLOODPLAIN LANDSCAPE



Jorge Salgado (University of Nottingham, UK); **Carl D. Sayer** (University College London, UK); **Nigel Willby** (University of Stirling, UK); **Ambroise G. Baker** (Teesside University, UK); **Stephen Brooks** (Natural History Museum, London, UK); **Thomas A. Davidson** (Aarhus University, Denmark); **Ben Goldsmith** (University College London, UK); **Helen Bennion** (University College London,UK); **Suzanne McGowan** (University of Nottingham, UK); **Ian R. Patmore** (University College London, UK); **Beth Okamura** (Natural History Museum, London, UK)

Floodplain lake landscape systems provide important ecosystem services while harbouring unique biota, including rare and highly specialized species of high conservation value. However, as with many other freshwater systems, the ecological integrity of floodplain lake landscapes has been compromised over the last two centuries by anthropogenic degradation. The most pervasive causes of degradation include increasing demands for flow regulation and drainage schemes, invasion and negative impacts of exotic species, and eutrophication. By combining data on environment, macrophyte and invertebrate surveys, and paleoecological data assembled from a large central lake and its satellite floodplain lakes in the Upper Lough Erne (ULE) system we aimed to understand the roles of connectivity, eutrophication and species invasions at the within- and between-lake scales in determining aquatic biodiversity over spatial and temporal scales. Our results reveal that eutrophication has spread unevenly across the lakes. Assemblages in the more eutrophic and isolated lakes have become more homogenous over time, unlike those in lakes with a higher degree of connectivity to the central lake. The central ULE Lake thus acts as a hub for preserving biodiversity by buffering the impoverishing effects of eutrophication and species invasions (e.g. Elodea canadensis) as a result of shared hydrological links with satellite lakes and the filtering impacts of the invasive zebra mussel (Dreissena polymorpha). Nevertheless, paleoecological data indicate the gradual spread of eutrophication across the lakes over the last five decades, which is slowly overriding biodiversity enhancement resulting from connectivity. We therefore urge management initiatives to tackle eutrophication issues now, as the buffering effects of connectivity cannot be expected to last.

Hydrological connectivity, eutrophication, invasive species, community homogenisation, palaeolimnology, macrophytes, macroinvertebartes

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THE IMPORTANCE OF FRESHWATER CONNECTIVITY AND LAND-USE ON TOTAL PHOSPHORUS AND CHLOROPHYLL-A IN SHALLOW VS DEEP LAKES



Laurence Carvalho (UK Centre for Ecology & Hydrology); **Anne Dobel** (UK Centre for Ecology & Hydrology); **Philip Taylor** (UK Centre for Ecology & Hydrology); **Craig Wilkie** (University of Glasgow); **Claire Miller** (University of Glasgow); **Marian Scott** (University of Glasgow); **Nigel Willby** (University of Stirling)

Lakes across landscapes are connected through flows of nutrients along the hydrological network, but also through nutrient transfer across land. Particularly important may be transformations in upstream lakes and lateral connectivity with ponds and wetlands in the surrounding landscape. The concentrations of total phosphorus (TP) and chlorophyll-a (Chl) are key water quality parameters in the management of shallow lakes. The relationship between the two, the Chl:TP ratio, provides a key metric of ecosystem functioning, representing how efficiently phosphorus is taken up into algal biomass, or algal losses from grazing. Much research has focused on landscape drivers of TP, but little is known about how these influence the Chl-TP ratio, and how hydrological and landscape connectivity alter this relationship. Here we report on the influence of a number of measures of freshwater connectivity and their interaction with catchment land-use on TP, Chl and Chl:TP ratio in 167 shallow lakes spanning a range of landscapes across the UK. We compare these with responses in 134 deep lakes. Results indicate that the Chl:TP ratio in shallow lakes is negatively explained by % urban land cover (positively affecting the TP response), and by the humic type of the waterbody affecting the chl-a response, the latter grouped by the proportion of peaty soils in the catchment. There were no significant effects of any of the connectivity metrics although the Chl:TP ratio was significantly affected by regional setting (river basin district). In contrast, in deep lakes, connectivity appeared to be more important, with the Chl:TP ratio positively related to the density of ponds in the landscape (negatively affecting TP concentrations) and number of fishing visits, alongside % agricultural land cover. The implications of these results for catchment management of shallow and deep lakes will be discussed.

hydrological connectivity, landscape, Chl:TP, chlorophyll-phosphorus ratio, productivity, land cover

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LEGACY METAL POLLUTANTS, LAKE CONNECTIVITY & FOOD CHAIN METAL BURDENS



Simon Turner (ECRC, UCL Geography, UK); **Neil Rose** (ECRC, UCL Geography, UK); **Handong Yang** (ECRC, UCL Geography, UK); **Carl Sayer** (ECRC, UCL Geography, UK); **Alan Law** (University of Stirling, UK); **James Shilland** (ECRC, UCL Geography, UK); **Helen Bennion** (ECRC, UCL Geography, UK); **Viv Jones** (ECRC, UCL Geography, UK); **Ambroise Baker** (Teeside University, UK)

Trace metal contaminants have altered past aquatic ecosystems and continue to affect freshwaters. Despite dramatic declines in trace metal release to the atmosphere, from fossil-fuel reduction and the post-industrialisation of the UK landscape, studies have shown that trace metal inputs have not diminished in fresh waters and may be increasing. The relative roles of contemporary and legacy metal contaminants in aquatic ecosystems and their burden on aquatic biota, however, remains largely unknown.\n\nAssociated with both historical and contemporary inputs is the role of aquatic connectivity. In isolated lakes, inputs have been maintained due to remobilisation of trace metals, historically stored in catchment soils; a process predicted to increase in coming decades due to climate-change induced soil erosion. Remobilisation of legacy metals outweighing contemporary inputs is not restricted to isolated water bodies, with the potential risk as great, if not greater in connected lowland and urban landscapes. This is due to their proximity to contaminant sources, the volume of waste incorporated into catchment soils and continued disturbance due to human activity. \n\nNERC Hydroscape has undertaken an assessment of the extent that trace metals have transferred to and through lakes and their aquatic biota in three different UK aquatic landscapes. A novel 210-Pb/Pb approach has been developed and applied to quantify the proportion of legacy versus contemporary metal inputs as well as an assessment of continued potential ecological risks from multiple sediment metal contaminants.

Metals, mercury, sediments, biota, legacy metal contaminants

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THE INFLUENCE OF CONNECTIVITY ON FISH ASSEMBLAGES IN SHALLOW LAKES OF A VERY FLAT, PRODUCTIVE LANDSCAPE

Pablo Martín Binder (Universidad de Buenos Aires, cátedra de Acuicultura - Ecología Acuática / BETA Technology Centre, University of Catalonia, Spain); **Evelyn Desiree Damonte** (Universidad de Buenos Aires, cátedra de Acuicultura - Ecología Acuática); **Daniela Celeste Nievas** (Universidad de Buenos Aires, cátedra de Acuicultura - Ecología Acuática); **Alejandro López** (Universidad de Buenos Aires, cátedra de Acuicultura - Ecología Acuática); **María Boveri** (Universidad de Buenos Aires, cátedra de Acuicultura - Ecología Acuática); **Armando Martín Rennella** (Universidad de Buenos Aires, cátedra de Acuicultura - Ecología Acuática)

SESSION 02

LINK TO THE STUDY VIDEO

Connectivity is one of the prominent variables describing the function of water bodies in several types of landscapes. The dynamic of connection and disconnection is critical for aquatic species in these systems. Shallow lakes located in very flat terrain under fluctuating climate offer variable opportunities for fish to settle, flourish and retract as water does. Our study area (1700 km2) is located in the central Pampas, a wide plain with an extremely gentle slope. This region is characterized by cyclical drought and flood episodes. Normalized difference water index (NDWI) was used to detect the surface water bodies in 2 contrasting hydrological summers, 2019 (wet) and 2020 (dry), using Sentinel Satellite Imagery with proper accuracy assessment. Post processing of the NDWI images included the calculation of a series of connectivity indexes reflecting the degree of linkage that controls water fluxes throughout the landscape. \nField sampling included 25 shallow lakes (mean depth <1m) during each of those years. Fish samples were obtained by hauling a bag seine net. Abundance, biomass and number of fish species in each lake were recorded.\nSpecies richness varied between 0 and 7. In the dry year, with the loss of connectivity, 14 of the originally sampled lakes were dry. Furthermore, the percentage of fishless lakes increased from 20% during the wet summer to 45% under drought conditions. These lakes exhibited, due to their location, absence of connection pathways which avoided water fluxes and thus, fish arrival. Lakes with fish during dry summer could be divided into those which had low diversity, inhabited by very tolerant species, and those which maintained higher fish richness (>4). The latter were in the lower sectors of the landscape and presented complex and heterogeneous aquatic environments. These systems represent the only suitable habitat for fish during drought, making them key landscape components acting as reservoirs for further fish repopulation.

Connectivity Species-richness NDWI Shallow-Lakes Drought-flood-episodes

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INTER-ANNUAL AND SPATIAL VARIABILITY OF NUTRIENTS IN A SHALLOW SYSTEM WITH MULTIPLE ALTERNATIVE STATES: THE ROLE OF EXTERNAL DRIVERS AND THE ASSEMBLY OF THE PHYTOPLANKTON



Paula Levrini (CURE-UdelaR Maldonado-Uruguay); **Claudia Fosalba** (CURE-UdelaR Maldonado-Uruguay); **Lucía González-Madina** (CURE-UdelaR Maldonado-Uruguay); **Juan Pablo Pacheco** (CURE-UdelaR Maldonado-Uruguay); **Paula De Tezanos** (Instituto de Botánica Darwinion, CONICET, Argentina); **Carolina Crisci** (Universidad de la República, Uruguay); **Andrea Cardozo** (Universidad de la República, Uruguay); **Juan José Lagomarsino** (Laboratorio OSE-UGD Maldonado-Uruguay); **Gustavo Méndez** (Laboratorio OSE-UGD Maldonado-Uruguay); **Néstor Mazzeo** (CURE-UdelaR. Instituto SARAS. Maldonado-Uruguay);

LINK TO THE STUDY VIDEO

Laguna del Sauce is composed by three connected shallow subsystems (34 ° 43´S, 55 ° 13´W, Maldonado, Uruguay), it is the second drinking water source in the country in terms of the number of people its upplies. Because of TN and TP levels Laguna del Sauce is a eutrophic system, with different ecosystem configurations in space (alternative states), with predominance of phytoplankton in the main body (where the water treatment plant is located) and excessive growth of aquatic plants in the other subsystems. Laguna del Sauce presents a wide spatial and temporal variability of the physical-chemical properties of water, linked to the dynamics of external contributions of nutrients, regulation of associated wetlands and export (tributary and water intake of the water treatment plant), meteorological conditions (precipitation and prevailing winds) and structure of phytoplankton (potentially nitrogen fixing species). The results indicate that the levels of total phosphorus [mean (M): 69.3 ug / L, coefficient of variation (CV): 25.7%] remain relatively stable over time compared to the interannual variability of total nitrogen (M: 465.5 ug / L, CV: 40.9%). The soluble reactive phosphorous (M: 48.53 ug / L, C.V: 39.1%) show greater temporal variability than dissolved inorganic nitrogen (M: 44.3 ug / L, C.V: 22.6%). The spatial and temporal variability of nitrogen is associated with denitrification processes by wetlands and the occurrence of potentially nitrogen-fixing cyanobacteria. The variability of the rainfall regime conditions the external input regime and the structure of the phytoplankton. The combination of external factors and internal processes allow us to understand and predict the spatial and temporal variability of limiting nutrients, regardless the statistical evidence, several causal mechanisms are partially known.

external contribution of nutrients, eutrophication, monitoring and follow-up, land use planning

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HABITAT RANGE AND CONDITION FOR DYSTROPHIC WATERBODIES IN ENGLAND

SESSION 02

Amy Pickard (UK Centre for Ecology & Hydrology); **Phil Taylor** (UK Centre for Ecology & Hydrology); **Ruth Hall** (Natural England); **Sally Mousley** (Natural England)

Dystrophic waterbodies are a distinctive habitat, typified by peat stained, acidic waters that only a small number of specialist macrophyte species are able to tolerate. Peatland degradation across England is considered to have reduced both the range and the condition of dystrophic habitats, but understanding these changes is difficult because previous habitat assessments have typically been made on a site-by-site basis, rather than on the national scale. Furthermore, very small, shallow waterbodies, often in the form of peat pools, are thought to comprise a large part of the habitat and these can only be delineated with high resolution mapping data. Here, we combined Natural England's peat data for England with high resolution OS MasterMap data to map potentially dystrophic waterbodies across England. We then interrogated records for 12 key dystrophic macrophyte species to further assess dystrophic habitat area, using a presence/absence approach at the hectad (10km x 10 km) scale. The inclusion of very small waterbodies in this national habitat assessment led to a total predicted habitat area of ~24 km2, although this approach requires validation through a ground-truthing exercise. In a comparison of pre-1990 and post-1990 records data for key dystrophic indicator species, it is clear that across much of the south of England the general trend is towards decline in occurrence and the inference, therefore, is that dystrophic habitats have been lost from this region. It is also evident that species losses are most often detected for individual hectads rather than hectad clusters, which indicates that smaller habitat areas are at greatest risk of loss, possibly due to their reduced connectivity with other dystrophic habitats. There are some notable areas where species occurrences have increased, including a number of National Parks in the north of England. These areas are likely to be most important for the future maintenance of the dystrophic habitat in England.

Dystrophic waterbodies; species analysis; mapping

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MICROBIAL STOWAWAYS: CAN WATERBIRDS FACILITATE THE DISPERSAL OF AQUATIC MICROORGANISMS?



Beáta Szabó (Centre for Ecological Research, Hungary); **Attila Szabó** (Centre for Ecological Research, Hungary); **Csaba Ferenc Vad** (Centre for Ecological Research, Hungary), **Emil Boros** (Centre for Ecological Research, Hungary); **Dunja Luki** (University of Innsbruck, Mondsee, Austria); **Robert Ptacnik** (WasserCluster Lunz, Austria); **Zsuzsanna Márton** (Eötvös Loránd University, Hungary); **Zsófia Horváth** (Centre for Ecological Research, Hungary; WasserCluster Lunz, Austria)

LINK TO THE STUDY VIDEO

In addition to aerial dispersal, many passively dispersing organisms depend on animal vectors (zoochory) in order to colonize habitats. In aquatic habitats, waterbirds are outstanding e.g. for dispersal of macrophytes. However, to date, we are rather unaware if waterbirds are significant in dispersing microbial organisms. Our aim was to investigate whether and which microorganisms can be dispersed by waterbirds within a landscape of ponds. We hypothesized that a number of aquatic taxa are not only ingested but eventually also internally transported and hence should be detectable in waterbird faeces. During a 2017-2018 sampling campaign, water samples from soda pans and fresh dropping of waterbirds were collected in the Seewinkel region of Lake Neusiedl (Austria and Hungary) and their bacterial and microeukaryote communities were identified via 16S and 18S rRNA gene amplicon sequencing. In line with our hypothesis, several representatives of strictly aquatic microbial groups which are typical members of soda pans in the region were found in the faeces, such as Cyanobacteria (e.g., Cyanobium, Oscillatoria), Actinobacteria (e.g., Nitriliruptor, Ilumatobacter), Betaproteobacteriales (e.g., Hydrogenophaga) and Verrucomicrobiales (e.g., Luteolibacter). Our study indicates a key role of waterbirds in the dispersal of aquatic microorganisms, thereby contributing to the understanding of regional processes in case of these passively dispersing organisms.

pond, waterbird, dispersal, internal dispersal, aquatic microorganisms

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WITHIN-LAKE VARIATION IN ZOOPLANKTON COMMUNITY STRUCTURE CAUSED BY DIFFERENTIAL PREDATION PRESSURES: HOW LARGE SHALLOW AREAS CHANGE TROPHIC DYNAMICS IN A SMALL LAKE



Riwan Leroux (University of Quebec at Trois-Rivières); **Marc Pépino** (University of Quebec at Trois-Rivières); **Pierre Magnan** (University of Quebec at Trois-Rivières); **Andrea Bertolo** (University of Quebec at Trois-Rivières)

LINK TO THE STUDY VIDEO

Whereas it is well accepted that predation plays a key role in shaping both size structure and species composition in lacustrine zooplankton communities, most studies focused on differences among lakes, neglecting the within-lake variation. Zooplankton communities might vary at small scale, as in the case of physical refuges from predators. The objective of this study was to investigate if small-scaled predation pressure can modulate the structure of zooplankton communities at the within-lake level. We compared the size spectra of zooplankton using imagery sampling from shallow and deep areas of a small boreal lake differently accessible to predators. This lake can be separated into two main basins: a well-mixed shallow basin inaccessible to fish during the summer because of a thermal barrier (mean depth: 1.5m; max depth: 2.5m) and a deeper one (mean depth: 7m; max depth: 18m) in which fish could predate on zooplankton. Zooplankton data were transformed into normalized biovolume size spectra to compare productivity and trophic efficiency between basins. Our approach showed a stronger productivity of the zooplankton in the shallow fishless basin compared to the deep one. Our results support the view that shallow areas inaccessible to fish could lead to strong within-lake variations in zooplankton community structure, with potential consequences for the trophic structure of the whole lake.

zooplankton size-spectra predation refuges

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CONNECTING DATA, CONNECTED FISH



Philip Taylor (UK Centre for Ecology & Hydrology - UKCEH); **Stephen Thackeray** (UK Centre for Ecology & Hydrology - UKCEH); **Craig Wilkie** (University of Glasgow)

LINK TO THE STUDY VIDEO

The UK Lakes Portal is an online database of lakes, currently with detailed information on over 32000 shallow lakes (<3m mean depth). As part of the Hydroscape project, a complex suite of connectivity metrics were created for these lakes to better understand how connectivity affects both biodiversity and the dispersal of stressors. Six key species were analysed: fish, birds, dragonflies, water beetles, molluscs & macrophytes, with the work on fish posing a particular challenge due to Salmonid species moving both upstream and downstream across the stages of their life cycle. In order to assess the impact of connectivity on these species, a new dataset has been created and will be presented here. It takes in data on the UK river network, obstacles to movement, meteorology, the Hydroscape connectivity metrics and an extensively compiled set of fish records (>300,000 records from 3 major fish databases). This dataset allows the complex connectivity of fish to be analysed as well as giving detailed data on fish assemblages and invasive species across the UK's shallow lakesFor the first time, this gives a detailed picture of the spatial distribution of fish across the UK and their inter-connectivity between lakes, allowing us to see how both upstream and downstream connectivity impact fish populations and diversity. These metrics have been published on the UK Lakes Portal, which also combines live hydrological data and species records, allowing the continued analysis of connectivity on fish populations over time as well as providing detailed data for all lakes in the UK.

Hydroscape, connectivity, fish, salmonids, UK, lakes

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USING NETWORK METRICS TO UNDERSTAND THE IMPORTANCE OF SCALE AND CENTRALITY-ISOLATION IN LAKE PLANKTON COMMUNITIES



David Cunillera-Montcusí (WasserCluster Lunz); **Zsófia Horváth** (Balaton Limnological Institute, Centre for Ecological Research, Tihany, Hungary); **Mia Bengtsson** (Institute of Microbiology, University of Greifswald, Germany); **Blake Matthews** (Eawag, Fish Ecology and Evolution Department, 6047, Kastanienbaum, Switzerland); **Christian Preiler** (WasserCluster Lunz, Austria); **Csaba Vad** (Balaton Limnological Institute, Centre for Ecological Research, Tihany, Hungary); **Robert Ptacnik** (WasserCluster Lunz, Austria)

Landscape features may affect aquatic communities in two very different ways. On the one hand, geo-physical characteristics at the catchment level have direct implications to any waterbody situated inside a catchment, as bedrock, soil, water residence time and so on. On the other hand, landscape position defines the connectivity among aquatic habitats, for example whether systems are physically connected within the same or different watersheds. While the general role of catchment properties as determinants of the physical environment is out of question, the role of connectivity is often debated - especially for passively dispersing organisms like bacteria, protists and microcrustaceans. The influence that landscape position might have on these organisms may largely vary depending on the different scale, or perspective, at which the landscape is considered or interpreted. Network theory grants access to several ways to represent and understand the role that different landscapes emerging from different scales might have on the biodiversity of such groups. Here, we sampled the plankton communities of 55 lakes in the northern Alps (16S & 18S amplicon sequences as well as phytoplankton & zooplankton) and calculated several community indices (e.g., multivariate fitting, alpha, beta diversity). We then built several regional networks responding to different landscape scales and calculated three indices related to connectivity, i.e., degree, betweenness and centrality. Each group showed variable patterns but beta-diversity partitions changed their interaction with centrality values both across scales and among groups. For example, increased centrality was related to higher replacement in phytoplankton while the other groups presented the opposite pattern. Such responses would highlight not only that smaller taxonomic groups are affected for the centrality-isolation gradient, they would indicate that the assembly of these groups is affected at different regional scales.

plankton, biodiversity, connectivity, metacommunities, dispersal limitation, environmental tracking

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QUANTITY, QUALITY OR CONNECTIVITY; WHAT MATTERS MOST FOR FRESHWATER BIODIVERSITY?



Alan Law (University of Stirling); **Ambroise Baker** (Teeside University); **Carl Sayer** (University College London); **Philip Taylor** (UK Centre for Ecology and Hydrology); **Nigel Willby** (University of Stirling)

Freshwaters are among the most globally threatened habitats and their biodiversity is declining at an unparalleled rate. In an attempt to understand this decline, studies have observed the effects of drivers at local and landscape scales. However, despite it being a fundamental component of freshwater ecosystems the effect of connectivity amongst waterbodies, and its potential interaction with stressors, is often overlooked.\nIn this talk we present the findings from an analysis of data on macrophytes, molluscs, beetles and odonates collected from 154 standing water bodies ranging from small ponds to large lakes nested in three contrasting landscapes in the UK; urban, upland and lowland agricultural, undertaken as part of the NERC Hydroscape project. We consider numbers of species, rare species and invasive species as responses and then compare the sensitivity of these responses to area and other predictors, including a suite of novel connectivity metrics, across taxa and landscapes. The mobile odonates and beetles were typically most diverse in small ponds. In contrast, richness of the more sedentary molluscs, and, to a lesser extent macrophytes, increased with area, highlighting the importance for these taxa of habitat heterogeneity and opportunities for dispersal via hydrological processes and human or avian vectors. Consistent with this finding, invasive species were twice as frequent in lakes compared to ponds. Our models highlight the need to consider mobility characteristics of focal taxa and stressor characteristics of focal landscapes when exploring such drivers of freshwater biodiversity, and suggest that there are constraints on generalising basic relationships across landscapes and taxonomic groups.

Lake, pond, connectivity, macrophyte, macroinvertebrate

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SMART NUTRIENT RETENTION NETWORKS: HOW TO BENEFIT FROM CASCADING EFFECTS OF WATER QUALITY



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Connections between aquatic systems may threaten downstream sites by allowing excess fertilizer, pesticides and other pollutants to travel through hydrological landscapes. However, ecological purification functions may mitigate such effects. The natural purification capacity of water systems for nutrients has direct links to its ecological state. Moreover, the ecological state strongly depends on nutrient loading. These links are especially pronounced in shallow lakes, known for their multiple self-reinforcing ecological states (submerged plant- vs phytoplankton-dominated). In connected systems, shifts towards a phytoplankton-dominated state through increased nutrient inputs can cause cascading effects throughout a hydrological network, as phytoplankton and their nutrients will be freely transported with the water flow. On the other hand, local shifts towards the - often preferred - submerged plant dominated state can increase nutrient retention and decrease nutrient flows to connected waterbodies, therewith stimulating the occurrence of submerged plants downstream. Managing such a complex set of spatially explicit ecological feedbacks requires a management framework that is specifically aimed at nutrient retention in hydrological networks. Here we will present the concept of Smart Nutrient Retention Networks (SNRNs), a novel management approach for nutrient conservation at a catchment scale. In SNRNs selective water quality management interventions are applied to contribute to a more sustainable future.

ecological feedbacks; hydrological networks; nutrient retention; nutrient reuse; smart management

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SHALLOW SALINE LAKES IN THE WORLD OF CHANGES

SESSION 03

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Shallow saline lakes are important landscape components playing a significant natural role and having high value for humans. They are very variable due to climate change and anthropogenic interventions in lakes and their watersheds and may be in different alternative strates. What are pecularities of their transformations? Are there strategies to conserve and sustainably use of them in the current changeable world?

CHANGES OF THE CRIMEAN SHALLOW SALINE LAKES IN XX-XXI CENTURIES

SESSION 03

Elena Anufreiieva (Kovalevsky Institute of Biology of the Southern Seas, Russian Academy of Sciences); **Nickolai Shadrin** (Kovalevsky Institute of Biology of the Southern Seas, Russian Academy of Sciences, Sevastopol, Russia)

The shallow saline lakes are among most threatened and changeable ecosystems worldwide despite their high natural, economic and social value. In Crimea, biggest peninsula in the Black Sea, there are more than 50 such lakes of different sizes and salinity. All of them demonstrated the sharp changes in salinity as well as in ecosystem structure and functioning during XX-XXI centuries due to climate variability and human interventions. Those changes resulted in dramatic shifts in possibility of their use by humans. On decades - centuries scale, fluctuations in the lake states occurred without directed trends due to climate variability. No one trend which was common for all lakes was observed. Changes of studied lakes demonstrated opposite trends according different proportions of climate variability and human impacts. Some lakes had not significant human interventions, and their salinity fluctuated only due to natural causes. Some such cases were analyzed. In changes of other lakes, anthropogenic impacts were driving one and surpass results of natural fluctuations. Several such cases were also analyzed. Several anthropogenic intervention and results from their impacts on lake ecosystems were also analyzed. To analyze and forecasting long-term changes of lake ecosystems, results of natural fluctuations and human impacts must be precisely separated.This study was supported by the Russian Science Foundation (grant 18-16-00001).

saline lakes, ecosystems, long-term changes, natural fuctuations, human interventions

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ABANDONED ARTIFICIAL SALINE POND – SAFE PLACE FOR RARE/ENDANGERED SPECIES



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LINK TO THE STUDY VIDEO

Inland saline ecosystems are characterized by very specific and unique biodiversity. Still, biodiversity studies of saline habitats are mostly focused on lakes and ponds of natural origin. We investigated the biodiversity of submerged macrophytes, phytoplankton and phytobenthos in the saline pond near Kikinda city (in Vojvodina, the northern province of Serbia) that was artificially made by commercial clay digging and abandoned in the landscape of the city suburban over time. Collecting samples and field measurements were conducted in July 2018. The dense cover of macrophytes in the litoral area consisted of a carpet of Chara canescens with sparse specimens of Zannichellia palustris. This is the second currently known locality of C. canescens in Serbia which was recently rediscovered. Despite the relatively wide range of this typically brackish species, populations of C. canescens are isolated, and it is worldwide considered threatened/endangered and rare.A total number of 27 algal taxa were detected in phytoplankton. A few taxa characteristic for saline or brackish water were detected – Oocystis submarina, Merismopedia warmingiana, Euglena proxima. However, the majority of detected taxa can be characterized as halotolerant. In the phytobenthic community 15 diatom taxa were recorded. The most dominant genus was Nitzschia (4 species). Brackish water species were also recorded (e.g. Tryblionella hungarica, T. apiculata). Navicymbula pusilla, first recorded in Serbian flora in 2018, was also discovered here. Generally low diversity, typical for saline habitats, was observed in relation to all communities, however typically brackish, rare/endangered species were recorded. Since our preliminary results (obtained after one sampling occasion) indicate the potential for detecting specific biodiversity in macrophyte, phytoplankton, and phytobenthic communities in one artificial saline pond, we propose conducting a detailed study of this and other ponds of similar origin.

artificial saline pond, biodiversity, macrophytes, phytoplankton, phytobenthos

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STUDY OF SUBMERGED AQUATIC VEGETATION USING REMOTE SENSING IMAGERY IN GALLOCANTA LAKE (ARAGON, SPAIN)

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SESSION 03

LINK TO THE STUDY VIDEO

Gallocanta Lake is a specific type of wetland zone that is currently rare in its biographical area, as it is an endorheic saltwater lake in the Mediterranean area of the Western Palaearctic. In addition, it is considered unusual because the water level shows different seasonality and greater period of fluctuation compared to other salt lakes. All this is of relevant interest to make more emphasis on this steppe salt lake considered as the best preserved in Western Europe. The advantage of remote sensing in this work is due to the transparency of the water, which allows the vision of the bottom, since in other shallow lakes the turbidity produced by the wind prevents observations. The maximum area of the lake is over 10 km2. Monitoring the flooding of the lake over a period of five years, between 2016 and 2020, has made it possible to observe the evolution of the submerged aquatic vegetation and that of the peripheral wetland area, the colonization processes after the flood, at which time salinity is lower; and the disappearance of plants when the level drops and salinity increases. The studies have been conducted using three vegetation indices that have been applied to Sentinel-2 satellite images. The observations show a significant coverage in the deepest areas. Thanks to its high visiting frequency (every five days), we can appreciate the moments of flooding and the evolution of the submerged vegetation, as well as that of the adjacent wetland. In a second step, it has been evaluated which is the most appropriate index for each period and situation of the lake.

saline lake, hydrophytes, vegetation index, remote sensing

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DEMOGRAPHY OF HEXARTHRA JENKINAE (ROTIFERA) FROM EPHEMERAL AND PERMANENT HABITATS OF LAKE TEXCOCO (MEXICO)

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SESSION 03

Life history strategies of rotifers vary in relation to biotic and abiotic factors. We compared the demography of Hexarthra jenkinae from ephemeral pools and the large, permanent Nabor Carillo Lake, both parts of the saline Lake Texcoco in the State of Mexico. We compared the population growth rates at salinities of 10, 12.5 and 15 g/l (a 1:1 ratio of NaCl and NaHCO3). Experiments were conducted at two food concentrations (0.25 and 1.0 x 106 cells ml-1) of Nannochloropsis sp. and at 25°C with four replicates per treatment. The population growth experiments were initiated with 10 individuals of a mixed population per replicate whereas for the cohort life table experiments we used 10 neonates per container. Observations were taken once (population growth) or twice (life table) a day; experiments continued until the populations declined or the last individual of each cohort in the life table study died. Survivorship and growth rates increased with increasing food availability. From the population growth studies we found that the clone established from the ephemeral pools had higher growth rates (0.23-0.55 d-1) than those from the permanent lake (0.12-0.34 d-1). Growth rates were lower in the lifetable experiments than the population growth studies. Our results are discussed in relation to habitat and life history strategies exhibited by rotifers in shallow saline waterbodies.

Rotifera, Saline-lakes, demography, life history strategies, egg ratio

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GETTING SALTY: THE EFFECT OF SALINITY AND WATER CHEMICAL TYPES ON BACTERIAL COMMUNITY COMPOSITION

SESSION 03

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LINK TO THE STUDY VIDEO

Moderately saline and alkaline environments such as soda and salt lakes are expected to become more common globally as shallow water bodies more often become concentrated and desiccated because of increased evaporation, which is further aggravated by groundwater depletion due to intensified agricultural irrigation practices. Despite their worldwide importance still little is known about the microbial communities of these shallow inland water bodies. Do the habitats with different salinity and water chemical types (carbonate or chloride anion dominance) have a distinct bacterial composition? How the bacterial communities of brackish waters would respond to changing climate? To answer these questions, we compared several bacterial 16S rRNA gene amplicon datasets (n > 300) obtained from various freshwater, brackish and saline aquatic habitats worldwide. The selected sample sets were processed with approximately the same wet lab protocol targeting the V3-V4 region of the 16S rRNA gene. During the bioinformatic analysis, sequences were filtered rigorously to avoid artifacts. Our results showed remarkable differences in bacterial community composition of freshwater, soda and saline habitats, however transitions between these habitats were also observed. Interestingly various differences were detected in the community structure of similar environments separated by large geographic distances. Above a certain salinity threshold, samples were clearly separated by water chemical types. In the case of soda lakes, planktonic actinobacteria (acIII-A1, Luna1-A2, uc_Nitriliruptoraceae) and uncultured members of the Rhodobacteraceae family were typical taxa. The decrease in relative abundance of certain freshwater groups (LD12, Flavobacterium, Aquirufa, Limnohabitans, Hydrogenophaga) indicated transition to brackish waters, while certain taxa such as Halomonas and some Synechococcus lineages were characteristic for chloride-dominated saline waters.

soda lake, saline lake, microbial communities, water chemical type

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LAGOONS OF ESTONIAN COAST - BUFFERING SYSTEMS OR HOTSPOTS OF SPECIES RICHNESS?



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LINK TO THE STUDY VIDEO

About 600 coastal lagoons (CL) border Estonian mainland and islands, formed in concurrence of permanent neotectonic uplift of earth crust (2-3 mm y-1) and accumulation of dynes. Salinity of CL differs from nearly fresh to brackish (?5 psu), depending on the age and connection with marine water. Extreme shallowness (max. depth of water ?2 m), changing water level and salinity determines the biota of CL. Strong sunlight causes converging of microscopic algae and protists in the surface of bottom sediments, while the main primary producers are macrophytes. Hygrophytes, helophytes and hydrophytes were studied in the 36 water bodies in 2003-2004 and 2019-2020. Altogether 138 species of vascular plants (13 protected), 14 species of charophytes (incl. Chara polyacantha as a specialist) and some mosses were found. Very shallow and old (>1000 years) CL with limestone bottom were the richest in rare helophytes. Many CL are widely occupied by tall helophytes Phragmites australis and Typha angustifolia, growing to the depth of 1 m and suppressing other species. Accumulation of reed litter causes change in the bottom sediments, thereby changing it unsuitable for previous inhabitants. Reed expansion depends on the bottom sediment, water depth and age of CL separation. It is faster in NW Estonia, where most of CL disjointed from the sea during the last 100 years. Regarding the eutrophication of the Baltic Sea, reeds are useful, retaining the nutrients from inflows and seaside and thereby supporting denitrification. Moreover, CL with intermediate reed development are highly favourable for birdlife. Cutting the reed and grazing by cattle to limit its expansion, as well as for commercial use, are on the rise. To keep CL as hotspots of species richness, we must avoid anthropogenic eutrophication of present open-watered CL and constitute a reasonable plan for the managing of overgown CL with reed.

coastal lagoons, macrophyte richness, expansion of reeds

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NOT TOO SALTY FOR FISH: THE IMPORTANCE OF VARIED SALINITY CONDITIONS FOR PRESERVING FISH DIVERSITY IN NEOTROPICAL COASTAL LAGOONS



LINK TO THE STUDY VIDEO

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Shallow coastal habitats are ruled by fluctuating environmental conditions, which lead to shifts in the composition, structure, and distribution of the associated communities. Since comparisons of rich tropical systems are often complex through species-based approaches, functional groups of habitat use and trophic level were used in this study to address fish diversity and composition among three Neotropical coastal lagoons. We hypothesized that the composition and diversity of these groups would respond differently to the intrinsic salinity levels of the three coastal lagoons (euhaline, mesohaline, and hyperhaline). Despite the importance of other environmental factors (i.e. temperature and transparency), salinity was the key structuring factor irrespectively the brackishness of the systems, accounting for the greatest amount of explained variance of the composition of functional groups. Piscivorous, omnivorous, and marine stragglers were typical of the hyperhaline system, but with a low diversity which is largely influenced by the harsh environmental conditions. On the other hand, a great number of indicator species, especially of typically marine (e.g. marine migrants and stragglers) were found for the euhaline system, probably due to the continuous and broad connection to the sea and environmental conditions more similar of true marine systems. Despite the presence of non-native species (i.e. Oreochromis spp), the mesohaline system apparently functions as an important refuge for freshwater groups, with many species being recorded exclusively in this system. Our results stressed the importance of variation in salt concentration in providing different patches of conditions which allows a greater variety of organisms to colonize those systems.

functional groups fish assemblage salinity coastal lagoon trophic guild habitat affinity

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TRANSFORMATIONS INTO THE NEW ECOSYSTEM STATES IN LONG-TERM DYNAMICS OF SHALLOW LAKES: A CASE OF THE CRIMEAN SALINE LAKES

SESSION 03

Dr. Nickolai Shadrin (Kovalevsky Institute of Biology of the Southern Seas);
Dr. Elena Anufriieva (Kovalevsky Institute of Biology of the Southern Seas)

LINK TO THE STUDY VIDEO

Environmental risks are increasing worldwide including from changes of shallow lakes capacity to provide natural, economical and social services. To support the successful environmental management of lakes, we need to have clear understanding of long-term lake ecosystem dynamics, its nature and causes. Every ecosystem pass in its long-term dynamics coherent and incoherent stages. Every ecosystem pass in its long-term dynamics the coherent and incoherent stages. During a coherent stage, an ecosystem fluctuates around some equilibrium point with smooth changes responding environmental factor variability. In an incoherent stage, ecosystem state destabilization occurres, and an ecosystem transits through the tipping point into a new state. To understand ongoing changes and forecast possible future of an ecosystem is impossible without clear identification of these stages. There are internal causes resulting in an ecosystem drift to a tipping point with inevitable transformation into a new state as well as a shift in the external driving factors (climate fluctuations or human interventions, alien species, etc.) may lead to same result. In the Crimean shallow saline lakes, salinity shifts due to climate fluctuations and/or human interventions are main causes of ecosystem transits into the new alternative states. Such dramatic transformations of several Crimean saline lakes were described and analyzed here. Peculiarities of transformations were identified. Transiting into some new alternative state, an ecosystem loses some natural opportunities for its human use but also creates new prerequisites for use of a lake by humans. This study was supported by the Russian Science Foundation (grant 18-16-00001).

alternative states, saline lakes, long-term changes, Crime

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PLANKTIVOROUS FISHES AS WATER QUALITY INDICATORS OF A SHALLOW NEOTROPICAL SALINE LAGOON

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SESSION 03

LINK TO THE STUDY VIDEO

Despite their importance as nursery and feeding grounds for many marine and estuarine fishes, coastal lagoons are increasingly threatened by anthropogenic activities, such as the growing inputs of nutrient loads that decrease water quality and biological integrity of these systems. This study aimed to assess the relationship of placktivorous fishes with proxies of water quality in Saquarema Lagoon, a c.a. 23 km2 shallow system, located in the Northern coast of Rio de Janeiro state. Beach seines (20 m x 1.5m; 7mm mesh) were performed bimonthly in nine beaches (i.e. three replicates per beach) distributed along three zones (inner, central and outer) of Saquarema Lagoon from September 2017 to July 2019. Eight species of planktivorous fish were caught, totalling 149,797 individuals and 38.46 kg, mostly Rio anchovy Achoa januaria, Brazilian menhaden Brevoortia aurea, and shortfinger anchovy Anchoa lyolepis, which together accounted for 97.6% and 95.7% of the total abundance and weight, respectively. Redundance analysis (RDA) revealed spatial differences for the composition and structure of planktivorous fish assemblages (Monte Carlo´s test; $p < 0.001$), which were overall negatively related, especially the biomass of the three most conspicuous species, with water transparency. Non-linear models (AIC; Generalised additive models - GAMs) were selected for total richness of planktivorous species, indicating unimodal responses with temperature, salinity, dissolved oxygen, and transparency ($p<0.05$). In contrast, linear and non-linear models were selected for total abundance and biomass of planktivores, which decreased linearly with transparency and temperature ($p<0.05$ for both), and increased non-linearly with dissolved oxygen. Although complex, our results indicate that planktivorous fishes could be used as indicators of water quality conditions in coastal lagoons.

Saquarema lagoon; eutrophication proxies; anchovy; water transparency

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ECOLOGY OF TEMPORARY ECOSYSTEMS

SESSION 04

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Global climate change is expected to intensify droughts, a critical filter to the biodiversity and food web structure in temporary systems around the world. The prolonged droughts may promote a general decrease in ecosystem resilience and changes in energy flow and trophic interactions. Due to limited knowledge of the ecosystem functions regulating energy flow and matter cycling, research still falls short in bridging the gap to assure proper management and conservation strategies of these temporary lakes, wetlands, small wetlands, rock pools, man-made reservoirs and streams. Since these temporary ecosystems are a source of several environmental services to human societies, the knowledge about their ecology is critical to draw effective conservation strategies. This special session will bring together specialists in the ecology of temporary ecosystems around the world to present and discuss results of experimental and field observations in the face of the huge challenge which is to understand the effects of different impacts (such as climate change and land use) in these ecosystems.

STOCHASTIC AND DETERMINISTIC PROCESSES CAN ACT IN THE SAME SCALE: THE CASE STUDY OF ZOOPLANKTON IN TEMPORARY WATERS



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The processes driving biodiversity patterns must be considered more broadly to provide insights about metacommunity assembly. Most studies have been emphasizing the stochastic-deterministic dichotomy in metacommunity, but the scale on which they operate is still poorly assessed. Discrete habitats provide excellent system to evaluate such scale-dependent processes, such as tank bromeliads and temporary ponds. Here, we tested whether habitat size influences environmental stability in the zooplankton metacommunity structure and how scale may change the predominant processes. Here, we expected (1) that alpha diversity will be lower in bromeliads than in ponds, since they have smaller habitat sizes and are more prone to drought. We also expect that (2) beta diversity (dissimilarity resulting from turnover) will be greater between bromeliads than between ponds, since the limitation in dispersion and instability of the system (i.e., less volume and greater propensity to drought) favoring stochastic processes. We first compared alpha diversity between two contrasting habitats using rarefaction and extrapolation with Hill numbers. Then, we partitioned ? diversity into turnover and nestedness components. Our results showed that turnover was the main component of beta diversity in both systems. The change in the composition of communities differed mainly between systems compared to water acidity and temperature. However, contrary to what we expected based on the species-area relationship, the turnover was four times higher in ponds than in bromeliads. Our results suggest that stochastic and deterministic processes can act simultaneously at the local scale.

Metacommunities beta diversity

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INFLUENCE OF RAINFALL AND LOCAL ENVIRONMENTAL FILTERS ON THE PHYTOPLANKTON COMMUNITY IN BRAZILIAN SEMIARID ROCK POOLS

Luciana Gomes Barbosa (Federal University of Paraíba); **Enio Wocyli Dantas** (State University of Paraiba); **Danielle Lima de Oliveira** (Federal University of Paraíba); **Fátima dos Santos Silva** (Federal University of Paraíba); **Jascieli Carla Bortolini** (Federal University of Goias)

SESSION 04

Rock Pools in drylands regions are vulnerable to temporal stress and habitat desiccation due to the occurrence of the unpredictable drought. Last years, the Brazilian semiarid region has presented an increase in the aridity conditions, with the rainfall reduction and increase of the evaporation promoting the potential resilience loss and deterioration of the water quality. Thus, we explore the importance of local environmental filters in space (urban and rural) and time (occurrence of rainfall) on the structure of the phytoplankton in temporary rock pools in the Brazilian semiarid region. The hydrological regime was extremely irregular with the most part of the months characterized by drought events. Thus, the rainfall intensity was considered a disturbance in the temporal scale. A total of eighty-three phytoplankton taxa were found, with the higher biomass identified in urban rock pools, while the rural rock pools were associated with the lowest values, being confirmed the temporal and spatial variations of phytoplankton structure. The phytoplankton structure was explained by the environmental, spatial, and temporal components, however, the environmental local filters have a greater contribution. Thus, we were able to verify how the occurrence of rainfall affects the structure of the phytoplankton over temporal phases, in addition to identifying how the local environmental filters influential the phytoplankton in two sets of rock pools (urban and rural), since understanding the dynamics of drylands and the consequences on biodiversity is essential because these ecosystems have been affected drastically by the extreme climatic variability.

drought; hydrological disturbances; inland temporary ecosystems; phytoplankton biomass

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FOOD QUALITY FOR AQUATIC PRIMARY CONSUMERS IN A HIGHLY HUMIC TROPICAL TEMPORARY POND

Clarice Casa Nova (Universidade Federal do Rio de Janeiro); **Dörthe Müller-Navarra** (Universität Hamburg); **Reinaldo Luiz Bozelli** (Universidade Federal do Rio de Janeiro)

SESSION 04

Fatty acids (FA) relative composition was analyzed in both seston and zooplankton samples from a highly humic environment in two distinct periods (December and February). Atoleiro is a small temporary pond that originated from underground water upwelling in the National Park of the Restinga of Jurubatiba, Northern Rio de Janeiro State, Brazil. Dissolved organic carbon (DOC) concentrations average 184 mgC/L, exceeding the mean values of this variable worldwide. The uniqueness of this system makes it an important and useful tool to understand how allochthonous carbon is processed and affects food quality available for primary consumers, such as cladocerans and copepods. Results indicate zooplankton dependency on omega-6 essential FA, such as linoleic and arachidonic acid, which might mean a higher terrestrial resource utilization in this highly humic environment. Food quality reflected seston and phytoplankton composition in zooplankters and differences in FA ratios and polyunsaturated FA composition suggests indirect effects of the high DOC observed. Saturated FA relative contribution in seston samples indicates the presence of lower quality resources, such as detritus and bacteria. In a broader context, these preliminary results help to understand how allochthony and autochthony shape primary consumer communities, shedding light on resource utilization especially considering contemporary natural and anthropogenic processes, such as browning and land-use change, respectively.

fatty acids; cladocerans; copepods; DOC; DOM

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NATURAL vs. COMMERCIAL HUMIC SUBSTANCES CHARACTERIZATION: A METHODOLOGICAL APPROACH ON OPTIC CHARACTERIZATION

Luiza Oliveira da Costa (Universidade Federal do Rio de Janeiro); **Clarice Casa Nova** (Universidade Federal do Rio de Janeiro); **Reinaldo Luiz Bozelli** (Universidade Federal do Rio de Janeiro)

SESSION 04

LINK TO THE STUDY VIDEO

Dissolved organic matter (DOM) is inherent to aquatic ecosystems and mainly comes from terrestrial organic matter runoff. DOM presents a wide range of molar masses and chemical structures and its major component is dissolved organic carbon (DOC). Decomposition of allochthonous material is the greatest contributor of DOC, though decomposition of autochthonous material (e.g phytoplankton) is present. The main components of DOC are humic substances (HS) - a result of the incomplete decomposition of OM, mostly allochthonous. Understanding DOM and DOC origin and composition is necessary to clarify its effects on aquatic ecosystems and organisms. Most of the attempts to characterize DOM/DOC focus on chemical aspects of the molecule, ignoring its reactivity and optical behavior. Our objective was to characterize and compare HS from a natural aquatic ecosystem and a commercial one, usually used in laboratory experiments. We performed absorbance readings, Specific Absorbance (SUVa) index calculations and Excitation-Emission matrix of treatments. We observed differences between natural and commercial HS in terms of phenolic composition and reactivity. The characterization based on absorbance reflected the general behavior of samples and showed similarity between HS. From the raw concentration data, a significant difference was noted between the amount of carbon in each HS, showing differences in HS composition. Applying the SUVa index, to understand the reactive behavior shown by the absorbance data, we observed differences in the behavior of the HS. The fluorescence profile was quite different, pointing out to molecular differences of the carbon. The differentiation observed in the fluorescence spectra confirms differences in the composition and reactivity of DOC that should be considered for the ecosystem's dynamics and organism's interaction with these substances.

Organic Dissolved Matter; Dissolved Organic Carbon; Humic Substances; Characterization

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PRELIMINARY CHARACTERIZATION OF SHALLOW TEMPORARY PONDS IN SEMI-ARID: EXTREME DAILY TEMPERATURE CHANGES, THERMAL STRATIFICATION AND IMPLICATIONS FOR CHLOROPHYLL MEASURES



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Climate poses as a major driver of both abiotic scenario and biodiversity in inland waters. Most shallow water bodies in semi-arid region of Brazil are yet poorly investigated despite their vulnerability regarding hydrological regime and consequences of extreme drought conditions. A limnological investigation involving physical variables and chlorophyll-a was undertaken in three tropical shallow temporary ponds (P1, P2 and P3) in semi-arid, Brazil. Monitoring of limnological variables were carried out in the dry season using multiparameter probe YSI -PRO PLUS and biological sampling were carried out for two consecutive day periods: i) 5 a.m.; before the sun rise and ii) 15 p.m., after the sun pick. Results showed mean depth <2m, short-term thermal stratification and daily changes were higher than 8°C. The large documented daily variation in temperature may have caused vertical mixing of the shallow water column. In general, local limnological variables local differences were minor for P1 and P2. More eutrophic conditions with higher chlorophyll-a concentrations (33.09 ?g L-1) and higher electrical conductivity (>1000 ?S cm-1) were found in P3. Despite all ponds showed low oxygen availability DO<4mg L-1 and basic pH (7.92-9.11), P3 also displayed anoxic condition (0.12 mg L-1,) and lowest pH. Temperature had negative significant relationship with chlorophyll-a concentrations (R2= -0.72) which may represent a rapid acclimation of phytoplankton via trade-off between light availability and intracellular concentration of this pigment. Notwithstanding the foregoing, the chlorophyll-a proxies should be revisited as basis productivity models in tropical systems as temperature increase is a undeniable reality on scenarios of climate changes and also has a very long history of helping the understanding of the variability of phytoplankton and its influence in life under waters. Finally, we suggest further investigations on the aquatic biota, mainly phytoplankton productivity,

Chlorophyll-a, climate change, limnology, temporary ponds, water quality

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UNDERSTANDING THE ROLE OF FEEDBACK PROCESSES IN LAKE ECOSYSTEM DYNAMICS: THEORETICAL ADVANCES

SESSION 05

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Ecosystem dynamics are notoriously difficult to predict, because interacting feedback processes will often enhance, buffer or reverse the direct impacts of environmental drivers. While negative feedbacks tend to stabilize ecosystems in a given state, positive feedbacks make ecosystems prone to abrupt state shifts. Typically, because multiple positive and negative feedback processes operate in parallel, their causal contributions to overall system dynamics cannot be understood from observational data alone. Process-based mathematical models offer a powerful tool to overcome this limitation, because the separate functions of each system component can be examined in controlled numerical experiments.
In this session, we aim at highlighting the fundamental role of process-based modeling in advancing our understanding of lake ecosystem dynamics. We illustrate this with our own work exploring how positive feedbacks in the coupling of benthic and pelagic system components can lead to abrupt state shifts along environmental gradients. We invite contributions with a similar focus on a mechanistic understanding of complex feedback dynamics. Contributions can be of three types: pure theoretical work (exploring the feasible), empirical studies that were designed to test process-based theory, or combinations of the two.

THERMODYNAMIC ECOLOGICAL INDICATORS FOR ASSESSMENT A REGULATED SHALLOW LAKE

SESSION 05

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LINK TO THE STUDY VIDEO

Water level regulation, specially due to the presence and functioning of dams, is one of the most common anthropogenic disturbances of lentic ecosystems. The objective of this study was to assess the ecological effects of water level regulation in a shallow lake caused by a run-of-river dam, using thermodynamic indicators, to support decision making in a dam decommissioning process. This study is part of a large joint scientific assessment of the ecological effects of a run-of-river dam in the Pandeiros River Basin, an important affluent of the São Francisco river, in Brazil. That assessment aims to develop ecological assessment methodologies to support decision making regarding a possible decommissioning of the Pandeiros Dam, which if realized will be the first in South America. For that we tested a hypothesis that the regulated lake supports less complex benthic macroinvertebrate assemblages than the naturally fluctuating lake. Our results show that the hypothesis, tested using two thermodynamic based indicators, eco-exergy and specific eco-exergy, was partially supported. This was illustrated, overall, by higher eco-exergy (degree of complexity) of the benthic assemblages in the naturally fluctuating lake, although the specific eco-exergies (capacities to use external energy resources) were similar. The fact that benthic macroinvertebrate assemblages had higher eco-exergy in the naturally fluctuating lake can also be explained by the higher level of available energetic resources represented by resuspended organic matter, resulting in a higher overall degree of complexity, stability and development of the macroinvertebrate assemblage. As a whole, our results endorse the importance of natural water level fluctuations as a driving force in shallow lake ecosystems and reinforced the idea that dam decommissioning is a good option for restoring natural conditions in this type of ecosystem.

Benthic macroinvertebrates; diversity; eco-exergy; tropical shallow lakes; water level fluctuation

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EXPLORING HOW CYANOBACTERIAL TRAITS AFFECT NUTRIENT LOADING THRESHOLDS IN SHALLOW LAKES: A MODELLING APPROACH

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SESSION 05

LINK TO THE STUDY VIDEO

Globally, many shallow lakes have shifted from a clear macrophyte-dominated state to a turbid phytoplankton-dominated state. Such shifts are often accompanied by toxic cyanobacterial blooms, with specialized traits including buoyancy regulation and nitrogen fixation. Previous work has focused on how these traits contribute to cyanobacterial competitiveness. Yet, little is known on how these traits affect the value of nutrient loading thresholds of shallow lake ecosystems. These thresholds are defined as the nutrient loading at which lakes shift water quality state. Here, we used the process-based ecosystem model PCLake+ to estimate the effects of traits on nutrient loading thresholds and explain the underlying mechanisms. We incorporated cyanobacterial traits in the model and obtained nutrient loading thresholds under four scenarios including cyanobacteria without traits, with buoyancy regulation, with nitrogen fixation, and with both traits. Results show that cyanobacterial traits can impede lake restoration that is implemented by nutrient loading reduction. However, these traits hardly affect the nutrient loading thresholds for clear lakes experiencing eutrophication. These effects can be explained by that cyanobacterial traits changed their interactions with nutrients and light. Our study provides references for nutrient loading thresholds and draws attention to cyanobacterial traits during the remediation of eutrophic water bodies.

Harmful algal blooms; regime shift; alternative stable state; light limitation; nutrient limitation; critical nutrient loading

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NO TWO LAKES ARE ALIKE: SPATIAL DIFFERENCES DETERMINE RESPONSE TO EUTROPHICATION AND MANAGEMENT



LINK TO THE STUDY VIDEO

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Many lakes on earth experience eutrophication resulting in toxic algal blooms. Management of algal blooms is often troublesome since shallow lakes typically respond non-linearly to eutrophication. Hitherto, the effect of spatial heterogeneity in nutrient loading and hydrology on the non-linear response of shallow lakes to eutrophication has been unclear. We present a dynamic-modelling approach to disentangle the effect of spatial heterogeneity in nutrient loading and hydrology on lake response to eutrophication and to help guide the management thereof. We used the PCLake+ model to study four lake types with contrasting nutrient loading (point versus diffuse) and hydrology (seepage versus drainage). We show that the nutrient loading type determines the chance of alternative stable states, whereas the lake hydrology type determines the maximum possible chlorophyll-a levels. By comparing the long-term effect of common restoration measures (nutrient load reduction, lake flushing or biomanipulation) in these four lake types, we found that restoration through reduction of nutrient loading is effective in all cases. In contrast, biomanipulation only works in seepage lakes with diffuse nutrient inputs, while lake flushing will even be counterproductive in lakes with nutrient point sources. The main conclusion of the presented analysis is that a priori assessment of spatial heterogeneity in nutrient loading and hydrology is essential to understand the non-linear lake response to eutrophication and the related successful restoration of lakes.

Spatial heterogeneity; Alternative stable states; PCLake; non-liniear response; management; hydrology; nutrient source

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TILAPIA LIFE-HISTORY IN TROPICAL LAKES AND RESERVOIRS

SESSION 05

Marcolina Lima Cardoso (Universidade Federal do Rio Grande do Norte); **José Luiz Attayde** (Universidade Federal do Rio Grande do Norte); **Maria André M. de Roos** (University van Amsterdam)

Tilapias are one of the major groups of introduced species, representing an important food source and improving the local development. However, changes in the size-structure of tilapia (from dense populations with large adults to overpopulations of stunted individuals) have threatened not only fishing but also appear to be responsible for the negative impacts on native species. In this work, we carried out an extensive review of the attributes of Oreochromis niloticus in tropical lakes and reservoirs, and we model the dynamics of individuals based on food level. We found that the asymptotic size, size-at-maturity, and maximum fecundity reported are positively related to the lake area, however are probably a function of tilapia competition for food/space. The model gave good estimates of growth and fecundity indicating a low investment in reproduction (15%) when compared to marine species. Tilapia's success seems a result of parental care and low juvenile mortality. As the energy required for reproduction is low, tilapia only ceases reproducing under very unfavorable food conditions and can survive with reductions of up to 80% of food resources. And, under low food availability, tilapias reproduce early, producing more eggs per gram of fish. Energy investment in growth is high (85%), accounting for the high somatic growth rates of tilapia. Such characteristics make tilapia successful in environments with harsh conditions, increasing their abundance and impacts on other species, as well as may not bring the desired economic benefits due to the stunting. The management of tilapia populations is recommended mainly in small and eutrophic lakes, to avoid competition for space and food that reduce tilapia growth rates but has low impact on reproduction.

Energy budget theory, exotic species, cichlids, stunting,

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MODELING WATER QUALITY IN THE ANTHROPOCENE: DIRECTIONS FOR THE NEXT-GENERATION AQUATIC ECOSYSTEM MODELS



Wolf M. Mooij (Netherlands Institute of Ecology - NIOO-KNAW); **Dianneke van Wijk** (Wageningen University & Research); **Manqi Chang** (Netherlands Insitute of Ecology - NIOO-KNAW); **Andrea S. Downing** (Stockholm Resilience Centre); **Jan J. Kuiper** (Stockholm Resilience Centre); **Sven Teurlincx** (Netherlands Institute of Ecology - NIOO-KNAW)

“Everything changes and nothing stands still” (Heraclitus). Here we review three major improvements to freshwater aquatic ecosystem models — and ecological models in general — as water quality scenario analysis tools towards a sustainable future. To tackle the rapid and deeply connected dynamics characteristic of the Anthropocene, we argue for the inclusion of eco-evolutionary, novel ecosystem and social-ecological dynamics. These dynamics arise from adaptive responses in organisms and ecosystems to global environmental change and act at different integration levels and different time scales. We provide reasons and means to incorporate each improvement into aquatic ecosystem models.Throughout this study we refer to Lake Victoria as a microcosm of the evolving novel social-ecological systems of the Anthropocene.The Lake Victoria case clearly shows how interlinked eco-evolutionary, novel ecosystem and social-ecological dynamics are, and demonstrates the need for transdisciplinary research approaches towards global sustainability.

Sustainable development; Eco-evolutionary dynamics; Novel ecosystem dynamics; Social-ecological dynamics;

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EFFECTS OF VOLUME VARIATION AND LIGHT AVAILABILITY ON TEMPORAL DYNAMICS OF PHYTOPLANKTONIC BIOMASS IN A SEMI-ARID TROPICAL RESERVOIR

SESSION 05

Carlos Alberto Nascimento da Rocha Junior (UFRN); **Joana Darc Freire de Medeiros** (UFRN); **José Luiz de Attayde** (UFRN)

The variation in algal biomass due to the eutrophication process is mainly dependent on the availability of resources, such as light and nutrients, and these can be influenced by the fluctuation in lake water volume. Most eutrophication models that try to explain the variation of the phytoplankton biomass assume that lake water volume is constant, which is clearly not the case in drylands shallow lakes. The aim of this study was to develop a mathematical model to help explain and predict the dynamics of algal biomass in shallow man-made lakes in a tropical semiarid region, assuming that light availability and volume variation are the main factors limiting the growth of phytoplanktonic biomass. The model describes the relation between lake water level and light-limited phytoplankton growth, assuming a dominance of phytoplankton by the cyanobacteria *Cylindrospermopsis raciborskii*. To calibrate and validate the model we used data from a lake water quality monthly monitoring program in Northeastern Brazil. Results showed a reasonably good fit between simulated and observed data, with an increasing trend in algal biomass as the lake water volume was reduced, except during an extreme drought period when observed algal biomass was prevented to increase due to high concentrations of inorganic suspended solids, not incorporated in the model. We conclude that lake water volume variation and light availability are important factor determining algal growth in drylands shallow lakes. However, other factors not incorporated in our model, such as the effect of inorganic suspended solids in the light availability to phytoplankton growth, are important during extreme drought events and need to be included in future theoretical work on algal biomass dynamics in drylands shallow lakes.

water balance, harmful algal blooms, water quality management

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TIMING MATTERS: EFFECTS OF SPRING PERIPHYTON DYNAMICS ON MACROPHYTE BIOMASS

SESSION 05

Alena S. Gsell (Leibniz Institute of Freshwater Ecology and Inland Fisheries); **Sven Teurlincx** (Netherlands Institute of Ecology); **Marta M Alirangues Nuñez** (Leibniz Institute of Freshwater Ecology and Inland Fisheries); **Sabine Hilt** (Leibniz Institute of Freshwater Ecology and Inland Fisheries)

Periphyton shading is supposed to play a key role in decline of macrophytes during eutrophication as well as in delay of macrophyte recovery during nutrient load reduction in lakes. In temperate lakes, light availability in spring/early summer is of particular importance for most submerged macrophyte species. Periphyton shading can vary strongly during this period due to the complex interaction between temperature increase, nutrient availability and top-down control by grazing. This variation could be decisive for the respective macrophyte biomass in summer, but detailed data on periphyton dynamics are scarce. The impact of temporal variation in periphyton shading in spring on macrophyte development thus remains to be unravelled. \n\nHere, we use the ecosystem model PCLake+ to explore the effects of variation in spring/early summer periphyton shading on macrophyte development in a generic, shallow lake. We first assess the overall effects of timing and absolute periphyton shading, and second, the effects of timing and duration of interim reduction in periphyton shading by grazing in spring on the persistence or loss of macrophytes in the lake system. These theoretical scenarios are then compared to field data on periphyton biomass sampled fortnightly from plastic strips exposed in shallow, temperate, eutrophic Lake Müggelsee. Our results will help to better understand the role of periphyton shading in macrophyte biomass development and improve PCLake+ as a tool for lake restoration in shallow lakes.

PCLake+, regime shift, shading

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ASYMMETRIC COMPETITION FOR NUTRIENTS AND LIGHT CAN PRODUCE NEGATIVE RELATIONSHIPS OF PRIMARY PRODUCERS TO TOTAL PHOSPHORUS

SESSION 05

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LINK TO THE STUDY VIDEO

One of the most pervasive patterns in limnology is a positive relationship between total phosphorus in the water and the production and biomass of pelagic microalgae. Together with direct evidence from nutrient enrichment experiments and observations following eutrophication, this has shaped a paradigm of primary production being nutrient limited in most inland waters. Recently, this view has been challenged for shallow, nutrient-poor boreal and subarctic lakes. In these lakes primary production decreases with increasing total phosphorus concentration, and light extinction by colored dissolved organic matter (cDOM) has been suggested to be the limiting factor. We use a dynamic model to show that the negative relationship between primary production and pelagic phosphorus can be explained by feedbacks involving spatially asymmetric competition for nutrients and light between benthic and pelagic producers. In line with data, the model predicts that benthic producers intercept the flux of nutrients from the sediment to the pelagic zone in clear but not in cDOM-rich lakes, creating strong negative co-variance between total (= benthic + pelagic) primary production and pelagic phosphorus concentration. Interestingly, the same model can explain a similar relationship observed in the other end of the productivity gradient. In a whole-system experiment, we observed a positive response of pelagic algal biomass to a 20-fold reduction in phosphorus loading to hypertrophic ponds. In that system vertical spatial asymmetries were reversed. Floating mats of filamentous algae pre-empted the light supply in the hypertrophic state, and nutrient reduction benefitted phytoplankton by alleviating competition for light. Spatial asymmetries in resource supply are common in aquatic systems. A mechanistic understanding of competitive interactions among primary producers is therefore greatly facilitated if biotic feedbacks on the vertical light gradient are included in dynamical models.

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TRAIT VARIATION AND THE ECOLOGY OF SHALLOW LAKES

SESSION 06

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Traits are key to how species respond to environmental change, determine interaction strengths and type among organisms, and are a key determinant of rates of ecosystem processes. Traits are also the common currency linking intra- and interspecific variation to community and ecosystem dynamics, and are therefore central in evolutionary ecology and eco-evolutionary dynamics. In this session we aim to bring together contributions that focus on how trait variation determines population, community and ecosystem ecology of shallow lakes. We welcome a broad range of contributions, e.g. on trait-based ecology, evolutionary ecology, eco-evolutionary dynamics, integrated analysis of intra- and interspecific trait variation, trait-based metacommunity ecology.

ZOOPLANKTON FUNCTIONAL DIVERSITY IN LACUSTRINE ECOSYSTEMS IMPACTED BY MINE TAILINGS: DISTINCTIONS BETWEEN SHALLOW AND DEEP LAKES



Gleice de Souza Santos (Universidade Federal de Ouro Preto); **Edissa Emi Cortez Silva** (Universidade Federal de Ouro Preto); **Eneida M. Eskinazi-Sant'Anna** (Universidade Federal de Ouro Preto)

LINK TO THE STUDY VIDEO

We hypothesized that shallow lakes present higher functional diversity of zooplankton in comparison with deep lakes due to the role of environmental complexity provided by macrophytes. Surveys were performed in 6 lacustrine ecosystems located at Lower Rio Doce basin, affected by Fundão tailing dam failure (Brazil). Zooplankton (sampled with 68µm net), limnological variables and metal concentrations were obtained from November 2018 to September 2019 at surface of limnetic zones. Matrices of density (ind.L-1) and functional attributes of the 67 species from shallow and deep lakes (<3 m and >3 m of depth, respectively) were used for measuring Functional richness (FRic), Functional evenness (FEve) and the number of functionally singular species (FSin) of zooplankton. These metrics were compared between shallow (n=3) and deep lakes (n=3). A cluster analysis was performed based on the matrix of functional traits. The relationship between densities of groups formed, limnological variables and metals were explored using a Redundancy Analysis (RDA). Deep lakes presented higher FRic, FEve and FSin compared to shallow lakes (Student's t-test, $p<0.05$). The cluster identified the groups: G1-calanoid copepods, G2-cyclopoid copepods, G3-filter feeder cladocerans and G4-scraper feeder cladocerans and rotifers. The RDA showed distinction between samples of shallow and deep lakes and explained 43% of the variability of the groups formed by the cluster. The G1 and G3 were positively influenced by iron, total organic carbon and total phosphorous of shallow lakes. The G2 and G4 were more influenced by chlorophyll a and related to deep lakes. We suggest that larger and deeper lakes provided more niche opportunities for zooplankton, which increased its functional diversity. A likely high predation pressure (by planktivorous fish) on G1 and G3 in deep lakes increased the importance of these groups for shallow lakes, despite the high metal concentration of these systems.

functional traits; functional richness; dam failure; iron

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STABLE ISOTOPE ANALYSES OF FISH COMMUNITIES IN AMAZONIAN WHITE- AND BLACKWATER FLOODPLAIN LAKES: IMPLICATION OF CARBON, NITROGEN AND HYDROGEN ISOTOPES

SESSION 06

Helen Agasild (Chair of Hydrobiology and Fishery, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences); **Arvo Tuvikene** (Chair of Hydrobiology and Fishery, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences); **Tõnu Feldmann** (Chair of Hydrobiology and Fishery, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences); **Katrit Karus** (Chair of Hydrobiology and Fishery, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences); **Tiina Nõges** (Chair of Hydrobiology and Fishery, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences); **Priit Zingel** (Chair of Hydrobiology and Fishery, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences)

The main objectives of the study were to analyse the food web structures and carbon sources of fish communities in two lakes of Central Amazonian floodplain: Lake Janauaca (Solimões River basin, white water) and Lake Prato (Rio Negro basin, black water). The research was performed during the high water level season (March 2016). The collection of fish in each lake was done during 24 hours by means of multisized Nordic type gillnets (12 sections, mesh size 5 – 55 mm, floating and sinking). In total, 57 fish species belonging to different feeding types (piscivorous, planktivorous, herbivorous, invertivorous, detritivorous, omnivorous) were analysed for stable isotopic composition of carbon, nitrogen and hydrogen. The results showed similar 13C range of basal food sources and fish communities between the lakes, while the 2H values of fish were more distinct and enabled differentiation of energy sources used in the food webs in the studied lakes.

Amazonian floodplain lakes, food web, fish, stable isotopes, carbon sources

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WATER HYACINTH TRAITS CONTROL METHANE EMISSIONS FROM FRESHWATER ECOSYSTEMS



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Wetlands are the largest contributors to natural methane (CH4) emission to the atmosphere. One of the emission pathways occurs through macrophytes, bringing CH4 from the sediment to the atmosphere. This study highlights the role of Eichhornia crassipes' traits in mediating CH4 emissions. We combined field data of CH4 emissions from Water hyacinth beds with results of laboratory experiments quantifying plant-mediated CH4 fluxes. The objectives of our study were to: (1): Investigate the influence of plant traits (i.e. biomass, surface area and vitality) on CH4 emission mediated by E. crassipes. (2): Investigate the role of key environmental factors mediating CH4 emission through E. crassipes. The field as well as the laboratory results clearly indicate that CH4 emission intensities increase proportionally with plant biomass, leaf/bulb surface and volume. In addition, we found plant vitality to impact CH4 emission. Intact plants emitted +/-25% more CH4 compared to artificially perforated plants. Within plant CH4 concentration and temperature varied greatly, with highest CH4 concentrations occurring in old bulbs. In the field as well as in the laboratory we found a strong positive relation between the CH4 concentration in the water surrounding the plant roots and plants' CH4 emission. A similar correlation was found for temperature. With a 36% rise in water temperature, emission intensities became on average 58% higher. CH4 emission intensity was not related to light intensity and CO2 uptake, suggesting that stomatal conductance plays no or only a minor role in plant-mediated CH4 emission. This study clearly shows that intra species trait variation can strongly govern ecosystem process rates. To accurately predict CH4 emissions from macrophytes these traits should be taken into account.

Eichhornia crassipes, plant characteristics, environmental factors, gas transport mechanism, greenhouse gas emission

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VARIABLE RESPONSES IN THE DEMOGRAPHY OF BRACHIONUS HAVANAENSIS (ROTIFERA) EXPOSED TO COPEPOD ALLELOCHEMICALS



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Members of the rotifer genus Brachionus respond to allelopathic communication with other zooplankton species. This chemically mediated communication can modify life history characteristics of the interacting species. Allelopathic communication in zooplankton species, especially between rotifers and copepods is poorly studied. In nature rotifers compete for food with both calanoids and cyclopoids, especially during their larval stages. In addition, females and males of a given copepod species may have different allelopathic effects on rotifers. To test this, we obtained daily but separately the conditioned medium (CM) from females and males of Arctodiaptomus dorsalis and Mesocyclops sp. Subsequently, the CM was used as test medium for conducting standard cohort life table experiments with Brachionus havanaensis. The CM of A. dorsalis, despite having no significant differences between males and females, caused a 15% reduction in survival parameters, and 35% decrease in the gross and net reproduction rates, while the generation time decreased by 10%. On the other hand, CM from males of Mesocyclops sp. had a 15% reduction in survival of B. havanaensis. Our study suggests that type of interaction that occurs between copepods and rotifers is more complex than is generally interpreted in terms of resource competition or predation.

life-histories allelopathy

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FISH-MEDIATED STABILITY OF ZOOPLANKTON-ALGAE DYNAMICS IN FRESHWATER SYSTEMS: THE IMPACT OF INDUCIBLE DEFENSES BY DAPHNIA

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The dynamics of Daphnia-Algae populations are a well-studied topic in freshwater ecology, and the addition of fish as a zooplankton predator is understood to have a stabilizing effect. Although antipredator behavior in zooplankton species as a response to fish presence is common, little is known about how inducible defenses can affect the stabilizing fish effect on these population dynamics. Inducible defenses may protect the zooplankton population against fish predation, but the development of defenses is generally assumed to impose metabolic or growth costs. In this work, we modify a well-established differential equation model to assess the effect that the manifestation of inducible defenses in Daphnia can have in a tritrophic web stability. Parameters are selected to reflect the original model as much as possible, while phenotypical plasticity parameters are obtained from the available literature. Using continual time analysis and bifurcation diagrams we show that inducible defenses can lead to system stability, but this will depend very much on the tradeoff between costs and benefits of such defense. Increasing costs, such as reducing the food assimilation efficiency of the defended zooplankton, produce a stabilizing effect, while low defense costs can lead to non-stability for any predation level. Thus, the originally found stabilizing effect of the occurrence of fish predation may not change due to the development of inducible defenses, as long the associated costs imposed on the defensive trait are high enough.

Phenotypic plasticity; Temporal variability; Mathematical modelling; Shallow lakes; Antipredator behavior; Predator-prey dynamics.

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MULTIVARIATE PHENOTYPIC TRAJECTORIES ALONG TEMPERATURE AND SPECIES RICHNESS GRADIENTS



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Understanding phenotypic responses to global change requires understanding how species traits change along an abiotic and biotic gradient. We estimated multivariate phenotypic trajectories of six freshwater ciliate species along a full-factorial design of six temperature times six species richness treatments. We found that species in higher temperatures and more species rich treatments ‘travel’ more in trait space (larger gross distance), but this did not necessarily result in larger trait distances between start and end point of a phenotypic trajectory or in more straight trajectories. When comparing phenotypic trajectories between treatments we found that trait distances between temperature treatments showed a more general patterns of increase during the first period of the experiment, followed by a decrease in trait distances between temperature treatments. Trait distances between richness treatments patterns were more species-dependent and showed less consistent patterns. While the results of this study are mainly explorative, it may provide important first steps to identify general patterns in multivariate trait changes along an abiotic and biotic axis of change.

phenotypic trajectories, freshwater ciliates, multivariate trait change, species diversity, temperature

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EXPERIMENTAL EVIDENCE OF RAPID HERITABLE ADAPTATION IN THE ABSENCE OF INITIAL STANDING GENETIC VARIATION



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LINK TO THE STUDY VIDEO

Selection on standing genetic variation is most often considered the dominant mechanism underlying rapid microevolutionary change in metazoan populations. However, a relevant question is to what extent populations may rapidly adapt to adverse conditions via alternative mechanisms, such as environmentally induced genetic modifications and non-genetic heritable phenotypes. The existence of such mechanisms may be very important to eco-evolutionary dynamics because they would provide an alternative accelerated pathway to adaptation. To test if adaptation can rapidly occur in the absence of initial standing genetic variation and recombination in small populations, replicate populations of the micro-zooplankton Brachionus calyciflorus composed of one of two genotypes were exposed to a culturing regime that selected for phenotypic variants with elevated population growth with either high or low phosphorus food for a period of 55 days. Population level responses were examined in two fully factorial common gardens at the midpoint and end of the exposure experiment. We observed a rapid (five generations) heritable adaptive response to nutrient limitation. However, the capacity for this shift in performance differed between the two genotypes studied. This study provides a clear example of rapid local adaptation in response to exposure to a stressful environment based on de novo heritable variation in an animal population. Our results suggest that alternative sources of phenotypic variation may play a role in adaptation and could aid in the establishment and persistence of populations with low genetic diversity.

non-genetic inheritance, phosphorus limitation, intraspecific variation, Brachionus calyciflorus

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RAPIDLY EVOLVING ZOOPLANKTON IN A SALINIZING WORLD: TO WHAT EXTENT DOES ADAPTATION TO ONE SALT INCREASE TOLERANCE TO ANOTHER ONE?



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In many parts of the world, freshwater organisms are increasingly exposed to higher levels of salinization, due to rising sea levels, increased evaporation, intensified irrigation and fertilization, industrial pollution and the use of road salts. Stress due to salinization does not only involve increased osmotic pressure but, depending on salt chemical identity, also toxicity by salt ions. Rapid evolutionary adaptation is a mechanism through which populations of aquatic organisms may be able to cope with these challenges. The objectives of our study were to test (1) the capacity of populations of the freshwater rotifer Brachionus calyciflorus to rapidly adapt to increased salinization (i.e. within an ecological time scale), (2) if salts differ in toxicity and (3) if evolutionary adaptation to one type of salt alters the potential to cope with other types of salts? For this we performed a laboratory evolution experiment subjecting replicate populations to low and high NaCl treatments. A subsequent common garden transplant experiment showed that under saline conditions populations with a history of salt exposure had higher exponential population growth rates than populations with a freshwater selection history. In a second common garden, populations from the evolution experiment were exposed not only to NaCl but also to CaCl2 and NaSO4. In each of these treatments, salt levels were gradually increased until populations realized zero net population growth and the corresponding osmolarities were calculated. Comparisons of these osmolarities between salt treatments show that adaptation to NaCl increases the ability of populations to cope with toxicity due to calcium but not to sulphate ions. To conclude, our results suggest that in a metapopulation context evolutionary adaptation to one salt type may facilitate colonization of patches that are salinized by other types of salts, but this outcome will largely depend on salt chemical identity.

Rapid evolution, adaptation to stressors, salinization, salt toxicity

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MICROEVOLUTIONARY ADAPTATION TO STOICHIOMETRIC MISMATCH REDUCES CROSS TOLERANCE OF CONSUMERS TO SALINIZATION



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Interactive effects of multiple stressors on organisms are becoming the core to study how environmental changes affect consumers in nature. Recently, increasing evidence has also shown that evolution is able to happen at similar time scales as ecological interactions, and therefore should also be explicitly incorporated in ecological studies. Till now, how the evolutionary history and various environmental stressors can interactively affect organisms is still unclear. Here, we studied how the selection history may interactively affect a herbivourous rotifer, Brachionus calyciflorus, with two different common stressors in nature, i.e. P limitation and increased salinity. We took advantage of two categories of rotifer populations, i.e. P limitation adapted and saline adapted populations, which were obtained from two previous lab evolution experiments. We subjected these rotifer populations, as well as the ancestral (reference) populations to four combined stressor treatments, i.e. high P food with low salinity (HP-LS), high P food with high salinity (HP-HS), low P food with low salinity (LP-LS), and low P food with high salinity (LP-HS), respectively, and measured their population growth rates. Our results showed the under LP food, the increased salinity had no impact on reference populations. Interestingly, adaptation to P limitation reduced the ability of animals to cope with increased salinity, but not vice versa. The adaptive benefits to either P limitation were consistent across treatments, while the magnitude of advantages varied depending on the presence of an additional stressor. Our study suggests that evolutionary history may add another dimension of factor that interactively affect organism with various environmental stressors.

microevolution; salinization; phosphorus limitation; cross tolerance; rotifera; Brachionus calyciflorus

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TEMPORAL DYNAMICS OF PHYTOPLANKTON IN A SHALLOW AND MESOTHROPHIC LAKE (LAGOA SANTA, MINAS GERAIS, BRAZIL)



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The phytoplankton community is very diverse and composed of different taxonomic groups, which include microalgae and cyanobacteria. The community structure is governed by different environmental and biological interactions, and the predominance of one group over another in a given aquatic system is related to certain ecosystem characteristics. Here we will present results from a study performed in a shallow mesotrophic lake in Brazil, located in a karst system, which has been suffering from environmental degradation. In previous years, this lake presented a permanent and stable dominance of Raphidiopsis raciborskii, a potentially toxic cyanobacteria. To follow up the dynamic of the phytoplankton community and verify the environmental factors that govern it, we performed sampling over a temporal gradient. Water physical and chemical characteristics were evaluated, as well as the phytoplankton community, through identification and quantification of organisms. The study revealed an alternation of dominance between Cyanobacteria and Chlorophyta. Differently from previous observations, the cyanobacteria species R. raciborskii dominated the community only during part of the year. The water column stratification and mixing processes observed in the lake may have favored the changes that occurred in the species composition and dominance patterns. A functional traits approach, used in the present study, was important to understand the strategies adopted by each species. Environmental variations seem to have produced an alternation between r- and K-strategist species over the temporal gradient. Biological interactions, like competitive exclusion to which phytoplankton species are subject, must also have contributed to the changes observed in the community. By focusing on the species morphological and ecological characteristics, it was possible to better understand the responses of the phytoplankton community in face of changes occurring in the ecological structuring factors.

Cyanobacteria, Raphidiopsis raciborskii, diversity, community, functional traits.

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LOCAL PATTERNS AND DRIVERS OF FUNCTIONAL TRAITS IN NUPHAR LUTEA



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LINK TO THE STUDY VIDEO

Macrophytes are getting increasing attention because of their multiple roles in aquatic ecosystems. However, eutrophication, invasive species and habitat degradation are threatening macrophytes and freshwaters globally. In this context, the use of functional traits (FTs; i.e. specific features measured at species/individual level) can give more quantitatively translatable information than the traditionally adopted taxonomic approach about their ecosystem functions and community dynamics. Here, we incorporate a local patterns approach (hundreds of meters) into trait-based macrophytes investigation, focusing on yellow water lily (Nuphar lutea (L.) Sm.). Our aim is to quantify the intra-specific plasticity of a wide set of functional traits (including leaf economic spectrum and pigments), integrated with genetic and spectral reflectance data at leaf to canopy scales, linking to ecological patterns. All data were collected from a hyper-eutrophic shallow lake, Chiusi Lake (Tuscany, Central Italy). We found support for trait meso-scale patterns along the main environmental gradients, expressed in terms of water depth, conductivity, and sediment features. A preliminary PCA analysis confirmed what previous studies had shown for aquatic and terrestrial plants, namely that the two main axes of traits variation are related to dimensional traits (leaf weight – LW – and area – LA) on one axis, and Leaf Dry Matter Content (LDMC) and Specific Leaf Area on the other. More specifically, we found that LW and LA, including the contribution of petioles, are positively related to water depth, while leaf pigments content shows a strong relation to water conductivity and sediment phosphorous. This evidence suggests a relevant environmental filtering force on intra-specific responses to abiotic factors and reinforces the key contribution of intraspecific trait variability to shed light on spatial patterns within ecosystems.

Nuphar lutea - macrophytes - functional traits - water depth - sediment - SLA

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ZOOPLANKTON TRAIT VARIATION ALONG ENVIRONMENTAL GRADIENTS IN SHALLOW LAKES FROM THE LOWER PARANÁ RIVER FLOODPLAIN (ARGENTINA)



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The floodplain of the Lower Paraná River is a mosaic of wetlands that includes numerous shallow lakes and hosts an exceptional high biodiversity. The local environmental conditions of the shallow lakes change constantly according to the discharge regime of the river, thus constituting a major challenge in understanding the distribution of biodiversity. We studied zooplankton (rotifers) communities in shallow lakes that differed in their connectivity to watercourses (connected/isolated) during different hydrological conditions (potamophase and limnophase). We used a trait-based approach to explore changes in community composition and functional diversity along environmental gradients in each phase and between them. Our results revealed a gradient of environmental conditions associated with the connectivity, which persisted at limnophase and potamophase conditions. Connected lakes presented high turbidity, suspended solid and nutrient concentrations, while disconnected lakes showed opposed features and could develop either low or high phytoplanktonic chlorophyll a concentration (representing clear or organic turbid conditions, respectively). The environmental heterogeneity of the lakes was similar between hydrological phases and connectivity of the lakes. Our first results regarding the zooplankton community indicate that functional diversity tended to increase during limnophase and in isolated lakes, and that individual community trait values were similar between phases and lakes connectivity. The community trait-environment relationship was overall weak and stronger during limnophase, and turbidity resulted in the most important variable in both conditions. Our results show that the connectivity of the shallow lakes determines their local environmental conditions and seems to have a weak influence on rotifers trait composition and functional diversity.

rotifers, connectivity, riverine floodplains, turbidity

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EFFECTS OF CLIMATE CHANGE ON SHALLOW LAKES

SESSION 07

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Shallow lakes around the world are being affected by climate change, and that includes changes in their physics, chemistry and biology, as well as interactions between their internal compartments and with their surrounding watersheds. The ecological responses of shallow lakes to climate change will become even more pronounced in the future, with continued global warming, increased evapotranspiration, altered patterns of rain and drought, and disrupted or amplified climate teleconnections. The ability of shallow lakes to provide habitat to aquatic species and ecosystem services to society is threatened as lakes diminish in size, become more saline, and/or have highly altered thermal properties. This thematic session welcomes research on how shallow lakes around the world are changing in response to climate warming as well as the expected future changes.

ZOOPLANKTON DIVERSITY AND TRAITS IN SHALLOW WATERBODIES OF TEMPERATE AND MEDITERRANEAN REGIONS OF EUROPE

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SESSION 07

LINK TO THE STUDY VIDEO

Zooplankton assemblages (Rotifera, Cladocera, Copepoda) have been assessed in over 30 shallow lakes and ponds, from temperate to Mediterranean regions of Europe (Poland, Croatia, Albania, North Macedonia, Greece). We presumed that zooplankton diversity, ecological and functional trait differences will correspond with environmental specificity more than geographical distance. Thus, the main idea was to compare different latitudinal and climate regions (temperate and Mediterranean), in order to provide insight into the possible future function of shallow lakes in a changing climate. Shallow waterbodies in both regions were selected by different area, depth, macrophyte coverage, phytoplankton biomass and fish stock with the aim to distinguish both climate and environmental specific factors affecting zooplankton. Preliminary results revealed that ecosystem heterogeneity, associated with macrophyte coverage, increased the diversity of zooplankton, irrespective of the climatic region. The opposite effect was observed in the case of fish presence, which in both climates decreased zooplankton diversity. Salinity is indicated as a specific driver in the Mediterranean region and it negatively impacted diversity. Along a latitude, the zooplankton abundance:biomass ratio indicated pronounced deterioration and higher densities of small-sized species in warmer regions in comparison to colder ones. The obtained results suggested a significant contribution of zooplankton to the biodiversity of shallow waterbodies and the pressing need for supporting the protection and sustainability of these vulnerable and valuable aquatic ecosystems.

Rotifera - Cladocera - Copepoda - macrophyte - fish - Eastern Europe

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DIRECT EFFECTS OF ELEVATED PCO2 MODULATE LIFE HISTORIES IN THREE FRESHWATER MODEL ORGANISMS



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Atmospheric CO2 is increasing globally and this alters environmental conditions in freshwater ecosystems. Small and shallow lakes are especially sensitive to increasing pCO2 (partial pressure of CO2) because of their large surface-to-volume ratio and absence of stratification. Thus far, most research has focused on indirect effects of pCO2 on primary consumers via primary producers. However, currently it is unclear to what extent pCO2 could have a direct effect on the life history of different primary consumers in freshwater. In a large-scale experiment, we exposed three model species representing three main functional groups of primary consumers (the water flea Daphnia magna, the ostracod Heterocypris incongruens and the rotifer Brachionus calyciflorus) to a realistic and extreme pCO2 scenario. We found that both scenarios of elevated pCO2 result in strong life history responses in the tested species. pCO2 decreased survival in all species under an extreme scenario, however the water flea was much more sensitive. Elevated realistic pCO2 reduced body size in the ostracod and the water flea. In addition, reproduction was delayed in all three species. We also found indications for acclimation in the ostracod and the rotifer while in the water flea, genetic variation in pCO2 sensitivity could be present. The variation in responses found among the different taxa indicates that direct effects of CO2 may lead to shifts in freshwater communities. Overall our results show that direct effects of future pCO2 levels on freshwater primary consumers may not be negligible and should be considered in attempts to model species responses to a changing biosphere. We conclude that, by differentially modulating life history in different functional groups, elevated pCO2 has the potential to change the evolutionary trajectories of populations as well as the ecological functioning of freshwater communities.

carbon dioxide - life history - primary consumers

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LAKE FOOD WEBS AND C METABOLISM ACROSS GRADIENTS OF CATCHMENT ALKALINITY AND CLIMATE

SESSION 07

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Based on the carbon balance, continuous measurements of lake metabolism, and C isotopic analysis, we assessed in Lake Võrtsjärv (270 km2, mean depth 2.8 m, Estonia) how a shallow alkaline lake influences the geological absorption of CO2. While most of the dissolved inorganic carbon (DIC) stream from the catchment flows unchanged through the lake, sedimentary calcite and much of the organic carbon settling in the lake are sourced from the catchment and not from the atmospheric gas exchange. This large and shallow eutrophic temperate lake proved to be relatively carbon neutral, where only during periods of intense photosynthesis the CO2 saturation drops to such level that it is taken from the atmosphere. The dynamics of dissolved oxygen (DO) and DIC in eight lakes covering a wide range of alkalinity suggest that at low alkalinity, DIC dynamics is mostly driven by aquatic metabolism but this relationship weakens with increasing alkalinity due to calcite precipitation. We could also show that large lakes are less sensitive to climate change than small lakes. However, the increase in nutrient content and water levels caused by climate change would enhance lake productivity and emissions of greenhouse gases including methane, some of which could be used as carbon source in aquatic food chains. Global warming and eutrophication will also increase the biomass of cyanobacteria, including toxic and bloom-forming species, in shallow eutrophic lakes. We have shown that cyanobacteria can make up the bulk of cladocerans diet. In Lake Peipsi (3555 km2, mean depth 7.1 m, Estonia/Russia) zooplankton eats Microcystis, the main toxin-producing cyanobacterium. If lakes continue to warm and get more eutrophic, the role of protozoans, especially ciliates, will increase and they will become the most important link between bacteria and the higher levels of the food chain. We have shown that ciliates play also an important role in the diet of fish larvae securing their survival.

Carbon cycle, food web, lake metabolism, methane, climate change impacts

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NITROGEN FERTILIZATION AND WARMING DRIVE CHANGES IN THE METHANE-OXIDING COMMUNITY OF SHALLOW LAKES

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SESSION 07

LINK TO THE STUDY VIDEO

Wetlands, including shallow lakes, are the largest contributor to natural emissions of methane (CH4), a 34 times stronger greenhouse gas than CO2. Shallow lakes are changing due to the effects of eutrophication and global warming, which increases their CH4 emissions. However, dynamics in the methane-oxidizing community of the sediment, which mitigate shallow lake CH4 emissions, are still poorly understood. We sampled the longest running (>16 years) eutrophication and warming shallow lake mesocosm experiment worldwide. The experimental setup consisted of 24 mesocosms with two nutrient treatments (N/P fertilized or not fertilized) and three temperature treatments (ambient, +2/3°C, +4/5°C). The year prior to sampling no nitrogen was added and we sampled 0, 8 and 52 weeks after nitrogen fertilization restarted. We determined CH4 emissions, methane-oxidizing bacteria (MOB) abundance, potential methane oxidation rates and MOB community composition.We found that nitrogen fertilization led to increased CH4 emissions, MOB abundance and potential methane oxidation rates. Warming increased MOB abundance but did not affect CH4 emissions or potential methane oxidation rates. There were distinct MOB communities in mesocosms of different temperature and nutrient load. Warming was correlated positively to Methylocystis and negatively to Crenothrix, while fertilization was positively correlated to Methyloparacoccus. Additionally, warming favoured type II MOB over type I MOB, which could be because of their slower growth rate. Consequently, the MOB community shifted from a community dominated by type I MOB to a community co-dominated by type I and type II MOB. This shift could potentially explain why warmed mesocosms, which had a higher MOB abundance, did not have higher potential methane oxidation rates. Overall, we show that eutrophication and global warming change the MOB community, which may result in an altered ability to mitigate CH4 emissions from shallow lakes.

Methane-Oxidation Climate-Change Microbial-Community Eutrophication Methane-Oxidizing-Bacteria Greenhouse-Gas-Emissions

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EFFECTS OF TEMPORARY STRATIFICATION ON GREENHOUSE GAS DYNAMICS IN A EUTROPHIC LAKE



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Greenhouse gas (GHG) emissions from lakes has been the focus of much research over recent years. This has highlighted both a paucity of data and the potential for positive feedbacks with climate change. The effects of climate change are manifold with both direct and indirect effects. Here we seek to investigate an indirect effect; the likely increase in frequency and duration of temporary stratification which will result from higher air temperature and more frequent heat waves. This is relevant as shallow lakes are both hot spots for the biogeochemical processes leading to GHG production, numerous globally and likely to be most affected by temporary stratification. Previous studies have suggested that stratification may potentially promote the production of the GHGs, in particular, methane (CH4) through more profound anoxia in the sediment, while others suggest reduced temperature at the sediment surface might reduce CH4 production and also slow respiration reducing carbon dioxide (CO2) production. Here we use data from Ormstrup lake in Denmark to investigate how temporary stratification, recorded by high frequency temperature measurement, effected the dynamics of the three main GHGs: CO2, CH4 and nitrous oxide (N2O). Dissolved gas concentrations in the surface and bottom waters were measured weekly for all three gases and bubble or ebullitive flux of CH4 was estimated from 40 bubble traps placed on the lake and sampled every two weeks. The studied lake underwent stratification for three weeks in June and a little over 3 weeks in August. Over these periods, CH4 concentrations reached 10 000 and 8500 ppm in the bottom waters of the lake – which was presumably released in a short period of time upon lake turnover. This was estimated to have released over 300 kg of CH4 on both occasions. Ebullitive CH4 flux also increased 4 fold during the stratification period with emissions rising to over 10 kg per day during stratification periods.

Stratification methane Greenhouse gases

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PATTERNS AND PROCESSES OF CH4 PRODUCTION AND OXIDATION IN DIFFERENT HABITATS FROM EXPERIMENTAL LAKES ON A GRADIENT OF TEMPERATURE AND NUTRIENTS



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Methane (CH4) is the second most important GHG after CO2 and wetlands, including shallow lakes, are the largest contributor to its natural emissions. Therefore, it is important to understand the patterns and controls of emissions from shallow lakes. The release of CH4 as bubbles, ebullition, in shallow lakes increases with higher temperature and eutrophication. Recent studies have indicated that increased submerged macrophyte abundance is associated with markedly lower rates of CH4 ebullition, while nutrient enrichment and increase of chlorophyll promotes CH4 release as bubbles. Therefore, the identity of the dominant primary producer, that is submerged plants versus phytoplankton, is crucial in shaping ebullition, the mechanisms at work however, are still not clear. Therefore, the aim of the experiment was to characterize the methane production/oxidation patterns in shallow lakes in the different habitats at different temperature and nutrient levels, which also had different macrophyte abundance.The experiment took place at the world's longest running (>16 years) eutrophication and warming shallow lake mesocosm experiment at AU, Denmark. The experimental setup consists of 24 mesocosms with two nutrient treatments (N/P fertilized or not fertilized) and three temperature treatments (ambient, +2/3°C, +4/5°C). Diffusive and ebullitive CH4 emissions were estimated from dissolved gas concentrations and from bubble traps respectively. Using bottle incubations, potential methane production was estimated for the upper layer of the sediment. In addition, the activity rate of methane oxidizing bacteria (MOB) associated with the different primary producers has been measured in each habitat (plant surfaces, submerged and floating filamentous algae, periphyton, sediment and seston) and determined using bottle incubations. How the production and consumption of CH4 in the different habitats relates to total emission will be discussed.

Greenhouse gases, methane production/oxidation, macrophytes

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INVESTIGATING THE EFFECTS OF INCREASED WATER TEMPERATURE AND AGRICULTURAL RUN-OFF ON SHALLOW LAKE ECOSYSTEM METABOLISM USING A MESOCOSM APPROACH



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Shallow lakes are the most abundant lake type worldwide, most of which are becoming warmer due to climate change. In agricultural regions, they are often subjected to chemical pulses of Agricultural Run-Off (ARO) containing pesticides and fertilisers. In many regions of the world, this pollution mechanism is enhanced by: (1) an increasing demand for agricultural products; (2) more frequent and intense rainfall events due to changing weather patterns; and (3) human-driven land cover alterations that favor run-off over infiltration (e.g., deforestation of rural catchments). The French-German project CLIMSHIFT investigates how these multiple stressors may affect the ecological functioning of shallow lakes and their resilience to undergoing abrupt shifts between alternative stable states. In the summer of 2019, an 8-week experiment was carried out using 16 outdoor mesocosms (600 L) inoculated with periphyton, phytoplankton, zooplankton, benthic macroinvertebrates (Dreissena polymorpha and Lymnaea stagnalis) and macrophytes (Myriophyllum spicatum, Potamogeton perfoliatus and Elodea nuttallii). Half of these mesocosms were artificially heated up, constantly kept 3°C warmer than the non-heated ones. A gradient of eight concentrations of a specified mix of organic pesticides, copper sulfate and potassium nitrate was applied to each group as a single, initial pulse. Oxygen, water temperature and illuminance loggers were installed in all mesocosms. Based on these data and information from public weather stations, we estimated daily, whole-mesocosm metabolic rates within a Bayesian statistical framework. Moreover, using generalized linear models and examining responses in light of complementary data, we attempted to disentangle the effects of warming and ARO. Estimates indicate all mesocosms were dominated by autotrophic processes, and that increased temperature and ARO pulses affect net ecosystem productivity in opposite directions, likely through indirect, cascading effects.

climate change, agrochemical pollution, multiple stressors, alternative regimes, shallow lakes, Bayesian statistics, ecosystem metabolism, generalized linear model

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THE IMMEDIATE RESPONSE OF FRESHWATER PHYTOPLANKTON TO INCREASED NITROGEN LOADING DIFFER AMONG CLIMATE WARMING SCENARIOS- A MESOCOSMS EXPERIMENT

SESSION 07

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The freshwater environments of the 21st century face several critical challenges. One is elevated water temperatures due to climate change and another is eutrophication caused by nutrient enrichment, and temperature and nutrients interactions may show synergistic effects as well.A much debated question is the relative importance of the two key nutrients – phosphorus (P) and nitrogen (N), responsible for the eutrophication process. To evaluate the effects of global warming and increased nitrogen loading on the phytoplankton of shallow eutrophic lakes, a flow-through experiment combining three temperature scenarios crossed with two nutrient levels was conducted in 24 outdoor mesocosms located in Denmark. A year prior to our study N-loading was reduced to a low level in all high nutrient level tanks while P loading was kept at high level. In the next summer (2019) N-loading was returned to the pre-reduction level. Phytoplankton community was tracked from May to August after the N-loading increase employing diagnostic pigments that were measured by high performance liquid chromatography. The phytoplankton biomass in N-limited mesocosms started to increase quickly after the N-loading was restored. The overall increase was highest in the mesocosms 2-3 °C above the reference. While the effect of increased N-loading on phytoplankton was more pronounced than the effect of temperature, its impact on phytoplankton groups varied – e.g. chlorophytes did not exhibit clear increase in biomass while an apparent build up occurred for cyanobacteria related diagnostic pigments.

Phytoplankton, Climate warming, Nitrogen

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THE COMBINED EFFECT OF AN ELEVATED TEMPERATURE AND THE PRESENCE OF HYPOXIA ON THE INTERSPECIFIC COMPETITION IN DAPHNIA



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Numerous studies have revealed an apparent decrease in individual body size among a variety of aquatic ectotherms, as well as the mean body size of their populations and communities at an elevated temperature, either spatially or temporally. In the case of zooplankton communities, one of the most likely explanations of the patterns is the relative decrease of the competitive abilities of larger- over smaller-bodied species because the production (i.e. growth and reproduction) of individuals of larger species is more limited due to their greater susceptibility to decreased oxygen at an elevated temperature either through a decreased oxygen concentration or increased oxygen demands (due to an accelerated metabolism). To test this, we performed competitive experiments at high and low oxygen concentrations (8.0 and 3.0 mg O2 L-1) at two temperatures (23 and 13 ºC) with two pairs of zooplankton species differing in body size: Daphnia longispina (smaller-bodied) and D. pulex (larger-bodied), as well as D. pulex (smaller-bodied) and D. magna (larger-bodied). In the case of D. longispina and D. pulex, our hypothesis was not confirmed, since larger-bodied species competitively excluded smaller species in all of the experimental treatments. Although in the case of D. pulex and D. magna, both species successfully coexisted for a very long period of time in all of the treatments, their relative densities were affected by both experimental variables. In accordance to our hypothesis, elevated temperature favoured smaller-bodied species. However, contrary to our hypothesis, low oxygen concentration favoured larger-bodied species, possibly due to higher haemoglobin concentrations in their tissues.

climate change competition freshwater zooplankton hypoxia

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POND STRATIFICATION IS COMMON, AND MAY INTENSIFY WITH CLIMATE CHANGE

SESSION 07

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LINK TO THE STUDY VIDEO

Lake mixing status is a primary characteristic used to categorize lentic waterbodies and describe ecosystem function. For instance, lake mixing patterns influence nutrient recycling, ecosystem metabolism, oxygen availability, and greenhouse gas emissions. Small and shallow waterbodies, such as ponds, are often assumed to be perpetually well-mixed systems. Yet, recent studies suggest that ponds may have more complex mixing patterns, ranging from well mixed to rarely mixed systems. In this study, we examined mixing patterns and their drivers for 39 ponds across Europe and North America. We found that during the summer, ponds fit into one of three mixing classes: frequently mixed, intermittently mixed, and rarely mixed, with the latter being most common. Pond depth and surface area partially predicted mixing type, with larger (> 41,702 m2) systems tending to mix frequently, smaller and shallower (< 0.74 m) systems tending to mix intermittently, and smaller and deeper (> 0.74 m) systems rarely mixing. Pond sheltering also mattered, with ponds in open landscapes exhibiting more mixing. Our results also suggest that pond mixing patterns may shift under climate change. Specifically, we found that in rarely and intermittently mixed ponds, stratification strength increased with increasing air temperature, whereas, in well mixed systems, wind most strongly predicted changes in stratification strength. As temperatures rise, we may see stronger stratification in small systems that are already infrequently mixed. Overall, ponds exhibit more diverse mixing patterns than previously assumed, which likely have consequences for how pond ecosystems function.

pond, mixing, thermal profile, temperature

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EFFECTS OF CHANGES IN N LOADING AND WARMING ON NUTRIENT LIMITATION OF PERIPHYTON: AN APPROACH USING QUANTITY AND QUALITY PROXIES

SESSION 07

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Periphyton is a key contributor to primary productivity, particularly in environments with a developed littoral area. The growth of lake periphyton is often limited by the availability of N and P. Limitation of periphyton growth by nutrients may be further impacted by climate warming. The quality, measured as the fatty acids (FA) composition of periphyton, also differs in aquatic ecosystems under differing nutrient and warming conditions. The objective of the present study was to elucidate how nutrient limitation affects periphyton quantity (measured as Chlorophyll-a, Chl-a) and quality (measured as FA), in mesocosms mimicking shallow lakes with contrasting temperatures (climate warming scenarios). In these mesocosms the external N-loading was reduced substantially for 1 year before it was again raised to normal high level. We added nutrient diffusion substrata (NDS, 2% agar alone or releasing N, P and combined N and P with a GF-F filter on top) to 12 mesocosms on the two occasions (before and after return to the normal high N-loading). In each occasion, the NDS remained in the mesocosms for 21 days to allow colonization by periphyton. We then measured periphyton Chl-a and FA amounts and composition. The analysis of Chl-a of the first NDS experiment indicated that the ambient temperature and the +3ºC scenario were N-limited in the low N-loading scenario. However, the warmest scenario (+4.5ºC) did not show any differential response to the addition of nutrients, either single nutrient limitation or co-limitation. The N limitation was not evident any more in the second NDS experiment in the high N-loading scenario. The FA profiles of periphyton growing in the NDS before and after the N-loading showed differences in physiological important FA as eicosapentaenoic acid (EPA). We showed that the quantity and quality of the periphyton changes with N-loading with differential effects in the different warming scenarios.

Periphyton

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ANALYSIS OF TIME SERIES OF THE ESSENTIAL CLIMATE VARIABLES FROM ESA CCI LAKES: A CASE STUDY IN A SHALLOW ITALIAN EUTROPHIC LAKE

SESSION 07

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Lakes are integrators of environmental and climatic changes occurring within their contributing basins. Understanding the complex behavior of lakes in a changing environment is essential to effective water resource management and mitigation of climate change effects. The CCI Lakes is a project combining expertise in the remote observation of lake water extent, lake level, ice cover, surface water temperature and surface water reflectance, founded by the European Space Agency. In the present study, the Lakes CCI satellite data package was used to analyze a time series of Chlorophyll-a (Chl-a), Turbidity and Lake Surface Water Temperature (LSWT) for Lake Trasimeno, a shallow eutrophic lake of central Italy which is included in the Long-Term Ecosystem Research network. ENVISAT and SENTINEL-3 satellite data from the sensors MERIS (2002-2012) and OLCI (2016-2019), were used to retrieve Chl-a and turbidity and AATSR and SLSTR were used to produce LSWT maps and data. In situ data of the parameters analyzed were obtained from the LTER dataset to validate and integrate satellite derived data. Meteo-climatic data were extracted to analyse the interrelationships between the trend in water parameters and climate factors. The North Atlantic Oscillation and Eastern Atlantic values were obtained from NOAA-CPC. Climatic data (wind speed and direction, precipitation, air temperature, cloud cover and humidity) were obtained from ERA5 - the fifth generation ECMWF reanalysis for the global climate and weather. Temperature has increased over 2 oC since the 1980s. Concordance in wind-driven algal dynamics was found between the satellite and high frequency in situ measurements. The high temporal frequency and the synoptic vision of the products analyzed over a period of almost twenty years has allowed us to have increased insight and improved the state of knowledge of the conditions and changes in the water quality of Lake Trasimeno and its relationship to climatic change.

Satellite, Trasimeno lake, chlorophyll-a, tubidity, water surface temperature

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FACING FUTURE TEMPERATURE EXTREMES AND CHANGES: HOW DO FRESHWATER ECOSYSTEMS UNDER CHEMICAL STRESS RESPOND TO REOCCURRING HEATWAVES AND INCREASED TEMPERATURES?

Markus Hermann (Wageningen University and Research); **Edwin Peeters** (Wageningen University and Research); **Paul van den Brink** (Wageningen University and Research)

SESSION 07

LINK TO THE STUDY VIDEO

Environmental alterations caused by a global changing climate is projected to push freshwater ecosystems and the various inhabiting forms of life outside of their thermal tolerance range. With an ongoing increase in global mean temperatures and more severe and frequent extreme weather events (i.e. heatwaves) expected until the end of the 21st century, aquatic ecosystems will face unprecedented environmental conditions. A strong decline in freshwater species documented over the past years indicate potential impacts of these natural pressures with, yet, unforeseen consequences due to unknown interactions with other anthropogenic stressors (i.e. chemicals). Most multiple stressor studies conduct experiments with single species and constant elevated temperature regimes. Population or community-level approaches including elevated, daily temperature fluctuations and thus natural variability are scarce. However, ecosystem complexity by considering intra- and interspecific interactions of species at the same or adjoining trophic level plus the variability factor in temperature are crucial aspects if we want to study chemical effects under environmentally relevant climate change scenarios. The study objective was to investigate the single and combined effects of future climate change scenarios (i.e. elevated temperature fluctuations, heatwaves) on zooplankton-dominated freshwater ecosystems under chemical stress (i.e. carbendazim). Temperature was operated in thirty microcosms by the Transportable temperature and heatwave control engine (TENTACLE). Results revealed a significant decline in the abundance of macro- and micro-zooplankton species after a heatwave under chemical stress. Copepods seem to be less sensitive towards thermal and chemical stress than crustaceans, while rotifers indicated high sensitivity for the combined stressors. Significant effects on primary producers were detrimental and differences in microbial degradation highlight the need for novel experiment.

global climate change, multiple stressors, temperature fluctuations, microcosm

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MEANS AND EXTREAMES - EFECTS OF CLIMATE WARMING SCENARIOS ON PLANKTON COMMUNITIES

SESSION 07

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LINK TO THE STUDY VIDEO

The ongoing global warming is characterized by a gradual increase in annual mean temperatures and an increased frequency and intensity of extreme heatwaves. Both can induce changes in the abundance, diversity, and richness of plankton communities, but comparative studies are largely lacking. Therefore, in a mesocosm experiment, we tested the effects of constantly increased (by 3oC) temperatures and recurring heat waves (+6oC) in a setup where both treatments received an identical energy input. This lasted for four weeks, followed by another four weeks where no treatment was applied to study ecosystem resilience. As a model community, we used the natural plankton of the large shallow Lake Balaton. Heatwaves were followed by an immediate increase in phytoplankton biomass. This was most likely a result of reduced grazing pressure by the decreasing densities of rotifers, likely driven by increased predation rates of copepods. At the end of the experiment, copepod abundances were significantly higher in heatwave treatments. The effects of constant warming were less visible in the short term, but phytoplankton biomass increased significantly towards the end. Our findings show that heatwaves can have immediate effects on biodiversity and trophic interactions, while the effects of constantly increased temperatures became only visible on a longer term, in line with the concept of press and pulse disturbances.

mesocosm, shallow lake, plankton, zooplankton, climate change, extreme event, heat wave.

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EFFECTS OF DOC QUALITY ON ZOOPLANKTON COMMUNITY STRUCTURE: A MESOCOSM EXPERIMENT



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While the climate-induced increase of allochthonous dissolved organic carbon (DOC) input to freshwater ecosystems is well studied, however, the effects of different DOC sources and their impact on seston quality, and in turn on the food webs and particularly on zooplankton biomass and composition is poorly understood. Accordingly, we tested the effects of recalcitrant and labile DOC pulse disturbances on zooplankton communities via outdoor mesocosm experiments for six weeks. We expected that zooplankton community biomass would be enhanced with labile DOC source compared to the recalcitrant, and zooplankton community composition would differ between particular DOC sources. Treatments included a single pulse of alder leaf leachate (L, labile DOC), Huminfeed (HF, recalcitrant DOC) and both together (HFL) compared to controls (no DOC). After day 10 of the experiment, relative to the control, zooplankton biomass increased in the L and HFL treatments but did not change in the HF treatment. The highest biomass increase was observed in HFL. Before the pulse, Ceriodaphnia spp. dominated approximately 60% of the total zooplankton biomass. At the end of the experiment, the community composition was different for L, HF and HFL. Unlike control, Daphnia spp. dominated (approx. 90%) biomass in L and HFL treatments, while Cyclopoid Copepoda and Diaphanosoma spp. were together (>50%) in HF. Despite the temporal variation, overall mean seston N:P ratio in L (mean+-std; 105.5+-47.1) and HFL (102.1+-35.2) was lower relative to HF (256.8+-117.9) and controls (208.4+-108.7). Additional seston phosphorus coming from labile DOC source led to lower seston N:P (molar) and in turn, may have favoured Daphnia spp. in L and HFL. Initial results demonstrated that labile DOC source could have major impacts on zooplankton biomass and composition, especially when it combined with recalcitrant DOC source.

Climate change, Dissolved organic carbon, Huminfeed, Pulse effect, Mesocosm, Freshwater, Zooplankton

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CHARACTERISATION AND IMPACT OF DIFFERENT ALLOCHTHONOUS ORGANIC MATTER ADDITIONS IN A MESOCOSM EXPERIMENT INVESTIGATING PULSE DISTURBANCE EVENTS IN MEDITERRANEAN SHALLOW LAKES



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Short periods of extreme precipitation are becoming more intense on top of longer drought periods. Such conditions boost the transport of allochthonous organic matter (allo-OM) to freshwater ecosystems. Yet, little is known about the changes in seston elemental stoichiometry and dissolved organic carbon (DOC) quality when different allo-OM sources impact planktonic communities. To date, studies of allo-OM disturbances to southern European aquatic systems are scarce. Therefore, during summer 2019, a mesocosm experiment located in a Turkish freshwater lake was designed to examine the alterations in the quantity and quality of carbon (C), nitrogen (N) and phosphorus (P) of dissolved and seston fractions after the pulse disturbance of three different allo-OM analogues. HuminFeed (HF) was used to increase water colour. The leaf leachate source (L) was used to examine the effects of the extra energetic inputs. Finally, the combination of both sources (HFL) was applied to test the interactions of the single treatment effects. Results indicated that L treatment added more colour than the HF treatment. HF increased the proportion of high recalcitrant humic-like DOC components, in contrast to the increase in less aromatic microbial derived humic-like molecules observed in L. HF added seston N and the L source mainly P. Seston C:P ratios remained below the P-limiting threshold in all tanks and temporal dynamics did not depend on the treatments. In contrast, seston N:P were significantly different for each treatment in that the L source reduced the P-limiting conditions, while HF increased them. We conclude that it is crucial to consider how the resources used to mimic real allo-OM input influence final outcomes extrapolated to real aquatic ecosystems. Consequences for planktonic communities will depend on the type of allo-OM used. New mesocosm studies should consider and better characterise other types of natural allo-OM sources.

climate change, allochthonous organic matter, pulse effects, HuminFeed, leaf leachate, DOC quality, seston nutrient stoichiometry, planktonic food webs

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EXTREME DROUGHT INCREASES BENTHIC MACROINVERTEBRATES BETA DIVERSITY IN SEMIARID RESERVOIRS IN BRAZIL

SESSION 07

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Global warming is expected to unveil unprecedented changes to freshwater ecosystems in drylands, mostly associated to water deficit increase and changes in the state and characteristics of freshwater bodies. These changes will increase reservoirs susceptibility to eutrophication leading to dramatic changes in the structure of benthic macroinvertebrates assemblages. This study hypothesizes that extreme droughts deteriorate reservoirs water quality and decrease environmental heterogeneity (EH), reducing functional and taxonomic diversity, and homogenizing the assemblages of benthic macroinvertebrates. To test this hypothesis, we used a comparative analysis of ecosystems in a space-for-time substitution approach to predict the consequences of drought intensification on water quality variables, EH and benthic macroinvertebrates taxonomic, functional and β-diversity components. We compared these variables between two sets of reservoirs located in two sub-basins with contrasting precipitation regimes. The two sets of reservoirs are totally inserted in the Brazilian semi-arid region and were compared in a dry and extremely dry period to assess the responses of limnological and biological variables to an extreme drought event. Contrary to what we expected our results showed that drought intensification increased reservoirs EH and macroinvertebrates β-diversity. Moreover, Chironomidae was the most important taxon driving the changes in macroinvertebrates β-diversity. However, drought intensification decreased water quality and caused no effect on benthic macroinvertebrates taxonomic and functional components of species diversity. These results suggest that extreme droughts will change the structure of benthic macroinvertebrates assemblages, but with no effect on taxonomic and functional diversities in semiarid reservoirs.

Biotic homogenization Eutrophication Drylands Beta diversity Environmental heterogeneity

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REWETTING BOOST CARBON EMISSIONS FROM MARGINAL RESERVOIR SEDIMENT WITH AGRICULTURAL CROPS



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LINK TO THE STUDY VIDEO

Prolonged droughts in semi-arid regions have increased due to climate change and marginal reservoir sediment have been more frequently exposed to the atmosphere. Due to the high proportion of drawdown areas, reservoir sediment are transformed into agricultural crop sites. Since crop intensification is often thought to increase greenhouse gases (GHG) emissions, this scenario defines new biochemically active areas that may influence the fluxes of two powerful GHG, carbon dioxide (CO2) and methane (CH4), after reservoir rewetting. Here, we experimentally evaluated the influence of rewetting on CO2 and CH4 fluxes from drawdown sediment of a Brazilian semi-arid reservoir with and without agricultural crops. The observed carbon (C) emission, as CO2 and CH4, was two and three times higher, respectively, in the sediment with agricultural crops. Higher values of organic carbon and organic matter content, nutrients, C:N ratio and moisture in the sediments with agricultural crops per se seems the best predictors for the highest CO2 and CH4 emissions. Understanding GHG emissions in reservoirs where agricultural activities are practiced is fundamental to refine the global C balance. Thus, C emissions from sediment of reservoirs with agricultural crops should be explicitly considered in total fresh waters systems emissions, since agricultural practices are becoming increasingly common due to longer droughts that keep reservoir sediment exposed for longer periods.

CO2, CH4, Sediment, Agriculture, Rewetting

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BLOOMS OF TOXIC CYLINDROSPERMOPSIS RACIBORSKII IN LAGUNA DEL SAUCE (URUGUAY): IMPACTS AND EXTERNAL DRIVERS

SESSION 07

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Laguna del Sauce (34° 43’ S, 55° 13’ W) is an eutrophic shallow lake and the second drinking water source in Uruguay. This ecosystem suffers recurrent blooms of nitrogen fixing cyanobacteria which are potentially toxic, mostly during summertime. The phytoplankton of this ecosystem has been monitored since 2015, as part of a vigilance monitoring program. In this study we analyze the impacts and environmental drivers linked to the occurrence, persistence, and toxicity of blooms of Cylindrospermopsis raciborskii in Laguna del Sauce from 2015-2020. During this period, two massive, persistent, and toxic blooms of C. raciborskii were recorded. The first bloom occurred in 2015 (104 mm3.L-1), and lasted from the end of summer until autumn, with high concentrations of saxitoxin (9.8 ?g.L-1). Saxitoxin concentrations remained high even after the bloom collapsed. This was the first time that saxitoxin was registered in the environment, and its high concentrations caused several interferences linked to water supply. In 2020 a second massive bloom occurred which lasted from summertime until winter. Despite this bloom was of high magnitude and persistence, its biovolume (6,3 mm3.L-1) and toxin content (0,9 ?g L-1) were much lower than the ones recorded in 2015. At this time, we were able to implement adjustments in the water plant facility which avoided a crisis in the water supply. Both blooms were associated with similar environmental conditions: low rainfall, low water level, high-residence time, and high-water transparency, with high irradiance in the water-sediment interface. Bloom collapse occurred in similar ways in 2015 and 2020 and was linked to low temperatures and strong precipitation events. Knowing the climatic and limnological characteristics associated with the massive and persistent blooms of C. raciborskii allows anticipating the onset of blooms and adapting the water treatment facilities to decrease the potential risks due to saxitoxin presence in water.

phytoplankton saxtitoxin water traetment

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Asymmetric responses of planktivorous fish and Daphnia to temperature increase may explain the smaller body size of zooplankton at an elevated temperature

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Numerous studies have demonstrated the trend towards a smaller body size in freshwater zooplankton populations and communities at an elevated ambient temperature. This pattern could be explained by a greater effect of temperature on the foraging rate of positive-size-selective planktivorous fish and in turn on the mortality rate than on the birth rate in zooplankton populations. While it is well known that the latter effect is close to the one anticipated by the Q10 = 2 assumption, the hypothesis would be confirmed if the effect of temperature on the foraging rate of planktivorous fish were greater than Q10 = 2. This could occur either when the thermal sensitivity of the standard metabolic rate (SMR) of planktivorous fish is greater than this prediction or when the traits relevant for the performance of both planktivorous fish and their prey (e.g. swimming speed) are affected asymmetrically by the elevated temperature. The thermal sensitivity of the performance of planktivorous fish would be expected to be greater than the Q10 = 2 when the fish forage either in the absence or in the presence of predator threat at a higher trophic level. We compared the foraging rate and SMR of 1-year-old rudd and Malabar danio individuals and the swimming speed of the fishes and their zooplankton prey (Daphnia) in the presence and in the absence of visual hints about the presence of predatory fishes (perch or striped snakehead) at temperatures of 16, 21 and 26 °C. The results confirmed our hypothesis as the foraging rate increased with rising temperatures much more than expected from the Q10 = 2 assumption, particularly for Malabar danio and in the presence of a predator threat at a higher trophic level. Such a great effect cannot be explained by the thermal sensitivity of SMR alone, since the Q10 for SMR was merely around 2. The most likely explanation seems to be a much greater (up to 11 times) effect of temperature on the swimming speed of the fish than of their Daphnia prey.

temeprature, capture rate, respration, swimming speed, temperature coeffcient

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SEASONAL RESPONSE OF PHYTOPLANKTON COMMUNITY TO WARMING AND NUTRIENT LOADING: A MESOCOSM EXPERIMENT

SESSION 07

Nur Filiz (Middle East Technical University, Turkey); **Jessica Richardson** (University of Stirling); **Heidrun Feuchtmayr** (UK Center for Ecology and Hydrology); **Laurence Carvalho** (UK Center for Ecology and Hydrology); **Burak Öğlü** (Estonian University of Life Sciences); **Erik Jeppesen** (Aarhus University); **Meryem Beklioğlu** (Middle East Technical University, Turkey)

Nutrients are the primary stressor in freshwaters that an approx. 72% of the shallow lakes in Europe are classified as eutrophic or hypertrophic with their summer nutrient concentrations. Eutrophication symptoms are exacerbated by rising temperatures and as it is predicted by IPCC (2013), global temperatures could rise 4.8°C by the end of the century. Since, freshwater phytoplankton communities are very sensitive and show fast respond to these environmental stressors, they can be good and early indicators of changes in lake ecosystems structure and function. Cell size is one of the key traits of phytoplankton, since it affects metabolism, nutrient uptake, grazing resistance, growth, and sinking rate which has been shown by recent studies that the mean cell size of phytoplankton tends to decrease with increasing temperatures. To understand the combined effects of warming and nutrient loading on seasonal changes in phytoplankton community and size structure, we used a mesocosm experiment in Lancaster, United Kingdom. The mesocosm facility consisted 16 enclosures (2 m in diameter, 1 m in total depth, imitating a shallow lake) simulating 4 treatments formed by two nutrient levels (eutrophic vs hypertrophic) and two temperature levels (ambient vs +4°C increase) with four replicates of each. The experiment lasted 12 months (from 30th July 2014 till 1st July 2015) and samplings were performed once a month for both phytoplankton community and physico-chemical variables. The same person performed the phytoplankton identification and counting which were performed by following the protocol developed in the WISER project (EU FP7, No.226273). We aimed to reveal the combined effects of the warming and high nutrients on the phytoplankton community structure, the seasonal variation of phytoplankton community within and between the 4 treatments and, the changes in the phytoplankton size structure over the course of the experiment which will be discussed during the presentation.

cell size; global warming; eutrophication; experiment; mesocosm; multiple stressors

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EFFECTS OF HEAVY RAINFALL EVENTS ON WATER QUALITY INDICATORS OF AN URBAN MULTI-IMPACTED LAGOON

SESSION 07

Raquel A. F. Neves (Federal University of the State of Rio de Janeiro); **Luciano Neves dos Santos** (Federal University of the State of Rio de Janeiro)

LINK TO THE STUDY VIDEO

Global climate change is expected to affect precipitation patterns over Southeastern South America by causing an increase in the number and intensity of extreme rainfall events. Heavy rainfall events unbalance the dynamics in shallow aquatic systems which may undergo several abrupt changes in water quality. The present study aimed to identify abrupt changes on abiotic and biological indicators of water quality in Rodrigo de Freitas Lagoon (RFL-Rio de Janeiro, Brazil) induced by heavy rainfall events. Our hypothesis is that extreme rainfall events drastically modify water parameters reducing the overall quality of this shallow coastal lagoon. In order to test our hypothesis, historical data (2011-2019) of daily precipitation (mm) was compiled from Jardim Botânico meteorological station to identify extreme rainfall events considering its threshold value (99th percentile ?80.7 mm day-1). Mean values of the following water parameters were compiled from available dataset of RFL two weeks before and after heavy rainfall events: dissolved oxygen concentrations (mg L-1), temperature (°C), phytoplankton abundance (cells mL-1), water transparency (cm), chlorophyll a (µg L-1), relative abundance of cyanobacteria, and densities (NPM 100 mL-1) of total coliforms and Escherichia coli. PERMDISP analysis was applied (i.e. using Hellinger distance and a nested-design to standardize variable unities and control for temporal autocorrelation) on the historical dataset to test for differences in these parameters over time (i.e. among heavy rainfall events) and before-after rainfall events. Water quality parameters did not change over time ($F= 2.77$; $P > 0.05$), but significant differences ($F= 16.21$; $P < 0.001$) before and after heavy rainfall events were detected. Our findings stress the importance of extreme rainstorms on the water quality of RFL, which tends to heighten the disturbances on ecosystem functioning considering future predictions for global climate changes.

Rodrigo de Freitas Lagoon; global climate change; abiotic variables; biological indicators

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RESPONSE OF MICROBIAL LOOP TO DIFFERENT QUALITY OF DISSOLVED ORGANIC CARBON (DOC) PULSE DISTURBANCE

SESSION 07

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LINK TO THE STUDY VIDEO

Freshwater ecosystems are exposed to variety of stressors driven by climate change that cause essential changes in lake ecosystem's structure and functioning. Increased precipitation and flush-floods recently lead to increased inputs of allochtonous material such as dissolved organic carbon (DOC) to freshwaters. Resultant decrease in light and increase in nutrients may alter composition and biomass of microbial loop (ML) communities. While the effect of labile DOC is heavily investigated for bacteria, studies testing the effect of DOC quality on ML are underrepresented in the literature. Therefore, in summer 2019, the effect of two different quality of DOC pulses on ML were investigated using mesocosm experimental set up (4x4) in Turkey. The treatments included: leachates of alder tree leaf as a labile DOC source (L), recalcitrant dominant HuminFeed DOC (HF) and combination of HuminFeed + labile DOC treatment (HFL) in addition to controls. Firstly, we hypothesized that DOC quality promote bacterial biomass when it is labile (L). Initial results support this since bacteria biomass increased sharply after the pulse in only L-containing treatments. However, there was no clear influence of different sources of DOC on the ciliate biomass, suggesting probable trophic interactions masking the effects. Secondly, we hypothesized that, HF enhance the browning effect and promote ML. Color data suggest that light limitation is present in HF while it is much more intense for L and HFL tanks. Both Chl-a data and bacteria data suggests that the effect of L DOC and nutrients from L treatment overrides the effect of browning in promoting ML. Lastly, we hypothesized that the analysis of functional stability of bacteria biomass would reveal a quality dependent response in stability to pulsed DOC disturbance. Results suggests significant response with biomass increase for HFL and L tanks suggesting low resistance, high resilience and full recovery at the end of 36 days of experiment.

climate change, Dissolved Organic Carbon (DOC), DOC quality, pulse disturbance, microbial loop (ML), bacteria

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WARMING ENHANCES CYANOBACTERIA AND CYANOBACTERIA ENHANCES WARMING

SESSION 07

LINK TO THE STUDY VIDEO

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The synergistic effect of climate warming and eutrophication favors blooms of cyanobacteria with consequences for the functioning of ecosystems (e.g. biogeochemical cycles and productivity). In this study, we evaluated the effects and potential feedbacks between eutrophication and warming of natural phytoplankton communities and ecosystem metabolic balance. We conducted an indoor controlled microcosm experiment with natural phytoplankton communities from eutrophic lakes, subjected to three temperatures for a 40-day period, providing non-limiting nutrients and no predation conditions, to avoid indirect or interacting effects of warming. We registered a reduction in species richness with increasing temperature and different community trajectories under the three treatments, leading to a dominance by green algae in the medium temperature and by cyanobacteria in the high temperature treatment. Warming promoted primary production, with a 10-fold increase in the mean biomass of green algae and cyanobacteria (mostly Raphidiposis raciborskii). The maximum resource use efficiency (RUE) occurred under the warmest treatment. Although we registered high CO2 influx, the magnitude of influx decreased with warming, almost transforming the microcosms in net sources of CO2 to the atmosphere. We demonstrated direct positive effects of warming on cyanobacteria and also found experimental evidence of positive feedback between eutrophication symptoms (blooms) and warming, via higher CO2 emission rates in cyanobacteria dominated warmer systems.

Climate change, metabolic theory, cyanobacteria blooms, eutrophication, global warming, resource use efficiency

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IS SALINITY A DRIVING FACTOR FOR THE PHYTOPLANKTON COMMUNITY STRUCTURE OF A BRACKISH SHALLOW MEDITERRANEAN LAKE?

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SESSION 07

LINK TO THE STUDY VIDEO

Depending on the region, shallow lakes are subject to daily, seasonal or long-term changes of varying intensity, which are somewhat more pronounced due to climate change. The phytoplankton is a well-studied group of organisms that change rapidly with environmental conditions, thus giving a quick and reliable response to short- and long-term changes. In this study we analysed the phytoplankton biomass, diversity and its relation to water chemistry from 2004 to 2019 in the shallow brackish Mediterranean Lake Vransko. Although protected as a Nature Park, the lake's natural succession is intensified by the anthropogenic influence from intensive agricultural activity in the catchment area, and an artificial channel connecting the lake to the sea. The analysis of phytoplankton shows a specific composition of the community strongly influenced not only by nutrients but also by the salinity gradient, shifting from freshwater to brackish water species composition. Conditions with higher salinity support the dominance of brackish species often with low biomass, while periods with low salinity are characterised by the dominance of cyanobacteria or other freshwater species, which are able to quickly upload nutrients and form algal blooms. The results suggest that changes in the lake transparency due to changes in the structure of the algae community strongly influence the entire lake system through the availability of macrophyte growth and sediment fixation. A highly dynamic and specific environment like this supports a high level of diversity and discovery of new species. These findings are crucial for the future lake management, especially for its hydrological regime and the maintenance of natural oligohaline and mesotrophic conditions. Understanding the phytoplankton's response to environmental conditions, which are further enhanced by anthropogenic influence and recent climate change, contributes to the protection of Mediterranean shallow lakes at local and global scale.

salinity, climate change, phytoplankton, anthropogenic influence, brackish system

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LONG-TERM CONTINUOUS MONITORING HELPS TO FOLLOW CHANGES IN THE CONDITION OF LARGE SHALLOW LAKES, BUT IT IS A CHALLENGE TO DISTINGUISH BETWEEN HUMAN IMPACT AND NATURAL FACTORS



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The ecological status of Estonian large lakes Peipsi and Võrtsjärv has been monitored by state almost for 30 years. Additionally, Peipsi has been monitored in the frames of Estonian-Russian cross-border cooperation programme. Mainly due to the decreased external nutrient loads, the both lakes show some signs of improvement, e.g., increasing species richness of phytoplankton and appearance of pollution-sensitive bottom invertebrate species in the littoral zone. Still, the influence of internal load remained high, especially in Peipsi. The analysis of the monitoring results is complicated by the fact that natural factors, especially fluctuating water levels, have a similar but much greater impact on the status indicators of these shallow lakes than direct human activities. In this way, it is often difficult to understand what is behind the changes that are taking place. In Peipsi, warmer winters and summers contribute to the increase in blue-green algal blooms but recently, diatoms have dominated alternately with blue-green algae for over a year despite low water levels.

monitoring, algal bloom, cross-border lake

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SMALL-SIZED OMNIVOROUS FISH PROMOTES STRONGER EFFECTS ON FOOD WEBS THAN WARMING AND EUTROPHICATION IN EXPERIMENTAL SHALLOW LAKES



LINK TO THE STUDY VIDEO

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Warming, eutrophication, and increased omnivory by fish are global change processes that induce major effects in the food web structure and primary producers of shallow lakes. Despite the key role of phytoplankton and periphyton in freshwaters, the combined and potential synergistic effects of fish omnivory, warming and eutrophication on these communities are unclear, especially for subtropical shallow lakes. We experimentally tested the food web effects on phytoplankton and periphyton induced by small omnivorous fish (Rhodeus ocellatus) applying a factorial design with nutrient enrichment and warming (+4.5°C, high A2 IPCC scenario) in mesocosms simulating littoral conditions of subtropical shallow lakes. Mesocosms included submerged macrophytes, Vallisneria denseserrulata and Potamogeton lucens and their artificial mimics at 50% plant volume inhabited. We found that omnivory by small fish had strong cascading effects enhancing phytoplankton dominance and periphyton loss. These effects were mediated through a decline in zooplankton biomass and a diversity loss both in zooplankton and macroinvertebrates as well as through an increase in snail abundance. Fish presence led to a collapse of cladocerans, thereby releasing the grazing pressure on phytoplankton. For macroinvertebrates, fish induced a replacement of predators and collectors by small snails (Radix peregra < 0.5 cm), resulting in enhanced grazing on periphyton. In contrast, warming and nutrient enrichment had weak or no effects on food webs. Our results suggest that omnivory by small-sized fish can promote stronger effects on periphyton, phytoplankton and the overall food webs, than the combined effect of eutrophication and a high warming IPCC scenario.

phytoplankton, omnivory, fish

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PHYTOPLANKTON AND ZOOPLANKTON RESPONSES TO WARMING – ANALYSES OF 30 YEARS MONITORING DATA FROM DANISH LAKES

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SESSION 07

We used 30 years monitoring data from Danish lakes to establish empirical relationships (on a monthly basis from March to November) between various phytoplankton and zooplankton variables and a set of explanatory variables including total phosphorus (TP), total nitrogen (TN), lake depth (LD) and water temperature (WT). As expected, TP, TN and LD had a strong effect on both phytoplankton and zooplankton biomass at the class or genus level. In addition, WT was also of key importance, especially during June to October. We found higher dominance of cyanobacteria in terms of biomass, most notably of the potential N-fixing forms, but also of dinophytes at higher WT. There was also an increase in chlorophyll a and phytoplankton biomass, while concomitantly diatoms became less important. Thus, the risk of dominance by potential toxic cyanobacteria will increase with warming and the period of cyanobacteria bloom will likely be longer. We found a decrease in the average size of both cladocerans and copepods with increasing temperature. This usually suggests enhanced predation by fish. A decrease in the zooplankton:phytoplankton biomass ratio and proportion of Daphnia among the cladocerans provided further evidence of higher fish predation with increasing WT.

Phytoplankton , zooplankton, empirical relationship, monitoring

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CARBON DIOXIDE AND METHANE DYNAMICS OF SHALLOW LAKES FROM THE PAMPEAN PLAIN WITH ALTERNATIVE EQUILIBRIA REGIMES (ARGENTINA)

SESSION 07

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Carbon dioxide and methane emissions from inland waters constitute a significant component of the global carbon cycle. Among inland waters, shallow lakes are considered biogeochemical hotspots and are highly abundant in some landscapes. The Pampean Plain in Buenos Aires, Argentina, is a region that hosts thousands of shallow lakes under different alternative equilibria regimes, characterized as turbid-phytoplanktonic and clear-vegetated. We followed seasonal carbon dioxide and methane diffusive (D), ebullitive (E) and plant mediated (PM) fluxes, as well as dissolved concentrations of both gases in the water (DW) and several other limnological parameters, of two clear-vegetated and two turbid-phytoplanktonic Pampean shallow lakes. Clear and turbid lakes showed similar annual average carbon dioxide DW, but clear lakes had higher annual average methane DW. In spring and summer clear lakes were undersaturated in carbon dioxide DW whilst in winter and fall they were oversaturated. Turbid lakes were mainly oversaturated in carbon dioxide DW, becoming undersaturated only in summer. Regarding methane DW, all lakes were oversaturated along the whole year. Average D, E and PM fluxes of both gases were similar between the two lake regimes. Methane D, E and PM fluxes of both regimes were exponentially related to temperature. Carbon dioxide D flux had a negative linear relation with temperature in clear lakes, and a negative linear relation with dissolved oxygen and phytoplankton abundance in turbid lakes. Carbon dioxide PM flux had a positive linear relation with temperature in both lake types. Average net emissions in terms of carbon dioxide equivalents (eq) were similar between regimes, being 758 and 678 mmol carbon dioxide eq day-1 m-2 for clear and turbid lakes, respectively. These results provide valuable information about methane and carbon dioxide fluxes and their main drivers, along with the first comprehensive emission budget for inland waters in the Pampean region.

Climate change, Greenhouse Gases, Shallow Lakes, Pampean Plain

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THE TEMPERATURE DEPENDENCY OF ANIMAL-MEDIATED NUTRIENT RECYCLING IN AQUATIC ECOSYSTEMS: RECONCILING PREDATION, PHYSIOLOGY AND STOICHIOMETRIC CONSTRAINTS



Rafael Dettogni Guariento (Federal University of Mato Grosso do Sul, Brazil); **Shawn J. Leroux** (Memorial University, Canada); **Michael J Vanni** (Miami University, USA)

Temperature and nutrients, which are key drivers of organism's performance, are often affected by global change. Elevated temperature causes increased metabolism and respiration in invertebrate organisms. However, there is no consensus on whether warming increases or decreases consumer needs for resources, and the concomitant effects on nutrient excretion rates and ratios. We predicted that aquatic invertebrate consumers will require higher feeding effort and carbon-rich diets in a warming environment, because of increased respiratory demands, which would increase nutrient release rate. Here, we evaluate this prediction using a stoichiometric model that has carbon and nutrients as currencies. We model constraints on prey feeding effort through metabolic scaling and predation risk. We also investigate how the dietary C:nutrient ratio needed for consumer growth (TER - Threshold Elemental Ratio) changes along temperature gradients based on recent theoretical advances. Our prediction was not entirely supported, indicating instead that resource requirements of aquatic invertebrates may change with temperature in a U-shaped fashion. These results indicate that consumer nutrient requirements, and consequently their nutrient excretion rates, at first decreases but then increases with increasing temperature, exhibiting a minimum at optimal temperatures. We also found that a diet switch to C-rich food at elevated temperatures compensates for the extra metabolic demands , especially when feeding effort is restricted due to predation. In conclusion, our analysis demonstrates that the effect of climate-driven changes on consumers' C-nutrient demand will likely increase the stoichiometric mismatch between consumers and their food, with important consequences for animal nutrient recycling in aquatic environments.

Global chnage, food quality, threshold elemental ratio, growth efficiency, metabolism, ingestion.

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THE EFFECT OF TEMPERATURE ON THE SELECTIVITY OF PLANKTIVOROUS FISH

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Numerous studies have shown that an elevated temperature contributes to a decrease of mean body size in zooplankton populations and communities, either spatially or temporally. One of the explanations of this phenomenon is the increased selectivity of planktivorous fish for large-bodied zooplankton due to their greater swimming speed at an elevated temperature. This could be expected since acceleration may either cause a decline in the relative visibility of smaller prey or make the cost of obtaining prey greater as a result of the energy expended for deceleration during the capture and for the post-capture acceleration, hence making it unprofitable to slow down for a small-bodied prey. We verified this hypothesis in experiments with planktivorous fish (juvenile rudd, Scardinius erythrophthalmus) foraging in each experiment in one of two temperatures (15 or 25 oC) at the same initial density (kept constant throughout experiments by regularly supplementing new prey in place of the eaten prey) of 2- and 5-day old Daphnia magna, whose age classes visibly differ in body size. The results of our study did not confirm the hypothesis, since the selectivity of the fish was up to 2 times lower at the higher temperature. The pattern was accompanied with up to a 2 times greater swimming speed, and up to a 5 times greater capture rate, which suggests that fish switch from a “qualitative” to “quantitative” foraging mode with increasing temperature.\n

global warming planktivorous fish size-selective predation zooplankton

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MITIGATION OF EUTROPHICATION AND HARMFUL ALGAL BLOOMS (HABS)

SESSION 08

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Néstor Mazzeo
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Harmful algal blooms (HABs) is one of the detrimental consequences of eutrophication in natural waters, which may pose serious threats to water quality, human and animal health, economic development and ecological function. Many tools have been developed to manage eutrophication and HABs, such as catchment management, physical techniques (flushing, aeration, oxygenation, dredging), geoengineering (chemical coagulants, P-sediment inactivation) and biomanipulation. However, existing technologies are still not satisfactory for the mitigation of such complicated environmental problems. Innovative and integrated principles employing geochemical, microbial, and material science principles are in great demand for pollution control (nutrients, heavy metals, persistent toxic substances, and greenhouse gases) and ecological restoration. This thematic session invites research on advances in restoration of shallow lakes and controlling of HABs, including laboratory experiments, field tests, modelling studies, and management protocols that may contribute to a sustainable, cost-effective, and environmentally friendly solution.

ABIOTIC FACTORS DRIVING CYANOBACTERIAL BIOMASS AND COMPOSITION UNDER PERENNIAL BLOOM CONDITIONS IN TROPICAL LATITUDES



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LINK TO THE STUDY VIDEO

While warming and eutrophication have increased the frequency and magnitude of harmful cyanobacterial blooms globally, the scenario for many eutrophic tropical freshwaters is a perennial year-round bloom. Yet, the drivers of persistent blooms are less understood when conditions such as light, temperature, and nutrients favor cyanobacteria growth year-round, and especially in regions facing recurrent periods of drought. In order to understand the drivers of cyanobacteria dominance, we assessed the abiotic conditions related to the abundance and dominance of the two dominant bloom-forming genera Raphidiopsis and Microcystis, in six shallow, man-made lakes located in the semiarid Northeastern region of Brazil during a prolonged regional drought. Reduced water level increased phosphorous and nitrogen concentration and consequently, phytoplankton biomass. Cyanobacterial biomass was also proportional to nitrogen and phosphorus concentrations during year-round blooms. Yet, the two dominant cyanobacterial genera, Raphidiopsis and Microcystis, seldom co-occurred temporally and the switch between them was driven by water transparency. Our results illustrate the effects of drought induced water level reductions on the biomass and composition of cyanobacterial blooms in tropical shallow man-made lakes. Given the ideal year-round conditions (i.e., high light and temperature), droughts may be expected to intensify the risk and multitude of problems associated with eutrophication.

Drought, drylands, Microcystis aeruginosa, man-made lakes, perennial cyanobacteria dominance, Raphidiopsis raciborskii.

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HURRICANE DISTURBANCE STIMULATED NITRIFICATION AND ALTERED AMMONIA OXIDIZER COMMUNITY STRUCTURE IN LAKE OKEECHOBEE AND ST. LUCIE ESTUARY (FLORIDA)

Justyna Hampel (University of Southern Mississippi); **Mark J McCarthy** (Wright State University); **Sanni Aalto** (Technical University of Denmark); **Silvia E Newell** (Wright State University)

SESSION 08

Nitrification is an important biological link between oxidized and reduced forms of nitrogen (N). The efficiency of nitrification plays a key role in mitigating excess N in eutrophic systems, including those with cyanobacterial harmful algal blooms (cyanoHABs), since it can be closely coupled with denitrification and removal of excess N. Recent work suggests that competition for ammonium between ammonia oxidizers and cyanoHABs can help determine microbial community structure. Nitrification rates and ammonia-oxidizing archaeal (AOA) and bacterial (AOB) community composition and gene abundances were quantified in Lake Okeechobee and St. Lucie Estuary in southern Florida (USA). We sampled during cyanobacterial (Microcystis) blooms in July 2016 and August 2017 (2 weeks before Hurricane Irma) and 10 days after Hurricane Irma made landfall. Nitrification rates were low during cyanobacterial blooms in Lake Okeechobee and St. Lucie Estuary, while low bloom conditions in St. Lucie Estuary coincided with greater nitrification rates. Nitrification rates in the lake were correlated ($R^2 = 0.94$; $p = 0.006$) with AOA amoA abundance. Following the hurricane, nitrification rates increased by an order of magnitude, suggesting that nitrifiers outcompeted cyanobacteria for N under turbid, poor light conditions. After Irma, AOA and AOB abundances increased in St. Lucie Estuary, while only AOB increased in Lake Okeechobee. After the hurricane, the AOA community shifted toward dominance by freshwater clades in St. Lucie Estuary and terrestrial genera in Lake Okeechobee, likely due to high rainfall and subsequent increased turbidity and freshwater loading from the lake into the estuary. AOB community structure was not affected by the disturbance. AOA communities were consistently more diverse than AOB, despite fewer sequences recovered, including new, unclassified, eutrophic ecotypes, suggesting a wider ecological biogeography than the oligotrophic niche originally posited.

nitrification, Microcystis, hurricane

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EFFECTS OF CYANOBACTERIAL CRUDE EXTRACTS ON THE DEMOGRAPHY OF TWO POPULATIONS OF THE ROTIFER BRACHIONUS HAVANAENSIS

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Rise in pollution of aquatic ecosystems by increase in the anthropogenic activities have led to increasing eutrophication, and with this an increase in cyanobacteria. These cyanobacteria have several effects in the zooplankton. The principal effect is due to the production of toxic secondary metabolites (cyanotoxins). The effects on zooplankton may vary even between strains of species since every strain is adapted to the conditions of its place of origin. We evaluated the acute and chronic effects of different concentrations of the cyanobacterial crude extract from Valle de Bravo Reservoir on two clones of the rotifer Brachionus havanaensis, one from Cuemanco canal, that has low cyanobacterial density throughout the year, and the other from Virgilio Uribe Rowing Canal, that always has high a cyanobacterial density, both localities in Xochimilco, Mexico City. We filtered 100 l of the lake water and estimated the diversity and density of the cyanobacteria. The crude extract after 5 cycles of freezing, thawing and sonication at 14 MHz, was filtered and the microcystin concentration quantified based on ELISA. Acute toxicity tests were based on 24h mortality. Chronic toxicity tests (life table experiments) were conducted at sublethal concentrations of the median lethal concentration. The lethal concentration for the Cuemanco clone was 34.25 µg/L and the sublethal concentrations were 1.7 and 3.4 µg/L. For the Virgilio Uribe clone the lethal concentration was 42.6 µg/L and the sublethal were 2.1 and 4.2 µg/L. The field sample was dominated by Dolichospermum planctonicum. For both clones survival and reproduction were lower in presence of the cyanobacterial crude extract but with a higher effect on the Cuemanco clone, which doesn't have constant contact with cyanobacteria. Our results show that clones from the same species differ in the effects caused by cyanotoxins depending on the characteristics of its place of origin.

Cyanobacteria, Dolichospermum, Crude extract, Acute toxicity, Chronic toxicity, Rotifers

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COMMUNITY STRUCTURE HAS GREATER EFFECT ON WATER COLUMN AMMONIUM CYCLING THAN NUTRIENTS AND TEMPERATURE IN SHALLOW LAKE MESOCOSMS



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Harmful algal blooms impact lakes worldwide and are caused by excess nitrogen (N) and phosphorus (P) loading from watersheds. Warmer temperatures and extreme precipitation/drought are projected to worsen eutrophication. We examined climate warming and nutrient loading effects on N cycling in shallow lake mesocosms. N loading to high nutrient mesocosms ceased in June 2018 and resumed in June 2019. Ammonium (NH4+) uptake, regeneration, nitrification, and nitrate uptake rates were evaluated. Before resumption of N loading in high nutrient mesocosms, NH4+ regeneration supported 46% of potential microbial NH4+ demand, versus 24% with N loading. Nutrient additions generally had a larger effect on rates than temperature changes, however, community structure (phytoplankton versus macrophytes) was the best predictor of NH4+ dynamics. Management strategies for eutrophic shallow lakes should aim to not only reduce external N and P loads, but also implement biomanipulation methods to obtain macrophyte-dominated, clear-water states.

nitrogen ammonium cycling freshwater lake mesocosms community structure HABs

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TOP-DOWN CONTROL OF PHYTOPLANKTON BY DAPHNIA OBTUSA KURZ IN SHALLOW LAKES WITH A DIFFERENT TROPHIC STATE: AN EXPERIMENTAL APPROACH

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SESSION 08

LINK TO THE STUDY VIDEO

Daphnia obtusa Kurz is a broad geographic distribution cladoceran specie with an essential role in controlling phytoplankton. It inhabits three small shallow lakes (<1.5 m depth) located in an urban ecological reserve (La Cantera Oriente, REPSA) in Mexico City. The lakes are adjacent and show different trophic conditions: North (mesotrophic), Central (eutrophic), and South (hypereutrophic). Using two outdoor semi-enclosure mesocosms plus one control (80 L) per lake, we analyze D. obtusa ability to control the biomass of phytoplankton when composition, abundance, and trophic state are different. D. obtusa were cultivated in laboratory conditions and added only once in each mesocosm (80 ind L-1). One experiment was carried out during the dry season (November-December 2017) and the second during the rainy season (July-August 2018). Mesocosms were sampled weekly until a decrease in Chlorophyll a (Chla) occurred. In the water column, selected physical and chemical variables were measured, and phytoplankton and zooplankton samples were obtained. We found that Chlorophyta species dominated phytoplankton composition in North and Central Lakes, and Cyanobacteria in South Lake; during the experiments, the phytoplankton genera dominance changed slightly as D. obtusa proliferated in mesocosms. A significative negative correlation ($R= -0.55$ $p<0.05$) between Chla and D. obtusa abundances was found only in the rainy season. Chla concentrations decreased with D. obtusa highest densities, with 85.5% Phytoplankton Control Eficiency (PCE, calculated using Chla data) for the Central lake in both seasons, followed by 74% PCE for the North Lake and 71% PCE for the South Lake. These results suggest that D. obtusa can exert top-down control on phytoplankton regardless of the trophic state, but its efficiency is better during rainy season, when chlorophytes dominate eutrophic conditions. The prevalence of cyanobacteria decreased D. obtusa population growth and their control on phytoplankton.

Biomanipulation, cladoceran, eutrophication, phytoplankton control

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BIOMANIPULATION: IMPLICATIONS OF ITS USE AND THE SEARCH FOR POSSIBLE CANDIDATES FOR AQUATIC SYSTEMS OF TROPICAL AND SUBTROPICAL REGIONS



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Cyanobacterial blooms are one of the most common problems affecting aquatic ecosystems around the world. Eutrophication often promotes the proliferation and permanence of cyanobacteria. The use of strategies for the reduction and control of cyanobacteria were developed in water bodies in temperate regions. The reduction of nutrients, the use of macrophytes in the biomanipulation has resulted in the improvement of water quality in some lakes and reservoirs. However, the implementation of these strategies in water bodies in tropical and subtropical regions has been complex. These regions are characterized by having a high nutrient load, particularly shallow urban lakes, in countries like Mexico where partially treated domestic wastewater is often used to refill these water bodies. The presence of small species (rotifers) is greater than that of large herbivores due to fish predation pressure on the latter. However, it has been shown that herbivores/omnivores such as Hyalella sp. (Amphipoda) is capable of feeding on cyanobacteria and is often found in shallow water bodies with dense cyanobacterial blooms. In biomanipulation, the removal of these manually or through the use of top predators (piscivorous fish) have favored the improvement of water quality. However, it has not been taken into account that Mexican waters are characterized by a high diversity of native and endemic planktivore fish species and that the introduction of alien species (piscivorous fish) could have an even more severe effect on the aquatic community. In this review, we discuss the possible effects of species used in biomanipulation and give our opinion on the best possible means to improve water quality in Mexican water bodies.

Cyanobacteria, Biomanipulation, Mexico

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EFFECTS OF ALUMINUM SULFATE TREATMENT ON NUTRIENT DYNAMICS AND A PLANKTOTHRIX BLOOM IN A SHALLOW, SEMI-ENCLOSED LAKE AREA

SESSION 08

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Grand Lake St. Marys is the largest (52 km2) inland lake in Ohio, USA, and receives high nutrient loadings (90th percentile for total nitrogen (N) and phosphorus (P) concentrations in the USA) from a watershed dominated by agricultural row-crops and livestock production. Eutrophication and cyanobacterial harmful algal blooms, dominated by non-N2 fixing Planktothrix, persist year-round, including in winter months. An aluminum sulfate (alum) treatment was conducted within a three-acre swimming enclosure on June 9th, 2020, to remove excess dissolved P from the water column. The objective of this study was to examine pre-and post-treatment biogeochemical and physicochemical conditions in contrast to the surrounding lake. Weekly sampling recorded chlorophyll-a and microcystin toxin concentrations ranging from 48-368 and 5.7-68.2 µg/L, respectively, persisting from April into November 2020 within the treatment area, indicating a failure of the alum treatment to reduce bloom conditions. Persistently high algal biomass contributed to a hypoxia/fish kill event in July 2020, with sediment oxygen demand (SOD) reaching >2000 µmol O2 m-2 h-1. A transition from net denitrification (N removal) to net N fixation (N source) in sediments during summer, coinciding with dissolved inorganic N depletion, suggested that internal N regeneration and recycling pathways were required to support Planktothrix biomass both within and outside the enclosure. N cycling and SOD rates in sediments suggested no difference between water column conditions inside and outside of the enclosure, as well as between pre- and post-treatment with alum. TP concentrations did not decrease after alum treatment.

HABs, nitrogen, planktothrix, denitrification, hypoxia

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CAN NUTRIENT RELEASE AND/OR CONSUMPTION BY NATIVE BIVALVE D. PARALLELOPIPEDON BUST PHYTOPLANKTON CYANOBACTERIAL DEVELOPMENT?



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Harmful cyanobacterial blooms (HABs) are common in freshwater ecosystem. Toxins released by cyanobacteria are highly toxic and affect both animals and humans. It is the main problem of drinking water systems around the world. Some strategies of biomanipulation has been development by induce a change in the primary production/herbivorous consumption ratio food web mainly with Daphnia sp. On the other hand, bivalves are key component in the ecosystem because they can directly reduce phytoplankton biomass through filtration but may also have an impact through excretion of nutrients. The aim of this study is understand the role of native bivalve D. parallelopipedon in phytoplankton dynamics by grazing and/or nutrient excretion. First, we run experiment to compared feeding of D. parallelopipedon over 1- phytoplankton assemblages: dominated by Cryptomonas sp. and 2-wild population of Microcystis aeruginosa complex (MAC). Secondly, we studied nutrient released of D. parallelopipedon nitrogen and phosphorus. The experimental evidence verify our hypothesis that D. parallelopipedon favor presence of MAC because it is not able to consume the species with capacity of buoyancy regulation. Additionally, Diplodon favors its growth through the nutrients release. Higher temperature during the summer periods promotes cyanobacterial blooms when the grazing pressure by Diplodon is reduced (in comparison with spring), however, the blooms being potentially busted by the nutrient released by the bivalve's community. In summary, some cyanobacterial blooms, like MAC, could be promoted by different causal mechanisms. The nutrient remineralization by D. parallelopipedon plays a critical role, especially in shallow ecosystems without stratification processes.

Bivalves, Nutrient released, Temperature, Cyanobacteria

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CONTROL OF INTERNAL PHOSPHORUS FERTILIZATION THROUGH THE APPLICATION OF COAGULANTS AND CLAYS IN WATER AND THE SEDIMENT OF A SEMIARID RESERVOIR SUSCEPTIBLE TO RESUSPENSION



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This study aimed to evaluate the efficiency of the application of coagulants and clays in reducing algal biomass and in controlling the internal fertilization of phosphorus (P) in an eutrophic reservoir in a semi-arid tropical region. The following hypotheses were tested: i) the combination of coagulant and clay has greater efficiency, than the isolated effect of the products, in the sedimentation of algal biomass and inactivation of P in the sediment; ii) resuspension causes release of P from the sediment even after the application of coagulants and clays, damaging the inactivation of P. The work was carried out on a microcosm scale. Water and sediment were collected in the Boqueirão reservoir to carry out the following experiments: (1) sedimentation of algal biomass and total P in the water (Floc & sink); (2) inactivation of P in the sediment (Floc & Lock); and (3) resuspension simulation of the sediment. The following were used in experiments 1 and 2: an inorganic coagulant, polyaluminum chloride (PAC); an organic coagulant, Tanfloc (TAN); a natural bentonite (BEN); and a lanthanum modified bentonite (BML). The coagulants alone were enough to promote sedimentation of algal biomass and total phosphorus in the water column. Even so, hypothesis 1 was proven, since in order to inactivate P in the sediment, a clay with high adsorption capacity is necessary, as in the case of BML. Both coagulants showed good results in experiment 1, but the PAC showed reductions in P and cyanobacteria that were much more expressive than the TAN. Despite being dispensable in the reduction and cyanobacteria in water, BML is indispensable in the capping technique, while natural bentonite did not present significant minimization in the release of P from the sediment. After resuspension simulation, all treatments showed an increase in P, even minutes after agitation, showing that the technique is vulnerable if the applied environment suffers from recurrent sediment resuspension events.

Floc & Sink, Cyanobacterial Sedimentation, Floc & Lock, Phosphorus Inactivation, Capping.

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PHOSPHORUS SORPTION POTENTIAL OF NATURAL ADSORBENT MATERIALS TO CONTROL EUTROPHICATION

SESSION 08

Fernanda Monicelli (UFRN); **Karina Patrícia Vieira da Cunha** (UFRN); **Fabiana Araújo** (UFRN); **Vanessa Becker** (UFRN)

The mitigation of eutrophication using geo-engineering techniques is a known alternative due to the manipulation of the biogeochemical cycle of phosphorus. The process of sorption immobilizes phosphorus (P), primarily via adsorption and precipitation. Many natural materials have been tested for phosphorus adsorbent, showing promising and lower-cost results. The aim of the present study was to evaluate the potential soluble reactive phosphorus (SRP) sorption of three natural P adsorbents (Luvisol, Planosol, and Scheelite tailing) from Brazil's semiarid region. Lanthanum-modified bentonite (LMB) was also used as a positive control due to its proven efficiency with regard to SRP sorption. The adsorption tests were done under pH 8 conditions. The effect of humic substances on SRP sorption was also tested. Luvisol and Planosol were incinerated to reduce their humic components, and new adsorption tests were done. Scheelite tailing and Planosol produced the highest percentages of SRP removal, with values of approximately 40–60% up to 20 mg L-1. Of the natural adsorbents, Luvisol achieved the highest maximum SRP adsorption capacity (Q) of 17.5 mg g-1, followed by Scheelite tailing (8.3 mg g-1) and Planosol (7.7 mg g-1). Scheelite tailing, Planosol and LMB increased the pH of the water. After treatment to reduce humic substances, Planosol showed a Q of 22.3 mg g-1 while Luvisol produced 11.1mg g-1. Reducing the amount of humic substances potentiated the sorption process in the Planosol. The SRP sorption potential of the natural adsorbents was high, at pH 8. The precipitation process was probably the main sorption mechanism, being more expressive than adsorption. Scheelite tailing was the most promising material for eutrophic environments because it is alkaline, calcium-rich, and contains little organic matter. The quality of the clay present in natural adsorbents was more important than quantity in the sorption process.

Clay minerals; humic substances; Langmuir; mitigation; phosphate; semiarid

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COMBINED APPLICATION OF FLOCCULANTS WITH NATURAL AND MODIFIED CLAYS AS A TOOL FOR THE RESTORATION OF AN EUTROPHIC RESERVOIR IN THE SEMIARID TROPICAL REGION

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SESSION 08

The objective of this study was to evaluate in microcosms the efficacy of flocculants aluminum sulfate (Al2SO4) and poly-aluminium chloride (PAC), solely and combined with different doses of the lanthanum modified bentonite clay (LMB) or natural bentonite clay (BEN) in the removal of algal biomass and phosphorus from water of Gargalheiras reservoir, located in the semi-arid region of Brazil. The experiments were performed in a pilot scale and separated in three steps that evaluated the ideal doses to remove the algal biomass and phosphorus from reservoir water: step 1- selection of ideal dose of PAC and Al2SO4; step 2 - selection of ideal dose of ballasts lanthanum modified bentonite (LMB) and natural bentonite (BEN) in combination with the selected doses of PAC and Al2SO4 in step 1; step 3 - a final full comparison experiment using a jar test equipment with isolated or combined application of the flocculants and ballasts doses obtained in steps 1 and 2. The results indicated that the most effective doses of flocculants and ballasts to remove algal biomass were: 6 mg.L-1 of PAC; 4 mg.L-1 of Al2SO4; 50 mg.L-1 for BEN and 100 mg.L-1 for LMB. To remove total phosphorus the most effective doses were: 4 mg.L-1 of PAC; 4 mg.L-1 of Al2SO4; 50 mg.L-1 for BEN and 50 mg.L-1 for LMB. It was observed in the step 3 that the isolated application of low doses of PAC and Al2SO4 had the same effect of the combined application of these flocculants with PAC and BEN in the removal of algal biomass and total phosphorus, reducing the algal biomass by 90% and total phosphorus by 70%. The application of BEN and LMB as ballasts in combination with flocculants did not contribute to increase the removal of algal biomass and total phosphorus from the reservoir water. Our data also showed that the use of geoengineering technique provided a rapid improvement in the water quality of Gargalheiras reservoir, changing the trophic state of the ecosystem to the mesotrophic state in a short time.

lake restoration, geo-engineering, floculation, semiarid reservoir.

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CRISIS IN THE SUPPLY OF DRINKING WATER AS TRIGGERS FOR CHANGES AND GREATER CAPACITY FOR ADAPTATION AND ANTICIPATION



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During 2015, adverse water quality conditions occurred in Uruguay's second source of drinking water in terms of the number of people supplied (Laguna del Sauce), linked to taste and odour interference, the presence of cyanotoxins and considerable daily variability in key physicochemical conditions (pH, oxygen and ammonium concentration). This configuration conditioned a crisis in the supply of drinking water with political consequences and the emergence of considerable distrust of users. The crisis promoted multiple transformations in a general context of changes of the water governance system from command-control to integrated management. This contribution analyses the processes of transformation and capacity building in a context of multi-stakeholder and multi-level networks (formal and informal), seeking to understand the development of a greater capacity for adaptation and anticipation of the eutrophication consequences. At the same time, the emergence of capacities and strategies related to the rehabilitation of the body of water is analysed. A similar ecosystem configuration of Laguna del Sauce during the summer of 2020 (Cylindrospermopsis bloom) allowed evaluating the performance of the changes and built capacities. The crisis accelerated and promoted changes that began in 2010 with the installation of the basin committee (first example in Uruguay). The role of this bridge structure (multi-stakeholder and multi-level space) has been key in the design of an action plan, the construction of multiple monitoring systems and development of early warnings, and has contributed to the watershed land use plan. The persistence and regularity in the functioning of the basin committee, the flexibility and openness in its integration, the building of trust among the actors (public and private), emerge as crucial attributes. Study funded by IAI, GWP, ANII and CSIC-Udelar

cyanobacterial blooms, eutrophication, transformation, governance

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USER-FRIENDLY PREDICTIVE TOOL FOR WATER-QUALITY MANAGEMENT USING MACHINE LEARNING MODELS

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LINK TO THE STUDY VIDEO

Water quality deterioration constitutes a problem of major concern worldwide, particularly in drinking water reservoirs. Uruguay is not immune to this problem and the water supply has been posing several challenges in recent years. In this context, water managers need to anticipate to non desirable water-quality conditions to optimize water treatment processes and guaranty an adequate supply to the population. The application of Machine Learning (ML) algorithms to predict water quality and its utilization for management in drinking water reservoirs is, nowadays, a poorly explored approach. The incorporation of ML tools coupled to user-friendly interfaces presents great potential because of its easy utilization and practically null costs. This work presents the results of the design of an app for water quality prediction in Laguna del Sauce (Uruguay). This ecosystem is a eutrophic shallow lake (34° 43’ S, 55° 13’ W) that represents the second drinking water source in Uruguay and which suffers recurrent cyanobacteria blooms of potentially toxic species, mostly during summer. Inside ML, we considered Random Forests since this was the algorithm with highest performance within several ML models tested. The response variables considered were: level of chlorophyll-a, level of cyanobacteria biovolume, presence/absence of morphology-based functional groups and of Microcystis aeruginosa. To train the models we considered a 17 year long daily data set. Model evaluation was done by means of an independent test set that was not used in the training processes. Models were evaluated by considering their global accuracy but also by their ability to predict specific classes. The global accuracy over the test sample was between 78 and 94%. Considering the predictive ability by class, performances were also very good with values over 80%.Models were integrated in a user-friendly app whereby water managers can obtain water-quality predictions in real time (for one day to another).

water-quality prediction machine-learning

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PHYTOPLANKTON COMMUNITY RESPONSES TO THE APPLICATION OF A EUTROPHICATION CONTROL TECHNIQUE (FLOC & LOCK) IN A TROPICAL COASTAL LAGOON

SESSION 08

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Excessive nutrients in water lead to increased biomass of primary producers including phytoplankton, mainly cyanobacteria. To reverse this, the Floc & Lock technique was developed, combining coagulants with phosphorus (P) adsorbents to remove dissolved and particulate P (including planktonic microalgae and cyanobacteria) from the water column. Furthermore, it prevents P release from the sediment, contributing to the mitigation of microalgae and cyanobacterial blooms. Here we aim to evaluate changes in the structure (biomass, composition, richness, diversity) of phytoplankton after the application of the Floc & Lock technique in a hypereutrophic coastal lagoon in mesocosm scale. Our hypothesis is that this technique not only reduces P, but also total phytoplankton biomass and increases phytoplankton richness and diversity. For this purpose, an experiment in mesocosms was carried out in Jacarepaguá Lagoon: control and two treatments i) poly-aluminium chloride (PAC) + lanthanum modified bentonite (LMB); and ii) PAC + LMB + zeolite (ZEO) in quadruplicate. Our results showed efficiency in reducing the SRP and TP concentrations in PAC+LMB (90 and 81 %, respectively) and in PAC+LMB+ZEO (80 and 76 %, respectively). A decline of the total phytoplankton biovolume was observed 24 hours after the application, mainly due to the removal of diatoms and chlorophyceans. This effect was weakened along the experiment and an increase in the total phytoplankton biovolume, was observed by the end of the study, when cyanobacteria appeared. We did not observe the expected influence on the species richness, which remained constant during the experiment, whereas the diversity showed a decrease only 24 hours after the application and a subsequent increase by the end of the experiment. The Floc & Lock technique could be a promising measure which focus on the internal loading. However, the uniqueness of the aquatic system should be taken to consideration to achieve the desired goals.

hypereutrophic and oligohaline system, mesocosms, lanthanum modified bentonite, zeolite, poly-aluminium chloride.

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TOP-DOWN AND BOTTOM-UP EFFECTS OF SUBMERGED MACROPHYTES, LARGE ZOOPLANKTON, AND NUTRIENTS ON PHYTOPLANKTON IN A BIOMANIPULATION EXPERIMENT IN A TROPICAL SHALLOW RESERVOIR

Cihelio Alves Amorim (Federal Rural University of Pernambuco); **Irma Carvalho e Silva** (Federal University of Rio Grande do Norte); **Ariadne do Nascimento Moura** (Federal Rural University of Pernambuco)

SESSION 08

LINK TO THE STUDY VIDEO

The biomanipulation of macrophytes, zooplankton, and fish have been successfully used to control eutrophication and cyanobacterial blooms in temperate lakes. However, its effects are still unclear for tropical environments. In this study, the isolated and combined effects of the submerged macrophyte Ceratophyllum demersum, large cladoceran Sarsilatona serricauda (>1mm), and nutrients (0.4 mg/L of nitrogen and 0.5 mg/L of phosphorus) on phytoplankton were evaluated in a mesocosm experiment in Tapacurá reservoir (Pernambuco, Brazil). Eight treatments were assigned, each one with 4 replicates: control (C), macrophytes (M), zooplankton (Z), nutrients (N), and the combination of all these factors (MZ, MN, ZN, and MZN). At the beginning, and after 5 and 10 days, total phytoplankton biomass, the biomass of cyanobacteria, chlorophytes, diatoms, and phytoflagellates were compared by a three-way ANOVA. At the beginning of the experiment, phytoplankton biomass was 206.5 mg.L-1, increasing to 296.9 mg.L-1 on the tenth day. A cyanobacterial bloom (relative contribution >99%) was registered, which was composed mainly of five Microcystis morphospecies and Raphidiopsis raciborskii. On the tenth day, macrophytes significantly reduced up to 85% of total phytoplankton and cyanobacterial biomass in the treatments M, MZ, MN, and MZN. Chlorophytes were inhibited in the treatment M (77.9%) and diatoms in the treatments M, MZ, MN, and ZN (up to 97%) after 10 days, while phytoflagellates were inhibited in the treatments M, Z, MZ, MN, ZN, and MZN (up to 77.2%) after 5 days. Considering that C. demersum efficiently controlled the cyanobacterial bloom even with nutrient addition, its effects can be attributed to allelopathy. Large cladocerans effectively consumed diatoms and phytoflagellates in the treatments ZN and/or Z. Accordingly, this study proves the efficiency of biomanipulation on the control of algal blooms in tropical shallow lakes, including potentially toxic cyanobacteria.

Cyanobacteria blooms Mesocosms Microcystis Tropical shallow lakes

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UNPREDICTED EFFECT OF CATTLE EXCLUSION AT THE BUFFER ZONES IN THE RESERVOIR PASO SEVERINO: THE POTENTIAL NUTRIENT SUPPLY OF THE PLANT LITTER.



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After a large bloom of cyanobacteria in the main water source of Uruguay (Santa Lucía River SLR), the Uruguayan Parliament promoted the protection of buffer zones (ZB) in priority areas, with the aim of reducing the load of nutrients from agricultural lands. Agriculture and livestock were excluded 100m from the margins of the Paso Severino Reservoir (SLR-Uruguay). However, the absence of herbivory in ZB could have a potential negative effect, since the accumulation of necromass of herbaceous and graminoids could potentially contribute nutrients to the aquatic system. The objective of this work was to analyze the accumulation of above ground necromass of herbaceous and graminoids present in different types of ZB (i.e., grassland, shrubland, native forest) and to estimate its potential contribution of nutrients by decomposition under different scenarios of rainfall, humidity and runoff. The necromass was measured and the amount of nitrogen and phosphorus (kg/ha*year) that could reach to the water body by decomposition under different scenarios was estimated. Through the analysis of satellite images, the current area occupied by each coverage of the ZB was obtained and knowing the amount of necromass in each ZB and the nutrients potentially released, current and future export values were estimated at the entire watershed. More necromass was found in winter. The ZB that accumulated more necromass and could therefore potentially provide more nutrients through decomposition, was the Shrubland, followed by grasslands and Native Forest. Different management measures are proposed.

Plant Necromass Buffer Zone Eutrophication

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EFFECTS OF HYDROGEN PEROXIDE TO REMOVE HARMFUL CYANOBACTEIAL BLOOMS IN A TROPICAL SHALLOW URBAN POND IN SOUTHEAST BRAZIL

SESSION 08

Marcela Miranda (Instituto Nacional de Pesquisas Espaciais); **Felipe Pacheco** (Instituto Nacional de Pesquisas Espaciais); **Natalia Pessoa Noyma** (Universidade do Estado do Rio de Janeiro); **Vera Lúcia Moraes Huszar** (Universidade Federal do Rio de Janeiro); **Leonardo de Magalhães** (Universidade do Estado do Rio de Janeiro); **Vivian Leite** (Universidade do Estado do Rio de Janeiro); **Erick Drummond** (Universidade do Estado do Rio de Janeiro); **Miquel Lürling** (Wageningen University & Research Centre); **Ernani Pinto** (Universidade de São Paulo); **Jean Ometto** (Instituto Nacional de Pesquisas Espaciais); **Marcelo Manzi Marinho** (Universidade do Estado do Rio de Janeiro)

LINK TO THE STUDY VIDEO

The control of eutrophication and mitigation of harmful blooms of cyanobacteria are considered key challenges for the management of water quality. The reduction of the nutrient load of surface waters is the preferred way to prevent these blooms; however, this is not always feasible. Quick curative measures are therefore preferred in some cases. The objective of this study was to verify the effects of techniques for removal of harmful cyanobacterial blooms in tropical systems. We conducted mesocosm experiments in tropical shallow urban pond (Mariano Procópio Museum Lake – Juiz de Fora, MG) to test controlling eutrophication using a combination of a low dose coagulant with a solid phase phosphate (P) fixative. Preliminary laboratory tests were conducted to determine the doses needed to flocculate and precipitate cyanobacteria and to reduce P efflux from the sediment. The coagulant used was poly-aluminium chloride (PAC) 6 mg L-1 and the ballasts local red soil (RS) 1200 mg L-1. To avoid resuspension of cyanobacteria biomass we test Hydrogen Peroxide (H2O2) 20 mgL-1 together with PAC and RS to remove cyanobacterial biomass and potential release of cyanotoxins. We observed a reduction of Chl, NT and TP regardless treatment applied (PAC + RS and H2O2+PAC + RS). In the H2O2 treatment the PSII Efficiency was reduced in T0, T1 and T2. But, this reduction did not remain over time. The treatment was efficient but more than one application of H2O2 would be necessary.

Eutrophication control experiments , Flock & Sink techinique, Hydrogen Peroxide

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CYANOBACTERIAL REMOVAL BY FLOC & LOCK APPLICATION AND ITS EFFECTS ON PHYTOPLANKTON COMMUNITY: A MESOCOSMS EXPERIMENT IN A TROPICAL RESERVOIR (UHE FUNIL, RJ)



Davi Almeida Barreto (UFRJ); **Natália Noyma** (UERJ); **Leonardo de Magalhães** (UERJ); **Vera Lucia Huszar** (UFRJ); **Marcelo Manzi Marinho** (UERJ); **Lidiane Lopes de Almeida** (UFRJ); **Nara de Azevedo Garcia** (UFRJ); **Lucia Helena Sampaio da Silva** (UFRJ)

Eutrophication of water bodies has generated environmental, social, and economic impacts worldwide, mainly through cyanobacterial blooms. To assist in mitigating these effects, geoengineering techniques have been considered as excellent tools for removing phosphorus (P) and cyanobacteria. However, the effects of the technique on the entire phytoplankton community remain unclear. To test the effectiveness of the coagulation and sedimentation technique on the cyanobacteria removal as well as their effects on the phytoplankton community we carried out mesocosm experiments in a eutrophic, tropical hydroelectric reservoir with recurrent records of cyanobacterial blooms (Rio de Janeiro State). We hypothesized that the technique reduces total phytoplankton biomass and species diversity increase at the end of experiment. For that, we used different combinations of coagulant and phosphorous adsorbents. Control and two treatments in four replicates were monitored during 28 days in a high cyanobacterial biomass: treatment 1, with combination of polyaluminium chloride (PAC) and bentonite modified with Lanthanum (LMB); and treatment 2, with PAC and LMB, plus local red soil (LRS). Phytoplankton biomass, mainly cyanobacteria, was significantly removed in both treatments in the first 24 hours, lasting until the end of the experiment. Despite the reduction in biomass, cyanobacteria still showed a large contribution to the total phytoplankton biomass, with a trend to an increase in the contribution of chlorophyceans, flagellates (chrysophyceans and cryptophyceans), in treatments 1 and 2, and diatoms only in treatment 2. We conclude that the use of the Floc & Lock technique is efficient in removing cyanobacteria biomass, favoring the increase of species diversity. LRS, an abundant material in nature rich in iron and aluminum, can reduce the cost of the technique, enabling its use in improving water quality in different systems.

Eutrophication control; Flock & Lock; experiments in mesocosms

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COMPLEX RESPONSES OF AQUATIC SPECIES TO CONTAMINATION OF PHARMACOLOGICALLY ACTIVE COMPOUNDS AND THEIR POSSIBLE ROLE IN SHALLOW LAKE EUTROPHICATION

SESSION 09

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The generally used wastewater treatment technologies are not or only partly suited to eliminate a series of chemical pollutants, allowing them to enter into the environment meanwhile their physiologically active state is retained. To date, members of the aquatic ecosystem (e.g., cyanobacteria, zooplanktons, molluscs, fish or macrophytes) are constantly being exposed to various chemical pollutants of anthropogenic origin (e.g., pharmacologically active compounds) resulting profound changes of the environment. These modified environment conditions, together with climate changes, induce for example cyanobacterial algal blooms and overgrowth of macrophytes in shallow lakes leading to eutrophication. At the same time, the animals have to adapt to these changes in the lake in order to survive the ecotoxicological effects of disturbing chemical factors. But how are they able to achieve it, and what types of physiological alterations are typical? Furthermore, what could be the fate of active substances in lakes and what may be the cyanobacteria role in these processes? Based on them, the first aim of this thematic session is to introduce the possible fate of pharmacologically active compounds and the exact role of cyanobacteria and organic matters in these processes, furthermore, their interactions in a shallow lake eutrophication. The second aim of this session is to present the various changes at behavioural, cellular or molecular levels in invertebrate and vertebrate aquatic species, following chronic exposition of active substances.

PRIMING EFFECT OF CYANOBACTERIAL-DERIVED ORGANIC MATTER ON ENHANCED DEGRADATION OF STEROID ESTROGENS IN ONE EUTROPHIC LAKE

Bai Leilei (Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences); **Jiang Helong** (Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences)

Climate change and increasing eutrophication are expected to expand the occurrence of cyanobacterial harmful algal bloom, leading to the increased release of cyanobacterial-organic matter (COM) into freshwater lakes. The augment of COM is closely associated with the biodegradation of steroid estrogens, which exhibits strong estrogenic potency at extremely low concentrations. Herein, the effects of COM on 17-ethinylestradiol (EE2) biodegradation by an EE2-degrading strain (Rhodobacter blasticus) and by the microbial community in sediments were investigated, respectively. In the first experiment, the amendment of 10 mg C L–1 COM increased the EE2 degradation efficiency from 10% to 44–53%, significantly higher than that of humic acid. The enhanced degradation was not only attributed to the increased growth of EE2-degrading strain, but also related to its stimulated metabolic activity, as indicated by the higher biomass-normalized degradation rate. In the second experiment, the EE2 degradation was significantly and positively correlated with the cometabolism of increasing organic carbon in COM-amended sediments ($P < 0.001$). The immediate breakdown of labile components such as proteinaceous substances in COM remarkably augmented the metabolic activity of bacteria in terms of the stimulated activity of extracellular enzymes, as well as the elevated production of extracellular polymeric substances. In the meantime, the bacterial community composition was reshaped toward a more eutrophic state, leading to the clear upregulation of metabolic function genes of xenobiotic. Correlation-based network analysis further determined the strong facilitative coordination between the community members and the compositional variability of COM in the cometabolism. These results suggest that cyanobacterial blooms-dominated zones are potential hotspot areas for steroid estrogen attenuation, a finding of significance for the control and management of complex pollution in freshwater lakes.

Cyanobacterial-bloom Steroid-estrogen Organic-matter Biodegradation

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EFFECT OF TETRACYCLINE ON THE DEMOGRAPHIC RESPONSES OF THREE ROTIFER SPECIES

SESSION 09

Andrea González Ávila (Universidad Nacional Autónoma de México); **S.S.S. Sarma** (Universidad Nacional Autónoma de México); **S. Nandini** (Universidad Nacional Autónoma de México)

LINK TO THE STUDY VIDEO

Increased drug resistance in humans and farm animals has resulted in the application of higher doses and for longer duration of antibiotics to treat infectious diseases. This in turn causes an increase in the concentrations antibiotics in wastewaters and drinking water bodies. Tetracyclines are a widely consumed group of broad spectrum antibiotics worldwide. Though a substantial part of tetracyclines breaks down rapidly in nature, some parts still persist in water bodies and come into contact with non-target aquatic organsims such as rotifers. Rotifers are the dominant component of shallow lakes. They are also widely used for ecotoxicological evaluations due to their ecological relevance, sensitivity, short generation time and high reproductive rates. In this work we present data on the effect of three sublethal concentrations of tetracycline on the demographic characterstics of three rotifers (Brachionus calyciflorus, Brachionus havanaensis and Plationus patulus) all of which were isolated from the shallow lake, Lake Xochimilco. Tetracycline concentrations ranging from 1.25 to 30 mg/L were used in the experiments. The results showed that there was an inverse relationship between tetracycline concentration and life history variables of the three rotifer species. Thus, increased tetracycline concentration decreased the survival, offspring production and population densities of the rotifers. The adverse effects of tetracycline on non-target organisms in shallow lakes have been discussed.

tetracycline, zooplankton, nominal concentrations, demographic responses

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USES OF BIOMARKERS IN CORBICULA FLUMINEA (MOLLUSCA, BIVALVIA) AS AN EARLY WARNING SYSTEM IN LAGUNA DEL SAUCE (MALDONADO-URUGUAY)

SESSION 09

Alejandra Kröger (Departamento de Ecología y Gestión Ambiental, CURE-UdelaR); **Franco Teixeira de Mello** (Departamento de Ecología y Gestión Ambiental, CURE-UdelaR); **Wilner Martinez Lopez** (Laboratorio de Epigenética e Inestabilidad Genómica. Iibce); **Soledad Marroni** (Departamento de Ecología y Gestión Ambiental, CURE-UdelaR); **Giancarlo Tesitore** (Departamento de Ecología y Gestión Ambiental, CURE-UdelaR); **Néstor Mazzeo** (Departamento de Ecología y Gestión Ambiental, CURE-UdelaR)

The principal problems of freshwater quality come from eutrophication and inputs of xenobiotic. In Uruguay, the main contributions of nutrients and pesticides derive from agricultural-livestock activities and the discharge of domestic and industrial effluents. The aim of this study is to develop an early warning strategy for detection of pesticides and the effects in the biota of a continental aquatic ecosystem (Laguna del Sauce, Maldonado-Uruguay), using Corbicula fluminea as bioindicator and two biomarkers (Micronucleus test -MT- and Comes assay -CA-). An acute experiment (24 h) was carried out employing different concentrations of Metholaclor (0.025, 0.05, 0.1, 0.2 µg/l) and Metalaxyl (0.0125, 0.025, 0.05, 0.1, 0.2 µg/l), pesticides previously detected in sediment and biota. The experimental design included a positive control (hydrogen peroxide) and a negative control (absence of xenobiotic). Micronucleus frequency significantly increases with 0.025 µg/l Metolachlor while primary DNA damage (evaluated whit CA) was significantly induced with 0.1 µg/l. On the other hand, Metalaxyl showed a significant increase of micronucleus with 0.0125 µg/l and primary DNA damage (evaluated whit CA) with 0,025 µg/l. In addition, genetic damage was evaluated in organisms in field versus laboratory conditions (absence of xenobiotic). Both test detected effects in field conditions in comparison with organisms acclimatized in the laboratory. The use of biomarkers such as MT and the CA in hemolymph of C. fluminea is a useful tool to detect the presence and effects produced by pesticide residues. This tool can be used in a complementary way in the classic monitoring programs, contributing to an early detection of xenobiotic and help to understand their potential effects on organisms and the potential effects on the ecosystems.

biomarkers, micronucleus test, comet assay, pesticides, Metolachlor, Metalaxil, water quality.

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EFFECT OF TEMPERATURE ON THE SURVIVORSHIP AND FILTERING RATES OF DAPHNIA PULEX (CLADOCERA) EXPOSED TO MICROPLASTICS

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SESSION 09

LINK TO THE STUDY VIDEO

Temperature changes and increased contamination are stressors that strongly affect aquatic organisms. Since 1950 the production of plastics has increased almost 200-fold; a large proportion of the wastes from plastic residues and personal care products reach aquatic ecosystems. The effect of microplastics on aquatic organisms can be diverse, from intoxication due to associated chemicals to mechanical damage by direct ingestion of the fragments or spheres. Rotifers and cladocerans are generalist filter feeders, capable of consuming particles between 20-100 µm, which, allows small particles of microplastics between 0.05 - 50 µm to be easily ingested, and this could have an adverse effect on their survival. The aim of this work was to evaluate the effect of 30 µm microplastics in contact with the three growth stages of Daphnia pulex; neonates, juveniles and adults. We determined the mean lethal time of the cladoceran under exposure to 0-50 mg/L of polystyrene (Sigma chemicals) particles during 96 hours. Later we compared the filtration rates of neonate, juvenile and adult cladocerans under two sublethal concentrations of microplastics at 15 and 25 ºC. The most affected stage during the experiments were the adults at 25 ºC. This result is mainly due to the fact that the higher temperature stimulates the metabolism of cladocerans, which causes an increase in filtration rates and therefore a higher intake of microplastic particles, having an adverse effect on both behavior and assimilation of resources. Our results have been discussed with reference to the impact of these emerging contaminants on the density and diversity of zooplankton in shallow freshwater ecosystems.

Microplastics, Daphnia pulex, Filtration rates, Intake rate, Ecotoxicology

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FILTRATION AND INGESTION RATE IN PLATIONUS PATULUS EXPOSED TO CADMIUM AND MICROPLASTICS



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Globally plastic production, consumption and discharge into the aquatic environment has increased exponentially during the last 6 decades. Few strategies have been developed by governments all over the world to minimize and manage this pollutant which occurs in aquatic ecosystems in large quantities. Polystyrene, a type of plastic produced in high volumes, is found in freshwater ecosystems with particles <5 mm, called microplastics. Due to their small size and the ability to adsorb other contaminants such as heavy metals including cadmium, microplastics affect many ecological functions such as the feeding and filtration rates of zooplankton. The rotifer Plationus patulus, a common component of tropical shallow lakes, is one of the non-target species of microplastic contamination. In this work, we evaluated the filtration and ingestion rates of Plationus patulus exposed to different concentrations of cadmium and microplastics. The results showed decreased ingestion rates of algal food consumption with increase in the concentrations of both heavy metal and microplastics. The ability to filter in the medium and the swimming rates of rotifers due to the presence of Cd and microplastics are mainly responsible for the decreased algal consumption by the rotifers.

Rotifera, Heavy metals, Feeding rate, Polystyrene, Ecotoxicology

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MORPHOLOGICAL ALTERATIONS IN Keratella SPP. (MONOGONONTA: BRACHIONIDAE) FROM LAKE PÁTZCUARO, MÉXICO

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SESSION 09

LINK TO THE STUDY VIDEO

Lake Pátzcuaro has been under an accelerated eutrophication process and it is strongly affected by anthropogenic contamination. Recently, it was reported that some organisms of Keratella cochlearis registered in the Embarcadero area, presented morphological alterations in the posterior spine. In this study, we present the characterization of the alterations found in the rotifers of the genus Keratella as well as some environmental characteristics of the Embarcadero area during the warm-dry season. We also verified if there were other species of Brachionidae family with morphological alterations, as well as their egg/female ratio. Brachionidae family was dominated by K. tropica (38.1%) follow by K. cochlearis (34.7%), Brachionus caudatus (11.9%), K. americana (10.1%), B. havanaensis (4.7%), Platyias quadricornis (0.07%), and B. calyciflorus (0.2%) with a total abundance of 414.6 ± 61.9 ind.L-1. It was quantified that 0.019% of the population of K. cochlearis had alterations in different spines, being the posterior spine the one with the highest frequency of alterations, followed by the left central antero-dorsal spine. Also, 0.008% of K. americana population showed morphological alterations in the posterior spine. Normal females (without alterations) of K. americana and K. cochlearis displayed an egg/female ratio of 0.19 and 0.015 respectively, all individuals showing morphological alterations did not have any eggs. It remains unknown the actual presence and concentrations of some pollutants within lake Pátzcuaro, as well as its possible consequences on the aquatic fauna. Thus, it becomes necessary to propose and implement management strategies to reduce the deterioration process of the lake and the loss of biodiversity.

Egg/female ratio, Eutrophication, Rotifera, Teratologies, Water pollution.

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SHALLOW LAKES IN AGRICULTURAL LANDSCAPES

SESSION 10

Maria Boveri
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All around the world, shallow lakes and ponds on gentle plains are now surrounded by agricultural land use. The externalities of modern intensive crop and cattle activities impact on these water bodies with excess of fertilizers, pesticides and siltation that can condemn them to hyper eutrophication, deoxigenation, fish kills or clogging. Big differences arise between landscapes where societies want and can regulate what humans do in the watershed, and those where people´s big economic needs threat water quality and ecosystem health. However, the current valorization of the services that these shallow lakes provide justify our attention, the development of restoration strategies and tools, and better protection policies.

EFFECT OF LAND USE ON FISH RICHNESS OF NEOTROPICAL COASTAL LAGOONS



Taís de Fátima Ramos Guimarães (UFRGS); **Ana Cristina Petry** (UFRJ); **Fernando Gertum Becker** (UFRGS); **Sandra Maria Hartz** (UFRGS)

LINK TO THE STUDY VIDEO

Anthropic influences on aquatic systems threaten biodiversity by altering the quality and heterogeneity of these environments. In coastal lagoons, anthropic effects may be more worrying due to the strong tendency of human occupation of coastal regions and because they are considered naturally stressful environments due to fluctuating salinity. In this study, we examined the response of fish species richness in 75 neotropics coastal lagoons along a gradient of landscape anthropic modification. We measured the proportion of agriculture and urbanization around each lagoon (from 1985 to 2012) and calculated their coefficient of variation (CV) as a measure of the temporal variability and instability of the landscape. We compiled the species composition in each lagoon from the literature review and museum records, and we analyzed the richness them separately according to different habitat uses by fish: bottom and water column use; littoral, limnetic and littoral + limnetic zone use. In regions where lagoons are more subject to variation in salinity, the interaction between agriculture cover and CV was present in all GLM models. In these regions, bottom species richness and littoral species richness were the most affected. For freshwater lagoons, both agriculture and urban variables were present in the models, and their effects were more relevant for total and bottom species richness. The fish fauna of freshwater coastal lagoons seems to be more sensitive to human modification of land cover because they lack a constant external source of incoming individuals and species, in contrast to saline lagoons connected to the sea. However, this apparent resilience of fish species in brackish lagoons must be regarded with caution, since several common estuary-associated marine fishes populations are declining worldwide.

anthropic influences, freshwater, havitat use, salinity, transitional waters

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KEY DRIVERS STRUCTURING ROTIFER COMMUNITIES IN PONDS: INSIGHTS FROM AN AGRICULTURAL LANDSCAPE



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Understanding the influence of environmental and spatial factors on the structure of aquatic communities in shallow water bodies exposed to intensive agriculture is essential for designing restoration and protection strategies for these ecosystems. This study aims to identify the main drivers of rotifer abundance and diversity in ponds embedded in an intensive agricultural landscape in Northeast Germany. We studied a set of 42 ponds of glacial origin (i.e. kettle holes) that covered a wide range of environmental parameters and were surrounded by different land use types. Fertilizer-driven salinization, along with internal nutrient recycling, primary productivity and sediment phosphorus release were the prevailing biogeochemical processes in the ponds. Rotifer alpha diversity was negatively affected by fertilizer-driven salinization. This impact was lower in forest ponds than in those surrounded by arable fields or grassland. However, rotifer diversity did not significantly differ among land use categories. The predominant factors structuring the rotifer metacommunity shifted from abiotic environmental filtering in spring to likely biotic interactions in autumn, while spatial factors remained unimportant. Our results indicate that the long-term impact of intensive agriculture in the region and the associated widespread eutrophication override the direct influence of land use on rotifer diversity but point to an indirect land use effect via fertilizer-driven salinization.

biodiversity, eutrophication, freshwater, water quality, zooplankton

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IMPACTS OF RICE HYDROPERIOD MANAGEMENT ON THE HYDROLOGY OF A SHALLOW MEDITERRANEAN LAKE DURING 2006-2020

SESSION 10

Lucia Vera (University of Valencia) **Juan Soria** (University of Valencia); **Javier Perez** (University of Valencia); **Susana Romo** (University of Valencia)

LINK TO THE STUDY VIDEO

Hydrological regimes define the structure and functions of a wetland, playing a vital role in controlling its physical, chemical and biological characteristics. In the last decades, in many cases, the times of temporary flooding of the wetlands have been controlled by agricultural requirements instead of natural seasonal flood cycles, affecting ecosystem functioning and altering the structure of its different aquatic habitats. The Natural Park of the Albufera (Valencia, Spain) is an important coastal Mediterranean wetland included in the RAMSAR and NATURA 2000 lists and is one of the three natural areas of Spain where rice is cultivated intensively. The Albufera Lake is located in the center of this Natural Park and its hydrology combines natural contributions (seasonal rainfall) with a complex human management, due to the rice cultivation. In addition, the lake has been eutrophic since the 1970s due to industrial and urban discharges and inputs of high nutrients loads from agricultural activity. The aim of this research is to deepen in the hydrological study of the Albufera lake and the surrounding wetland by the monitoring of the rice fields hydroperiods during 2006-2020 using Landsat time-series imagery. The residence time (or renewal time) will also be evaluated in order to quantify how the lake hydrodynamics is conditioned by the agricultural management. This study, therefore, presents a holistic approach, considering the connectivity between all the aquatic systems of the wetland, and the results can contribute to improve the knowledge about the hydrology and ecology of this shallow lake and to develop more specific management plans for this water body taking into account the impacts of rice cultivation.

coastal laggon, ricefields, Landsat, hydrology, agriculture

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CATCHMENT LAND COVER AND SOIL AS PREDICTORS OF ORGANIC CARBON, NITROGEN, AND PHOSPHORUS LEVELS IN TEMPERATE LAKES



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Allochthonous supply of dissolved organic matter (DOM) and nutrients from the catchment affect the physical and chemical properties of lake water and have a substantial impact on the functioning of lake ecosystems. Transport of DOM and nutrients is controlled by local climate and catchment characteristics. The aim of this study was to relate land cover and soil characteristics of 52 temperate catchments to variability in DOM (measured as dissolved organic carbon, DOC), total organic nitrogen (TON), and total phosphorus (TP) in lakes and to assess the relative importance of different land cover and soil types as sources of these substances. While the role of land cover types has been thoroughly studied, only few studies have evaluated catchment soil types so far, especially linking DOM and nutrients in lake water with organic C and nutrients in catchment soils. DOC, TON, and TP were very diverse in studied lakes: the range of DOC was 4.6-47.7 mg/l, and TON and TP concentrations ranged over almost the entire trophic scale from oligotrophic to hypereutrophic. Patterns of DOC, TON, and TP were similar, indicating that their variability was driven by similar factors. Catchment soil cover was the best predictor of DOC, TON, and TP levels in lakes, explaining up to 40.6% of the variability. This was partly due to different soil organic carbon (SOC) content of soils: soils with higher SOC, including fertile agricultural soils, induced higher lake DOC and TON, whereas soils with low SOC corresponded to lower DOC and TON. We confirmed the role of bogs and peat soils as a major source of DOM in temperate lakes. Bogs were also a source of TON and TP, although our results indicated the importance of human impact on their concentrations. Understanding the impact of different catchment characteristics on DOC, TON, and TP in temperate lakes is crucial for developing transport models used for predicting future levels of DOM and nutrients under changing climate and land use.

eutrophication, nutrients, organic matter, land use, soil types

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BIOTIC INTERACTIONS SHAPE THE EFFECT OF COMBINED STRESSORS ON SHALLOW LAKE ECOSYSTEMS: INSIGHT FROM MICROCOSMS EXPERIMENTS



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Organisms living in aquatic ecosystems such as shallow lakes are generally affected by multiple anthropogenic stressors such as pesticides and nitrate input from agricultural runoff or increase in temperature due to global warming. While organisms are affected directly by the stressors, they are also affected indirectly through biotic interactions. The aim of our study was to determine the implication of biotic interactions in the effect of multiple stressors on shallow lake ecosystems. We performed a set of microcosm experiments in which organisms were exposed to a cocktail of organic pesticides, copper and nitrate to simulate agricultural runoff. Different scenario of pollutant input, as one or several pulses, were used. A 4°C warming was also used to simulate the impact of global warming. Two separate experiments were performed to determine the direct effect of on a primary producer community (submerged macrophytes, periphyton and phytoplankton) and on a primary consumer, the benthivorous snail Lymnaea stagnalis. In a third experiment, primary producers and three different primary consumers (Daphnia, mussel, snail) were exposed together to allow trophic interactions. When primary producers and consumers were exposed separately, agricultural runoff had a direct positive effect on phytoplankton and a strong negative effect on L. stagnalis. When exposed together, phytoplankton showed in contrast a significant decrease. Using structural equation modelling, we determined that this effect on phytoplankton was not a direct effect of the agricultural runoff but an indirect effect. Indeed, inhibition of L. stagnalis grazing on periphyton induced a positive effect of agricultural runoff on periphyton, while periphyton reduced the development of phytoplankton through competitive interactions. This demonstrates the importance of taking into account biotic interactions to understand the effect of multiples stressors on shallow lake ecosystems.

Multiple stressors, aquatic ecosystems, agricultural runoff, global warming, biotic interactions

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EXPOSURE PATHWAYS MATTER – A MICROCOSM STUDY TO EVIDENCE EFFECTS IN PHOTOTROPHIC COMMUNITIES BY AGRICULTURAL RUN-OFF INTRODUCED VIA SEDIMENT OR THE WATER PHASE



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Shallow lakes and ponds suffer from various stressors like high nutrient loads and pesticides from agriculture. Also, they are strongly affected by increasing temperature due to climate change. Yet they are complex ecosystems with a high abundance of phototrophic micro- and macroalgae and macrophytes who compete for nutrients and light. The winner of this inter-species competition changes with differing environmental conditions potentially resulting in regime shifts and alternative stable states. The contrasting effects of nutrients and pesticides affecting this competition may lead to various possible outcomes. In the French-German collaboration project CLIMSHIFT, we investigate the combined effects of agricultural run-off (ARO) and elevated temperatures on thresholds inducing regime shifts in micro- and mesocoms. As part of this project, we here focus on the question, whether the ARO effects differ depending on the exposure pathway (sediment versus water phase). Using 8L-microcosms with photoautotrophic communities, we tested these two exposure pathways for an artificial ARO mixture consisting of nutrients and pesticides. Both pathways were tested at two different temperatures (22°C & 26°C). Three different macrophyte species typical for shallow lakes and a natural microalgae inoculum were introduced to the microcosms. While exposure via the sediment had little effect on macrophyte growth, exposure via the water phase inhibited growth. In contrast, phytoplankton grew strongest when the ARO was exposed via the water phase. We conclude that impacts on the macrophytes rather derive from indirect effects by shading from phytoplankton in water-exposed microcosms than from direct effects from the ARO . We show that the ARO exposure pathway matters for inter-species competition and must be taken in consideration for extrapolation of microcosm studies to in-situ scenarios.

agricultural run-off, climate change, microcosm, exposure pathways

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ASSESSMENT OF COVER AND ABUNDANCE OF PRIMARY PRODUCERS IN A SHALLOW EUTROPHIC LAKE IN AGRICULTURAL WATERSHED USING HYPERSPECTRAL SATELLITE DATA



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LINK TO THE STUDY VIDEO

Nutrient excess in freshwaters can favor eutrophication processes up to levels where algal and macrophyte growth cannot be controlled by grazing, resulting in rapid infilling and risk of hypoxia. The Mantua lakes (6,21 km²; Italy) is a shallow eutrophic fluvial lake system. The watershed is characterized by intensive agriculture (68% of the watershed) and livestock farming (240 x103 cattle and 700 x103 pigs). These anthropic pressures were principal factors leading to the eutrophication of the Mantua Lakes, which owing to their shallow nature still harbour a coexistence of phytoplankton and macrophytes. Remote sensing (RS) data are widely used to assess the primary producers spatial extent and abundance at different spatial-temporal scales. A focus of RS applications is currently on cyanobacteria species dominated by phycoerythrin or phycocyanin pigments exploiting hyperspectral data. In the present study, hyperspectral imagers such as the recently PRISMA (Precursore Iperspettrale della Missione Applicativa of the Italian Space Agency) and DESIS (DLR Earth Sensing Imaging Spectrometer of the German Aerospace Center) missions are used to monitor and assess the abundance of the primary producers of the Mantua lakes system (2019-2020). The hyperspectral images corrected atmospherically with ATCOR were compared with synchronous multispectral Sentinel-2 MSI and Sentinel-3 OLCI images. Analysis are focused on aquatic vegetation, from emergent (e.g. common reed, sacred lotus) to floating-leaved (e.g. waterchestnut) macrophytes and on the different pigments useful to identify phytoplankton groups such as diatoms and cyanobacteria. The preliminary results show a great advantage in using hyperspectral data, with adaptive semi-empirical algorithms based on the use of higher number of bands dedicated to the peak of absorption and reflectance of different pigments, for the characterization of the biodiversity of primary producers and in supporting management of aquatic habitats.

phytoplankton, macrophytes, cyanobacteria, hyperspectral satellite data, shallow fluvial lake, remote sensing

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DECADAL CHANGES IN SIZE, SALINITY AND BIOTA IN LAKES IN THE KONYA CLOSED BASIN, TURKEY, SUBJECTED TO INCREASING WATER ABSTRACTION FOR AGRICULTURE AND CLIMATE CHANGE



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The Konya Closed Basin (KCB) in Turkey has a cold semi-arid to warm Mediterranean climate and hosts the largest Turkish freshwater lake, Lake Bey?ehir, in the upstream, and the iconic saline Lake Tuz in the downstream of the basin. Using published as well as own ground-truth and remote sensing data, we give a brief description of the paleo-environmental changes in KCB, followed by a detailed description of the changes in land use, crop production, groundwater and surface water levels and climate, and the implications that the changes have had for the lake water surface area, salinity, and biotic (waterbird and fish) communities during the past 40 years. KCB is intensively farmed, and crop production has increased substantially, especially since 2000 with mainly water thirsty crops. This, combined with climate warming, has led to a substantial reduction of the groundwater level (up to 1 m/year) as well as of the surface area of the lakes and wetlands, followed by salinisation, and some have already dried out completely. Three globally threatened waterbird species face extinction in the basin, while 18 out of 62 breeding species have already been lost. Similarly, KCB has 38 fish species of which 74% of endemic, and 61% of those are considered threatened or near threatened. Modelling projections using various climate and land use scenarios indicate serious additional reductions in water level in the future due to climate change, which will cause serious damage to the lake ecosystems and the services that they provide.

saline lakes, salinisation, climate, land-use change, habitat loss

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CHARACTERIZATION OF THE VEGETATION BELT AND ITS ABILITY TO PROTECT THE SHALLOW LAKES ON THE PAMPEAN LANDSCAPE



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While in a large part of the world small shallow lakes and wetlands in human influenced landscapes are protected, in the Pampa Plain they are still threatened by agricultural activities. An important ecological component of these lakes is the fringing littoral vegetation. It shelters an important biodiversity and acts as a buffer zone in front of the impact of land use in the surroundings, so its preservation helps to conserve the ecosystem health. The purpose of this work is to describe the aquatic macrophytes belt in the upper littoral zone of different small Pampean shallow lakes. We measured richness (species number), biomass (g m-2) and the coverage (%) of each plant biotype over 84 sample plots from the vegetation belt of 11 shallow lakes using the Quadrats Standard Methods. Complementary, floristic composition samples were collected. We built a correlation matrix for general descriptive modelling and used Cluster analysis (Ward Method) in order to group the lakes with similar vegetation features. We employed the multivariate analysis to examine the relationship between vegetation characteristics and the lake's Secchi Disk lecture (SDL). Emergent hydrophytes cover in the littoral zone is the variable most related with lake water transparency. No significant influence of the surrounding macrophytes biomass in the transparency was found. Otherwise, species richness was negatively related to the Secchi Disk reading, probably because higher richness was mainly due to invasive herbaceous upon former naked soil. Our results suggest that differences in macrophyte communities in the littoral zone can have an important influence on water transparency. Surrounding land use may influence the species cover of the vegetation belt. This information has important implications for the further management, conservation and restoration projects of the Pampa Plains wetlands.

Macrophytes Pampa Plains Littoral Buffer Zone

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MORPHOMETRY OF LITTORAL ZONE AND ITS EFFECT ON LIGHT ENVIRONMENT IN SHALLOW LAKES WITHIN AN AGRICULTURAL LANDSCAPE



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Along the Central Pampas countless small shallow lakes with its associated wetlands splash the agricultural landscape. The adjacent vegetation ring of a water body offers several ecological services, being the mitigation of agricultural impacts one of the most relevant. Although the idea of the protective effect of a vegetated buffer zone is already stablished, an exhaustive study on the morphology and integrity of this adjacent vegetation ring has not been thoroughly performed. To fulfill this gap, the objective of the present study is to characterize the vegetated buffer zone and to relate the presence and integrity of rooted vegetation on water transparency. Littoral morphometry of 11 small shallow lakes was characterized by processing satellite images with proper field data validation. Upper littoral zone (the zone of emergent rooted vegetation) was delimited with GPS and SWMaps(R) application obtaining the internal and external borders. Field assessment included water transparency, depth, land use in the surrounding and macrophyte type in the adjacent area. Littoral zone size and shape were summarized into 4 different indicators: mean width, buffer-water area ratio, integrity and development of the border line (DL). Photic zone: mean depth ratio (Zfot/Zm) was calculated as an estimator of the capacity of light to reach the lake bottom. Multivariate analysis was employed to cope the inherent variability of data: Cluster Analysis and PCA for data grouping. Variability was explained positively in PCA1 (axis) for mean width, buffer-water area ratio and integrity, and PCA2 (axis) for Zfot/Zm and negatively DL. As a result, 3 sets were identified: turbid with a deteriorated vegetation belt, clear with a health littoral vegetated zone, and clear with submersed macrophytes. We discuss the importance of maintaining integrity of the vegetation ring to conserve water quality of shallow lakes immersed in productive landscapes.

littoral morphometry small wetlands buffer zone emergent macrophytes agriculture

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PRECIPITATION, LANDSCAPE PROPERTIES AND LAND USE INTERACTIVELY AFFECT WATER QUALITY OF TROPICAL FRESHWATERS

SESSION 10

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LINK TO THE STUDY VIDEO

Globally, conversion of pristine areas to anthropogenic landscapes is one of the main causes of ecosystem service losses. Land uses associated with urbanization and farming can be major sources of pollution to freshwaters promoting artificial inputs of several elements, leading to impaired water quality. However, how the effects of land use on freshwater quality are contingent on properties of the local landscape and climate is still poorly understood. This study aimed to evaluate the effects of landscape properties (morphometric measurements of lakes and their catchments), precipitation patterns, and land use properties (extent and proximity of the land use to freshwaters) on water quality of 98 natural lakes and reservoirs in northeast Brazil. Water quality impairment (WQI) was expressed as a composite variable incorporating parameters correlated with eutrophication including nitrogen (N), phosphorus (P) and Chlorophyll-a concentration. Regression tree analysis showed that WQI is mainly related to highly impacted “buffer areas”. However, the effects of land use in these adjacent lands were contingent on precipitation variability for 13% of waterbodies and on surface area of the buffer in relation to the volume of waterbody (BA:Vol) for 87% of waterbodies. Overall, effects on WQI originating from the land use in the adjacent portion of the lake were amplified by high precipitation variability for ecosystems with highly impacted buffer areas and by high BA:Vol for ecosystems with less impacted buffer areas, indicating that ecosystems subjected to intense episodic rainfall events (e.g. storms) and higher buffer areas relative to aquatic ecosystem size (i.e. small waterbodies) are more susceptible to impacts of land use. Land use at the catchment scale was important for the largest ecosystems. Thus, our findings point toward the need for considering a holistic approach to managing water quality, which includes watershed management within the context of climate change.

Shallow lakes Subsidy Nonpoint source pollution Nitrogen Phosphorus

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EVALUATING MULTIPLE STRESSOR EFFECTS ON SHALLOW AQUATIC SYSTEMS: DIFFERENTIAL EFFECTS OF PESTICIDES, NITRATES AND HEATWAVE ON PRIMARY PRODUCERS AND THEIR CONSUMERS



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The high surface-to-volume ratio and widespread occurrence in agricultural landscapes render shallow lakes very susceptible to negative effects caused by multiple stressors e.g. agricultural run-off (ARO) or climate warming. The French-German project CLIMSHIFT addresses the combined effects of these multiple stressors by studying the effect of nitrates and inorganic or organic pesticides combined with a heatwave on the first two trophic levels in a series of micro- and mesocosms experiments, using different exposure scenarios and different levels of complexity. Our project goes beyond the common studies of alternative stable states in these shallow systems by including periphyton besides phytoplankton and macrophytes as functional groups of primary producers. We used zooplankton (Daphnia), mussels (Dreissena) and snails (Lymnaea) as primary consumers, reflecting different feeding modes. One microcosm experiment disentangled the potential antagonistic effect of nitrate and pesticides. After four weeks of exposure, we observed a strong negative impact of pesticides and a positive effect of temperature increase on macrophyte growth. We also observed a negative effect of nitrate on one species, Myriophyllum spicatum. Phytoplankton increased in all pesticide treatments linked with a strong decline in Daphnia numbers. Pesticides had a negative effect on snails and a marginal effect on periphyton at ambient but not at elevated temperature, indicating further effects on benthic organisms. Nitrate had no additional effects on any of the functional groups. In another experiment with different pulses and intensities of ARO exposure, zooplankton did not control phytoplankton and periphyton became the dominant competitor for macrophytes in ARO treatments, accompanied by reduced snail grazing. Our experiments provide a good base for models that are needed to fully grasp the complexity of possible interactions between stressors and components of shallow lakes.

pesticides, climate warming, nitrate, periphyton, phytoplankton, submerged macrophytes

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RELATIONSHIP BETWEEN LAND USE AND WATER TRANSPARENCY IN SHALLOW LAKES FROM A WIDE AGRICULTURAL LANDSCAPE

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LINK TO THE STUDY VIDEO

The Pampa Plain is one of the most vast and productive agricultural basins in the world. From the beginning of the XVII century, the economy of inhabitants was based on cattle first and crops later so the natural grasslands went back from 500.000km2 to few isolated patches today. Countless shallow lakes received an ignored impact as final receptors of anthropic surplus. In the ´90s, a wet pulse pushed the more rentable agriculture upon remnant natural grasslands so at present thousands of hectares of soybean take the ground. Changes in land use are often indicated as an important factor in state switch for shallow lakes. The current tendency to value and take care of wetlands and water bodies is just beginning to manifest in South America.\r\n To learn about the state of the small shallow lakes of the central Pampean agricultural landscape, we carried on a wide limnological assessment of 23 permanent and temporary water bodies in a 1700km2 area during summer of 2019, 11 of which were surrounded by croplands and 12 by grasslands. We aim to associate the influence of main land uses by means of a chlorophyll / transparency relationship.\r\n The wide range found in chlorophyll concentration, transparency, turbidity and light at the bottom don't discriminate between those surrounded by crops or by pastureland. But differences appeared inside each group of land use. Among the water bodies on grassland, the presence of cattle in the very littoral zone is related with higher phytoplankton biomass and less transparency. On the other hand, among the shallow lakes on cropland, those located in uplands retain a clear state dominated by submersed macrophytes, while those in midland and lowland are distinctly more turbid and dominated by phytoplankton. We point out some issues on the externalities of crop and cattle activities on the structure and function of small shallow lakes immersed on agricultural landscapes.

Pampa Cropland Grassland Cattle Turbidity

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WHICH FACTORS INFLUENCE THE OCCURRENCE OF CHAOBORUS LARVAE IN NEOTROPICAL SHALLOW LAKES?

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SESSION 10

LINK TO THE STUDY VIDEO

The larvae of the Diptera Chaoborus is a strong regulator of the zooplankton assemblage, controlling its structure and density. We aimed to determine which factors influence the occurrence of Chaoborus larvae in shallow lakes. We sampled thirteen shallow lakes located in different landscapes of the northwestern region of São Paulo State, Brazil, during the dry season of 2019. Land use was categorized into: 1. Agro-pasture/Urban, 2. Forest/Agro-pasture and 3. Agro-pasture, using a 1 km buffer. We measured limnological parameters with a multi-parametric probe and a Secchi's disk. We also analyzed Chlorophyll-a, Phosphorus and total Nitrogen in the water. Samples of Chaoborus larvae were collected at the end of the day using a vertical drag with a plankton net. Fish were collected with either a hand seine, a casting net and waiting net, with a sampling effort of 3 hours. Chaoborus larvae and fish were quantified in total abundance, and fish species were categorized according to the trophic guild: Omnivores, Carnivores, Detritivores, Algivorous, Invertivores and Planktivorous. The average abundance of chaoborids was higher in shallow lakes located in Forest/Agro-pasture lands, not differing statistically from the others p=0.62. Using a CCA, we observed that the limnological variables such as depth, Chlorophyll-a, pH and temperature correlated with the presence of Chaoborus larvae, suggesting that they are factors that influence the occurrence of the larvae. The places with the highest abundance of Chaoborus larvae were also the ones with the lowest abundance of planktivorous fish. We suggest that predation by planktivorous fish is the main factor influencing the occurrence of Chaoborus larvae in shallow lakes; limnological variables may have secondary effects on the larvae abundance. Land use, showed low influence, although the Diptera adults are terrestrial and phytophagous, have a short life phase and, often, little depend on adjacent terrestrial environments.

Land Use; Zooplankton; Fish; Predation

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A SPATIAL APPROACH FOR DECISION-MAKING PROCESSES TO MANAGE EUTROPHICATION OF SHALLOW LAKES



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Eutrophication is a growing problem in Uruguay as it limits the provision of ecosystem services from aquatic freshwater systems, for example the drinking water supply. Local water-quality models are useful tools to understand the main drivers and to identify the possible causal mechanisms. These models minimize the problems of access to high temporal and spatial resolution data, and do not require the adjustment of regional / global models to particular conditions. The main objective was to model total nitrogen and phosphorus concentrations in Laguna del Sauce watershed (Maldonado-Uruguay). In order to achieve this aim, Geographical Information Systems (GIS), Remote Sensing (RS) and Generalized Additive Models (GAM) were integrated. Additionally, a Land use Changes Modelling (LCM) was carried out to the year 2030 and the concentrations of nitrogen and total phosphorus were estimated. The research was based in 117 basins, with data collected in two seasons (winter-spring and summer-autumn). Models performed well in local conditions with small error calculated from independent samples. The models highlight the importance of drivers like: land use, soil type and state of conservation of the riparian zone. The nitrogen and phosphorus concentrations sampled in water, and the concentrations expected according to the 2030 scenario, show a complex situation regarding to the eutrophication process of Laguna del Sauce. The combination of theoretical and methodological approaches confirm that it is possible to elaborate a spatial model of nutrient contributions at a local scale, applicable in different geophysics and land use conditions, and in short time-lapses, according to water resources management demands and local data collection capability. Finally, the developed model is a powerful tool for land planning and water resources management.

freshwater models nutrients land-use land-planning management

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ASSEMBLY AND REASSEMBLY OF FRESHWATER COMMUNITIES UNDER THE INFLUENCE OF AGROCHEMICALS IN DIFFERENT SPATIAL CONTEXTS

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LINK TO THE STUDY VIDEO

Many lentic aquatic environments embedded in agricultural fields are vulnerable to contamination by agrochemicals, which can differently affect local communities, depending on how isolated they are. We conducted a field experiment to assess how agrochemical intensification simulating the conversion of savannas into managed pastures and sugarcane fields affects freshwater insect communities at different levels of spatial isolation. We constructed 45 1,200-L artificial ponds in a savanna landscape at three different distances from a source wetland (30 m, 120 m, and 480 m). Ponds were spontaneously colonized by aquatic insects and amphibians and treated with no agrochemicals (control), fertilizers ('pasture' treatment), or fertilizers and a single pulse of the insecticide fipronil and the herbicide 2,4-D ('sugar cane' treatment) following realistic dosages and application schedules. 'Pasture' communities were not different from controls. 'Sugarcane' communities, however, largely diverged from the other treatments by negatively affecting insect abundances and positively affecting amphibians. The abundance of herbivores/detritivores peaked in more isolated ponds, likely due to a reduction in the abundance of some predatory taxa, but we found no interaction between spatial isolation and land use treatments. Because agrochemical application frequently overlaps with the rainy season in many monocultures, it may strongly affect temporary pond communities. Specifically, ponds in sugarcane fields, might experience a decline in insect populations, followed by increases in the abundance of amphibians tolerant to environmental degradation. Furthermore, we found no evidence that isolation by distance can change the general effects of chemical intensification likely because the species most beneficiated by the agrochemicals were not dispersal limited in our experiment (e.g. amphibians), which may not be true in real crop fields.

Fertilization impacts; Impacts of agriculture; Macroinvertebrate communities; Metacommunity; Nutrient Enrichment; Pesticide impacts; Spatial isolation; Sugarcane impacts.

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DRIVERS OF PLANKTONIC CHLOROPHYLL A IN PAMPEAN SHALLOW LAKES: A REGIONAL APPROACH



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The Pampean plain of South America hosts thousands of shallow lakes. Most of them are eutrophic or hypereutrophic, subjected to anthropic activities. The majority of these lakes are turbid with high phytoplankton biomass. However, some of them are in a clear state with beds of submerged macrophytes and low phytoplankton abundance. Therefore, we ask: what are the main drivers of phytoplankton biomass in Pampean shallow lakes? We performed a linear mixed model with data of 60 shallow lakes located in 10 different regions that were sampled irregularly from 2015 to 2019. Our model was performed with LN(Chla) as dependent variable and land use, limnologic, morphometric, and hydrologic characteristics as independent fixed factors. We also included the region membership of each lake as a random factor. We performed a model selection process to obtain the best fitted model according to Akaike Index Criteria. The best-fit model indicated a non-linear relation between LN(Chla) and TP in these lakes. This model included the interaction between TP and macrophytes in combination with %Agriculture (estimated in a 1 km buffer area). %Agriculture was statistically significant and positive, while the presence of submerged macrophytes was statistically significant and negative. Region membership explained 30% of the variance. For a more detailed analysis, we split the data set into lakes with (n=9) and without submerged macrophytes (n=51). For shallow lakes with submerged macrophytes, the only statistically significant driver variable was TP with a positive coefficient. On the other hand, lakes without macrophytes exhibited a small but negative relationship with TP. These results demonstrate that 1) for these Pampean shallow lakes, the relationship between TP and LN(Chla) is non-linear, 2) in most of these lakes, TP is not a limiting factor for algal growth, and 3) in clear lakes, the presence of submerged macrophytes is a key factor modulating the relation between LN(Chla) and TP.

model, eutrophic lakes, submerged macrophytes, phytoplankton biomass

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LAKE ECOSYSTEM MODELS AS SUPPORT TOOLS FOR MANAGING SHALLOW LAKES – BENEFITS AND CHALLENGES FROM A DANISH PERSPECTIVE



Tobias Kuhlmann Andersen (Aarhus University, Department of Bioscience, Denmark and Sino-Danish College, University of Chinese Academy of Sciences China); **Nicolas Azaña Schnedler-Meyer** (Aarhus University, Department of Bioscience, Denmark); **Fenjuan Rose Schmidt Hu** (Aarhus University, Department of Bioscience, Denmark); **Anders Nielsen** (Aarhus University, Department of Bioscience, Denmark); **Karsten Bolding** (Aarhus University, Department of Bioscience, Denmark and Bolding & Bruggeman ApS, Denmark); **Dennis Trolle** (Aarhus University, Department of Bioscience, Denmark and Sino-Danish College (SDC), University of Chinese Academy of Sciences, China)

LINK TO THE STUDY VIDEO

Lake ecosystem models are increasingly applied as tools to support management decisions and policy making to mitigate and combat the impacts of eutrophication and global climate changes on lake ecosystems and their biodiversity. In this presentation, we illustrate the benefits and challenges of applying complex, lake ecosystem models in a management context with a focus on shallow lakes impacted by high nutrient loading from catchments dominated by agriculture. Five lake ecosystem models were set-up, calibrated and validated on a +10 years comprehensive dataset covering temperature, nutrients and plankton dynamics for five Danish lakes. Most model simulations showed good to excellent agreement with observed data for water temperature, total nitrogen and phosphorus, as well as chlorophyll-a concentrations. To support management of catchment areas, scenario simulations with lake models can estimate nutrient loading thresholds for when a specific lake will achieve good ecological condition. Furthermore, lake ecosystem models can simulate a range of restoration strategies and methods (e.g. oxygenation of hypolimnion and fish harvest) to explore and assess impact of measures for a specific lake. Challenges remain when trying to simulate frequent shifts between turbid and clear water states. A model-ensemble approach may to some extent address this. To conclude, lake ecosystem models can serve as a powerful support tool for lake managers and water authorities in guiding restoration strategies and protection policies.

lake ecosystem model, lake management, eutrophication

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ECOLOGY AND MANAGEMENT OF SHALLOW URBAN LAKES

SESSION 11

Christina Wyss Castelo Branco
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Bernadette Pinel-Alloul
(Université de Montreal, Canada)
Alessandra Giani
(Federal University of Minas Gerais, Brazil)

Shallow urban lakes are important part of the scenery of many cities across the globe and differently from other lakes they usually have more people coming into contact with them. They can be deeply associated with local landscape and are frequently important for aesthetic improvement as well as for preserving local and even regional biodiversity. The frequent existence of eutrophic to hypertrophic conditions in these systems has been a challenge for researchers and local municipalities. This challenge has been occurring in tropical, subtropical and temperate regions, and there are comparatively few strategies implemented for management and recovery of these shallow lakes. One of the major tasks relating urban lakes has been to integrate nearby or surrounding resident people for sustainable conservation activities around these ecosystems involving water quality improvement and conservation and/or recovery of the native biota. Overall, our knowledge still has many gaps on the ecology of these varied systems, strategies for their recovery, and on possible local disturbances that are ongoing or will come as result of climate changes. The suggestion for this session is to encourage discussion about these ubiquitous and most often endangered shallow urban lakes.

INDICATORS OF ECOLOGICAL INTEGRITY AND AQUATIC BIODIVERSITY IN URBAN WATERBODIES OF MONTRÉAL CITY (QUÉBEC, CANADA)

SESSION 11

Bernadette Pinel-Alloul (Université de Montréal); **Alessandra Giani** (UFMG)

Freshwater systems in urban regions are important habitats which play a crucial role in the conservation of aquatic biodiversity. Therefore it is necessary to develop knowledge on aquatic ecosystems in large cities in order to select the best bioindicators for assessing their ecological integrity, and particularly their water quality and biodiversity. In this study, we tested the potential of various metrics based on plankton and benthic communities as useful bioindicators to evaluate biodiversity and water quality in 20 urban waterbodies (ponds, lakes and wetlands) of the city of Montréal (Québec, Canada). Metrics based on species richness and taxonomic composition of phytoplankton, zooplankton and macroinvertebrates served to distinguish specific groups of permanent and temporary aquatic systems, representing different types of environment and management. Our study showed that urban waterbodies in Montréal support high diversity of plankton and benthic organisms and are essential habitats for sustaining aquatic biodiversity at local and regional scales. Spatial variations in biodiversity and community structure were related to the waterbody origin, the presence of macrophytes and fish, trophic status, and the management practices. Aquatic vegetation in littoral habitats constitutes an important refuge for biodiversity, and temporary ponds offer unique conditions for very rare species. To evaluate their ecological integrity, the waterbodies were ranked based on trophic status indicators (total phosphorus, chlorophyll) and biotic indicators (species richness and composition of planktonic and benthic communities). We selected the best bioindicators for future assessment of biodiversity conservation and water quality of urban ponds and lakes and we recommended as best conservation practices to maintain a vegetated littoral zone, various types of ponds, and an optimal management.

urban lakes - phytoplankton - zooplankton - Macroinvertebrates - Ecological indicators

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DIFFERENT PROCESSES OF EUTROPHICATION IN SHALLOW AND CONNECTED ARTIFICIAL LAKES, LOCATED IN URBAN AREA

SESSION 11

Heytor Lemos Martins (Universidade do Estado de Minas Gerais); **Rodrigo Ney Millan** (Universidade do Estado de Minas Gerais); **Eliana Aparecida Panarelli** (Universidade do Estado de Minas Gerais)

Dams form reservoirs known as intermediate systems between rivers and lakes. Reservoirs on a river are differentiated by its morphometric characteristics and land use in the drainage basin. The greater the distance between dams, the differentiation of the drainage area is greater between the reservoirs. Considering three shallow reservoirs connected by a first-order river, in the urban area of the municipality of Frutal (MG), we hypothesized the similarity among their trophic conditions, because they are shallow enough to maintain an unstable thermal structure, have a similar shape (margin development index between 1.27 and 1.04), surface areas in the same order of magnitude (2351, 3251 and 4360 m2), and areas of drainage basin almost overlapping. We proposed an increase in eutrophication over the study period as a second hypothesis. Three years with monthly data evaluated the pH, dissolved oxygen, electrical conductivity, temperature, total ammoniacal nitrogen, nitrate, nitrite, and total phosphorus. The principal component analysis showed a discrepancy between the first and third years of study. The first year had a greater influence on water temperature, and the third year was associated with higher pH values, electrical conductivity, nitrate, total ammonia nitrogen, and total phosphorus. Considering the differences between reservoirs, the principal component analysis showed a greater discrepancy between reservoirs 2 and 3. The reservoir 2 was associated to total ammoniacal nitrogen, and reservoir 3 was related to electrical conductivity, dissolved oxygen, pH, nitrate, total phosphorus, and water temperature. The results showed eutrophication of the reservoirs over the studied period. The Reservoir 2, the only having macrophyte banks, remained less eutrophic, and the Reservoir 3, which receives an additional fluvial drainage, had a highest eutrophication. Thus, progressive eutrophication occurred, with distinct dynamic among the reservoirs.

trophic status, physical-chemical variables, nutrients

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DOMINANCE OF PHYTOPLANKTON OR FLOATING AQUATIC PLANTS IN A HYPEREUTROPHIC URBAN LAKE: CONSEQUENCES FOR CARBON AND NITROGEN CONTENT IN THE WATER AND FOR THE PLANKTON COMMUNITIES

Samira G. M. Portugal (Universidade Federal do Estado do Rio de Janeiro); **Karen N. Costa** (Universidade Federal do Estado do Rio de Janeiro); **Christina W. Castelo Branco** (Universidade Federal do Estado do Rio de Janeiro)

SESSION 11

LINK TO THE STUDY VIDEO

Lagoa das Taxas (0.12 km2) is a hypereutrophic shallow lake inside a Natural Park surrounded by residential buildings in Rio de Janeiro City. The lake receives untreated urban drainages and at the same time is a refugee for wildlife such as capybaras and broad snouted caimans. As a consequence of a mechanical removal of floating plants once a year, the lake presented two alternative conditions - a complete coverage by aquatic macrophytes or a dominance by phytoplankton. We studied limnological features and the plankton of the lake during the dry and rainy seasons from 2014 to 2019. In the last two years, the content of carbon, nitrogen and phosphorus were also evaluated. When the aquatic macrophytes dominated, the lake showed anoxia (dissolved oxygen average of 0.41±0.22 mg.L-1), and a drop in chlorophyll-a (average 15.5±8.2 µg.L-1). Under the macrophytes, chlorophyceans and or synurophyceans dominated the phytoplankton. Without macrophytes, chlorophyll-a attained higher values (average 79.0±75.0 µg.L-1) and euglenophyceans and/or filamentous cyanobacteria prevailed. Small-sized testaceans, ciliates, rotifers, cladocerans and cyclopoid copepods comprised the zooplankton, being species richness higher under phytoplankton dominance. The mechanical removal of plants improved the conditions of dissolved oxygen, and caused a decrease in the concentrations of total carbon (from an average of 78.8 to 59.6 mg of TC.L-1) and total nitrogen (from 31.9 to 20.7 mg TN.L-1) in the water. Apparently, it had no effect on the total phosphate content (average around 1.2 mg.L-1 in both conditions). Plankton communities showed strategies to deal with the changes in the hypereutrophic lake: prevalence of mixotrophic taxa in phytoplankton under dominance of aquatic macrophytes; intense reproduction of rotifers in favourable conditions; accessory pigments in microcrustaceans during anoxia; and common presence of sexual reproduction in cladocerans with the production of ephippia.

eutrophic, tropical lake, anoxia, cyanobacteria

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PRIMARY PRODUCTION IN THREE URBAN SHALLOW LAKES AT HIGH ALTITUDE

SESSION 11

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LINK TO THE STUDY VIDEO

Shallow urban lakes can reach high primary production values due to the contribution of nutrients from the surrounding areas. In this study, we measured gross primary production (GPP), net primary production (NPP), and respiration (R) in three small shallow urban lakes within an urban ecological reserve in Mexico City at 2270 m a.s.l. The lakes of La Cantera Oriente (Eastern Quarry) are filled by springs that flow from the rock, and they are adjacent. Chlorophytes and diatoms dominate the phytoplankton in North Lake, chlorophytes in the Central Lake, and cyanobacteria in the South. Primary production values were measured in two climatic seasons: warm-rainy (May-September) and cold-dry (October-April) using the oxygen changes measured directly in the lakes through a HOBO U26-001 dissolved oxygen data logger. Oxygen concentration records were taken every 15 min in periods of 8-14 days. Chlorophyll a concentration, light intensity, and nutrients were also measured. The records corresponded to the years 2017 to 2019. South Lake (157-1505 mg C m-3 h -1) and Central (105-1234 mg C m-3 h -1) were the ones with the highest GPP and were characterized as hypertrophic, while the North Lake (325 to 749 mg C m-3 h -1) was eutrophic-hypertrophic. The NPP was: South 95-1149 mg C m-3 h -1, Central 93-1060 mg C m-3h -1 and North 232-738 mg C m-3 h -1. The range of respiration values was South 93-465 mg C m-3 h -1, Central 10-472 mg C m-3 h -1, and North 10-284 mg C m-3 h -1. Significant differences were found between the dry and rainy seasons; the South and Central lakes were more productive in the warm-rainy season and the North during the cold-dry season. The water's residence time in each lake would be the most important factor causing these differences, and the rainy season accelerates the flow of water through the lakes, but the effect is differential. Seasonal variation in solar radiation availability for each lake is also a driver of primary production.

gross production net production respiration small lakes eutrophcation

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REHABILITATION OF EUTROPHIC SUBTROPICAL URBAN SANDPIT LAKES IN CANELONES (URUGUAY): FIRST TEN YEARS FOLLOWING AN ADAPTIVE MANAGEMENT APPROACH



LINK TO THE STUDY VIDEO

Guillermo Goyenola (Centro Universitario Regional del Este, Universidad de la República); **Sandra Acevedo** (Dirección General de Gestión Ambiental, Intendencia de Canelones); **Lucía Boccardi** (Latitud-LATU Foundation, Uruguay); **Maite Burwood** (Centro Universitario Regional del Este, Universidad de la República); **Silvia Cabrera** (Dirección General de Gestión Ambiental, Intendencia de Canelones); **Clementina Calvo** (Centro Universitario Regional del Este, Universidad de la República); **Sheila Cardoso-da Silva** (Programa de Pós-Graduação em ecología e Manejo de Recursos Naturais; Universidade Federal do Acre-UFAC); **Virginia Fleitas** (Centro Universitario Regional del Este, Universidad de la República); **Claudia Fosalba** (Centro Universitario Regional del Este, Universidad de la República); **Javier García-Climent** (Centro Universitario Regional del Este, Universidad de la República); **Lucía Gaucher** (Centro Universitario Regional del Este, Universidad de la República); **Leonardo Herou** (Dirección General de Gestión Ambiental, Intendencia de Canelones); **Carlos Iglesias-Frizzera** (Centro Universitario Regional del Este, Universidad de la República); **Alejandra Kröger** (Centro Universitario Regional del Este, Universidad de la República); **Paula Levrini** (Centro Universitario Regional del Este, Universidad de la República); **Laura López-Cortes** (Centro Universitario Regional del Este, Universidad de la República); **Anahí López-Rodríguez** (Centro Universitario Regional del Este, Universidad de la República); **Néstor Mazzeo** (Centro Universitario Regional del Este, Universidad de la República; SARAS); **Juan Pablo Pacheco** (Centro Universitario Regional del Este, Universidad de la República); **Martín Pacheco** (Centro Universitario Regional del Este, Universidad de la República); **Franco Teixeira-de Mello** (Centro Universitario Regional del Este, Universidad de la República); **Giancarlo Tesitore** (Centro Universitario Regional del Este, Universidad de la República); **Lucía Urtado** (Centro Universitario Regional del Este, Universidad de la República); **Nicolás Vidal** (Centro Universitario Regional del Este, Universidad de la República)

In the urban matrix of Ciudad de la Costa (Canelones, Uruguay) there are more than twenty artificial lakes, as remains of sand extraction started 70 years ago. All of them were formed by infiltration from water table and lacks permanent surface connectivity. Like similar urban sandpit lakes around the world, these were subject of strong anthropogenic pressures. First fish kill was reported in 1986. Moreover, in the nineties the area began to change from vacation to residential use, resulting in an explosive population growth and exacerbating pressure. Environmental management started in 2008 with the implementation of a Water Quality Strategic Plan defined by the municipality, in collaboration with the Universidad de la República. As a result, the diagnostic was clear: eutrophic state was generalized, but displayed responses depends on specific local conditions. After some adaptive management cycles, detailed information about the ecosystems state and functioning was generated. With this basis, some management options were selected, while a big number was discarded by means of a process of technical, logistic and financial analysis. The management interventions concretized had included macrophytes harvest, nutrient's immobilization and destratification. On a first approach the management challenge was assumed as a technical constrain. However, we identify that the key to success is to generate the appropriate organizational design, ensure sustained financing and develop a group of specific capacities. A permanent monitoring program was implemented, including the collaborative original inter-institutional partnership and integrating high school students and teachers, and trained neighbors. So far, three telemetric monitoring buoys were designed, built and installed, assuring open access to the data. Next short-term goals include numeric modeling of ecosystem processes and responses.

Environmental management rehabilitation urban lakes eutrophication subtropical

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RETRIEVING CHLOROPHYLL-A IN A SHALLOW PRODUCTIVE TROPICAL ESTUARINE-LAGOON SYSTEM USING SENTINEL-2 MSI IMAGERY

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LINK TO THE STUDY VIDEO

Estuarine systems are complex transitional zones between continent and ocean and can be very productive due to their unique characteristics, harbouring high biodiversity and providing essential ecosystem services. However, they can be heavily impacted by anthropogenic activities such as increased nutrient discharge, wastewater, and unrestrained fishing. Monitoring of chlorophyll-a (chla), performed with remote sensing tools, has been frequently used to evaluate the trophic state of water bodies due to its sensitivity to environmental factors. In this study, we validated chla algorithms using Sentinel-2 MSI imagery in a productive tropical system, the Mundaú-Manguaba Estuarine-Lagoon System (MMELS), which consists of two connected turbid lagoons located in an urban area in Northern Brazil. We used 3 dates with pairings between field-collected chla data and satellite imagery between 2018 and 2019, totalling 49 pairs of data. The images were atmospheric and sunglint corrected using ACOLITE and GRS, respectively. Seven algorithms were selected based on the optical water type of the lagoons, and a calibration and validation procedure was employed. Considering each lagoon separately, the results are very different, with the algorithms performing well in Manguaba (r^2 of 0.72, %RMSE of 23.8% for the best results), but not in Mundaú (r^2 of 0.29, %RMSE of 65.8%). By combining both datasets and considering MMELS as a whole, four algorithms showed similar performance, with r^2 of 0.77–0.81 and %RMSE of 34.5–38.7%. This combination improved the results for Mundaú lagoon and increased r^2, although %RMSE also increased for Manguaba. However, we considered that this improvement compensates for the loss in terms of %RMSE, and thus chla can be modelled in MMELS using a single algorithm, with the semi-analytical NIR-red ratio algorithm being recommended. This study is the basis for continuous, remote monitoring of the ecological status of this anthropised ecosystem.

chlorophyll-a (chl-a), Sentinel-2 MSI, shallow tropical lagoon

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SEASONAL VARIATION OF ACTIVE AND INACTIVE ROTIFERS (ROTIFERA: MONOGONONTA) AND HATCHING PATTERNS IN AN URBAN AND SHALLOW LAKE IN MEXICO CITY



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LINK TO THE STUDY VIDEO

Zooplankton is one of the aquatic invertebrate groups that carry out diapause. Monogonont rotifers (one of the principal component of freshwater zooplankton) have a life cycle that altern the asexual and sexual reproduction, in this last, where the resting eggs produced. Resting eggs are accumulated in the sediments and conforming the egg bank, that it's considered as a genetic reservoir. However, the knowledge about the density of resting eggs produced, hatching rate, and factors that promote these processes in natural population had been few studied. Due to that, the principal aim of this research was to analyze the seasonal variations of the rotifers both in the water column (active) and their contribution to integration to egg bank (inactive) in a shallow water body. We took water samples to obtain active zooplankton and we put sediment traps to collect resting eggs (differentiating the hatched, viable and non-viable resting eggs). We measured water physical and chemicals variables in situ and ex situ. All of this was carried out with samplings every fifty days during an annual period (august 2018 to august 2019). Species richness was 22 rotifers species: 7 species found both in water column and sediment, 2 exclusively in the sediment, while the rest of species (13) were observed only in the water column. We obtained rotifers density of 20 to 8078 ind. L-1 and 5 to 37 resting eggs cm-3. The higher resting eggs density was observed in dry-cold season, and in a general way, resting eggs hatched were observed in a proportion media of 78%, highlighting that this system presents a high and constant hatching rate in the most of species found in the egg bank. The physical and chemical variables that explain better the variation of the active and inactive rotifers density were temperature, nitrates, chlorophyll-a, alkalinity, hardness, turbidity, deep and conductivity.

rotifers diapausing eggs hatching seasonal changes

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DYNAMICS OF POTENTIALLY TOXIC CYANOBACTERIA SPECIES AND THEIR TOXINS IN A EUTROPHIC URBAN LAKE TREATED WITH A LANTHANUM MODIFIED CLAY

SESSION 11

Bruna Barçante (Universidade Federal de Minas Gerais); **Daniel Albuquerque Pereira** (Universidade Federal de Minas Gerais); **Alessandra Giani** (Universidade Federal de Minas Gerais)

Cyanobacterial blooms have become more frequent and intense in urban lakes worldwide. Blooms have a negative impact on the ecosystems functioning and represent a threat to human health because some species can produce toxins. Pampulha lake, located in southeastern Brazil, has been suffering from persistent cyanobacteria blooms, with several potentially toxic species. Between 2016-2018 the municipality of the city of Belo Horizonte started a treatment with a lanthanum modified clay (Phoslock®) in this lake to reduce phosphorus concentration and eutrophication. The goals of this study were to: (1) follow up the seasonal dynamics of the cyanobacteria species and the cyanotoxins during a 2 years field study in Pampulha lake; and (2) investigate the relationship between the potentially toxic species with the toxins detected. Results showed signs of water quality improvement and phytoplankton structure recovery in some periods. However, cyanobacteria still persisted for a long time during the treatment. Cyanobacteria community was mainly composed by the potentially toxic species: Raphidiopsis (Cylindrospermopsis) raciborskii, Microcystis aeruginosa, Planktothrix agardhii and P. isothrix. M. aeruginosa was the main predictor of the microcystins presence in Pampulha lake. R. (C.) raciborskii and Planktothrix spp. were predictors of the saxitoxins occurrence (GTX1, GTX4, NeoSTX, dcSTX). Saxitoxins detection in the Pampulha lake should be taken as a warning that these toxins may be more widely distributed in urban lakes than has been reported and species less reported in the literature may be associated with blooms with high saxitoxins levels. Our study offers a contribution to the knowledge about the presence of toxins in urban eutrophic lakes and their seasonal variation due to changes in the potentially producing cyanobacterial species in that environment.

cyanotoxins; saxitoxins; microcystins; Pampulha lake; Phoslock; cyanobacterial blooms

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LINKING INTERNAL PHOSPHORUS LOADING AND MACROPHYTE DISTRIBUTION IN A SHALLOW RESERVOIR UNDER RESTORATION (WESTERN POLAND)

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LINK TO THE STUDY VIDEO

The Rusalka Lake is a man-made reservoir, situated within the City of Poznan (Western Poland) with surface area of 36.7 ha, average depth – 1.9 m and maximum depth – 9.0 m. As water quality deteriorated and cyanobacterial blooms occurred in summer, restoration measures (iron treatment) were carried out in 2006-2007 and again since 2014. Small amounts of iron sulphate (ca 2 kg per ha) are dosed several times during the year. Submerged macrophytes (mainly Potamogeton crispus) are harvested once a year, in early summer since 2017. In late summer macrophytes disappear and water blooms are observed. To determine the changes in the direction and intensity of internal phosphorus loading from bottom sediments, experimental studies were conducted throughout the restoration period, covering all seasons. Undisturbed sediments cores were collected in triplicates from two stations, representing profundal (9 m of depth) and littoral (2 m of depth) zone, and exposed in controlled conditions (temperature, oxygen content). Changes in phosphorus concentrations in water overlying the sediment were transformed into phosphorus exchange in the sediment-water interphase. Long-term studies revealed a decrease in internal phosphorus loading at both zones in the reservoir as a result of increased sorption complex in the sediments. Changes in the internal loading were also induced by macrophyte cover due to stabilisation of sediments (less resuspension) and phosphorus uptake as well as the decomposition of macrophytes deposited on sediments.

bottom sediments, lake restoration, phosphorus internal loading

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LINKING FUNCTIONAL TRAITS WITH ECOSYSTEM FUNCTION ACROSS LANDSCAPE SCALES

SESSION 12

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The study of functional traits and their diversity is increasingly popular in aquatic ecology. Yet, we are still far from using such traits to predict energy flow and nutrient cycling. This is, at least partly, due to a diverse set of traits, some of which are difficult to asses or compare across species (e.g., herbivory vs. omnivory, predator escape). Moreover, local adaptation may selectively alter certain traits (e.g., size, stoichiometry, tolerance) but not others (e.g., grazing mode, reproduction) within a given species. Finally, there may not yet be enough information to complete a trait-based study of trophic interactions. When can functional traits be used to predict ecosystem function? What is the role of phytoplankton, zooplankton and other taxonomic groups traits on stoichiometry, respiration, or trophic transfer efficiency? Do specific traits correspond to specific trophic interactions? How to link pattern with process using a trait based approach? We invite those interested in shedding light on these knowledge gaps to participate with data from theoretical, experimental, or monitoring studies.

FLOWER AND LEAF LITTER INTERACTION PROMOTES THE NON-ADDITIVE EFFECTS IN THE AQUATIC ENVIRONMENT

SESSION 12

Mery Ingrid Guimarães De Alencar (Federal University of Rio Grande do Norte); **Adriano Caliman** (Federal University of Rio Grande do Norte)

Across a landscape, terrestrial-aquatic interfaces within and between ecosystems are hotspots of organic matter (OM) mineralization. The modification of OM decomposition by labile litter input is called the priming effect (PE) and represents a critical global biogeochemical process. In general, labile organic matter (LOM) is naturally produced in low quantities and their concentrations can affect the magnitude of the priming effect. However, no study evaluated if and how the interaction labile and refractory litter with different proportions affect the occurrence, direction, and symmetry of the PE. For this, we performed microcosm experiments using flower and leaf litter of Tabebuia aurea. We utilized treatments with different proportions between litter type (mixture) and monoculture. Our results show that the occurrence and direction of the PE. In general, ours resulted indicated that, the mixture of flower and leaf litter enhanced reciprocally the decomposition, which the effects of floral litter higher than leaf litter in the decomposition process. Despite the no variation in the total decomposition, we detected the PE along the gradient in the mixture. Our study demonstrated for the first time the occurrence of PE among flower and leaf litter. This result may be an initial point to demonstrate the biogeochemical importance of species that present high reproductive investment in floral biomass and the interaction between litter may be an important route on nutrient and carbon recycling on both small and large spatial scales, including riparian regions.

terrestrial-aquatic interfaces within-individual variation decomposition

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ZOOPLANKTON GRAZING MODE AND BODY SIZE PREDICT ECOSYSTEM FUNCTION ACROSS 16 TROPICAL LAKES

SESSION 12

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While trait-based approaches to link pattern and process in plankton ecology are increasing, a more mechanistic understanding of the relationship between trait diversity, identity, and ecosystem function is lacking. Moreover, functional trait studies in plankton often focus on body size as a master trait, which makes the role of other potentially important traits less understood. To address these gaps, we compared the relationship between trait diversity (body size) and trait identity (biomass weighted mean community size, biomass of grazing modes, and selectivity) for predicting the resource use efficiency of zooplankton (RUE) using data from 16 tropical artificial lakes sampled 4 times over two years. We hypothesized that both diversity and the biomass of specific trait identities would be important predictors of RUE, and that mean community size of zooplankton would be a better predictor of RUE compared to grazing traits. Surprisingly, size diversity was not significantly related to RUE. Moreover, the abundance of specific grazing traits associated to cladocerans (i.e., suspension filter feeder) explained more variability in RUE than mean body size of zooplankton. Results also show that the biomass of some zooplankton traits (e.g., raptorial grazers) was unrelated to RUE. These results emphasize how integrating zooplankton grazing traits with body size improves our understanding of trait-based approaches to link pattern and process. More generally, we show that accounting for trait identity is paramount for predicting ecosystem function.

Resource use efficiency, size diversity, body size, grazing traits, phytoplankton, zooplankton

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EFFECTS OF DISSOLVED ORGANIC CARBON (DOC) AND ZOOPLANKTON GRAZING PRESSURE ON MICROBIAL LOOP

SESSION 12

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LINK TO THE STUDY VIDEO

A major consequence of global climate change is extreme precipitation events that increase allochthonous organic matter input into aquatic systems via flooding. Dissolved organic carbon (DOC) is a common allochthonous organic matter in lakes. While DOC is a source of energy for heterotrophic organisms in aquatic systems, its effects on trophic interactions, and especially on the microbial food web, are poorly understood. Similarly, the top-down effect of contrasting zooplankton traits (i.e., generalist vs. selective) on DOC enriched food webs is also unknown. We compared both the bottom-up effects of DOC and the top-down effects of zooplankton with contrasting grazing selectivity (copepod vs. Daphnia) on the biomass and composition of microbial food webs (i.e., bacteria and ciliates) in a series of laboratory and in-situ mesocosm grazing experiments. We predicted that the total biomass of bacteria and ciliates would be enhanced by DOC addition (especially with a labile carbon source) and reduced by grazers. Additionally, we expected that copepods would have higher grazing pressure on ciliates than Daphnia due to grazing mode (i.e., selective feeder). We found that both grazers and DOC generally had negative effects on the biomass of bacteria and ciliates. Effects varied by orders of magnitude depending on the specific grazer and prey combination. Specifically, the top-down effect was stronger than the bottom-up effect, and the strongest grazer effect was in the copepod – ciliate link. Moreover, DOC changed the functional feeding groups of ciliates (i.e., algivore, bacterivore, predator, nonselective) and enhanced nonselective ciliates in no grazer and Daphnia treatments, while in copepod treatments these groups remained the same. Neither grazer influenced ciliate composition significantly. Overall, the effects of DOC on heterotrophic microplankton were modulated by contrasting zooplankton grazing traits.

climate change, dissolved organic carbon, pulsed disturbance, freshwater lakes, microbial community, zooplankton functional traits

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COMBINED BOTTOM UP EFFECTS OF DOC AND TOP-DOWN EFFECTS OF ZOOPLANKTON WITH CONTRASTING TRAITS ON PHYTOPLANKTON BIOMASS AND COMPOSITION



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While global climate change has major impacts on freshwater ecosystems, a mechanistic understanding of these effects on food web dynamics is poorly understood. A key effect of climate change is increased allochthonous dissolved organic carbon (DOC) input to aquatic environments, which serves as an energy source for heterotrophic plankton and alters food web dynamics. We aimed to link pattern and process in a plankton ecosystem by comparing the bottom up effects of DOC (i.e., Humin Feed and local source) to the top-down effects of zooplankton with contrasting grazing selectivity (Daphnia vs. calanoid copepods) on phytoplankton biomass and composition in a series of laboratory and in-situ mesocosm grazing assays. We expected that both DOC and zooplankton would reduce phytoplankton biomass; stronger herbivory by Daphnia compared to copepods; and stronger grazing on larger sized phytoplankton. The laboratory experiment revealed that DOC reduced total phytoplankton biomass, and that smaller species were reduced more than larger ones. Both grazers reduced total phytoplankton biomass, though effects varied such that zooplankton increased the biomass of smaller phytoplankton while they reduced the biomass of larger phytoplankton. Moreover, copepods had a stronger effect on phytoplankton biomass compared to Daphnia, but only in the treatments with DOC. The mesocosm experiments, however, showed that both DOC sources increased total phytoplankton and species-specific biomass, except Chlorophyta spp., which declined in the Humin Feed treatment. Overall, the results highlight the role of zooplankton grazing traits not only for regulating top-down effects but also for the bottom up effects of DOC.

climate change, dissolved organic carbon, pulse disturbance, zooplankton functional traits, phytoplankton community, planktonic food webs

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NUTRITION FACTS: IMPACT OF CYANOBACTERIAL BLOOMS ON C:N RATIO OF FRESHWATER CRUSTACEAN ZOOPLANKTON



LINK TO THE STUDY VIDEO

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Planktonic crustaceans are important members of zooplankton community, establishing a pathway of energy flow in freshwater food webs. Crustaceans are not a homogenous group as their functional traits vary remarkably, even within taxonomical groups. They may feed on different food sources (bacteria, algae, animal prey), often having adaptations to feed on more than one source. The relatively large body sizes of planktonic crustaceans and high amount of energy stored within a single specimen define their attractiveness as food for higher trophic levels, having implications for nutrient cycling in the ecosystem. The attractiveness is related to amount of lipids and fatty acids content, and may vary depending on circumstances in a food web, especially under conditions of harmful algal blooms (HABs), which are predicted to proliferate and intensify in the face of global climate changes. The aim of the study was to explore the effect of cyanobacterial blooms on the nutritional aspect of planktonic crustaceans (quality as a food source) in shallow waterbodies across the latitudinal gradient in Europe. The samples for C:N content ratio (proxy for fatty acids and lipids content) analysis of four groups planktonic crustaceans (Calanoid copepods, Cyclopoid copepods, Daphnia spp., Diaphanosoma spp.), were collected from three shallow, blooming waterbodies: Lake Sakadaš (Croatia, Southern Europe), Tyniec 2 oxbow lake (Poland, Central Europe) and Lake Gineitišk (Lithuania, Northern Europe). The highest mean C:N ratio were identified in Daphnia spp., the lowest mean C:N ratio in Calanoid copepods, and intermediate mean values in Cyclopoid copepods and Diaphanosoma spp. Furthermore, C:N ratio of particular groups differed between sampled waterbodies. Since all of the waterbodies were exposed to cyanobacterial blooms, the result indicates local adaptations of studied crustacean populations.

Zooplankton, Cyanobacterial blooms, C:N ratio, functional traits, ecosystem functioning

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CHANGES IN PLANKTON SIZE DIVERSITY ARE DRIVEN BY BOTH BOTTOM-UP AND TOP-DOWN CONTROL IN SEMI-ARID RESERVOIRS



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Climate changes are driving unprecedented shifts in the hydrodynamics and trophic status of dryland freshwaters. These changes might affect aquatic food webs and size structure of communities. We hypothesize that nutrient enrichment reduces size diversity of phytoplankton and accordingly of zooplankton due to strong environmental filtering driven by water level reduction and drought. We also propose that the relative importance of omnivorous fish to affect zooplankton size diversity is higher than by phytoplankton in reservoirs with lower concentrations of nutrients, because the strength of fish effects on food webs may rely on trophic state in lower latitudes. To test these hypotheses, we used data from two sets of reservoirs, sampled in a dry and in a rainy period, located in two watersheds with contrasting nutrient status in the Brazilian semi-arid. Contrary to our expectations total phytoplankton size diversity increased in the dry period, while an opposite pattern occurred for total zooplankton. Interestingly, total phosphorus was positively related to phytoplankton and zooplankton size diversities in reservoirs with high concentrations of nutrients, while an opposite pattern was shown for the less eutrophic reservoirs. However, the zooplankton size diversity was more important to explain changes in phytoplankton size diversity than the limnological variables and the direction of the effect varied according to reservoirs trophic status and zooplankton size (micro and mesozooplankton). Furthermore, the increase of omnivorous fish size diversity reduced mesozooplankton and enhanced microzooplankton size diversity in eutrophic reservoirs, whereas a positive effect was observed for the mesozooplankton in less eutrophic reservoirs. Our results suggest that the direction of the effect on phytoplankton and zooplankton size diversities depends on both bottom-up and top-down control, but the strength of the effect relies on the trophic status in semi-arid reservoirs.

climate change drylands phytoplankton zooplankton omnivorous fish size classes

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APPLICATION OF TBI INDEX IN THE ECOLOGICAL STATUS ASSESSMENT OF THE SHALLOW EOLIAN LAKE LUDAŠ (SERBIA)

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SESSION 12

LINK TO THE STUDY VIDEO

Shallow saline lakes are unique habitats, highly susceptible to negative effects of climate change and adverse anthropogenic activities. Recently, several indices, including a trait-based index (TBI), have been developed for the assessment of their ecological status. The TBI index is calculated as a ratio of traits (diatom groups) that indicate good or excellent ecological conditions (motile species with small cell size and more elongated valves) and traits that are related to degraded ecological status (low and high profile ecological guilds and planktic life form). We tested the applicability of the TBI index in Lake Ludaš that was originally an alkaline saline lake. Epiphytic diatoms together with water samples for chemical analyses, were collected in June 2019 at the southern part of the lake where a dense population of Ceratophylum demersum was observed. A total of 35 diatom taxa were identified in this hyposaline lake. The highest number of species belonged to the genus Nitzschia. Typical sodic water taxa for this part of the Pannonian Plain, such as Nitzschia austriaca, Navicula veneta and N. wiesneri, were not observed. Instead, species characteristic for disturbed saline habitats, for example Navicula wendlingii and Tabularia fasciculata, were recorded. In Lake Ludaš, functional groups of diatoms connected with high conductivity reached only one-third of the total abundance. On the other hand, a higher percentage of low and high profile guilds and planktic diatoms were recorded. Consequently, the TBI index indicated the low ecological status of Lake Ludaš, and confirmed the negative effect of a disturbed hydrological regime.

saline lake diatoms TBI index ecological status assessment

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UNDERSTANDING PHYTOPLANKTON COMMUNITY ASSEMBLAGE PROCESSES OF TURKISH SHALLOW LAKES USING DIFFERENT FUNCTIONAL DIVERSITY COMPONENTS

SESSION 12

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In 2001, Tilman defined functional diversity as “the value and distribution of species and their organismal traits that influence the ecosystem functioning”. Since then, scientists have realized that functional diversity may work better than species diversity in explaining and predicting ecosystem level processes. Thus, many have used different functional diversity measurements to explain ecosystem functionality and ecosystem level processes. In our study, by using different functional diversity indices measured by commonly used and relevant functional traits, we try to understand whether dispersal or filtering through the abiotic and biotic factors are the main force driving phytoplankton community assemblages of Turkey’s shallow lakes. For this purpose, data from a total of 48 shallow lakes differing in their climate, latitudinal and altitudinal positions, nutrients concentrations, and community compositions at different trophic levels were used. Our study follows the steps: 1) Scoring phytoplankton functional traits for identified taxa in order to calculate at least three different functional diversity indices at local scale for each lake, 2) Quantifying local biotic and abiotic variables to see if they influence functional diversity of communities 3) Relating functional and taxonomic similarity/dissimilarity with the geographic distances between lakes to understand the role of dispersal and environmental factors in the community assembly. 4) Simulating null distributions for the functional diversity measures to reveal the dominant processes in the community assembly at the local scale. We expect to see a decrease in taxonomic similarity between the lakes with increasing geographic distances if dispersal is a limiting factor in the community assembly. If dispersal is not a limiting factor and local environmental conditions are driving the community assembly, then we expect functional similarity to decrease with increasing environmental distance between the lakes.

functional diversity, community assemblage

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PHOSPHORUS TOTAL AND PH ARE KEY VARIABLES FOR FUNCTIONAL STRUCTURE OF ZOOPLANKTONIC COMMUNITIES IN AGROPASTORAL LANDSCAPE

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SESSION 12

LINK TO THE STUDY VIDEO

The main influence of agricultural activities on the natural environments is the nutrient runoff, as nitrogen and phosphorus, which are applied on the crops, affecting drastically aquatic ecosystems and ecological services. Aiming to understand the influence of agropastoral landscapes on the ecosystem functioning of shallow lakes, this study analyzed the effects of total nitrogen (TN) and total phophorus (TP), dissolved oxygen (DO), temperature and pH on the functional diversity of zooplankton. Zooplankton was sampled from the littoral and pelagic zones of 8 reservoirs through vertical hauls with a 45 ?m plankton mesh net. The reservoirs' landscape was characterized based on the type of the agropastoral activity: pasture, citrus, and sugar-cane. The functional characterization of the zooplankton community was based on 4 traits: body size, feeding type, habitat type, and group trophic. The functional diversity was estimated using the indices: FRic, FEve, FDis, and FDiv. All functional estimates were modeled with TP, TN, DO, temperature and pH using generalized additive mixed models (GAMM). Moreover, we used partial RDA to analyze the influence of these environmental variables on the sharing of functional group among the sample sites. Our analyses showed the pH as a key variable for the local functional diversity, once it was related to the variation in all indices. More acidified waters showed the lowest FRic values, but high FEve and FDis. The lowest values of FDiv were found in sites with low concentration of TN and low pH. Variations in pH was associated with the TP concentration, which presented a strong and positive linear relationship. The TP concentration was the single variable that explained the functional group sharing. The geographic space showed strong explanation of the functional group sharing. In conclusion, our study indicated that alkaline waters provide a more complex functional structure in zooplankton communities.

land use, diversity functional, human impact, environmental changes

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THE IMPORTANCE OF COPEPOD GRAZING AND CYANOBACTERIA DEFENSE TRAITS ON THE TOP-DOWN CONTROL OF CYANOBACTERIA



Ewaldo Leitao (University of Connecticut); **Renata Panosso** (Federal University of Rio Grande do Norte); **Kemal Ali Ger** (Federal University of Rio Grande do Sul)

LINK TO THE STUDY VIDEO

The evaluation of functional traits that directly impact predator-prey interactions in plankton communities is key to understand onset and termination of harmful algae blooms (HAB). HABs are a threat to biodiversity and ecosystem functions, that worsens with eutrophication and climate change. In eutrophic-low latitude shallow lakes, copepods are often observed co-existing with high abundances of toxic cyanobacteria blooms. One mechanism by which copepods can co-exist with cyanobacteria is to reject consumption of toxic or inedible particles. Meanwhile, copepods can consume edible fraction of phytoplankton, potentially facilitating cyanobacteria bloom onset and persistence. Copepods and cyanobacteria have multiple traits that directly modify their interaction. Copepods have different grazing traits (i.e. raptorial and current filter feeders), whereas cyanobacteria can have different toxic and morphological traits (i.e. colony and filaments). In two separate experiments, we tested whether copepods (current filter feeders) can facilitate single celled cyanobacteria (Microcystis), and whether copepods with different grazing traits (current filter vs raptorial feeders) can facilitate filamentous cyanobacteria (Raphidiopsis) dominance over an edible phytoplankton. Current feeders increased the biomass of single celled Microcystis over edible algae. In our second experiment, both current feeders and raptorial feeders consumed filamentous cyanobacteria, once the latter became more abundance in food particle pool. Current feeders had higher consumption of filamentous cyanobacteria than raptorial feeders, switching diet from edible phytoplankton to cyanobacteria over the course of the experiment. Combined, these results show that the traits of both grazing traits and cyanobacteria defense traits should be considered to fully understand the trophic interactions and copepods' top-down potential in cyanobacteria dominated lakes.

functional traits, predator-prey, Raphidiopsis, harmful-algae

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TRAIT-BASED ZOOPLANKTON COMMUNITY ASSEMBLY AND THE FUNCTIONING OF AQUATIC ECOSYSTEMS ALONG A PRODUCTIVITY GRADIENT



LINK TO THE STUDY VIDEO

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Hundreds of experiments conducted over the last decades demonstrate a positive diversity-ecosystem functioning relationship. Yet, most of these studies have manipulated species richness artificially by assembling communities randomly. Natural communities along ecological gradients, however, often show niche-based responses to selection gradients and species extinction order is not a random process. Such responses are commonly trait-mediated and the effects of communities on ecosystem functioning also depend on species traits. Here we revisited a community assembly mesocosm experiment that simulated typical gradients of productivity and plant structural complexity to test how body size diversity and composition of zooplankton responded to such gradients and whether and how such trait responses impacted on top-down control of algae, a key ecosystem function in aquatic systems. We find a positive effect of nutrient addition on both zooplankton size diversity (SD) and community average size (CAS). We also demonstrate a strong positive influence of SD and CAS on zooplankton resource use efficiency. Our findings clearly indicate that limited productivity filters out larger zooplankton species whereas high productivity seems to increase competition, leading to higher size diversity than expected by chance, potentially due to limiting similarity in size. The presence of large zooplankton and the complementary responses of small and large species through time in more productive systems allow for enhanced top-down control via both selection effects and size-based compensatory dynamics. Although we focused here on the effects of productivity, our findings are likely representative to any selection gradient that influences SD and CAS in zooplankton, given the importance of size as response and effect trait. Our study illustrates the potential for trait-based community assembly experiments to reveal biodiversity responses to environmental change and their effects on ecosystems.

Ecosystem functioning; resource use efficiency, metacommunity ecology

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BIODIVERSITY AND FUNCTIONAL STABILITY LINKAGES UNDER CHANGING DISTURBANCE REGIMES

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Carl-von-Ossietzky
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SESSION 13

Shallow lakes are recipient of diverse environmental disturbances, either natural or driven by humans. The current functioning of the global climate and biogeochemical cycles are however causing profound changes in disturbance regimes, such that they show different frequencies, durations, intensities or spatial extents. This has recently revived significant scientific interest into how such evolving disturbance regimes affect biodiversity and also how biodiversity itself affects the stability of ecosystem functions. This session aims to gather most recent theoretical and empirical studies that investigate how changes in disturbance regimes impact lake biodiversity (e.g., taxonomic, functional traits, genetic), and how these effects are reflected in different functional stability aspects. We also strongly encourage studies assessing drivers that interact with diversity to stabilize communities and ecosystem functions across temporal and spatial scales (e.g., spatial connectivity or legacy effects). The session is ultimately intended to promote discussions and interactions among researchers in order to provide with a synthetic overview of current knowledge and research gaps on how biodiversity drives the ecological stability and functioning of shallow lakes under changing environments.

ECOLOGICAL RELATIONSHIPS PROMOTE COEXISTENCE BETWEEN CYANOBACTERIA AND ZOOPLANKTON IN TROPICAL FLOODPLAINS SYSTEM

SESSION 13

Cleber Nunes Kraus (Instituto Nacional de Pesquisas Espaciais - INPE); **Leonardo Fernandes Gomes** (Universidade de Brasilia - UnB); **Marie-Paule Bonnet** (Institut de Recherche pour le Développement - IRD); **Ina de Souza Nogueira** (Universidade Federal de Goiás - UFG); **Maria Tereza Morais Pereira Souza Lobo** (Universidade Federal de Goiás - UFG); **David da Motta Marques** (Universidade Federal do Rio Grande do Sul - UFRGS); **Jérémie Garnier** (Universidade de Brasília - UnB); **Ludgero Cardoso Galli Vieira** (Universidade de Brasília - UnB)

In tropical floodplain system such as Amazon, hydrological periods drives a complex interaction between different aquatic planktonic groups. We evaluated if the phytoplankton-zooplankton relationship structure results in a feedback system that conduces to a coexistence pattern between the zooplankton and the phytoplankton group of cyanobacteria in the Amazonian Curuai floodplain. In the Curuai floodplain, there is variation in phytoplankton and zooplankton community structure between different hydrological periods, and these differences are in part, consequential responses due to the interaction between these communities. Most of the phytoplankton species belong to a few functional groups in the same way that zooplankton belongs to a few taxa. Our results showed that only 4 taxa in the rising period and other 4 taxa in the flushing period have a significative relationship that acts structuring the phytoplankton community. Although the environmental conditions are the main factor that structures planktonic communities, the relationship between phytoplankton and zooplankton also is also a driver also of importance in Curuai floodplain. The cyanobacteria are the dominant phytoplankton group in the flushing period and the phytoplankton-zooplankton relationship promotes a pattern that can allow coexistence between zooplankton and cyanobacteria in tropical floodplain system.

Tropical-wetlands Planktonic-community Ecological-process Shalow-lakes

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EFFECTS OF MULTIPLE STRESSORS ON THE DIMENSIONALITY OF ECOLOGICAL STABILITY



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The multidimensional conception of ecological stability is the focal framework to comprehend ecosystems' response to and recovery from anthropogenic disturbance. To utterly quantify stability response to disturbance, several ecosystem properties need to be measured, such as resistance, resilience, recovery and invariability. Here, we studied the single and combined effects of common agricultural stressors (pesticides and nutrients) on the dimensionality of stability (DS) at the community and population levels, using a complex, species-rich freshwater assemblage. At the community level, we quantified compositional stability using Bray – Curtis dissimilarity as state variable, whereas functional stability's measurements were based on abundance or biomass. We found that disturbance type and trophic status determine DS, both at the community and at the population level. At the community level, compositional and functional stability responded differently to disturbance. We also found that eutrophication reduces the overall DS in response to disturbance, which has important implications for the protection and management of ecosystems. Moreover, since eutrophication caused a reduction in diversity and a consequent increase in dominance by tolerant species, we discuss the implication of our findings in light of the diversity – stability relationship, making relevant considerations on how functional stability is measured. Finally, we demonstrate that different disturbances can modify the correlation between functional and compositional aspects of stability.

multiple stressors disturbance ecological stability mesocosm experiment community ecology populations resilience composition function recovery

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ECOLOGICAL EFFECTS OF RIVER REGULATION BY A HYDROPOWER DAM ON MACROINVERTEBRATES ASSOCIATED TO AQUATIC MACROPHYTES IN FLOODPLAIN PERMANENT AND TEMPORARY SHALLOW LAKES



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Aquatic macrophytes provide habitat heterogeneity, and organic matter as food source and shelter for invertebrate assemblages in river floodplains. Small Hydropower Dams (SHD) change macrophyte-associated invertebrate assemblages in marginal shallow lakes with regard to ecological resilience, resistance and stability against hydraulic disturbances due to river regulation. There is a lack of knowledge about the short-term impacts of dam-removal in assemblages of macrophytes and associated macroinvertebrates in the neotropical region. To test the hypothesis that in dam-regulated non-hydroelectric shallow lakes there is greater heterogeneous distribution of macroinvertebrates in different macrophyte groups, four shallow lakes were sampled during the dry season, two upstream (regulated) and two downstream (not regulated) a SHD. Aquatic macrophytes with different habitats including submerged roots, floating roots, emerged leaf roots and their associated macroinvertebrates were collected in triplicates in each of the four shallow lakes. The structural and functional composition of macroinvertebrates associated with macrophytes, maintenance of communities' ecological stability (e.g., resilience, resistance and stability), habitat preference by invertebrates and their distribution in the Aquatic-Terrestrial-Transition Zone in lagoons at the Pandeiros river basin are evaluated. The results contribute to subsidize, model and predict the potential ecological benefits of future restoration of the river continuum and flood pulse after dam-removal of the Pandeiros SHD.

flood pulse, distribution gradient, hydropower, dam decommissioning

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ENVIRONMENTAL HETEROGENEITY INCREASES PLANKTON DISSIMILARITY BETWEEN TWO SEMI-ARID SHALLOW LAKES UNDER A SEVERE DROUGHT EVENT

SESSION 13

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Extreme weather events are likely to become more frequent in the future due to climate change, and how they will affect communities is a major challenge to ecologists. In this study, we assessed the effects of drought intensification on environmental heterogeneity components and phytoplankton and zooplankton diversity and ?-diversity between two semiarid shallow lakes from Northeastern Brazil. We hypothesize that drought intensification decreases phyto- and zooplankton richness and increases between-lakes environmental divergence and accordingly between-lakes plankton β-diversity and species turnover. To test our hypothesis, we performed generalized least squares regressions (GLS) to relate the effects of time, lake and their interactions on phyto- and zooplankton communities as a whole and separately by their size groups (nano, micro and mesoplankton). Our results partially concur with our hypothesis and showed that drought intensification increased between-lakes environmental heterogeneity, but the direction of the effects on phytoplankton richness diverged within the two lakes, while no effect of drought was observed on zooplankton richness in both lakes. Furthermore, environmental heterogeneity and time increased plankton β-diversity and turnover between-lakes. However, when size was taken into account only nanophytoplankton and microzooplankton β-diversity increased with environmental heterogeneity. In summary, extreme droughts might increase environmental and plankton compositional divergence between lakes, but their effects on local richness are contingent on community involved and its environment.

extreme drought; phytoplankton and zooplankton diversity; β-diversity; turnover; semiarid shallow lakes

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TEMPERATURE FLUCTUATION EFFECTS ON A NATURAL PHYTOPLANKTON COMMUNITY DEPEND ON THE FREQUENCY BUT DO NOT DIMINISH ECOSYSTEM FUNCTIONING



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With increasing frequency and intensity of climate change events, the temperature tolerance of primary producers is an important thermal trait. In a controlled indoor-mesocosm set-up, we tested the effect of a fluctuation frequency gradient, when maintaining the same amplitude and mean temperature, on a natural phytoplankton community. We found that the effect of temperature fluctuations depends on the fluctuation frequency, but that ecosystem functioning could be generally maintained. Temperature fluctuation with higher frequency than natural diurnal fluctuations acted performance-enhancing and accelerated biomass production. Whereas, under temperature fluctuation with lower frequency than diurnal fluctuation performance could be maintained or was slightly reduced compared with the constant control. In addition, minor differences in diversity and composition were observed. These rather small effects of temperature fluctuations indicate that phytoplankton communities may be already well adapted to fluctuating environments, and thus, may be more resilient towards temperature change than previously thought.

fluctuation frequency phytoplankton temperature function composition

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NUTRIENT AVAILABILITY MEDIATES EFFECTS OF PHYTOPLANKTON RARE SPECIES LOSS ON ECOSYSTEM FUNCTIONING



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Biodiversity-ecosystem functioning relationships are mediated by functional diversity, but theoretical studies suggest that environmental variability is also fundamental for detecting a positive effect of diversity on functioning. Thus, phytoplankton diversity is expected to enhance biomass production under heterogeneous nutrient availability due to high species complementarity in resource use. However, this prediction has been poorly tested under experimental conditions. Here, we conducted a mesocosm experiment coupled with an additional microcosm experiment to evaluate the interactive effects of diversity and nutrient availability (concentrations and ratios) on ecosystem functioning (resource use efficiency and standing biomass) and phytoplankton stoichiometry. We manipulated a natural phytoplankton community to generate a diversity gradient simulating non-random losses of rare species. This diversity gradient was exposed to different nutrient conditions based on nitrogen (N) and phosphorous (P) manipulations. We found a positive diversity effect on ecosystem functioning when a wide range of nutrient ratios was supplied. This effect was driven by the extreme diversity levels and mediated by nutrient ratios. In contrast, changes in nutrient concentrations maintaining similar ratios did not show significant differences in ecosystem functioning among diversity and nutrient treatments. These patterns were supported by the phytoplankton carbon:nutrient ratios, while N:P ratios reflected the environmental nutrient availability. Hence, our results show that under uniform environmental conditions, the effects of diversity loss on ecosystem functioning was compensated by the prevalence of common species in the community. However, under variable environmental conditions the loss of rare species might have important consequences for ecosystem functioning, supporting theoretical predictions.

diversity, N:P ratios, environmental variability, resource use efficiency

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INTEGRATING MULTIPLE DIMENSIONS OF ECOLOGICAL STABILITY INTO A VULNERABILITY METRIC



Pablo Urrutia Cordero (Uppsala University); **Silke Langenheder** (Uppsala University); **Maren Striebel** (Oldenburg University); **Peter Eklöv** (Uppsala University); **David G. Angeler** (SLU); **Stefan Bertilsson** (SLU); **Lars-Anders Hansson** (Lund University); **Egle Kelpsiene** (Lund University); **Maria Lundgren** (Lineaus University); **Linda Parkefelt** (Lund University); **Ian Donohue** (Trinity College Dublin); **Helmut Hillebrand** (Oldenburg University)

Ecological stability encompasses multiple dimensions of functional and compositional responses to environmental disturbances and fluctuations. As no single dimension used in isolation can fully reflect the overall response to environmental change in nature, a common vulnerability assessment that integrates across multiple stability components is desirable for ecological risk assessment and ecosystem management. Here, we develop an integrative metric of overall ecological vulnerability (OEV) that works independent of perturbation type and response variable. When quantifying the response as deviation from unperturbed controls, OEV corresponds to the area under the curve over the time of observation. We tested this metric using data from a modularized experiment replicated in five lakes across a large climate gradient over two seasons, examining functional and compositional responses to both pulse and press perturbations across three trophic groups of organisms. OEV showed a strong negative correlation with individual functional and compositional stability metrics (that is, for resistance, temporal stability and final recovery) for both pulse and press perturbations, though less so with resilience defined as a process rate after a pulse. Importantly, we found a strong positive relationship between functional and compositional OEV in some trophic groups, whereas other groups achieved high functional stability (low OEV) independent of their compositional vulnerability to perturbation. Thus, OEV emerged as the most integrative metric to compare the magnitude of overall compositional and functional vulnerability between trophic groups, as well as to represent the functional consequences of biodiversity change. Our results demonstrate a pathway to integrate discussions on multiple dimensions of ecological stability into an overarching framework for quantifying overall vulnerability of ecosystems to environmental change, thus opening further possibilities for risk assessment

Ecological stability, disturbances, biodiversity, ecosystem functioning, pulse disturbances, press disturbances, global change

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DRIVERS OF MACROPHYTE PATTERNS IN SMALL WATER STANDING-WATER ECOSYSTEMS IN WESTERN SICILY

SESSION 13

Rossano Bolpagni (Parma University); **Lorenzo Lastrucci** (University of Florence); **Alice Dalla Vecchia** (Parma University); **Orazio Caldarella** (Palermo University); **Lorenzo Gianguzzi** (Palermo University)

Macrophytes play fundamental ecological roles as habitat-forming for a multitude of other species, acting as key metabolic regulators of colonized ecosystems, particularly in small water bodies. Macrophyte assemblages can serve as effective proxies of short-term effects of climate change in the Mediterranean region, especially in islands and xeric areas. In Sicily - the largest island in Italy - small standing-water ecosystems (SWEs) are generally rare, isolated, and threatened by multiple pressures (e.g., drying, trampling, eutrophication). To shed light on the drivers of macrophytes, a detailed survey of SWEs in Western Sicily was carried out, focusing on the Special Protection Area “Monti Sicani, Rocca Busambra e Bosco della Ficuzza”. Here, we paid attention to the physical and chemical features of water and sediments to explore the metacommunity patterns of macrophytes in 10 isolated SWEs, for a total of 35 aquatic vegetation units. A total of 40 macrophytes were recognized, among which the most relevant are: Callitriche brutia, C. obtusangula, Glyceria plicata, Iris pseudacorus, Ranunculus aquatilis, R. peltatus, R. rionii, and Schoenoplectus lacustris. Other exceedingly rare taxa are: Alopecurus aequalis, Ceratophyllum submersum, Sparganium erectum, Potamogeton pusillus and P. trichoides. Physical and chemical features were highly variable, with sediment organic matter and soluble reactive phosphorous in the range 6.9 to 34.8% and <5 to 1116 PO43- µg L-1, respectively. Despite macrophytes are largely shared between SWEs, each of them is characterized by a strong physical and chemical distinctiveness resulting from local evolution dynamics (origin, management and use, and trophic status). This affirms the uniqueness of each site and calls for site-specific conservation actions, and for further investigations aimed at clarifying the role of regional vs local drivers on macrophyte patterns and stability.

Aquatic plants, Ponds, Human drivers, Mediterranean

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DO EUTROPHICATION AND SALINIZATION DECREASE TAXONOMIC AND FUNCTIONAL DIVERSITY IN TROPICAL MAN-MADE SHALLOW LAKES?

SESSION 13

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LINK TO THE STUDY VIDEO

Climate changes will cause unprecedented shifts in drylands tropical freshwaters mainly due to rainfall reduction. These changes will increase lakes susceptibility to eutrophication and salinization, because the water deficit driven by prolonged droughts reduces lakes water levels and consequently increases the concentration of dissolved salts and nutrients in the water. These shifts usually cause striking effects on environmental heterogeneity and fish diversity by constraining species establishment through selection on their functional traits. We expect that the increase of nutrients and salts will decrease environmental complexity and reduce fish taxonomic and functional diversity in tropical lakes. To test this hypothesis, we used limnological and fish data from 14 lakes located in northeastern Brazil. Lakes were sampled in a rain and in a dry period and along gradients of salt (Na+ and Cl-) and nutrients (P, N and C) concentrations. Since water level was not correlated with the previous variables, we also included it as a predictor in the regression models. Our results showed that in the dry period total phosphorus increased fish taxonomic and functional diversity and was more important than water level and Na + to explain variations in the diversity components. For the rain period, however, the water level was the most important variable and increased fish taxonomic and functional diversity, whereas Na+ showed an opposite pattern. Our findings showed that the responses of diversity components to environmental gradients rely on seasonal changes with the relative importance of salts being highest during the rain period. Therefore, to understand the impacts of salinization and eutrophication on aquatic communities and diversity components, seasonal changes must be taken into consideration, so as to help in the development of effective strategies for managing and mitigating the effects of rainfall reduction on lakes in tropical regions.

climate changes. taxonomic and functional diversity. eutrophication. salinization.

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THE EFFECT OF MICROPLASTIC PARTICLES ON THE INTERSPECIFIC COMPETITION OF DAPHNIA



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The pollution of aquatic habitats by microplastics is currently one of the most intensely studied issues in the field of ecology. Many studies attempt to estimate the distribution and concentration of MP in various environments and determine how it affects their inhabitants. However, much less effort has been undertaken to assess the effect of MP particles on the inter- and intraspecific interactions among aquatic organisms, including the interspecific competition of Daphnia. We assumed that the presence of MP may mitigate interspecific competition. To test this, we performed 3 long-lasting (60 days) competitive experiments in the absence (control) and the presence of different types of MP particles (polyhydroxybutyrate, polystyrene and high-density polyethylene, each of 30 μm in diameter), at limited algal food concentration (0.2 mg × C L-1 supplied daily) and 3 pairs of Daphnia species: (i) Daphnia magna and D. pulex, (ii) D. magna and D. galeata, (iii) D. pulex and D. galeata. In the presence of each of the three types of MP, the population density of the superior competitor (D. magna in relation to D. pulex and D. galeata, and D. pulex in relation to D. galeata) decreased while the population density of the inferior competitor increased in relation to the controls. The negative effect of MP on the population density of superior competitors was due to an increasing mortality rate rather than a decreasing birth rate.

Microplastic particles, interspecific competition, Daphnia

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FISHING IN LAKE SYSTEMS: PROBLEMS AND SOLUTIONS

SESSION 14

Priscila Lopes
(UFRN, Brazil)

Lakes are an important source of fish around the globe, including developing and developed countries. Yet, lake fishing receives considerably less attention from governments and decision makers, despite the fact that, similar to what has happened in the oceans, they have been amply overfished. Solutions to address the ecological and economic consequences of lake overfishing and habitat degradation range from promoting stock enhancement and recreational fishing initiatives to pond aquaculture, which can cause additional environmental and social problems. We invite researchers working on different lake systems, subject to various impacts (aquaculture, hydroelectric dams, deforestation, pollution and overfishing, etc.) to provide an overview of large-scale issues, to identify commonalities within and across regions, and potential solutions related to lake fishing that can potentially be replicated in different parts of the globe.

NATURAL LAKES IN THE BRAZILIAN SEMI-ARID REGION: USE, OCCUPATION, AND ICHTHYOFAUNA



Francisco Hélio Coelho de Lima (Universidade Federal do Ceará-UFC**);** **Jonathas Freitas Torres** (Universidade Federal do Ceará-UFC); **Barbara Oliveira Frota** (Universidade Federal do Ceará-UFC); **José Roberto Feitosa Silva** (Universidade Federal do Ceará-UFC); **Waldir Mantovani** (Universidade Federal do Ceará-UFC)

LINK TO THE STUDY VIDEO

Lakes are important ecosystems in the world and are the habitat of animals and plants. Human populations settle adjacent to them due to the provision of ecosystem services, such as water, fish, and other services. In the present study, we discussed the use, occupation, lists of species, and distribution of diversity of fish assemblages in three lakes of different geoenvironmental units in the Brazilian semi-arid region. We observed human activities in the lakes and collected the ichthyofauna in four moments of 2019, twice in the rainy season(February/May) and twice in the dry season (August/November). In each sampling event, we collected fish at four equidistant points from the margin of the lakes up to 1.5 meters deep with standardized fishing gear and time. The fish were identified and quantified as species according to the point of collection, and morphometric measurements (weight and length) were performed. We collected 4,319 individuals and 20 species and then we calculated the Shannon index. Results showed that traditional farmers and fishermen inhabit the surroundings of the lakes assessed. Lake 1 showed a low diversity of species of fish in the driest month, which favors an increase in the population in this type of environment. The rainy season showed an increase in fish species diversity. Lake 2 also presented an increased number of fish species diversity in the rainy season and a decrease in the dry season. Lake 3 showed an increased number of individuals and a decreased number of fish species in the dry season, while diversity increased and the abundance of individuals decreased in the rainy season. The level of water in the lakes affected the dynamics and diversity of fish assemblages. Fisheries followed the dynamics caused by the weather: their frequency is lower with the reduction of water. There was an increase in subsistence agriculture on the margins of the lakes, which followed the receding water and demonstrated complex social-ecological systems.

Ecosystem services of lakes, fish assemblages, Brazilian semi-arid region

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COUPLING PALAEOLIMNOLOGY AND IN SITU EXPERIMENTS TO DETERMINE THE INFLUENCE OF FISH ON LAKE FUNCTIONING AT LAKE SOFIA, MADAGASCAR; IMPLICATIONS FOR LAKE RESTORATION



Lilian Unger (University College London); **Laurence Rasoamihaingo** (University of Toliara); **Professor Viv Jones** (University College London); **Dr Andy Bamford** (Wildfowl and Wetlands Trust); **Dr Hannah Robson** (Wildfowl and Wetlands Trust)

LINK TO THE STUDY VIDEO

A large proportion of the population in Madagascar rely on subsistence living. Fishing provides a vital source of nutrition and income. Tilapia (Oreochromis species) are freshwater, herbivorous fish that have been widely introduced across the tropical regions of the world for fishing. A combination of modern ecological survey and experimental data is complemented by palaeolimology, to investigate the impact of Tilapia introduction to Lake Sofia, Madagascar. Fish catch and macroinvertebrate data have been collected monthly since 2018 and 2015, respectively. Enclosure experiments have been set up to study the influence of fish exclusion on the growth of different submerged plants and macroinvertebrates. This has shown that the growth of submerged plants and associated invertebrate abundance is reduced with Tilapia presence. Today macrophytes are dominated by emergent species (Papyrus marsh) with no charophytes and few floating plants. Dated sediment cores representing the last c. 150 years show a decline in submerged plants (e.g. water lily) and the disappearance of charophyte oospores, associated with an overall decline in the diversity and abundance of macroinvertebrate remains (e.g. Bryozoa, Tricoptera). One invertebrate which increases since Tilapia introduction is Chaoborus spp., possibly indicating less predation by zooplanktivorous fish. In the dry season, Lake Sofia has an average Secchi depth and water depth of 0.8m and 1.2m, respectively. In the past it is likely the water was clearer to support the growth of charophytes. It is hypothesised that the introduction of Tilapia to Lake Sofia has resulted in the loss of native fish species, together with the loss of submerged macrophytes through direct grazing and sediment disturbance. This data will help to inform the future management of this lake and others like it in Madagascar and across the tropics.

MADAGASCAR TROPICAL TILAPIA MACROINVEREBRATES MACROPHYTES

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FISHERS' PERCEPTIONS UNVEIL HISTORICAL POPULATION TRENDS OF AN OVEREXPLOITED LAKE FISH



Carolina Freitas (UFRN); **João Vitor Campos-Silvac** (UFAL); **Helder M.V. Espírito-Santo** (UFPA); **Leandro Castello** (Virginia Tech); **Priscila Lopes** (UFRN)

Even tough wildlife has been intensely exploited for centuries, studies addressing the current status of the populations often ignore their past conditions. Humanity is commonly deceived by the "shifting baseline syndrome", and each generation subconsciously accept as a baseline the environmental conditions that occurred in their youth. Moreover, most studies addressing the shifting baseline are restricted to the marine realm, while freshwater ecosystems have gone largely disregarded. However, freshwaters may have been even more drastically impacted than marine or terrestrial systems, and the shifting baseline syndrome likely affects our current evaluations and management targets. Here we attest to this idea by addressing temporal trends of the arapaima (Arapaima sp.), an iconic fish that used to be the most important commercial fishery resource in the Brazilian Amazon, targeted in oxbow lakes. This fish was largely overfished, which led to some local extinctions. Through a comprehensive survey encompassing 247 interviews in 67 communities of two major tributaries of the Amazon river, we assessed fishers' perceptions on the relative changes of arapaima stocks over the last ~70 years, by comparing fish sights in the same lakes over time. We showed that arapaima populations are recovering in some areas, but still declining in others. However, even where the stocks are increasing, they have not yet reached its past abundance. We address specific strategies to be adapted to use fishers' perceptions for accessing data on banned species in data-poor scenarios worldwide and discuss specific findings regarding the fishing of iconic lake-dependent species.

arapaima; lake fishing; shifting baseline syndrome

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BIOLOGICAL INVASIONS IN SHALLOW LAKES

SESSION 15

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Bruno R. S. Figueiredo
(UFSC, Brazil)

The proposed session will deal with biological invasions in different ecological levels of organizations, also considering a variety of concepts related to predation, competition, herbivory and other factors affecting the establishment and persistence of invasive species in shallow lakes. This topic is quite timely because climate change has been linked to species expansion and contractions of species ranges, significantly impacting the biodiversity and ecology of invaded areas.

ACUTE TOXICITY EFFECT OF COPPER (CU) ON THE FRESHWATER COPEPODS MESOCYCLOPS PEHPEIENSIS AND MACROCYCLOPS ALBIDUS (CRUSTACEA: COPEPODA) DURING DIFFERENT LIFE STAGES



Leticia Esmeralda Cruz Escalante (UNAM); **S. Nandini** (UNAM); **S. S. S. Sarma** (UNAM)

The invasive copepod Mesocyclops pehpeiensis and the cosmopolitan Macrocyclops albidus could be two good freshwater ecotoxicity testing organisms due to their wide distribution, short life cycle and the role of these predators in food webs. One of the reasons for the widespread distribution of M. pehpeiensis is possibly due to its resistance to toxicants. Copper (Cu) is one of the most important heavy metal pollutants in Mexico. Although copepods are often the most abundant organisms in the zooplankton (in terms of biomass), they have not been used widely in ecotoxicology in spite of the fact that they are easy to maintain under laboratory conditions, have different life stages and habits and are vulnerable to contaminants. In order to protect inland waters, accurate diagnosis of the toxic effect of pollutants on species representative of these systems should be routinely done. We conducted acute toxicity tests (LC 50) using five concentrations of Cu with nauplii, adult females and males of each species in order to assess the sensibility of Mesocyclops pehpeiensis and Macrocyclops albidus. We found differences in the sensitivity of these copepods with respect to their developmental stage, sex and species.

ecotoxicology, copepods, copper, freshwater

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POSSIBLE MEANS OF INVASION BY A SUBMERGED PLANT CABOMBA CAROLINIANA IN THE LAKE TAIHU DRAINAGE BASIN

SESSION 15

XIAOLONG HUANG (Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences)

A new invasive plant, Carolina fanwort (Cabomba caroliniana), has recently received considerable amounts of attention in the downstream of the Yangtze River Delta. The plant is a perennial submerged plant species native to the United States and South America and is often introduced as an aquarium plant in the rest of the world. Currently, C. caroliniana is in the early stage of its invasive outbreak in China, as it was only recently recognized as an invasive plant. No extraordinary removal measures have been developed, and salvage requires a high amount of human resources. During this process, the species easily forms stem fragments that may produce new populations with water flow, benefitting its spread. The rapid spread of C. caroliniana may indicate that the plant has not yet reached its distribution limit. We found the dominant aquatic plants have changed from native plants to invasive plants in the Lake Taihu drainage basin (LTDB) and C. caroliniana has become a dominant species in this area. Furthermore, we conducted two mesocosm experiments to compare the competitive ability of C. caroliniana and two common native submerged plant counterparts, Hydrilla verticillata and Myriophyllum spicatum and then record the responses of the three plant species to herbivory by two native herbivorous generalist snails, Radix swinhoei and Bellamya quadrata. Our results demonstrated that C. caroliniana did not show higher trait values or have more advantageous traits than native plants H. verticillata or M. spicatum. However, it was more resistant to herbivory by two snails R. swinhoei and B. quadrata. Our results indicate that the successful invasion by C. caroliniana is facilitated by herbivorous snails rather than by winning the competition with other species, which potentially changes the species composition of submerged plants in the plant community.

Cabomba caroliniana; Submerged Plant; Lake Taihu Drainage Basin;

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MUTUAL FACILITATION AND BOOM-BUST DYNAMICS OF INVADERS PAVE THE WAY FOR NATIVES: TESTING BIOLOGICAL INVASION THEORIES AT THE ECOSYSTEM LEVEL



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With the global increase of invasive populations, a plethora of hypotheses has been developed to describe their observed dynamics, including the invasional meltdown hypothesis (IMH) and boom-bust dynamics (BBD). According to the IMH, non-indigenous species can facilitate one another and thereby increase the likelihood of ecological impact. The BBD suggests that invaders show an outbreak phase with rapid population growth, followed by a dramatic decline. However, studies supporting these hypotheses at the ecosystem level are rare. Here we present 10-years of data on the establishment of two invaders in a shallow temperate lake. Nuttall's waterweed (Elodea nuttallii), listed as Invasive Alien Species of European Union Concern, and the quagga mussel (Dreissena rostriformis bugensis), were first detected in Lake Müggelsee (Germany) around 2011/12. Our data show that filtering by dreissenid mussels increased the light availability in littoral areas, which enabled E. nuttallii to spread rapidly and become the most abundant macrophyte in 2017. In turn, E. nuttallii provided surface for mussel colonization. This suggests that both invasive species facilitate each other, thereby supporting the IMH. By 2019, E. nuttallii had dropped to <10% of its maximum abundance, a typical feature for BBD. Its niche was filled by a native macrophyte, Ceratophyllum demersum, which rapidly increased in abundance after 2017. The abundance of the native Najas major also increased. Both native species are less prone to fish herbivory than E. nuttallii, and numbers of herbivorous rudd (Scardinius erythrophthalmus) increased between 2015-20. Maximum colonization depths of macrophytes were higher in 2017-20 than before. While existing theories thus in principle allow explaining the observed population dynamics of invaders, we still need more mechanistic understanding of their complex interactions with natives to manage their impacts on important ecosystem functions and services in lakes.

Ceratophyllum demersum, Dreissena rostriformis bugensis, Elodea nuttallii, herbivory, macrophytes, quagga mussel, rudd

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NON-NATIVE FISHES HOMOGENIZE NATIVE FISH COMMUNITIES AND REDUCE ECOSYSTEM MULTIFUNCTIONALITY IN TROPICAL LAKES OVER 16 YEARS



LINK TO THE STUDY VIDEO

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Non-native species are considered a major global threat to biodiversity, and their expansion to new ecosystems has recently increased. However, the effect of non-native species on ecosystem functioning is poorly understood, especially in hyper diverse tropical ecosystems where long-term studies are scarce. We analysed the relationship between richness, biomass, and β-diversity of non-native and native fishes during 16 years in five hyper diverse tropical shallow lakes. We further elucidated how an observed increase in the proportion of richness, biomass, and β-diversity of non-native over native fishes affect crucial multifunctional processes of lakes (decomposition and productivity). We found a general positive relationship between the richness and biomass of non-native and native fishes. However, the slope of this relationship decreased continuously with time, displaying an increase in non-native species richness and a decrease in native species richness over time. We also detected a negative relationship between the β-diversity of non-native and native fishes over time. Moreover, the increase in the non-native:native ratio of species richness, biomass, and β-diversity over time decreased ecosystem multifunctionality. Our results suggest that non-native fishes caused a homogenization of the native fish species over time, resulting in impoverishment of ecosystem multifunctionality. Therefore, focus on long-term effects and use of multiple biodiversity facets (α- and β-diversity) are crucial to make reliable predictions of the effects of non-native fish species on native fishes and ecosystem functioning.

Biodiversity; Decomposition; Ecosystem functioning; Invasive species; Productivity; Species diversity

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INVASIVE SPECIES HOMOGENIZES ASSEMBLAGES OF NATIVE AQUATIC MACROPHYTES FROM DIFFERENT FUNCTIONAL GROUPS OVER TIME IN A HYDROELECTRIC RESERVOIR



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Biotic homogenization is the increase in species similarity among a set of communities over time. Species invasion has been pointed out as the main cause of biotic homogenization in natural systems, but it is still unclear the effect size of invasive species on native species communities over time. Here, we analyzed how the presence of an invasive macrophyte (Urochloa arrecta) affects the beta-diversity of native macrophyte assemblages in a reservoir over time. We evaluated the relationships of the invasive macrophyte with the overall macrophyte assemblages, and with three life forms (submerged, floating, and emergent). We used presence and absence data of native macrophytes assemblages in 235 sites in the Itaipu Reservoir (Brazil), between 2007 and 2019. Our results showed that U. arrecta presence decreased the beta-diversity of the native macrophytes assemblages, which included the three life forms. Moreover, we found that beta-diversity of native macrophytes (both the overall community and life forms groups) decreased over time in the presence of U. arrecta. Conversely, a native beta-diversity increased over time in the absence of U. arrecta. Our results revealed that the presence of U. arrecta increases the similarity between species of native macrophyte assemblages in space and time, causing biotic homogenization of native macrophyte assemblages. Furthermore, the natural fluctuation in species composition resulted from seasonal variations, is lost when U. arrecta is present, suggesting that only a few species can co-occur with this invasive macrophyte. These findings suggest that aquatic assemblages will become increasingly homogeneous in the future as results of increased number of human-mediated biological invasion events, which requires attention in biological management and conservation measures.

aquatic plants, biological invasion, life forms, similarity.

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CAN ROOSTING BARNACLE GOOSE POPULATIONS INCREASE EUTROPHICATION IN LAKES?

SESSION 15

Laura Härkönen (Finnish Environment Institute, Freshwater Centre); **Ilkka Sammalkorpi** (independent researcher); **Markku Mikkola-Roos** (Finnish Environment Insitute, Biodiversity Centre)

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The Eurasian population of Barnacle Goose (Branta leucopsis) has increased drastically over the last decades to 1.3 M individuals. The species is strictly protected under EU Birds Directive and Bern Convention on the Conservation of European Wildlife and Natural Habitats. The Arctic-breeding geese congregate in large flocks at several sites over northern Europe during migrations. Barnacle Geese forage on vegetation near open water, often on fields causing increasing damage to farmers and pressure on agricultural policy. Geese have also been noted as potentially significant vectors transporting nutrients and microbes from terrestrial to aquatic systems. They return to a freshwater roost site at least once a day to rest in between feeding. To study the water quality effects of roosting geese, two shallow southeastern Finnish lakes (372-510 ha, mean depth 0.7-2.4 m) known as important roosting sites, were sampled before, during and after roosting. Both lakes are clay-turbid and suffer from diffuse source loading. On every sampling, i.a. total and dissolved nutrients, suspended solids, and coliform bacteria were measured. A maximum of 100,000-120,000 geese were found at lakes, forming a biomass of up to 400-457 kg/ha/roost. No instant effect on nutrients was observed in the surface water samples during roosting. Coliform bacteria however, increased slightly. Our findings are in line with the previous results that goose faeces sink rapidly and effects on eutrophication may occur with a delay. With geese already gone, delayed response was supported by our last sampling coinciding with a storm effectively mixing the lake waters. Consequently, the concentrations of nutrients, especially nitrogen, and coliform bacteria increased remarkably in the water, indicating that nutrient increment mainly originated from sedimented faeces. To better understand the ecological role of roosting geese in lakes, it is crucial to further investigate their contribution to internal loading.

nutrient loading, coliform bacteria, barnacle goose, roosting, internal loading

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THE INCIDENCE OF ALIEN SPECIES ON TAXONOMIC, FUNCTIONAL AND PHYLOGENETIC DIVERSITY OF MACROPHYTE COMMUNITIES DOMINATED BY PHRAGMITES AUSTRALIS (CAV.) STEUD. IN TWO DIFFERENT TYPES OF ENVIRONMENT, LOTI

SESSION 15

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The structure of native communities can be drastically changed by alien plant invasion. Two main hypotheses attempt to predict the incidence of invasion: i)Environmental filtering that would cause biotic homogenization; ii)“Darwin’s naturalization hypothesis” predicts that invasion bring to an increase in phylogenetic and functional diversity of invaded communities. Common reed-dominated stands are an important component of submerged and emergent shores. They are essential for biodiversity conservation, in particular in the Mediterranean areas where anthropic activities promote the invasion of alien species. Several studies described plant communities dominated by P. australis from the floristic and phytosociological point of view. However, comparative analyses have rarely been carried out in terms of plant diversity between reeds of lentic and lotic habitats and, as far as we can know, works evaluating the incidence of alien plants on taxonomic, functional, and phylogenetic diversity on these particular communities are totally absents. To this purpose, we investigated the differences in the richness and relative abundance of alien plant species of lentic and lotic habitats from central Italy. We furthermore aimed at investigating the effect of alien plant species on the different facets of taxonomic, phylogenetic, and functional diversity of the two habitats. Preliminary results suggest that alien species are linked to the modification of the taxonomic, phylogenetic, and functional structure of the communities, in both habitats. Functional diversity, in particular, appeared directly linked to new traits due to the alien species, while modification in taxonomic and phylogenetic diversity was linked also to a modification of native species composition. Further analysis still in progress will clarify the role of alien species in modifying the functional dimension of these communities.

macrophytes, alien species, functional diversity, phylogenetic diversity

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FEEDING BEHAVIOR OF THE INVASIVE COPEPOD MESOCYCLOPS PEHPEIENSIS AND THE NATIVE SPECIES MESOCYCLOPS LONGISETUS WHEN CULTURED SEPARATELY OR TOGETHER

SESSION 15

LINK TO THE STUDY VIDEO

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Mexico has more than 120 invasive aquatic species, of these, 60% of aquatic invasive taxa are from freshwater. Among copepods, in Mexico, there are four invasive species: the Eurasian Thermocyclops crassus, the Afro-Asian Mesocyclops aspericornis, and Mesocyclops thermocyclopoides, and the Asian Mesocyclops pehpeiensis. Of these, M. pehpeiensis has the widest distribution; it has been reported in 14 countries throughout the American, Asian, and European continents, colonizing different environments such as rice fields, artificial water containers, wells, ponds, rivers, and hypersaline lakes. Feeding experiments indicate the success of an invasive species; these are often ecologically harmful to native species and are characterized by their efficient use of resources. In the present study, we evaluated the prey preference index of M. pehpeiensis in the absence and presence of the native copepod M. longisetus with a diet composed of ten species, five rotifers, and five cladocerans. In terms of preferences, in separate environments and together in the same environment, both copepods, M. pehpeiensis, and M. longisetus preferred to consume four of the ten prey species offered in the diet. However, in terms of consumption, when separate, both the species of Mesocyclops consumed a greater number of prey (35-40 individuals) when compared to mixed species predator populations (33 individuals). Therefore, when the two species of Mesocyclops are in the same habitat, there is some interference between them, which resulted in decreased prey consumption. Our results have been discussed with emphasis on the effect of invasive species on native species of copepods.

Copepoda, invasive species, native species, prey preference index

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EFFECT OF RAINBOW TROUT INTRODUCTIONS ON FOOD WEBS IN LAKES OF THE ARID PATAGONIA



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The exotic rainbow trout (Oncorhynchus mykiss) has been stocked in naturally fishless lakes on the reproductive area (Southern Patagonia) of the critically endangered Hooded grebe (Podiceps gallardoi), an aquatic bird endemic of this region. The effects of trout introduction were proposed as one of the potential causes of their critical situation. Trout could modify the trophic structure of the aquatic community, altering the trophic relationships of stocked lakes and could generate changes in the spatial distribution and/or diet of its main prey, which is strongly domined by amphipods in this aquatic system, affecting their trophic position, and inducing the use of alternative carbon sources. We compared the food webs between two fishless and two stocked lakes using stable isotope analysis, based on Layman's community metrics. Results provided evidence that the presence of fish exerts a marked influence on the food web structure of the studied communities, as well as on the limnological characteristics. Lakes stocked with trout showed enriched values of 15N and higher values of total nitrogen, conductivity, dissolved organic and inorganic carbon compared to fishless lakes. Community metrics estimation evidenced an increase in trophic redundancy in stocked shallow lakes, which could be explained by the high degree of trout omnivory. Additionally, the study evidenced changes in use of carbon sources in amphipods between stocked and fishless shallow lakes. The spatial distribution of the amphipods towards littoral zone of the stocked shallow lakes, as an anti-predatory response, could has impacts on the Hooded grebe.

carbon, exotic fish, nitrogen, stable isotopes, Strobel Lake plateau.

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POPULATION DYNAMICS OF THE INTRODUCED CRAYFISH PROCAMBARUS CLARKII (DECAPODA: CAMBARIDAE) IN THE LITTORAL OF A HIGH-ALTITUDE MEXICAN RESERVOIR



LINK TO THE STUDY VIDEO

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Procambarus clarkii is a native crayfish from northwestern Mexico and the southeastern USA with high commercial importance. Because of this, it has been worldwide introduced in many aquatic systems causing serious problems associated with the acceleration of eutrophication and the decrease of biodiversity. This species was introduced to central Mexico where is beginning to spread. This study aimed to determine changes in abundance, fecundity, sex ratio, and morphometry associated with environmental variation in the Taxhimay reservoir (State of Mexico) during a year. To achieve this, we monthly sampled P. clarkii and environmental variables in four sites (4 replicates each) using cylindric traps; the catch was counted, checked for sex and the total length, carapace length, and width, dactyl as well as chelae length and width were measured. We also calculated gonadosomatic (GSI) and hepatosomatic (HSI) indices for females. According to the principal component analysis, Secchi transparency, conductivity, and chlorophyll a explain most environmental variation along the year, and no statistical differences were found among sites after PERMANOVA analysis. We captured a total of 464 organisms where 43% were females and 57% males (with only 26 organisms at non-reproductive stages). The months corresponding to the greatest abundance were May and April. Fecundity analysis showed significant differences among months. PCA for morphometrics showed differences between males and females: Length of the right and left cheliped (LRC, LLC) and total length (TL). The reproductive season of P. clarkii in Taxhimay reservoir occurs between the months of July-September and January-March. Hence, Taxhimay reservoir has the physical and chemical characteristics necessary for the successful development of P. clarkii; however, biological assessment including predation and food limitation is still needed.

Crustacea, Environmental variables, Fecundity, Invasive species, Morphometry.

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FISHPONDS: ECOLOGY, BIOGEOCHEMISTRY AND AREAL EXTEND

SESSION 16

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Ernandes Sobreira
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Nathan Barros
(UFJF, Brazil)

Although the exact areal extend of fishponds is unknown, it is clear that their number and thereby their footprint on the landscape is booming worldwide. Despite their high and increasing abundance, these special type of 'shallow ponds' have received relatively little attention from limnologists. In this session we welcome scientist working on (micro)ecology and biogeochemistry in fishponds as well as on their impact on downstream waters. In addition, we welcome scientist working on assessing the areal extent of the ponds, for instance using remote sensing.

FISH FARMING IN A TROPICAL RESERVOIR: SEDIMENT BIOASSESSMENT AND GREENHOUSE GASES EMISSION



Marcelo Gomes da Silva (Embrapa Environment); **Mariana Silveira Guerra Moura e Silva** (Embrapa Environment); **Ana Paula Packer** (Embrapa Environment); **Artur Jordão de Magalhães Rosa** (Embrapa Cerrados); **Ana Maria Cirino Ruocco** (Embrapa Environment); **Josilaine Taeco Kobayashi** (Embrapa Environment); **Viviane Cristina Bettanin** (Embrapa Environment); **Danilo Francisco Trovo Garofalo** (Embrapa Environment); **Joaquim Ernesto Bernardes Ayer** (Embrapa Environment); **Fernanda Garcia Sampaio** (Embrapa Environment); **Letícia Aliberti Galego Alves da Silva** (Embrapa Environment)

Fish farming in Brazil has experienced a significant expansion during the last decades. According to Peixe BR (2020), in 2019, the Brazilian production reached 758,006 tons, with a 4.9% increase when compared to 2018. Furthermore, FAO points out that aquaculture production in Brazil is expected to increase approximately 105% by 2025, reaching 1.15 million tons. According to Decree No. 4,895 (11/25/2003), 1% of the area of the Union's reservoirs is allocated for aquaculture. However, accelerated aquaculture growth must be accomplished with sustainability, since water has multiple uses. So, this study aimed to evaluate the influence of Nile tilapia (Oreochromis niloticus) net-cage culture in sediment quality and greenhouse gases emission. Three field campaigns were carried out during 2019 to evaluate sites upstream, in the net-cages, and downstream of the cages site, in two fish farms in the Ilha Solteira reservoir. The following parameters were measured: organic matter, phosphorous, and metrics of macroinvertebrate benthic community (taxonomic richness (S), dominance (DOM), density, Shannon diversity (H') and Pielou evenness indexes (J)). Sediment was sampled using an Ekman-Birge grab. Biotic samples were fixed with 4% formaldehyde and sent to laboratory for taxonomic identification. Diffusive methane (CH4), carbon dioxide (CO2), and nitrous oxide (N2O) fluxes were determined using the static chamber technique. GHG bubbles were estimated with submerged inverted funnels. Results indicated diffuse CH4 flux and bubble CH4 flux were significantly increased in the net-cage sites. CH4 fluxes showed a positive correlation with organic matter in the sediment. CO2 and N2O did not show influence of the net-cage. Significant differences were also detected for phosphorus concentration, ecological attributes of fauna (H', J and DOM) and CH4 flux (CH4-D and the bubble CH4 flux) which presented higher values at production sites, excepted for H' and J were reduced in these sites.

Ilha Solteira; Nile tilapia; macroinvertebrtes; net cages; methane

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FISHING FOR METHANE: FIRST INSIGHTS INTO VARIABILITY, PATHWAYS AND POTENTIAL DRIVERS OF METHANE EMISSIONS FROM BRAZILIAN FISH PONDS



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Fish constitute an important protein source in the human diet. Accordingly, the combination of ever-increasing global protein demand and dwindling wild fish stocks has caused the aquaculture sector to boom in recent years. Due to a high input of organic matter and nutrients through fish feed, aquaculture ponds are potentially strong emitters of methane (CH4), a greenhouse gas with a 34 times higher global warming potential than carbon dioxide for a 100-year time scale. However, very little is known about the magnitude, pathways and drivers of these emissions.\n\nWe studied CH4 emission in 52 fish ponds located in 21 freshwater fish farms in Brazil, where aquaculture production has increased over a hundredfold since 1995. We measured diffusive CH4 fluxes at the edge and the centre of each pond using a closed chamber connected to a greenhouse gas analyser. In a subset of ponds (n=32) we additionally quantified ebullitive CH4 fluxes using funnels, and took water and sediment samples for biogeochemical analyses. Diffusive CH4 fluxes were relatively low (median 8.4 mg CH4 m-2 d-1) but varied substantially between ponds (0.7 to 85.8 mg CH4 m-2 d-1) and were higher in the centre (median 11.4 mg CH4 m-2 d-1) than at the edge (median 6.4 mg CH4 m-2 d-1) in 90% of ponds. Ebullitive fluxes contributed substantially (57% on average) to total CH4 emissions, surpassing diffusive emissions in 63% of ponds. We measured several extreme ebullitive fluxes of up to 725 mg CH4 m-2 d-1, comparable to rates commonly observed in hypereutrophic aquatic systems. Our study shows a large variation in CH4 emissions between and within fish ponds, likely due to different production practices and sediment quantities. CH4 ebullition contributed considerably to total emissions and should not be overlooked when calculating aquaculture emission factors. Unravelling drivers for these emissions is essential for the development of sustainable management practices in aquaculture.

pisciculture, greenhouse gas emissions,ebullition, freshwater

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METHANE AND NITROUS OXIDE HAVE SEPARATED PRODUCTION ZONES AND DISTINCT EMISSION PATHWAYS IN FRESHWATER AQUACULTURE PONDS



Junji Yuan (Institute of Soil Science, Chinese Academy of Sciences)

Aquaculture systems receive intensive carbon (C) and nitrogen (N) loadings, and are therefore recognized as major anthropogenic sources of methane (CH4) and nitrous oxide (N2O) emissions. However, extensively managed aquaculture ponds have been identified as methane (CH4¬) emission hotspots but weak nitrous oxide (N2O) sources. Here, we investigate annual CH4 and N2O fluxes from three earthen ponds used for crab culture, of different sizes, in southeast China. Our purposes are to identify the spatiotemporal variations of CH4 and N2O emissions and their components among ponds and to evaluate the zone for CH4 and N2O production. Static chamber-measured CH4 flux ranged from 0.03 to 64.7 mg CH4 m^{-2} h^{-1}, and temperature, followed by dissolved organic C (DOC) concentration, and redox potential (Eh), were the primary drivers of seasonal CH4 flux patterns. Ebullition accounted for 79.1-83.5% of the total CH4 flux. Annual CH4 emissions were correlated with sediment DOC concentrations but negatively ($P < 0.05$) correlated with water depth across ponds. Upon NO3? depletion, the ponds were a weak source of N2O annually and even an N2O sink in summer. The calculated diffusive N2O flux by the gas transfer velocity was 0.32-0.60 times greater than the measured N2O emission, suggesting that N2O in water column can not only evade as water-air fluxes but diffused downwards to be consumed in anaerobic sediments. This also indicates that N2O was produced primarily in water column. According to our results, the current global CH4 budget for inland waters is probably underestimated due to a lack of data and underestimation of the contribution of ebullitive CH4 flux in small lentic waters. The downward N2O diffusion from the water column into sediment indicates that the extensively-used model approach based on gas transfer velocity potentially overestimates N2O fluxes, especially in small eutrophic aquatic ecosystems.

Aquaculture ponds methane Nitrous oxide Diffusion Ebullition

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IMPLICATION OF RESTING FORMS TO METACOMMUNITY DYNAMICS ON PERMANENT AND TEMPORARY SHALLOW SYSTEMS

SESSION 17

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The production of resting stages is a common feature in many aquatic groups. From an ecological point of view, these structures are an adaptation for populations to survive adverse environmental conditions, avoid local extinction and spread their populations. The cumulative production of resting stages leads to a “dormant egg bank” in the lake sediments, which is very important for dispersal as well as influence the future time and spatial dynamics of pelagic populations. Moreover, colonization of a local community can occur from dormant stages, not just from other habitat patches, as is commonly assumed in metacommunity theory. Since local and regional scale processes has yet not been thoroughly incorporated into metacommunity ecology we invite works that could promote the discussion and aim to elucidate how colonization from the seed bank contribute to observed biodiversity patterns in both permanent and temporary ecosystems, across different spatial and temporal scales.

IMPACTS OF EXPOSURE TO MINE TAILINGS ON HATCHING OF A ZOOPLANKTON RESTING-EGG BANK

SESSION 17

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In the last 5 years, two colossal environmental disasters involving iron-enriched mine tailings occurred in Brazil, affecting many aquatic ecosystems over the short, medium and long terms. This study investigated whether these iron-enriched mine tailings affect the main biotic strategy to restore zooplankton populations affected by severe stress, i.e., hatching of dormant stages. A 30-day hatching experiment was conducted, using a resting-egg bank from a natural lake, exposed to 3 concentrations of mine tailings: control (0 g), T25 (25 g) and T50 (50 g). A total of 22, 15 and 16 species hatched in the control, T25 and T50, respectively. Conochilus sp., Filinia terminalis, Hexartha mira, Bosmina longirostris and Ceriodaphnia silvestrii hatched only in the control, which suggests that they are sensitive to any concentration of mine tailings. A gradual decrease on richness and hatching abundance was recorded from the control (7.9 ± 1.7 species.day–1 and 106.4 ± 11.2 hatchings.day–1) to T25 (6.8 ± 1.2 species.day–1 and 82.3 ± 14.5 hatchings.day–1) and then to T50 (5.6 ± 1.4 species.day–1 and 40.42 ± 7.0 hatchings.day–1). Our results suggest that exposure of zooplankton resting eggs to iron-enriched mine tailings may negatively impact these egg banks in natural ecosystems, with potential impacts on the restoration of zooplankton communities and metacommunities structure after even short-term exposures.

Dam failure Mining waste Microcosms Dormant communities

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DOOMED TO REPEAT IT, DORMANT STAGES FROM THE PAST DETERMINE ACTIVE ZOOPLANKTON COMPOSITION COMMUNITIES IN TEMPORARY SUBTROPICAL PONDS



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LINK TO THE STUDY VIDEO

Zooplankton community structure is affected by the interaction of biotic (i.e. competition and predation) and abiotic factors (i.e. climate, hydrology, water quality). The resting strategy of different zooplankton groupsis variable and be influenced by the hydrological regime, which strongly affects the capacity to inhabit different water bodies. In temporal ponds, the egg bank plays an important role in determine the community composition in the next flooding season, the previous history of the system (resting bank) determine the actual community structure. 2. We compared the structure of the active community and those hatched from sediment (resting bank), two groups of ponds with contrasting hydrology (i.e. large and short hydroperiod) were used to test these hypotheses. We collected sediments cores during the dry seasons and transported to the laboratory and the hatching experiments were conducted using filtered water from each pond. 3. We found a strong correlation between the structure of the active and resting communities indicating a resilient effect of the system memory in the sediments. Furthermore we found a singular composition of each kind of pond, with ostracods dominating the short hydroperiod ponds and cladocerans in the large ones. 4. On the light of these results the study of resting community appear to be a good representation of the active zooplankton community inhabiting the ponds, indicating that the hydrological restrictions play a key role also in the dormant community in the sediments.

Zooplankton temporary ponds sediments resting eggs hydrological regime

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STRUCTURE OF CLADOCERA RESTING EGG BANKS IN TROPICAL RESTORED LAKES AFTER LONG-TERM DROUGHTS

SESSION 17

Thamires Brazil Martins Machado (Federal Rural University of Rio de Janeiro); **Ana Clara Lima Caetano** (Federal Rural University of Rio de Janeiro); **Jayme Magalhães Santangelo** (Federal Rural University of Rio de Janeiro)

LINK TO THE STUDY VIDEO

Cladocerans may produce resting eggs when facing harsh environmental conditions. Resting eggs may accumulate in sediments and combine to produce resting egg banks. When lake conditions are suitable again, resting eggs hatch and active populations develop. Thus, the characterization of egg banks is crucial to infer the ability of lakes to recover after disturbances. In this study we evaluated the structure of Cladocera egg banks in restored lakes located in Reserva de Guapiaçú, Atlantic Forest, Rio de Janeiro State, Brazil. In the past the lakes remained dry for 25 years and now they have been flooded again for 15 years. Sediment samples from three lakes were taken in order to characterize the structure of Cladocera egg banks by quantifying different morphotypes. In two of these lakes, sediment samples were taken in areas with and without aquatic macrophytes, making together 5 sampling stations. Resting eggs were isolated from the sediment and each morphotype was photographed and incubated under favorable hatching conditions. Viable resting eggs were observed at all sampling stations, making together 14 species. Four out of five sampling stations showed Moina micrura as the most abundant species. Ceriodaphnia cornuta was the most abundant species in the fifth sampling station. Abundance varied from 3585 a 24076 resting eggs per m2, while species richness varied from 2 to 7 per sampling station. Abundance, species richness and community composition differed between some sampling stations. Within a lake, sampling sites with and without aquatic macrophytes were overall similar. Our results suggest that quantifying morphotypes is adequate to characterize resting egg banks, because species with low abundances in the sediment or low hatching rates can be assessed. We conclude that 15 years after reflooding the lakes, viable egg banks developed in different regions and egg banks from different areas are complementary in Cladocera diversity between the lakes.

zooplankton, Cladocera, resting egg bank, sediment

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MORPHOLOGICAL STRUCTURE OF CLADOCERAN RESTING EGGS FROM THREE SHALLOW LAKES IN SOUTHEASTERN BRAZIL

SESSION 17

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Cladocerans commonly produce resting eggs that are able to survive harsh environmental conditions. Resting eggs accumulate in lake sediments and have many ecological and evolutionary implications. For example, sampling resting eggs may provide knowledge on species richness and composition in lake systems without extensive sampling of active organisms in the water column. However, because most egg species are unknown, this method requires resting eggs to be hatched under laboratory conditions to determine species identity. In the present study we compared some morphological characters of cladoceran resting eggs to identify possible features allowing egg identification and searched for similarities among different species based on resting egg morphology. A total of 57 resting eggs of 11 species, collected in five sampling stations of three lakes in southeastern Brazil, were compared through microscope photographs and image analysis. For each resting egg, length and height of ephippium were measured, in addition to egg chamber area and ephippium area. The eventual presence of any appendages, such as spines, and the number of embryo per ephippia were also registered. Higher ephippia size and higher similarity on overall egg morphology were observed between Ilyocriptus, Macrothrix and one non-identified Sididae, while opposite features were observed in Ceriodaphnia, Chydorus and Coronatella. Similar patterns in resting egg morphology may be linked to phylogeny relationships and/or similar selective pressures in the habitats they live. Based on the species we compared, this would be the case for i) Ilyocriptus and Macrothrix (with larger ephippia) and ii) Ceriodaphnia, Chydorus and Coronatella (with smaller ephippia).

Zooplankton, sediment, resting egg morphology, Cladocera egg diversity

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MACROPHYTE-PLANKTON INTERACTIONS IN SHALLOW WATERBODIES

SESSION 18

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Macrophytes are diverse, and often dense, in many shallow lakes. In tropical and subtropical lakes they grow throughout the year whereas in temperate and arctic water bodies they are frozen in winter. Plankton species richness is often high in these habitats as these plants provide substrata and refuge against predation by vertebrates and invertebrates. The effectiveness of macrophytes as refuge depends on the structure of their stems and roots. There are also a few studies that report allelopathic interactions between macrophytes and phytoplankton. During this special session we hope to get more quantitative information on the species richness and abundance of phytoplankton and zooplankton associated with macrophytes in shallow lakes from different waterbodies in tropical and temperate regions. We also discuss the problems associated with quantifying plankton and predators from these habitats and the importance of macrophytes in improving water quality, directly by decreasing nutrient concentrations and indirectly by providing refuge to large, generalist filter feeders such as cladocerans, amphipods and ostracods.

THE EFFECT OF SHELTER ON THE RECOVERY OF SUBMERGED AQUATIC PLANT BEDS AND THEIR PHYTOPLANKTON-ZOOPLANKTON INTERACTIONS



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Shallow lakes can be dominated by different primary producers, including aquatic plants, phytoplankton, and periphyton, which each can lead to a different food web structure and alternative stable state. Trophic transfer efficiency is an important ecosystem function, which is constrained by the efficiency at which herbivores can consume primary producers. Zooplankton, an important herbivore in the aquatic ecosystem, affects the production of higher trophic levels, such as fish and fish-eating birds, as they are the key linkage between phytoplankton and these higher trophic levels. In large exposed shallow lakes, wind-induced turbulence following by sediment resuspension may prevent aquatic plants to recover, while weakening the pelagic food web due to a low transfer efficiency between phytoplankton and zooplankton under the turbulent conditions. We tested whether shelter, aiming at reducing the wind effect, could (1) facilitate the shift from phytoplankton dominance to aquatic plant dominance, while (2) improving the trophic transfer efficiency between phytoplankton and zooplankton. To this end, we constructed 12 mesocosm enclosures at the Marker Wadden, an archipelago of five newly created islands in the Markermeer. The results showed that shelter facilitates the shift from phytoplankton dominance to aquatic plant dominance by inhibiting periphyton growth. At the same time, shelter favored the trophic transfer efficiency between phytoplankton and zooplankton within the mesocosms by decreasing the concentration of sediment in the water column and increasing zooplankton biomass.

shelter transfer efficiency Marker Wadden

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CHOOSING BETWEEN FLOATING CARPET AND PEA SOUP – THE EFFECTS OF EICHHORNIA REMOVAL ON PHYTOPLANKTON IN A HYPERTROPHIC LAKE



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Many hypertrophic shallow lakes are either dominated by floating plants or phytoplankton. The floating water hyacinth (Eichhornia crassipes) often covers large areas of tropical shallow lakes or reservoirs. When dominant, this species seriously affects aquatic communities, biogeochemical cycles and usability of the water body for local people. Water management aims to remove Eichhornia but the ecological consequences of this costly intervention are not well-understood. We studied growth and photosynthesis of phytoplankton before and after removal of Eichhornia in the hypertrophic Hartbeesport Dam, South Africa. We incubated phytoplankton in dialysis bags and in impermeable bottles at different depths in a cleared and a vegetated control site to separate shading and allelopathic effects of Eichhornia. Less than 1% of global radiation penetrated the Eichhornia mat. Accordingly, biomass of phytoplankton incubated at the vegetated site declined in all depths. After clearing, the depth of the euphotic zone increased from 0.2 to 1.8m. Within five days after clearing, the phytoplankton biomass increased by more than 1000% in near-surface incubations. Phytoplankton of the vegetated site was dominated by diatoms. After clearing, green algae and cyanobacteria grew fastest. Growth rates were lower in dialysis bags than in bottles at the vegetated site but not at the cleared site. The photosynthetic efficiency of phytoplankton incubated in or below Eichhornia stands was about 50% lower in dialysis bags than in bottles or after mowing, indicating allelopathic suppression of photosynthesis at low light intensities. In this way, the shading effect of Eichhornia on phytoplankton was amplified. Both shading and allelopathic effects acted only directly in or below Eichhornia stands; open sites were rapidly occupied by potentially toxic cyanobacteria. Without substantial reductions in nutrient loading, clearing just shifts the balance between the two evils.

bistability, Eichhornia, phytoplankton, allelopathy

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DYNAMICS OF TOTAL PHENOLS IN THE MACROPHYTE MYRIOPHYLLUM AQUATICUM AND THEIR ALLELOPATHIC ACTIVITY ON THE ALGA SCENEDESMUS ACUTUS



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The total phenolic compounds (TPC) released by macrophytes show seasonal variability and thus can have variable allelopathic effects on phytoplankton. Seasonal changes in the temporal dynamics of TPC substances from three different tissues (apical region, leaves and stems) of the macrophyte M. aquaticum were quantified. The exudates from the macrophyte were used to evaluate the growth response of S. acutus. For a given season, significant differences were observed among the TPC levels in the different tissues of the macrophyte: apical region had higher levels of TPC (42-140 µg g-1 DW) compared to submerged stems (4-45 µg g-1 DW). In addition, the pattern of TPC levels in the different tissues of the macrophyte also varied seasonally. The TPC in the exudates of M. aquaticum varied between 6.4-9.15 µg ml-1 during the experiment macrophyte growth. The exudates had an inhibitory effect on the algal growth. Our study shows that this invasive macrophyte may have adverse effects on the planktonic community and thus the trophic structure in lakes.

Myriophyllum aquaticum Allelopathy Total phenolic compounds Exudates Algal growth

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PLANKTIVOROUS FISH PREDATION AND FREE-FLOATING MACROPHYTES: HOW THEY INFLUENCE THE FUNCTIONAL DIVERSITY OF ZOOPLANKTON COMMUNITIES?



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The structure of the zooplankton community can be influenced by both predation and the presence of macrophytes. Fish can exert selective pressure on the community, excluding species with certain traits, but in the presence of macrophytes, the effects of predation can be altered. Thus, it is possible that the presence of macrophytes is a factor that reduces the effects of predation on the structure of the functional traits in zooplankton. This study aimed to evaluate experimentally, if the presence of free-floating macrophytes can influence the effects of predation by planktivorous fish on the functional structure of zooplankton. The experiment, which lasted 5 weeks, was carried out using mesocosms in a shallow lake, with the following treatments: control without fish and macrophytes (C), presence of fish (F), presence of fish + free-floating macrophytes (F + FFM). Fish of the species Astyanax lacustris were used as predators and free-floating Eicchornia crassipes as macrophyte. Functional diversity indexes were determined, as well as the densities of the functional groups, compared between treatments. The abundance of the different functional groups varied significantly between treatments. Low densities of the trait Daphnia filtration were associated with the presence of the fish. Functional traits as burrow, pause and jumping, benthic and herbivore-detritivore were significantly more abundant in the treatment Fish + FFM. Functional richness (FRic) was significantly higher in the Fish + FFM treatment. Data indicate that macrophytes cannot diminish the effects of predation on some functions such as herbivores, but they provide the emergence of other traits, increasing the functional richness. The traits associated with the presence of macrophytes are more related to the detritus chain, which highlights an important role for macrophytes in the functioning of the detritus chains and the cycling of organic matter in aquatic environments.

trophic interactions, Astyanax lacustris, Eichhornia crassipes, mesocosm

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PREDATORS EFFECTS ON ZOOPLANKTON IN VEGETATED PATCHES OF SHALLOW EUTROPHIC LAKES. A MESOCOSM SIMULATION

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SESSION 18

LINK TO THE STUDY VIDEO

In Pampean shallow lakes, as in almost all the Neotropics, macroinvertebrates and small fishes are abundant among macrophytes in littoral zones and could be important predators of zooplankton, reducing the refuge effect provided in diel horizontal migration. Predator-prey interactions are key in maintaining a clear water state. Management programs should consider those factors that could attempt against the objective of sustain a clear water state in a context of growing eutrophication. The aim of this work is to analyze the effect of both predators, fish and macroinvertebrates, on zooplankton in the littoral zone of shallow eutrophic lakes and its consequences on phytoplankton abundance and water turbidity. We carried out a 15 days mesocosm experiment in 12 cylindrical tanks (1000l) simulating the littoral zone, in a cross-treatment design as follows: 1) 6 nymphs of Anisoptera, 2) 2 visual zooplanktivorous (silverside, Odontesthes bonariensis), 3) 6 Anisoptera and 2 silversides, and 4) control without predators. Results show clear effects of silverside treatment on abundance and distribution of zooplankton, mainly a depletion of Cladocera abundance concentrated among the macrophyte zone. In the Anisoptera treatment, contrary to our expectation, we don't find a reduction in zooplankton abundance neither a preference for the zone without macrophytes. Water turbidity increases only in those treatments with silversides. The presence of Anisoptera alone didn't trigger a cascade trophic effect on phytoplankton and water turbidity as those given by treatments with silversides. Contrary to previous experiences with shrimps or Zygopteras, we don't find results that show a reduction in the refuge effect of macrophytes in the presence of Anisoptera. We think that macroinvertebrate predators should be considered carefully in food web studies and its consequences on shallow lakes state.

Anisoptera- Macroinvertebrates- Macrophyte refuge- Silverside

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OTHER TOPICS ON THE ECOLOGY OF SHALOW LAKES

SESSION 19

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LANDSCAPES AND FRESHWATER BIODIVERSITY CONSERVATION IN THE ANTHROPOCENE: THE CONTRIBUTION OF ARTIFICIAL WATERBODIES

SESSION 19

OERTLI Beat (University of Applied Sciences and Arts Western Switzerland); **DEMIERRE Eliane** (University of Applied Sciences and Arts Western Switzerland); **FAIT Pauline** (University of Applied Sciences and Arts Western Switzerland); **ILG Christiane** (University of Applied Sciences and Arts Western Switzerland); **WEZEL Alexander** (Department of Agroecology and Environment, ISARA); **ROBIN Joël** (Department of Agroecology and Environment, ISARA); **CALVO José F.** (Department of Zoology and Physical Anthropology, University of Murcia, Spain); **OLIVA-PATERNA Francisco J**. (Department of Zoology and Physical Anthropology, University of Murcia, Spain); **ZAMORA-MARIN Jose M.** (Department of Zoology and Physical Anthropology, University of Murcia, Spain)

LINK TO THE STUDY VIDEO

The number of artificial waterbodies, such as man-made ponds and shallow lakes, is sharply increasing in most landscapes. They are forecasted to dominate in the Anthropocene, and even to replace in number the natural waterbodies. They offer ecosystem services linked to socio-economic activities and they are rarely designed or managed for hosting the freshwater biodiversity. Nevertheless, artificial waterbodies can probably still contribute to the conservation of the regional biodiversity. To test this hypothesis, we investigated the contribution provided by artificial ponds and shallow lakes to the regional species pool, in six landscapes from Western Europe (Switzerland, Spain, France). We sampled aquatic snails, water beetles and amphibians, in 38 gravel pit ponds, 22 mountain watering ponds, 102 urban ponds, 8 alpine snowmaking reservoirs, 83 fishponds and 38 semiarid watering ponds. Our results indicate that the artificial waterbodies host in average only 50% of the regional species pool. Fishponds contribution was highest (60%) and mountain watering pond lowest (28%). There were also discrepancies among the taxonomic groups. Amphibians benefited most of the presence of artificial waterbodies while beetles and snails benefited less. This heterogeneity underlined the complementary of the different waterbodies types at the regional scale. Based on these results we forecast that future human-dominated landscapes will be particularly impoverished in freshwater biodiversity. The natural waterbodies have therefore to be preserved and well managed, and “near-natural” waterbodies have to be created. The artificial waterbodies could nevertheless contribute for supporting biodiversity at the regional scale, but their design must be improved. We evidenced also that the density of waterbodies must be large enough for conserving the regional species pool. A regional approach is also particularly relevant through a management promoting a diversification of pond types.

Small waterbodies; man-made ponds and shallow lakes; landscapes of the Anthropocene; regional species pools; freshwater biodiversity conservation; Coleoptera; Gastropoda; Amphibia

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LAND COVER IS THE MAIN CORRELATE OF PHYTOPLANKTON BETA DIVERSITY IN SUBTROPICAL COASTAL SHALLOW LAKES



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In lentic environments, beta diversity can be generated by local factors, such as limnological heterogeneity and productivity, and regional factors, such as landscape characteristics and land use and cover. We studied phytoplankton beta diversity in 25 shallow lakes in southern Brazil and tested for the effects of limnological heterogeneity, primary productivity, spatial extent, connectivity among lakes and land use and cover in determining within-lake beta diversity. We measured beta diversity using four dissimilarity coefficients (Sørensen, Bray-Curtis, modified Gower log10 and modified Gower log2) that provide a gradient of emphasis on compositional and abundance changes. We found that beta diversity differed among lakes and that its correlates were strongly dependent on the dissimilarity coefficient used. Beta diversity measured with the Sørensen and the modified Gower log10 and log2 was positively related with the percentage of land cover by wetlands (such as lakes, streams and natural or artificial channels) and negatively related with the percentage of land cover by grasslands (with or without livestock). Also, when based on the Gower log2 coefficient, beta diversity was also positively related to limnological heterogeneity. On the other hand, when using the Bray-Curtis coefficient beta diversity was not correlated to any predictor variable. We showed that phytoplankton beta diversity in shallow lakes is promoted by factors acting at multiple scales. Moreover, the positive relationship between beta diversity and surrounding wetlands indicates that the conservation of freshwater habitats in a landscape scale is essential to maintain aquatic biodiversity. Finally, we showed that the use of dissimilarity coefficients providing a gradient of emphasis on compositional and abundance changes should help us to advance on the understanding of beta diversity patterns. The results presented here were recently published (DOI: https://doi.org/10.1007/s10452-020-09790-w).

Heterogeneity; Microalgae; Productivity; Landscape; Dissimilarity measures

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LINKING MACROECOLOGICAL PATTERNS TO MICROECOLOGICAL DYNAMICS OF COMMUNITY ASSEMBLY IN METACOMMUNITIES



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LINK TO THE STUDY VIDEO

Simple multitrophic models and short-term experiments suggest that the relationship between primary producer biomass and primary consumer biomass, as well as their respective linear scaling with total phosphorus (TP) are negative. However, observed natural patterns deviate from these results, in that there are general positive correlations between phytoplankton and zooplankton biomass in lakes and ponds. In addition, both groups generally show continuous positive log-linear scaling with TP in nature. A suggested reason for this observed deviation is that simple models and short-term experiments do not consider the effects of ecological and evolutionary processes that happen over longer time scales such as the effects of colonization and extinction dynamics that qualitatively change community composition. Evidence for this hypothesis is not easy to find, because it is difficult to conduct appropriate experiments. Here we wish to place these ideas in a landscape context that can connect basic macroecological patterns (biomass scaling and diversity patterns) to microecological dynamics of community assembly in metacommunities in a continent-wide setting. To do this we combine emerging methods to evaluate the possible roles of basic community assembly processes (abiotic filtering, biotic patterning of co-distributions, dispersal and drift as estimated from joint species distribution models) on macroscopic patterns of ecosystem attributes (biomass relations in eutrophication gradients, by linking these results to a community-ecosystem framework using structural equation models).

biomass, diversity, lakes, phytoplankton, zooplankton, environment, co-distribution, spatial auto-correlation, connectivity

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CLADOCERAN CHYDORUS SPHAERICUS FEEDING ON CYANOBACTERIA IN LAKE VÕRTSJÄRV (ESTONIA)



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Small-bodied zooplankters are becoming increasingly dominant over large zooplankton species in eutrophic waters where they often coexist with cyanobacterial blooms. But still, relatively little is known about their algal diet preferences. In large shallow eutrophic Võrtsjärv (North-East Europe, Estonia) cyanobacteria (mainly filamentous) form up to 90% of phytoplankton biomass. Among metazooplankton biomass a small-bodied cladoceran species Chydorus sphaericus dominate. We studied C. sphaericus feeding and selection of phytoplankton in lake Võrtsjärv by using a combination of different methods. HPLC technique was used to determine markerpigment composition in C. sphaericus guts while highly sensitive molecular methods were used to identify more precisely the dietary composition of cyanobacteria and presence of potentially toxic strains. According to the present study C. sphaericus preffered mainly colonial (Microcystis spp.) but also filamentous cyanobacteria as a food source. Another phytoplankton groups common in Võrtsjärv, like diatoms, cryptophytes and chlorophytes, formed minority part of C. sphaericus diet.

Chydorus sphaericus; cyanobacteria; pigments; zooplankton feeding; Lake Võrtsjärv

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COMPARISON OF LARVAL PERCH FEEDING BETWEEN LITTORAL AND OPEN-WATER SITES OF THE LAKES

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LINK TO THE STUDY VIDEO

The first feeding of perch (Perca fluviatilis) larvae was studied in 4 Latvian and 4 Estonian lakes in spring, 2019. The main aim of the research was to compare larval perch feeding in littoral and open-water sites of the lakes. Larval fish samples were collected by drawning a scoopnet in littoral sites of the lakes and a bongonet in open-water sites of the lakes horizontally through the water column. Larval fish diet was estimated by a gut segmentation methodology using epifluorescence microscopy. To evaluate larval and juvenile fish prey importance, feeding homogeneity and feeding strategies at the population level we calculated from the collected fish feeding data several indices of dietary importance, e.g.: relative importance of food type percent by number (%N); - percent by weight (%W); - percent frequency of occurrence (%O); index of food items relative importance (IRI); percent index of food items relative importance (%IRI); food consumption index (Ti%); Ivlev`s selectivity index (E); and Hurlbert's standardized niche breadth index (Ba). A more detailed comparison about the feeding conditions of perch larvae in open-water and littoral sites of the lakes will be presented during the 10th International Shallow Lakes Conference in March, 2021.

perch larvae diet of fish larvae zooplankton littoral area open-water area

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EFFECT OF PREDATION BY PLANKTIVOROUS FISH AND MACROINVERTEBRATES ON THE FUNCTIONAL DIVERSITY OF ZOOPLANKTON IN SHALLOW SUBTROPICAL LAKES

SESSION 19

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LINK TO THE STUDY VIDEO

Zooplankton is one of the main communities that plays a fundamental role in structuring aquatic food webs. The regulation of the zooplankton community in the food webs is done by predation by fish and macroinvertebrates. Therefore, the study aims to assess the effect of predation by fish and macroinvertebrates on the functional diversity of the zooplankton community in shallow subtropical lakes. Samples from a previous experiment that was performed in 3 shallow lakes were used Four treatments were tested: planktivorous fish (F), macroinvertebrates (INV), both predators (F + INV), and no predator (CON). Two samples were taken, one at the beginning and at the end of the experiment (49 days). Microcrustaceans were identified, counted and classified according to functional traits. Functional diversity index were obtained and compared between treatments through ANOVA. Densities of the functional groups decreased in the treatments (F) and (F + INV). In one of the lakes there was a significant difference for some functional trades between treatments (F) and (INV) and (P + IN) and (INV). The fish proved to be predators with a strong influence on the microcrustacean community since all functional groups decreased their densities at the end of the experiment in treatments that had only the fish. Some functional attributes are more selected by the fish, such as the large size, the D-type filter, and the fast swimming. Macroinvertebrates proved not to have a strong influence on functional diversity of microcrustacean community In conclusion fish species have a strong influence on the selection of the different functional groups, while predation by macroinvertebrates does not show to have such a significant influence in comparison with fish.

Trophic interaction, selectivity, ecosystem ecology

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THE ROLES OF AQUATIC VEGETATION AND SOLAR RADIATION IN DRIVING YELLOW PERCH LARVAE DISTRIBUTION IN A SHALLOW FLUVIAL LAKE



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LINK TO THE STUDY VIDEO

Dispersal of pelagic fish larvae is deemed mainly passive in both freshwater and marine systems, but several examples suggest that active habitat selection might be determinant for their survival. Once a suitable habitat to settle is found, larvae still need to avoid threats that reduce their fitness and exacerbate mortality risks. The aim of this study was to assess yellow perch (Perca flavescens) larvae distribution along two isobaths of a shallow fluvial lake in relationship with factors potentially affecting their survival: daily variations in solar irradiance, optical properties of the water column and aquatic vegetation. More precisely, we have evaluated the importance of variations in both visible and UV light radiation, turbidity and aquatic vegetation abundance in relationship with the vertical distribution of yellow perch larvae as proxies of larvae active behavioral habitat choice. We also assessed the importance of aquatic vegetation and UV risk in driving the differences in abundance between different locations (i.e. between shallow and deep isobaths). Our results show that larvae always aggregated in the lower part of the water column (40-80cm depth) and that aquatic vegetation (but not UV risk) apparently drove their the abundance both within (i.e. on the vertical axis) and among stations. Turbidity also resulted to be a driver of larvae distribution on both the vertical and horizontal axis, being associated to higher abundances at both the shallower depth and isobath. Finally, after controlling for the other factors, variation in visible light irradiance was associated to a higher aggregation of larvae at surface layers. This study shows how aquatic vegetation, turbidity and light have the potential to drive yellow perch larvae distribution in the water column in shallow lakes, with potential consequences on their population dynamics.

Yellow perch larvae, vertical distribution, UV and PAR radiation, aquatic vegetation, turbidity, shallow fluvial lakes

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BLACK AND WHITE, DAY AND NIGHT - FISH DIURNAL MOVEMENTS IN TWO DIFFERENT AMAZONIAN LAKES

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Amazonian floodplain lakes will be severely impacted by the climate change, regarding both water levels and dissolved oxygen concentrations. In the same time these ecosystems are very important nursery areas for new-born fish. The aim of the current study was to follow the impact of changing dissolved oxygen concentrations to fish movements in different lakes and biotopes. Therefore we studied fish species composition, their relative biomass and diurnal movements in two Amazonian lakes in Brazil: Lake Janauaca (Solimões River basin, white water) and Lake Prato (Rio Negro basin, black water) during high (March 2016) and low (November 2019) water level seasons. The survey of fish in each lake was done during 24 hours by means of multisized Nordic type gillnets which were put into the lake in the evening before sunset, after sunset, before sunrise and after sunrise. Both littoral and pelagial were sampled. Concurrently fish food organisms were collected. High frequency multisensors were applied to record water temperature, oxygen content and pH after every 15 minutes. The fish abundance in different lake zones was compared with their feeding type, abundance of zooplankton and oxygen regime in case of high and low water level seasons. The relative biomass of fish was higher in white water lake and in both lakes more fish were detected during low water season. The fish diurnal movement patterns in different lake systems and in different biotopes will be discussed in more detail.

Amazonian lakes, fish, diurnal movement, dissolved oxygen

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EFFECTS OF MULTIPLE STRESSORS ON INVERTEBRATE COMMUNITIES IN SHALLOW FRESHWATER HABITATS



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Due to their special characteristics, shallow aquatic freshwater habitats provide vital ecosystem functions but are also vulnerable to multiple stressors. These stressors can have a multitude of effects on pond communities. Interactions between organisms, indirect effects and the combination of more than one stressor make predictions about how stressors affect ecosystem dynamics nearly impossible.\nIn this project we investigated the combined effect of elevated temperatures and a pulse of agricultural runoff (ARO) including biocides, copper and nitrate on pond food web dynamics. We analysed how these combined stressors influence dynamics, functional diversity and abundance of invertebrates. Artificial outdoor ponds were exposed to a gradient of ARO, either at ambient temperature or +3°C. Laboratory microcosms contained only regularly fed zooplankton, exposed to the same ARO biocides, nitrate and a 3°C temperature increase in a multifactorial design, to allow for disentangling of the effects of single and combined stressors.\nIn the mesocosms, no clear pattern could be shown for combined effects of ARO and temperature on zooplankton. Investigations in less complex and highly controlled microcosm systems showed no effects of stressors on abundance of total zooplankton but compensating positive and negative effects of biocides and nitrate on individual zooplankton groups. Similar microcosm experiments with different zooplankton communities showed very strong effects of community identity on experimental outcomes.\nIn summary, these result show that the effects of the stressors ARO and temperature on abundance and diversity of invertebrates differed in dependency of the complexity and composition of the observed community. Indirect effects resulting from stressors can mask the direct effects, hence zero net effects of stressors on bulk parameters of complex communities should not be misinterpreted as a no-effect scenario.\n

agrochemical pollution, multiple stressors, shallow lakes, zooplankton

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STRESSOR INTERACTIONS IN SHALLOW AQUATIC SYSTEMS: A MICROCOSM STUDY TO BETTER UNDERSTAND REGIME SHIFTS UNDER MULTIPLE STRESS



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Shallow lakes embedded in agricultural landscapes are threaten by a multitude of anthropogenic stressors including fertilizers, pesticides and climate-change related warming. While stressor interactions have mainly been investigated with stressors acting in the same direction, interaction patterns of stressors acting in opposite direction are less studied and might be even more complex in systems characterized by regime shifts. Further, consequences of pesticides nor combined stress for shifts between alternative stable states from macrophyte- to phytoplankton-dominated shallow lakes have been described in detail, so far. Aim of the presented study in the French-German project CLIMSHIFT was to disentangle stressor interaction patterns of potentially opposed acting stressors along a stressor gradient, on shallow aquatic systems potentially occurring in two alternative stable states. We performed microcosm studies using three macrophyte species, phytoplankton and periphyton. We used a factorial dose-response design of stressors, frequently observed in agricultural systems: nitrate, copper and a herbicide. We tested them individually and in a pesticide mixture, at six concentrations at 22°C and 26°C. After 4 weeks of exposure effect sizes were calculated from individual and combined treatments from biomass of autotrophic communities and compared to predicted additive effects: nitrate and the herbicide treatments showed opposite effects for macrophyte dry weight but mainly a negative synergistic effect in mixture. However, interaction patterns showed a dose dependency. A decrease in macrophytes indicated a system shift and indirect effects from elevated plankton growth. This effect was even more pronounced at higher temperatures. The study illustrates the complexity of stressor interactions but also the need to understand multiple stressor effects when aiming to preserve shallow systems in stable conditions or prioritize stressor mitigation processes in future.

multiple stress, global change, regime shifts, alternative stable states, lake conservation

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IN-SITU MESOCOSMS EXPERIMENT FOR INVESTIGATING IMPACTS OF MICROPLASTICS ON LITTORAL FOOD WEB



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Microplastics (MPs) are ubiquitous pollutants found in marine, freshwater and terrestrial ecosystems, and MP pollution is a major environmental concern globally. Despite this, the impact of MPs on freshwater ecosystems is largely neglected, with most research concentrating on marine systems and organisms. Owing to their small and wide range of size classes, and high abundance, MPs are potentially available for a broad range of aquatic species. However, to date, no in situ mesocosm experiment has been carried out to investigate the impact of MPs on freshwater lake ecosystems. Here, we carried out a large scale in-situ mesocosms experiment out to study the impacts of MPs on the littoral food web exposing water surface and column, and sediment in mesocosms simultaneously to the cocktail of microplastic polymers. Treatments included environmentally relevant concentration, 10 X higher concentrations in all of its compartment, and control. Each treatment included four replicates and the experiment lasted for two months. Mesocosms were inoculated with phytoplankton, zooplankton, macro-invertebrates (dragonflies, mayflies and non-biting midges). According to the results, zooplankton groups, odonate and chironomid larvae ingested MPs. However, there were no significant effects on total zooplankton biomass directly arising from MP ingestion. No robust evidence was found supporting the trophic transfer of MPs from primary consumers to secondary consumers. Besides, ingestion of water column MPs did not affect emergence patterns of odonates. Conversely, emergence patterns of sediment-dwelling organisms were significantly affected by MP presence. Finally, we found very limited evidence for MP transfer to terrestrial ecosystems by emerging aquatic insects.

Microplastic, shallow lakes, food web, trophic transfer

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FUTURE THREATS TO SHALLOW LAKES AND FRESHWATER SYSTEMS: NANOMATERIALS AS A NOVEL ENVIRONMENTAL STRESSOR

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SESSION 19

LINK TO THE STUDY VIDEO

Nanomaterials and nanoparticles (NPs) are, due to their small size and large surface area, of great commercial interest. However, coupled to an increased use are the concerns related to the potential release of the materials into nature, and especially the aquatic environment. NPs can also be produced during the break-down processes of larger pieces of a material, e.g. the production of plastic NPs during plastic break-down. Several laboratory studies have shown negative effects of NPs on freshwater algae, zooplankton and fish. Although these studies are important for our understanding, there is a need to expand our knowledge by assessing environmental effects and fate of NPs in more natural ecosystems. When entering an ecosystem, NPs will undergo transport and transformation processes, that could affect their fate and hazard potential. We aim to evaluate the fate and effects of different NPs at population, community and ecosystem level, using constructed artificial wetlands. We here present the first results of the distribution of plastic NPs in two constructed artificial wetlands. To be able to track the particles in the system, we used plastic NPs labelled with a gold core that could be quantified using inductively coupled plasma mass spectrometry (ICP-MS). The outlet water from the wetlands was collected daily during 56 days. At the end of the experiment, we also collected organisms, sediment and macrophytes from each wetland to quantify NPs distribution within the system. The results showed that some NPs moved through the wetland and came out in the outlet water. Moreover, we found that NPs were retained in the sediments and organisms. Overall, the distribution could be explained by the internal hydrodynamics. Future studies, using several replicated wetlands, will be performed to evaluate the fate and effects of different NPs on those systems, with the aim to address if nanomaterials will become a major environmental threat to our future freshwater ecosystems.

Nanoparticles Artificial-wetlands Mesocosms Nanomaterials Future-threats

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EFFECTS OF TEMPORARY STRATIFICATION ON NUTRIENT CYCLING BETWEEN SEDIMENT AND WATER IN A EUTROPHIC LAKE

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SESSION 19

Many shallow lakes may stratify temporarily for shorter or longer periods during summer depending on their morphological characteristics and climatic variations. In Denmark, about half of all lakes are estimated to have a depth where they may stratify temporarily. This temporary stratification may have a number of important effects including those on the nutrient cycling between sediment and water at changing redox conditions at the sediment water interface. In this study, we will use frequent measurements and sampling during summer in 12 ha Lake Ormstrup, Denmark. Lake Ormstrup has a maximum depth of only 5 m and a mean depth of 2.3 m but stratified temporarily several times during the summer of 2020. The lake is eutrophic with very high phosphorus and chlorophyll a concentrations, low Secchi disk depth and an almost complete absence of submerged macrophytes. During the summer's short-term stratification events, oxygen was depleted at depths below 2-3 m, from almost complete oxygen saturation to complete anoxic conditions within a few days. This had a significant impact on the recycling of nutrients between the sediment and water, and large pools of phosphate were created in anoxic waters, sometimes up to 1 mg/l. During mixing, this pool was released to the surface water. We will also show data from a large number of Danish lakes to illustrate the frequency of these temporary stratification events in relatively shallow lakes. These temporarily stratifying lakes may represent a common lake type where the cycling of nutrients between sediment and water is accelerated during summer due to short term stratification events, enabling build-up of a large biomass of phytoplankton

Temporary stratification, sediment, nutrient release, phosphorus, nitrogen, oxygen, temperature

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SEDIMENT PHOSPHORUS FRACTIONATION AND SEDIMENT-WATER P FLUX IN A TROPICAL SHALLOW LAKE

SESSION 19

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LINK TO THE STUDY VIDEO

The aim of the present study is to evaluate the potential phosphorus (P) release from the sediment to the water column of a tropical shallow lake in the northeast of Brazil, based on the sediment P fractions and the flux of P between water and sediment. To do so, we employed a sequential extraction method to analyse the different P fractions of the sediment of Lake Extremoz. We also carried out a 40-day microcosm experiment to analyse the flux of P between the water and the sediment of said lake. The experiment was set up by flooding 200g of sediment from the lake with 800 mL of 1.2 µm filtered lake water in 1 L beakers. Every 5, days we analysed: soluble reactive phosphorus (SRP), total phosphorus (TP), organic phosphorus (Org-P), dissolved oxygen (DO), temperature, and pH of the water. The largest fraction of P in the sediment of Lake Extremoz is Refractory-P, which is non-mobile. The main mobile fraction of this lake's sediment is composed of P bound to Fe and Mn oxides (BD-P) which is redox sensitive. During the P flux experiment, the water was always oxic and with nearly neutral pH. The temperature of the water increased by almost 4 °C due to the increase of the atmospheric temperature. SRP, TP and Org-P concentrations in the water had a general decrease in the first 20 days. But, on the second half of the experiment, those concentrations increased and the fluxes of P from sediment to water, mainly Org-P, were positive. Even with this increase in concentrations, which indicates a period of P release, overall fluxes were negative. The main mobile fraction of the sediment is redox sensitive, therefore it has the potential to be released in case of oxygen depletion. Under current conditions, most of the P released by the sediment is in organic forms, indicating that, in the presence of oxygen, the balance of P between water and sediment is controlled by the effects of organisms on P as well as temperature.

Internal Loading Oxic Mobile Phosphorus Lake Extremoz

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GREENHOUSE GASSES FROM SUBTROPICAL SHALLOW LAKES: SUBMERGED MACROPHYTES VERSUS PHYTOPLANKTON OR LOW PRIMARY PRODUCTION

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SESSION 19

LINK TO THE STUDY VIDEO

Fluxes of carbon dioxide (CO2) and methane (CH4) in shallow lakes depend on their dominant primary producer and the associated trophic structure. In temperate regions, the higher primary production by submerged macrophytes (SM) may promote lower emissions than in phytoplankton (PHY) dominated lakes, or even CO2 fixation. Likewise, SM promote sediment and water column oxygenation, hampering CH4 emissions. Less is known about the subtropics, where SM typically host high densities of fish and invertebrates. Higher ecosystem respiration rates would thus be expected than in PHY dominated systems. In turn, macrophytes are poorly consumed by aquatic herbivores and the higher their biomass, the higher the decomposition of organic matter and the substrate for CH4 production. Here, we evaluated CO2 diffusion and CH4 diffusion and ebullition in three shallow lakes from Uruguay, with contrasting conditions. Blanca Lake (BL), dominated by SM, was sampled during winter, spring and summer. Capilla Lake (CL), dominated by PHY, and Muddy Lake (ML), turbid but with extremely low primary production, were sampled in summer. Fluxes were estimated from 5 random sites at pelagic and littoral zones in each lake. For BL, no significant differences were found in CO2 fluxes among seasons, acting mostly as a CO2 sink except for the littoral zone during winter and summer. The littoral zone of BL at summer also showed the highest CH4 ebullition among seasons. In contrast, those emissions were similar to ebullition in the pelagic zone of CL. The lowest CH4 ebullition occurred in the pelagic zone of ML. CH4 diffusion was extremely low for all lakes and seasons. In summer, the highest fluxes in CO2 equivalents (CO2 + 34*CH4 fluxes) occurred at the littoral zone of BL. Dominant primary producer acted as a key factor for carbon fluxes in our lakes, by the time respiration and decomposition seemed to be relevant processes increasing net emissions at subtropical systems dominated by SM.

carbon dioxide, methane, dominant primary producer

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PHAGOTROPHY BY CRYPTOPHYTE AND CHRYSOPHYTE ACROSS NUTRIENTS AND LIGHT GRADIENTS USING DIFFERENT MEASUREMENTS TECHNIQUES

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SESSION 19

LINK TO THE STUDY VIDEO

Mixotrophy is a relevant process for carbon flux and ecosystem functioning. Limiting resources for photosynthesis drives mixotrophs success across environments. This study aimed to evaluate how inorganic nutrients and light, affect phytoflagellates mixotrophy, estimating grazing rates by evaluating beads consumption using epifluorescence microscopy and flow cytometry. Moreover, we tested if a lysosome probe (LysoTracker) can be used to differentiate autotrophic vs mixotrophic metabolisms, based on the assumption that different resources conditions induce phagotrophy. We performed two experiments to estimate phagotrophy by cryptophyte and chrysophyte, using fluorescent-labeled preys and LysoTracker, across three levels of nutrients and light combined. Cryptophytes had higher grazing rates in high-nutrients treatments using both techniques. In contrast, chrysophytes had lower grazing rates in high-light treatments only with flow cytometry. We also found that LysoTracker increased fluorescence for mixotrophic species five times for chrysophytes and two times for cryptophytes. However, there were no significant differences between treatments. Our laboratory experiments demonstrated that (1) nutrients is the main limiting resource that induces phagotrophy for the cryptophyte and light for the chrysophyte; (2) flow cytometry was more sensitive in quantifying grazing rates and (3) LysoTracker can be used as a qualitative method, however cannot be used to quantify phagotrophic activity.

Mixotrophy, Flow cytometry, LysoTracker, Grazing, Nutrients, Light

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DISENTANGLING THE ROLE OF POTENTIAL CONTROL FACTORS OF PHYTOPLANKTON PRODUCTIVITY IN SUBTROPICAL DYSTROPHIC SHALLOW LAKE (LAGUNA DEL CISNE, URUGUAY)



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LINK TO THE STUDY VIDEO

The ecology of sub-tropical dystrophic shallow lakes is of particular interest as most of the research has been carried out in boreal lakes. Alterations to these systems, mainly promoted by anthropogenic causes, are threatening its structure and function. In this study, we analyzed the influence of in-lake and catchment scale processes on ecosystem functioning of Laguna del Cisne (-34,75°; -55,84°), a dystrophic lake which provides potable water to approximately 100.000 inhabitants during the summer season. Using data from bibliographic search, field monitoring and laboratory experiment, we aimed to identify and understand the influence of the main factors that control the phytoplankton productivity, such as light limitation, colored dissolved organic matter (CDOM) and nutrient availability. Results showed that the P concentration of this lake has multiplied by 7 in 25 years, reaching a maximum value of 700 ?g P.L-1 during 2012 spring. However, there is a discrepancy between the phytoplankton productivity expected and expressed, as blooms have not been reported for this lake, even though the dissolved fraction of P is almost entirely available (?90%). Experiments carried out in the lab consisted of microcosms (treatments=8; replicas=5) set on a climatic chamber (24°C). Each treatment followed a factorial design of 3 factors: light (L), nutrients (N) and water, with 2 levels (+/- for L and N; Cs and D for water coming from the studied lake and dechlorinated, respectively). Results showed that light availability played a major role in determining phytoplankton productivity, as L+D treatments presented differences in chlorophyll productivity with respect to the rest of the treatments. This means that the effect of CDOM by decreasing water transparency is the most important factor that prevent phytoplankton blooms. Due to the characteristics of this ecosystem, this research represents an important landmark in the study of dystrophic lakes in the subtropical region.

sub-tropical dystrophy CDOM phytoplankton productivity

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DIVERSITY OF TESTATE AMOEBAE ASSOCIATED TO DIFFERENT AQUATIC ENVIRONMENTS: FIRST ECOLOGICAL STUDY AND FIRST STEP TO FUTURE RESEARCH AS BIOINDICATORS IN THE IBERA SYSTEM

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SESSION 19

The Ibera is one of the biggest subtropical wetlands in South America. It is a complex system that includes terrestrial environment and aquatic lentic and lotic environments, so it constitutes an important reservoir of biodiversity. Although it has been studied from different perspectives, there are no tools yet that allow a quick monitoring of the changes that natural environments have undergone due to anthropogenic influence. Therefore, testate amoebae are interesting organisms to be used as environmental and paleoecological indicators to aquatic monitoring due to their rapid response to stressful environmental changes. This study evaluated the composition and abundance of testate amoebae communities among different sites in the Ibera (anthropized and non-anthropized environments; associated and macrophyte-free zones), during warm and cold seasons. Biological samples were taken with a 20 um plankton net to be performed in vivo analysis, while water samples were taken for physical-chemical analysis. Data was analyzed using parametric and non-parametric tests, diversity and similarity indices. A total of 14 species were found at the study area. Significant differences were observed in species richness between anthropized and non-anthropized environments (p=0.04), as well as in species abundance (p= 0.03). There were no differences in species richness (p= 0.09) between associated and macrophytes-free zones, but there were differences in abundance (p= 4,49E-04), with a predominance of species in areas associated to macrophytes. There were no significant differences in the abundance of species during the warm and cold seasons (p= 0.12), but there were differences in their species richness (p= 0.04). The study of testate amoebae communities is a key step to use them as bioindicators on water bodies. Furthermore, this study confirms for first time the presence of the 14 species of testate amoebae in the Ibera System.

Testate amoebae Bioindicators Ibera

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DISTRIBUTION OF HABITAT-SPECIFIC ROTIFER SPECIES (ROTIFERA) FROM SHALLOW LAKES IN MEXICO

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SESSION 19

LINK TO THE STUDY VIDEO

Mexico has a large number of natural and artificial shallow water bodies, which vary in depth, trophic status, and physical and chemical properties. Rotifers as trophic link in aquatic ecosystems are also uselful as bioindicators of water quality. Though zooplankton collections for the Mexican rotifer species are available for different waterbodies, efforts to present the data on the basis of their distribution in the pelagic, the littoral and benthic regions are rare. The present work aims to analyze the macroecological features that determine the rotifer diversity in Mexico using nestedness analysis (mean matrix temperature). Further we attempt to characterize if there is a random distribution (high entropy) or if there is a structure (low entropy) between the species richness and the habitats from which different rotifer taxa have been reported. Our review showed that approximately 400 species of rotifers have been reported in more than 100 collection sites from different waterbodies in Mexico. This species richness represents 72 genera in 25 families. The genera Lecane, Trichocerca, Brachionus and Cephalodella have the highest species diversity (64, 30, 26 and 24, respectively). Of the two main functional groups, the microphages exceed the raptorials (58 and 42% of genera and 62 and 38% of species, respectively). The nestedness analysis shows T = <10° indicating that the species richness is not distributed randomly in the Mexican territory but is structured on large scales characterizing species as being litoral or pelagic or dependent on the trophic state of the waterbody. The role of seasonal collections and habitats from where rotifers are collected is discussed for enhancing our knowledge on the ecology and distribution of rotifers in Mexico

Rotifera macroecology bioindicators distribution

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HOW TO ENHANCE THE VISIBILITY OF ONE'S PUBLICATIONS

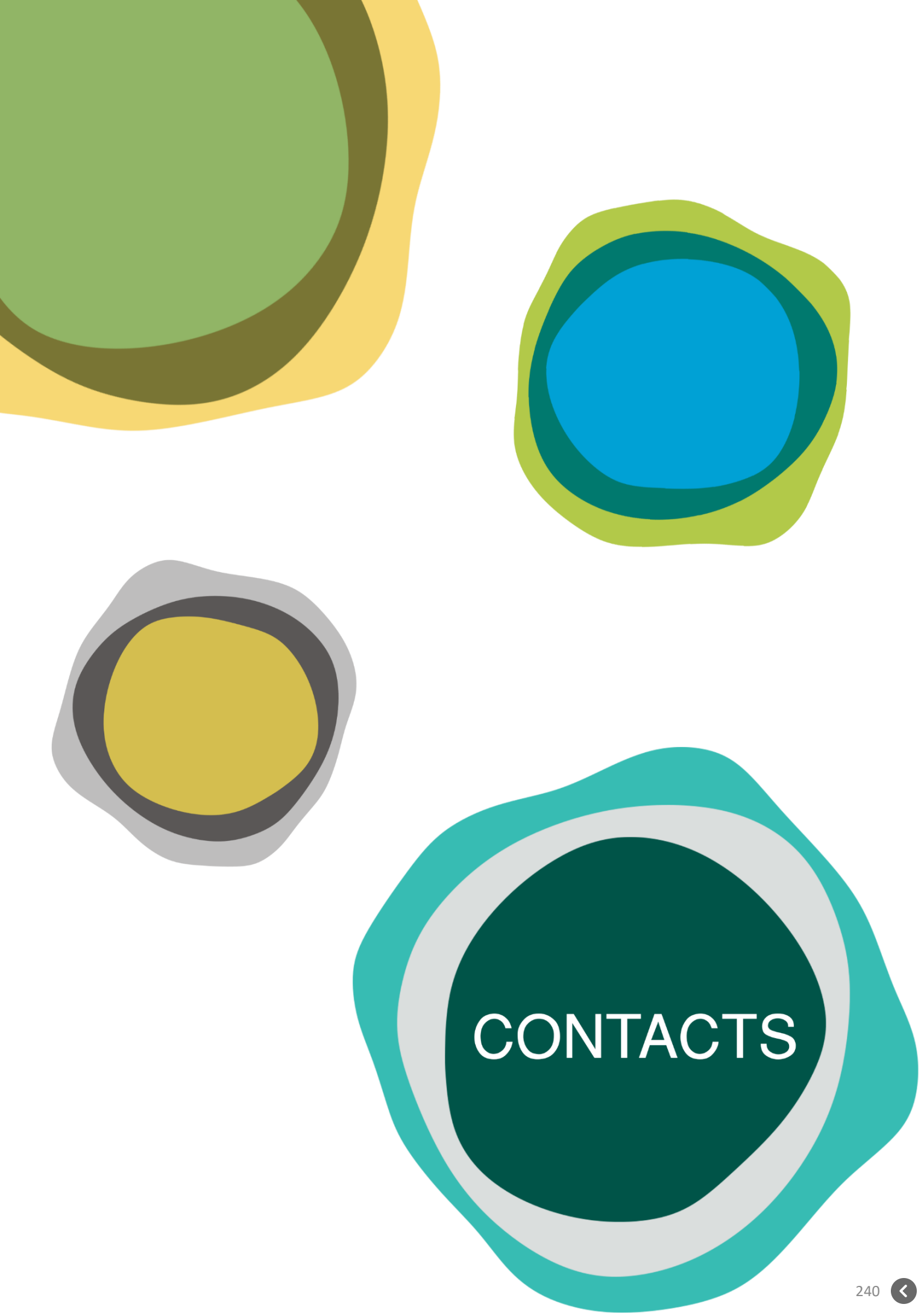


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With an increase in the number of journals, articles and authors, researchers, have a wide choice of where to publish and whom to cite. However, the selection still centers on the visibility of one's own contributions. Reviewers and journal editors are also equally concerned with type of citations present in the submitted manuscripts. Therefore, the visibility of a given author's works occupies a central role in these decisions. Young researchers usually devote a substantial part of their time for publishing but rarely look into the different possibilities to enhance the visibility of their own contributions. Delayed recognition of works of an author damages his/her own prestige in the academic world, while total absence of recognition is a loss to the reservoir of knowledge. In this presentation, various possibilities that are freely available in the web and ways to approach each of them without spending a lot of research time are suggested. The recommendations also include means to avoid doubtful websites or those that demand financial commitment from the young researchers for offering visibility of their work.

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