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A brief synopsis of phycological studies in Uruguay



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## CINTILLO LEGAL

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No hay fronteras ni tiempos para las algas. Nuestras aproximaciones a las regiones, espacios geográficos y distribución donde viven las algas son en una escala que está muy alejada de la que es aplicable a su vida y más si estas son microscópicas. Los factores ambientales que reconocemos como importantes en la vida de las algas son tan distantes en su escala como las que tenemos con los planetas o estrellas cercanas. Las escalas temporales y espaciales en las algas son en el ámbito de nanosegundos a meses y de micrómetros a metros y los comparamos con nuestras escalas de días o semanas a años o más y de metros a kilómetros cuadrados. Entender a otros (incluyendo a los organismos no humanos) empieza por “ponerse en los zapatos” de ellos. De otra forma, aplicamos nuestras propias limitaciones a la explicación que damos a nuestro entorno. Una práctica científica cada vez más difundida es la interdisciplina, con la confluencia de visiones distintas sobre un mismo objeto de estudio, el límite entre esta práctica y las aproximaciones polifásicas, polifacéticas o de taxonomía integral es difuso y puede crear la confusión de una continuidad entre las visiones concurrentes en un texto. Sin embargo, esta visión de unidad no es la única en la manera como nos ponemos los zapatos de los otros, también existe una visión particular a cada disciplina, producto de la historia y las prácticas cotidianas de ellas. Es común la expresión sobre las diferencias de opinión sobre un concepto entre zoólogos y botánicos (el de especie, por ejemplo) y esas diferencias son más drásticas cuando son entre practicantes de disciplinas diferentes, un biólogo molecular no evalúa de la misma manera los datos que obtiene un biólogo de campo, por ejemplo. Esa evaluación diferencial tenemos que explotarla y aprender a entendernos, como si se trataran de dos idiomas distintos, a traducirnos y a crear equivalencias conceptuales que sean puentes entre las disciplinas. O al menos entender que lo que nuestro colega dice es válido para su disciplina, pero no para la nuestra. Construir o reconstruir nuestra disciplina (la ficología) empieza por repensar nuestros conceptos, por ejemplo: ¿son los factores ambientales como el pH, la temperatura del agua o la concentración de nutrientes los mismo que conceptualmente utilizan los limnólogos o

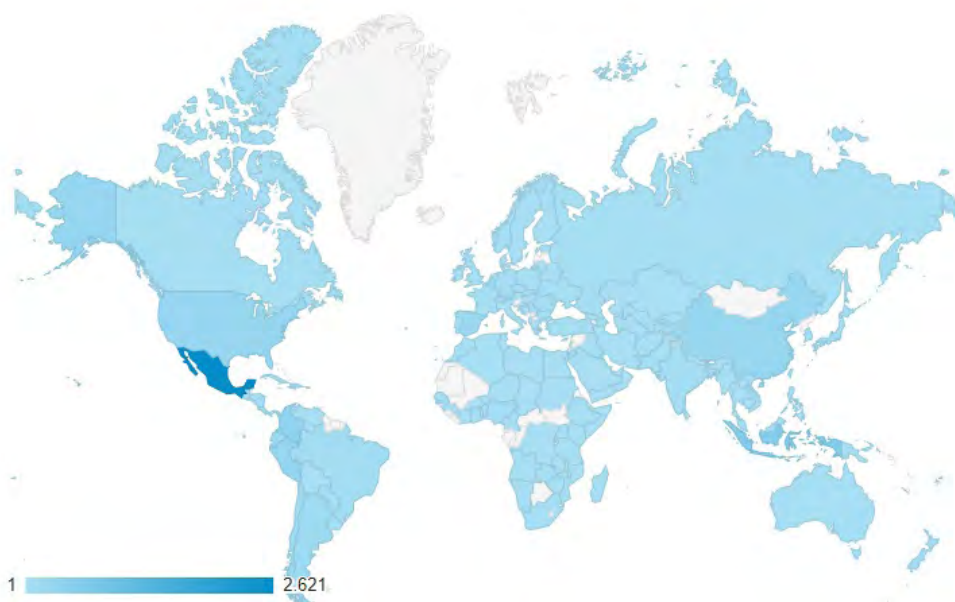


los oceanólogos? Aunque utilicemos los mismos dispositivos para obtenerlos, no tienen el mismo valor para las algas que para los cuerpos de agua como un todo. El espacio y el tiempo de cada célula, colonia, crecimiento masivo o pradera algal es diferente para el cuerpo de agua y por tanto su "impacto" es diferente. Pensar desde las algas nos permitirá entenderlas mejor, tanto en sus grandes poblaciones como en sus respuestas genéticas particulares.

En el inicio de este volumen presentamos una aportación que muestra la ausencia de fronteras en el estudio de las algas, agradecemos a la Dra. Sylvia Bonilla su colaboración sobre la historia de la ficología en Uruguay y la semblanza y merecido homenaje a la Dra. María del Carmen Pérez. También se incluye otra contribución en la Sección de Nomenclatura relacionada con el uso de las categorías infraespecíficas. Una tercera contribución

importante es la reseña por el Dr. Daniel León del libro Guía morfo-anatómica para la determinación taxonómica de la familia Dictyotaceae de la Dra. Alejandrina Ávila y colaboradores, un texto que será de gran ayuda a los estudiosos de las algas marinas del Golfo de México y el Caribe mexicano. Por último, incluimos los resúmenes de tesis que muestran el impulso de los jóvenes en el desarrollo de la ficología.

Nuestro optimismo nos mantiene al ver que el número de lectores sigue aumentando y el número de países que nos visitan son cada día más: tuvimos 529 lectores en 2018, 609 en 2019, 826 en 2020, 1617 en 2021 y ¡2621 en todo 2022! Los diez países que más nos visitaron fueron: México, Indonesia, Colombia, Estados Unidos, Perú, China, España, Ecuador, Argentina y Chile. Datos de Google Analytics.



# A brief synopsis of phycological studies in Uruguay<sup>1</sup>

## Una sinopsis breve de los estudios ficológicos en Uruguay

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<sup>1</sup> In memory of the Uruguayan taxonomist María del Carmen Pérez (1959-2022).

<sup>1</sup> En memoria de la taxónoma uruguaya María del Carmen Pérez (1959-2022).

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### ABSTRACT

In this article, I summarize the development of the phycology in Uruguay since the beginning of the 19<sup>th</sup> Century. Uruguayan phycological research has been dominated by ecological, eco-physiological and taxonomical studies of freshwater phytoplankton, influenced by the development of limnology, with few studies completed on marine macroalgae. Other areas such as biotechnology, evolution and the biology of algae and cyanobacteria are still largely unexplored. I pay homage to María del Carmen Pérez (1959-2022), who was the most important Uruguayan phytoplankton taxonomist ever, and a kind, enthusiastic and hard-working person with a distinctive passion for phytoplankton taxonomy.

*Keywords:* blooms, history, macroalgae, phytoplankton, taxonomy.

### RESUMEN

En este artículo realizo un repaso del desarrollo de la ficología en Uruguay desde comienzos del siglo 19. La investigación en ficología en Uruguay ha estado centrada en la ecología, la ecofisiología y la taxonomía de fitoplancton de agua dulce, influido por el desarrollo de la limnología. Existen muy pocos trabajos referidos a macroalgas. Otras áreas como la biotecnología, la evolución y la biología de las algas y cianobacterias, permanecen mayormente inexploradas. Rindo homenaje a María del Carmen

Pérez (1959–2022), quien fuera la taxónoma de fitoplancton más relevante de Uruguay, una persona amigable, entusiasta y trabajadora incansable, con una gran pasión por el fitoplancton.

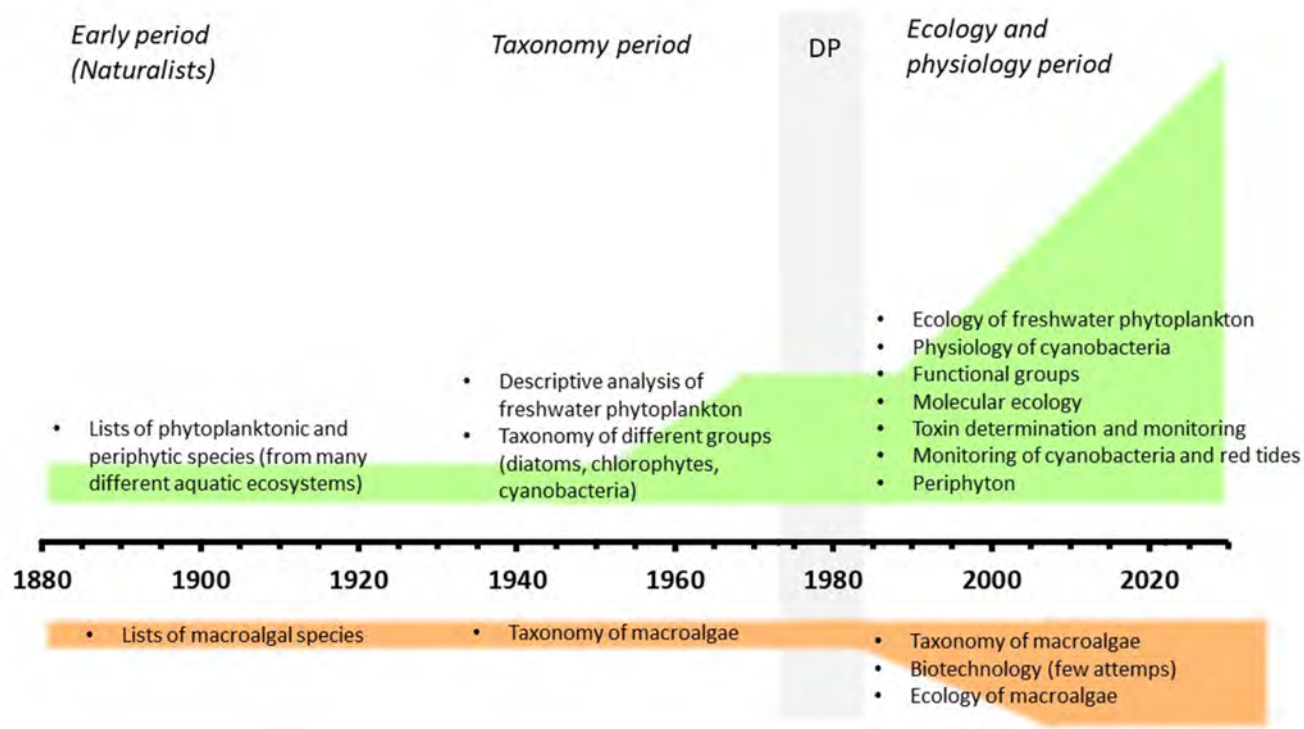
*Palabras clave:* fitoplancton, floraciones, historia, macroalgas, taxonomía.

Located at the southern limit of the subtropical climate zone, Uruguay is one of the smallest and least populated countries in South America (between 30° and 35° S, and 53° and 58° W). The small territory (176,200 km<sup>2</sup>) is crossed by a rich freshwater network of rivers, streams, and shallow lakes. Uruguay's coastline on the Río de la Plata estuary and the Atlantic Ocean extends for more than 600 km. Despite the numerous aquatic ecosystems, its phycological history is relatively brief and encompasses the development of other biological and environmental disciplines. In this work I refer to phycology in its broadest sense, including the taxonomy, biology, physiology or ecology of macro and microalgae (as well as cyanobacteria).

The first algal studies were carried out in the 19<sup>th</sup> century by naturalists that listed species of algae found in freshwaters and marine coasts. José Arechavaleta (1838–1912) was an active scientist and promoter of the natural sciences and was probably the first systematist collecting and identifying flora (plants and algae) in the country (Arechavaleta 1883, 1884). Flo-

rentino Felippone (1852-1939) was another notably prolific and curious naturalist; he was responsible for the first samples identified from the country, having developed a list of 22 species of green and red algae including a new species that was named after him (*Callithamnion felipponei* Howe 1931). Around that time, the cyanobacterium *Spirulina jenniferi* (Gomont) Geitler was first described from samples collected in a pond near Montevideo (Gomont 1892). Taxonomic studies, or species lists, were reported in the early 20<sup>th</sup> Century, mostly with reference to freshwater and marine diatoms and green algae (Allen & Herter 1934; Carbonell & Pascual 1925; Frenguelli 1933a, b; Muller-Melchers 1953; Santibañez 1939). The country's public university, the Universidad de la República, was created in 1849 with few program options. Later, in 1945, the Facultad de Humanidades y Ciencias (Faculty of human and sciences studies) was incorporated and it boosted the development of natural sciences, although areas such as botany, limnology and phycology were virtually absent. The main areas of phycological research developed

in Uruguay followed the main trends of research carried out in Latin America. The study of the taxonomy of microalgae and cyanobacteria have a long tradition in Latin America, strongly influenced by the European schools and focused on descriptive studies or the compilation of species lists (Irfanullah 2006). In the first half of the 20<sup>th</sup> Century, Uruguay was part of that trend, although with a slower development in comparison with their neighbors (Argentina and Brazil). Until late 1980s, most publications from Uruguayan waterbodies were species lists, mainly of microalgae and cyanobacteria (Coll 1979) (Fig. 1). The development of limnology in Latin America, initially centered in the study of lakes and communities, was also influenced by the European schools (Elster 1974; Tundisi & Matsumura-Tundisi 2011). Freshwater phytoplankton ecology studies increased after ~1930 in Brazil and somewhat later in other countries (~1950s in Colombia and Argentina, ~1960 in Ecuador, and ~1984 in Uruguay) (de Buen 1950; Conde & Sommaruga 1999; López & Mariazzi 1994; Roldán 2020; Steinitz-Kannan *et al.* 2020).



**Fig. 1:** Trends in phycological studies along the history in Uruguay. There are three large periods, Early, Taxonomy and Ecology. DP: Dictatorial period (1973-1984) indicated with a grey bar. Green shaded areas: microalgae and cyanobacteria, orange shaded areas: macroalgae. The size of the areas indicates the relative development of the different research lines in phycological studies.

The Uruguayan military dictatorship (1973–1984) had a strong impact on slowing scientific research, dismantling existing research groups and leaving the country in great academic isolation (Markarian 2015). The creation of the Limnology Division at the Universidad de la República in 1984, coupled with the increased awareness of environmental issues and the appreciation of water as a resource, favored the development of limnological studies, including phytoplankton (Conde & Sommaruga 1999) (Fig. 1). Cyanobacterial toxic blooms in freshwaters of the country have been increasing for decades in response to eutrophication, affecting the major watersheds and restricting the use of the water (Aubriot *et al.* 2020; Bonilla *et al.* 2015; Conde *et al.* 2002; De León & Yunes 2001; Goyenola *et al.* 2021). This phenomenon had gained great attention in limnological research, particularly after the 1990s. Studies related with microalgae and cyanobacteria in freshwaters included taxonomy and ecology (i.e.: Bonilla 2009; Bonilla *et al.* 2005, 2006; De León & Chalar 2003; Ferrari 2020; González-Madina *et al.* 2017; Haakonsson *et al.* 2017; Kruk *et al.* 2009; Pacheco *et al.* 2021), ecology with emphasis in functional groups (i.e.: Kruk *et al.* 2002; Pacheco *et al.* 2010; Segura *et al.* 2013), ecophysiology of cyanobacteria (i.e.: Aguilera *et al.* 2017, 2019; Amaral *et al.* 2014; Aubriot 2019; Aubriot & Bonilla 2018; Aubriot *et al.* 2011; Beamud *et al.* 2016; Bonilla 2012; Fabre *et al.* 2017), molecular studies of cyanobacteria (i.e.: Beamud *et al.* 2016; Martínez de la Escalera *et al.* 2017, 2019; Piccini *et al.* 2011; Rigamonti *et al.* 2019; Vico *et al.* 2016) and phylogenetic studies of cyanobacteria (Vico *et al.* 2020). Despite the vast network of rivers and the presence of shallow lakes, favorable environments for the periphyton, studies on the taxonomy and structure of the periphyton are still scarce (Bonilla 1997; Pacheco 2016). A special mention deserves María del Carmen Pérez, the most prominent Uruguayan taxonomist, to whom I pay homage in the next section.

The first study of coastal marine phytoplankton was carried out by an expedition during the early 1930s (Hentschel 1932, in Ferrari & Vidal 2006). Early studies about the ecology of coastal phytoplankton described the distribution of species in relation to main environmental factors (Bayssé *et al.* 1986, 1989; Ferrando 1962). In February 1980, a massive red tide resulted in an event of acute human neurotoxin intoxication due to the consumption of contaminated mussels (Galasso *et al.* 1980). This event triggered the implementation of the national red tide monitoring program, including the determination of dinoflagellate species

and toxin detection (Méndez 2006). Red tides have been increasing in magnitude and duration during the last several decades along the marine coasts of the country, where toxic *Dinophysis cf. acuminata* Claparède & Lachmann is becoming more frequent, probably associated to eutrophication and climate change effects (Martínez *et al.* 2017). Most of the common phytoplankton blooms along the coast of the country are of cyanobacteria (*Microcystis aeruginosa* (Kützing) Kützing complex and *Dolichospermum* spp.), dinoflagellates (*Ceratium hirundinella* (O.F. Müller) Dujardin, and the marine *Alexandrium tamarense* (Lebour) Balech and *Gymnodinium catenatum* Graham) and diatoms (*Aulacoseira* sp., *Skeletonema costatum* (Greville) Cleve, *Leptocylindrus* spp., *Chaetoceros* spp., *Rhizosolenia* spp., among others) (Bonilla 2009; Ferrari & Méndez 2000; Ferrari & Vidal 2006; Haakonsson *et al.* 2017; Kruk *et al.* 2019; Martínez *et al.* 2017; Méndez 2006; Pacheco *et al.* 2021). Research about the physiology of benthic cyanobacteria growing in rice fields (Irisarri *et al.* 2001, 2007; Pérez *et al.* 2012, 2020) is probably the only research line related with biotechnology. A few other studies were focused on the lipidic content of microalgae (Pagano 1993; Pagano *et al.* 1998).

Macroalgae have been largely overlooked or neglected in scientific studies in Uruguay, and the knowledge of the macroalgal flora is still limited (Coll & Oliveira 1999) (Fig. 1). Most of the 670 km of Uruguayan coastline is sandy, with few rocky habitats for marine macroalgae. The large influence of the estuary Río de la Plata, one of the largest in the world, implies a highly dynamic environment with frequent and large changes in turbidity and salinity, limiting the number of algal species that tolerate those conditions. In a survey conducted by the phycologist Javier Coll, compiling information along the Uruguayan coast, macroalgal species were mainly characteristic of subtropical or warm temperate regions (45% and 38% of the total, respectively) or were cosmopolitan. Coll listed 53 species of red algae (where the most frequent and common species were *Cryptopleura ramosa* (Hudson) Newton, *Chondria atropurpurea* Harvey, *Corallina officinalis* Linnaeus, *Gymnogongrus griffithsiae* (Turner) Martius, *Hypnea musciformis* (Wulfen) Lamouroux and *Jania rubens* (Linnaeus) Lamouroux) and 26 species of green algae (from the genera *Bryopsis*, *Chaetomorpha*, *Cladophora*, *Codium*, *Enteromorpha*, *Ulva* and *Rhizoclonium*) (Coll & Oliveira 1999). The brackish conditions that dominated large areas of the coastline were pointed out as the main factor for the presence of only 8 species



of brown algae, where *Scytosiphon lomentaria* (Lyngbye) Link was the most frequent and abundant (Coll & Oliveira 1999). Higher temperatures during summer play a role in explaining an increase in the richness and biomass of subtropical species on rocky marine shores (González-Etchebehere *et al.* 2017). A recent study that focused on the ecology of macroalgae proposed morpho-functional groups as an innovative approach to study these organisms (Vélez-Rubio, *et al.*, 2021). There are only few attempts evaluating biotechnological uses of agar-producing marine macroalgae (Porzekanski *et al.* 1965).

### MARÍA DEL CARMEN PÉREZ (1959–2022)

María del Carmen Pérez was an enthusiastic and highly dedicated phytoplankton taxonomist. Starting as an autodidact, she quickly became in an expert, and developed into the best and most experienced taxonomist in Uruguay ever. Being a pioneer, she started working on taxonomy of phytoplankton with no guidance and few resources, motivated only by her interest and passion. María del Carmen started her bachelor's degree in biology in 1984 at the Universidad de la República in Montevideo. Several years later she joined the Botany Department as an honorary collaborator. Although the department was focused on mycology, María del Carmen had her very first opportunity to observe hundreds of water samples under a microscope. At that time there were no experts in academia working in taxonomy or ecology of phytoplankton. The university was still recovering from the repression during the military dictatorship, which implied the absence of specialized literature and good facilities for research. However, those harsh conditions never discouraged her; on the contrary, she devoted herself with great passion to observing fresh samples that she herself collected. She worked on the weekends when the lab was available. During that period, María del Carmen became amazed by the diversity of forms and organisms that passed in front of her eyes, and her burgeoning excitement for taxonomy increased exponentially. In the early 1990s she took specialized courses and did internships about taxonomy and biology of freshwater microalgae in Argentina and Brazil. Her enthusiasm and outgoing personality ensured that she had no barriers to making friends and establishing strong academic relationships with colleagues and experts from other countries. Later, she worked in tight collaboration with many taxonomists, among others, Nora Maidana (Argentina), Augusto Comas (Cuba)

and Célia Leite Sant'Anna (Brazil). After finishing her studies at the Universidad de la República (Bachelor in Biological Sciences, 1994) she moved to Spain, where she continued her postgraduate studies (DEA: advanced studies diploma, Universidad Politécnica de Valencia, 2010; and doctoral studies at the same university). She visited the laboratory of Professor Jiri Komárek (Czech Republic) to work in cyanobacteria, with whom she established a long-lasting academic cooperation. María del Carmen worked as a professional in phytoplankton taxonomy in different institutions along her prolific and active career, in Uruguay (the national fisheries resources: DINARA, the technological laboratory: LATU, the national water facility: OSE and the Universidad de la República) and Spain (Universitat Politècnica de València, Conselleria de Medi Ambient, Universidad de Girona). She analyzed phytoplankton samples with optical and electronic microscopes (Fig. 2), worked actively in monitoring programs of red tides and water quality (DINARA and LATU), monitoring of phytoplankton and cyanobacteria in water sources (OSE) and in many research projects related with phytoplankton ecology (Facultad de Ciencias, Universidad de la República) (Fig. 2). Wherever she has worked, she has stood out for her hard, meticulous, and rigorous work. She became an academic reference in taxonomy of phytoplankton, frequently consulted by Uruguayan colleagues. María del Carmen loved teaching young researchers in practical courses. She dedicated many hours to the training of technicians and postgraduate students who were beginning their studies in phytoplankton taxonomy (Fig. 2). Her contagious enthusiasm spread easily to the students, and she always provided relevant information for species identification, details not found in books and that are only learned from experience.

María del Carmen significantly contributed to the knowledge of the microalgae flora of Uruguay. She characterized for the first time the phytoplankton communities of important freshwaters such as the Río Negro (Conforti & Pérez 2000; Pérez 2002; Pérez *et al.* 1999b), the large Merín Lagoon (Pérez & Odebrecht 2005; Sophia & Pérez 2010), the Uruguay River (Ferrari *et al.* 2011) and coastal lagoons (Bonilla *et al.* 2005). She significantly contributed to the knowledge of the phycological flora of Uruguay, including the discussion of the type material of *Nodularia spumigena* Mertens ex Bornet & Flahault from a coastal lagoon (Pérez *et al.* 1999a) and the discovery of a new species of cyanobacteria *Dolichospermum uruguayense* Kozlíková-Zapomělová





**Fig. 2:** Different scenes of María del Carmen Pérez along her career. A: International posgraduate course on cyanobacteria, organized by Limnology Division, at Facultad de Ciencias, Universidad de la República, Montevideo, 2016 where María del Carmen participated in the practical lectures (she is the fourth person from the right, back row); B: Analysing samples at the Technological Laboratory of Uruguay (LATU), Montevideo, 2013 (María del Carmen left, Graciela Ferrari, right) C: Sampling phytoplankton at Laguna del Sauce, 1994, Uruguay; D: Analysing samples at the scanning electron microscope, Universitat Politècnica de València, Spain and E: Participation in the practical lectures of the posgraduate course in phytoplankton (Master of Ingeniería Hidráulica y Medio Ambiente del Departamento de Ingeniería Hidráulica y Medio Ambiente de la Universitat Politècnica de València), Spain, 2020-2012 (María del Carmen is seen sitting on the left). (Photo credits: S. Bonilla, G. Ferrari, A. Manjón and V. Benedito Durá).

& al. (Kozlíková-Zapomlová *et al.* 2016). She greatly contributed to the taxonomy and ecology of brackish and freshwater phytoplankton of Spanish ecosystems (Carrillo *et al.* 2008; Falco *et al.* 2006; Pérez & Carrillo 2005; Pérez *et al.* 2009, 2010; Tornés *et al.* 2014); also she found two new chlorophyte species: *Pediastrum willei* Comas *et al.* and *Lobocystis fottiana* Comas *et al.* (Comas & Pérez 2002; Comas Gonzalez *et al.* 2006). Beyond her technical contributions, her biggest legacy may be her enthusiasm and generosity in sharing her knowledge. She always maintained her openness and her ability to be surprised by new organisms, and by samples with rare species, and she was able to pass this enthusiasm to the people around her.

### FUTURE CHALLENGES

Unfortunately, Uruguay is one of the countries with the lowest investment in science and tech-

nology of Latin America, which greatly limits the development of new lines of research (Ciocca & Delgado 2017). In this context, the most important challenges for phycology in Uruguay are related to the development of new areas, especially those related to basic studies (physiology or evolution) to generate the bases that promote applied areas such as biotechnology. More basic studies of the molecular biology of algae (macro and micro), and more studies related to the periphyton (biology, physiology, and ecology) are also needed.

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# DIRECTORIO

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Mesa Directiva 2023-2025

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## CRÉDITO DE FOTO DE LA PORTADA

Seaweed Grazer

Molusco: *Elysia diomedea*

Algas de varios géneros: *Codium*, *Ulva*, *Ceramium* entre otros.

Localidad: La Paz, B.C.S, Golfo de California

Fecha: 21-mayo-2016

Sustrato: Rocas, conchas y arena

Foto: M. C. Tonatiuh Chávez Sánchez