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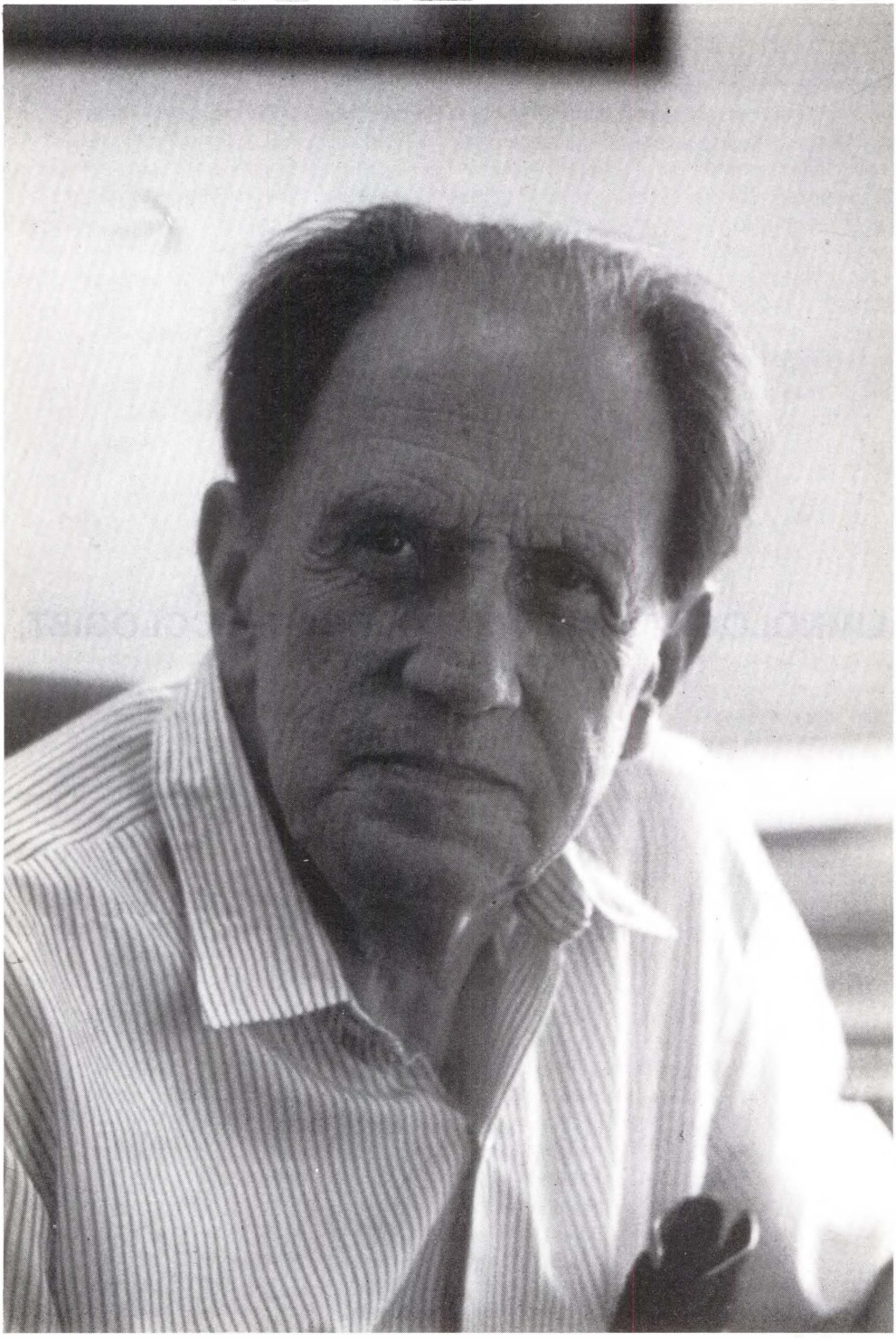

Professor Ramon Margalef in 1990

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# RAMON MARGALEF, LIMNOLOGIST, MARINE BIOLOGIST, ECOLOGIST, NATURALIST

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Professor Ramon Margalef has pioneered ecological research. Since the early forties, he has worked in nearly all aspects of aquatic ecology - limnology and oceanography - and has put together a very thorough, comprehensive theory of ecology, based mainly on his own work but universal enough to be widely accepted and praised as the main corpus of theory of a scientific discipline still in its early years.

His scientific ideas have had an influence on more than a generation of ecologists, through his university lectures and his papers and books, which number nearly 400 (see Appendix I). Of these, *Perspectives in ecological theory* (1968) and *La Biosfera, entre la termodinámica y el juego* (1980), represent what is generally considered to be one of the main efforts to establish ecological knowledge on a proper footing. His books *Ecología* (1974) and *Limnología* (1983) are considered by the specialists to be among the best text books ever written on these topics, and have had great influence worldwide, especially in Spanish-speaking countries.

Ramon Margalef was born in Barcelona in 1919, where he began his studies in business school, but soon developed an interest in natural history and biology. His education was interrupted by military service during the Spanish Civil War. At the end of his military duties (in 1943) he took a job with an insurance company, but continued his scientific interests at the Institut Botànic de Barcelona. He built his own microscope with spare parts bought in second-hand markets and began an intensive study of freshwater algae, while he read all the books he could get his hands on on biology, physics and other subjects to which, had he followed a stricter syllabus, he may not have had access.

At the same time as acquiring a wide self-education, Margalef published the results of his first research. His studies attracted the attention of university officials, who offered him a fellowship; he could thus follow a formal university curriculum. By 1951 he had received his doctorate (on "Temperature and morphology of living beings") and became a member of the Institut d'Investigacions Pesqueres (of the Spanish National Research Council, CSIC), which he would later direct and convert into an oceanographic centre of international repute.

At the beginning of the sixties, he formalized what would be the seeds of his text books on Ecology (*Comunidades naturales* dates from 1962) and began to give informal classes on Ecology. Later he would become the first Professor of Ecology in Spain (1967). Margalef has done all his scientific work in this country, where as a senior professor and a senior researcher he has had a hand in training a very numerous group of limnologists, oceanographers, ecologists and marine biologists (see in Appendix II the relation of the Ph. D. Theses he has directed). In

turn, these people are now spreading their scientific message in ecology departments and research institutions in Spain and abroad. But Margalef's influence stretches to many countries around the world where he has worked (mainly in North and South America and Europe) and where he is currently invited to give lectures and courses and to participate in research programmes or scientific conventions. In turn, Margalef has entertained guest scientists from all over the world in his laboratory in Barcelona.

Professor Margalef contributed greatly to the international recognition of his Department of Ecology (University of Barcelona), and previously of the Institut d'Investigacions Pesqueres (now Institut de Ciències del Mar), which he directed in the sixties. He achieved this in part through the scientific journals of which he was editor: *Publicaciones del Instituto de Biología Aplicada* (now discontinued), *Investigación Pesquera* (now *Scientia marina*), and *Oecologia aquatica*, of which this is the tenth issue. For many years, under his direction, *Investigación Pesquera* was one of Spain's most internationally influential scientific journals.

Ramon Margalef is an oft-quoted authority in all fields of ecology and aquatic sciences, and the most quoted of all Spanish scientists (1978-82). *Perspectives in ecological theory* and the articles "On certain unifying principles in ecology" (*Amer. Natur.*, 1963) and "Life-forms of phytoplankton as survival alternatives in an unstable environment" (*Oceanol. Acta*, 1978) have been quotation classics. He has been awarded honorary doctorates by several universities and has received important scientific awards, among them the Prince Albert Medal (from the Oceanographic Institute of Paris), the Huntsman Award (considered as the equivalent of a Nobel Prize in Oceanography), the Naumann-Thienemann Medal (equivalent of a Nobel Prize in Limnology), the Ramón y Cajal Award (the highest honour for a Spanish scientist) and the Narcís Monturiol Award (the highest honour for a Catalan scientist).

This comes as no surprise to the scientific community, Margalef and the men in whose honour these prizes were established being (paraphrasing the words of G. E. Hutchinson, a distinguished ecologist and limnologist himself) "*facile principes* in their chosen fields". Professor Margalef reached retirement age in 1986, and was later appointed Emeritus Professor at the University of Barcelona.

The main fields of Professor Margalef's research and study can be listed as follows: Limnology, Biological Oceanography, General and Theoretical Ecology. He has also made contributions to Human Ecology and Theoretical Biology in general. In what follows the reader can find a summary of his scientific work. A list of his publications is given in Appendix I, and the doctoral theses he has directed are listed in Appendix II.

## THE LIMNOLOGIST

Although Ramon Margalef owes his international reputation to his research on oceanography and to his development of a coherent theory of ecology, it is in the study of continental or fresh waters where we find his most extensive, most enduring and, at the same time, his most innovative work. Indeed, his first scientific papers, written nearly fifty years ago, dealt with the biology and ecology of both animal and plant aquatic organisms.

This is a field which Margalef truly pioneered in Spain. Beginning in the early forties, without academic or institutional support, he launched a one-man, multi-year study of virtually all the land waters of Spain. The extent of this was such that, out of all researchers on freshwater communities, it could be said that he is the one who has done the most work, covered the most fields, trained the most

limnologists and, above all, in relation to ecology, the one who has formalised the immense range of his work into a coherent whole, creating the first corpus of limnology in his country and abroad. This work in limnology earned him the recognition of the Societatis Internationalis Limnologiae (SIL), which in 1989 awarded Margalef the Naumann-Thienemann Medal, *De limnologia optime merito*. The highest SIL award was conferred to Professor Margalef "for sharing his creative gifts of insight, intuition and synthesis of the ecological foundation of limnological phenomena and for his influence on limnology in the Spanish-speaking world". As proof of this international recognition he has been asked to organise the XXV SIL Congress, to be held in Barcelona in 1992.

River and lake phytoplankton algae constitute the first block of Margalef's limnological works. These studies are at the heart of his later dedication to marine phytoplankton (see below), and form the basis for his work on identifying ecological factors common to both types of aquatic communities. The task of identifying and drawing up an inventory of these organisms under the microscope involved enormous effort, kept up over many years; indeed, it still occupies Margalef, the limnologist, even today (especially the phytoplankton of some one hundred reservoirs all over Spain). This study forms part of a very ambitious piece of research, which will be further examined below.

The study of freshwater animals has been a similarly fertile area of research. The study of the biology and ecology of crustaceans, among other aquatic animals, enabled Margalef to produce a monograph as early as 1953 on *Los crustáceos de las aguas continentales ibéricas*, which continues to be used as a standard reference work in Spain.

But Margalef's greatest claim to fame is his global study of the environmental factors and the organisms of nearly all the freshwater and salty water bodies in the Iberian Peninsula and Balearic Islands, and certain places in North and South America, and Europe, although he concentrated on those of his own country. This integral study of lakes and water courses very soon enabled Margalef to write a monograph ("Limnosociología", 1947) which put Spanish limnology on a par with European limnology as far as basic knowledge is concerned. *Los organismos indicadores en la limnología* (1955) is a complement to his previously quoted treatise on Iberian crustaceans and, later on, various general works lay down the main lines of a regional form of limnology in this peninsula.

Within this field, special mention should be made of the ambitious Spanish reservoirs programme, which began twenty years ago through an agreement with the Spanish Ministry of Public Works. Since then, the Department of Ecology of the University of Barcelona has had a limnological team working on the physical, chemical, biological and ecological features of over a hundred reservoirs throughout the Iberian Peninsula (*Limnología de los embalses españoles*, 1976). Besides the numerous articles published on the results of this study (perhaps the most complete study of this type carried out anywhere in the world up to now), one should highlight the number of specialists (from Barcelona University and from other research centres in Spain) who have come together in a single limnological team that is both coherent and multidisciplinary. It is, above all, the first time that in-depth knowledge of freshwater ecology in Spain has been obtained. Besides directing and promoting this study, Margalef has published many papers, either alone or in collaboration with the above team. The study of Spanish reservoirs is currently being repeated, some fifteen years later, by another team in the Department of Ecology, and Professor Margalef is working on it once again.

The scope of Margalef's limnological work is remarkable; it includes improvements in methodology, taxonomy,

ecology, palaeolimnology and biogeography. He has also examined pollution in continental waters. Mention should be made here of the achievements of his article "El concepto de polución y sus indicadores biológicos" (1969) and the already mentioned "*Los organismos indicadores en la limnología*", which contributed greatly to an increased awareness of the subject.

Margalef's encyclopaedic knowledge of limnology in general and of Iberian land waters in particular is embodied in his *Limnología* (1983), where the author has managed to put his enthusiastic stamp on a topic of study that has always been very dear to him.

## THE MARINE BIOLOGIST

Margalef began to study marine organisms through the knowledge of continental water life-forms and after joining the Institut d'Investigacions Pesqueres (IIP). His concentrated efforts in the field of marine studies go far beyond the strict marine ecology or biological oceanography fields, and he has excelled in the study of marine unicellular algae. After publishing several works about the phytoplankton of the Catalan coast, he then collaborated with M. Massutí on a book entitled *Introducción al estudio del plancton marino* (1950), a monograph which is still widely used for identification purposes.

Professor Margalef's stays in various IIP laboratories around the Iberian Peninsula led to a series of studies on the hydrography, phytoplankton and primary production dynamics of the coasts of Blanes, Barcelona, Ebro delta, Castellón, Cádiz, Ría de Vigo, and of American (the Caribbean) and African (Sahara) coastal regions. Many publications and syntheses had their source in the quantitative study of an incredibly high number of plankton samples, whose inventories were the raw material on which a series of theoretical concepts about marine ecosystems, like species diversity and phytoplankton succession, for example, were based.

When thirty years ago the Institut d'Investigacions Pesqueres had no oceanographic ships available, invitations from other countries allowed Professor Margalef to take part in various international oceanographic cruises. At a time when automatic analysis in the field of oceanography was still very much in its infancy and computers were not available, his works reflected his pioneering attitude towards the development of automatic sampling, analysis and evaluation methods that allowed continuous readings of the marine environment and plankton characteristics to be taken. The use of multidimensional statistical analysis methods in his marine plankton studies were equally as pioneering.

When Margalef was researcher at the IIP (both before and after his short period as director of the Institut), he made considerable contributions to its consolidation as the Spanish Mediterranean's foremost laboratory and to its international prestige. He achieved this by surrounding himself with competent, enthusiastic collaborators and attracting internationally renowned researchers, involving them in high level research programmes and training courses, and raising the tone of his magazine, *Investigación Pesquera*. His many research stays in marine laboratories in Spain and abroad were always training courses for local students and young oceanographers.

One of Margalef's achievements was recognising the importance of phytoplankton organization - which had generally been considered as an unstructured suspension - in the study of marine communities. On this matter, he has often pointed out the faults in classical statistics which do not take space into account. Several of Margalef's most internationally renowned works have

concentrated on the study of the small-scale spatial distribution of phytoplankton and on the role of auxiliary energy in phytoplankton production.

From the early seventies onwards, Margalef promoted the basic oceanographic study of the upwelling areas of the African coast, whose interest for fisheries had been highlighted by various IIP prospection cruises; he directed some of the oceanographic cruises in waters of the Saharan continental shelf and was personally responsible for the chemical and physical study of the upwelling, the analysis of phytoplankton and ciliate communities and primary production. In more recent years, his influence in the detection, study and interpretation of the Catalano-Balearic hydrographic front has also been significant.

Margalef also studied the population behaviour of phytoplankton algae cultivated in the laboratory in several types of recipient that allowed a certain local heterogeneity to be created in environmental conditions. His aim was to obtain conditions which were midway between the low volume classical shaken culture and natural sea ones in order to detect phytoplankton succession-related phenomena. His profound knowledge of plankton ecology - and phytoplankton ecology in particular - and various incursions into the study of production by seagrasses and corals, the biology of commercial fish species and other areas of oceanographic research enabled him to produce two multi-author books on marine ecology: *Ecología marina* (1967) and *Western Mediterranean* (1985).

## THE ECOLOGIST

Perhaps Margalef's contributions to theoretical ecology are what have brought him international fame and prestige, and have made him one of the most frequently quoted contemporary ecologists. All his publications contain elements which reflect his concern to find general regularities, unifying principles (as he himself would call them in one of his best-known papers; see below), which explain how aquatic systems (both continental and marine) and terrestrial systems work or, to put it another way, how the entire biosphere works. He has been able to extrapolate from his immense work on aquatic environments to global problems of the first order concerning evolution, ecology and even human affairs.

In his introductory speech at the Reial Acadèmia de Ciències i Arts de Barcelona, Professor Margalef spoke about the use of information theory in Ecology ("La teoría de la información en ecología", 1957). He suggested applying certain information theory methods to the study of the variety or diversity of species of an ecosystem. The fact that this seminal paper was published in English just one year later ("Information theory in ecology", 1958) gives us some idea of the influence it had on ecologists at that time. Margalef had already set out his ideas in various articles about the regularities and the correlation between global or synthetic characters of ecosystems and their variations throughout the ecological succession.

"On certain unifying principles in ecology" (1963) was another paper that exerted a great deal of influence over contemporary ecology, as the numerous reprints and its inclusion in several *Readings in Ecology* demonstrate. As Margalef himself says, the article contained several points of view aimed at constructing a general frame of reference in which to order and unify ecological observations. This aspect of Margalef's work does not just affects basic ecological concepts; it also affects interesting problems related to nature management and the role man plays in the biosphere (see below).

Let us take a look at what Margalef himself has to say about his contribution to a more synthetic formalisation of the

science of Ecology by referring to his seminal papers and books:

"At the beginning of the 1960s I was working in a research institute, with leisure and freedom, without administrative duties, and with just the supplementary stimulation provided by a small number of good students registered on a voluntary basis in a course on general ecology. A few years before I had shifted my principal interest from freshwater to the oceans, and had recently had the occasion to work in the Mediterranean and the Caribbean, as well as in the fjordlike rias of NW Spain. Weekly strolls over the countryside with my children were regular. At the time, I had the occasion to travel widely abroad, mostly in the US, and discuss my ideas in many personal contacts.

"I developed a feeling about the current trends in ecology and did not like them completely. Mathematical ecology was attractive, but I could not see any essential improvement since Volterra, and many current assumptions did not make much sense to me from the point of view of physics. I had been nurtured in the tradition of the old continental European approach to ecology. Thienemann, Braun-Blanquet, and, later, Hutchinson, influenced me strongly.

"My work leading to the speculations, or supporting the conclusions of this paper ["On certain unifying principles in ecology"], was published in Spanish and was almost unknown. So this first summary published in English conveyed ideas born and bred in relative isolation.

"From my discussions with colleagues and from the reaction to my seminars at the time, I feel that a part of the success of this paper was because it provided a relatively orthodox frame related to physics, that is, to thermodynamics, and to information theory to supplement a strictly individualistic approach to ecology. Most biologists accepted and accept that the success of an individual who has passed part of his genes to a new generation is everything that counts, and that no more questions should be asked. My point was that physical laws place a number of constraints that add to the proximity and interaction between organisms, in a way that, to some extent, we can anticipate who will overcome the selection test and what the ecosystem will look like. This was consistent with accepting that possibilities for life are almost boundless and that the approach called reductionistic is very effective in ecology. My approach could also be easily extended to humanized ecosystems.

"I have tried to present my recent views on the whole subject in *La Biosfera, entre la termodinámica y el juego*".

Margalef has also taken a very active part in the development of Ecology as a quantitative science, although he has always warned ecologists about the dangers of mathematical bewilderment that could make them lose sight of the rich biological reality. In this context, it should be mentioned that his sentence "We should try not to let statistics become the opium of the ecologist" has not always been correctly interpreted.

Any list of Margalef's works that involve important contributions to theoretical ecology would be very long. It should include his papers and books on species diversity and connectivity as a measure of ecosystem organization and complexity; the ecological succession as an evolutionary framework of ecosystem development; trophic level ecosystem models and network organization; the role of exosomatic or auxiliary energy in the production of organic matter in the biosphere; ecological equilibria, etc.

Margalef has periodically formalised his contribution to theoretical ecology in various books. The first of these was *Perspectives in ecological theory* (1968), which originated as a series of lectures given at the University of Chicago, and which meant a broadening of his above-mentioned corpus of theoretical work. "My purpose is only to express the

conviction that some aspects of the solid ecology of yesterday and of today allow us to build a theoretical superstructure that, perhaps, is not irrelevant after all." (*Perspectives in ecological theory:* v). At that time, the book had an enormous impact on the world of ecological science (in Margalef's own words, "These works did provoke a certain amount of controversy and several points of view put forward in them have been accepted and have had some influence on present day Ecology") and it was translated into several languages, Japanese and Spanish to name but a few.

*Ecología* (1974), his monumental and authoritative text book, is permeated throughout his chapters by his conceptual framework and by creative and controversial thoughts about ecological science. Margalef himself explains this relative decrease in "eclecticism and objectivity" which are generally taken to be sensible text book features: "Personally, I have always been more interested in books that are highly personal and partial (as far as the selection of material or the points of view are concerned) than in those that claim to give a balanced, aseptic and neutral vision of science. Universities need creativity and a certain amount of controversial provocation. No science is static." (*Ecología*: vii-viii).

*La Biosfera, entre la termodinamica y el juego* (1980) is an update of *Perspectives* (with a "naturalist" bias and "somewhat passionate, in contrast to the most commonly accepted ecological theory"). The title itself already suggests two boundary levels in the happenings of the biosphere: the inexorability of physical laws and the randomness of fate. It is, in a sense, an ecological answer to the idea that is revealed in *Le hasard et la nécessité* (MONOD, 1970) about the evolution of living beings and the biosphere. Margalef understands that "ecology is more transdisciplinary than interdisciplinary, in as much that it suggests points of view that closely relate areas of knowledge which are traditionally kept separate", and thus bridges are built between traditional ecology and the above-mentioned sciences. At the same time, he removes some of the dead weights from the ecology he has helped to create and which contribute to its stagnation: "Several concepts used in ecology, and some of my favourites, such as niche, diversity, stability, succession... lose their value when they are critically examined, and I believe they are unnecessary" (*La Biosfera, entre la termodinámica y el juego*: vii).

Ecological theory and Margalef's own ideas on this matter also pervade *Limnología* (1983). Margalef's approach to limnology may be considered to be modelled on G. E. Hutchinson's, mainly by his multiple approach method to limnological and ecological problems and his willingness to master a great deal of detailed information.

As with *Perspectives*, *La Biosfera* stemmed from the organisation and formalisation of materials from postgraduate and specialist courses on theoretical ecology. *Teoría de los sistemas ecológicos* (1991) has the same origins, and it represents Margalef's third attempt (his own words) to offer a "personal view, and probably a heretical one, of what the biosphere is". Perhaps this "heretical" or heterodox feature is one of the reasons why this text has not appeared in English. Indeed, when he was asked to do an English version of *La Biosfera*, Margalef not only translated the original, but expanded and updated it, and renamed it *The Biosphere in the making*. As the American editors suggested modifications and changes and his colleagues made further suggestions, the manuscript became *A view of the Biosphere*, whose publication was delayed or postponed indefinitely on the basis of it being too speculative. However, it would not be at all hazardous to suggest that, as happened with *Perspectives* and *La Biosfera*, this most recent book is so far in advance of the

thought of most ecologists that the just recognition of its merits will probably be delayed for some time.

In *Teoría de los sistemas ecológicos*, Professor Margalef develops "a theoretical conception in which a personal vision of what is known about the aspects of ecological systems and how they work can be framed, from individuals of different species to all of them as a whole within more or less large areas, and their connection with time examined. The biosphere is the living cover of the planet and it embraces all living organisms, their supports and the signs of their activity. The characteristics of the Earth as a planet, its materials and the availability of energy act as the framework for the biosphere. All the pieces of the puzzle fall into place in different ways. Their examination leads to a historical and organismic vision, which accepts the strong dependence of the physical environment, which, in turn, is strongly modulated by the existence of life...

"Perhaps there are very few 'laws of Nature' and, for the most part, they will be more like principles of impotence. The most important thing in nature - and life in particular - is its constructiveness: the tendency to complicate coherent or continuous structures... the tendency to increase information... strengthened by the constant selective pressure towards bigger structures having unified behaviour patterns, at the heart of which the value of the information is multiplied or becomes stronger. Recovery, in the form of information, of a part equivalent to the entropy produced in the system and its environment, explains most of the properties of life, organisms and ecosystems...

"Special emphasis is placed on trying to characterise organisms and ecosystems as physical systems, which forces the properties of the systems in general to be considered, especially as far as self-organisation is concerned. This took a big step... when systems formed by replicable subsystems were adopted. Ecosystems... combine inanimate, living subsystems and materials, whose interaction is clear in material cycles and in the history of the biosphere, in the role of external or exosomatic energy and in the apparent indetermination that enters any mechanism when it reaches a field of relatively low energy... The extraordinary capacity for making new things stems from the restrictions imposed by the few identifiable physical laws. Those related to thermodynamics are possibly the most constructive and the only ones that can be used to make any predictions. However, attempts at making predictions in ecology have not been very accurate..." (*Teoría de los sistemas ecológicos*: 18-19).

## THE NATURALIST

In most of his books and articles, and in many other places too, Margalef defines himself as a naturalist, a profile which is surely dearer to him than any of the previous ones. This is so even though Margalef was "the" Spanish limnologist from the forties onwards, "the" marine biologist when he began to study marine plankton and, later, when nobody in Spain had even heard about ecology, "the" Spanish ecologist. Undoubtedly, the term "naturalist" is the one that fits best this universal Catalan who has become, in his own right, the most prominent naturalist in Spain - where nature scholars of whatever bent have always been thin on the ground.

Indeed, if we take a look at his publications (see Appendix I), especially those published during the first fifteen years, it is surprising to see that he has taken an interest in all animal and plant groups inhabiting aquatic environments, environments which he seems to have studied with panoptic vision. Professional profiles such as phycologist, carcinologist, phytoplanktologist and so on fit him

perfectly. But a careful reading of his books on ecology, limnology and marine biology reveals that aquatic invertebrates and algae are not the only objects of his attention and study. Margalef is a keen entomologist and knows higher plants and terrestrial and aquatic vertebrates very well. His knowledge of physics, chemistry and geology is wide and this is apparent throughout the pages of his books. His contributions to biogeography (mainly of continental waters), micropaleontology and evolutionary biology (the causes of microevolution and large-scale patterns in the history of diversity through geological time) are by no means less substantial.

Other aspects of his character make him an out-of-the-ordinary naturalist, of he lineage Stephen Jay Gould calls Galilean, that is, the naturalist that "delights in nature's intellectual puzzles and our quest for explanation and understanding. Galileans do not deny the visceral beauty [of nature], but take greater delight in the joy of causal comprehension and its powerful theme of unification" (GOULD, 1991). The way Margalef the naturalist enjoys his research and his probing of the workings of the biosphere has inspired the subtitle of this volume of tribute.

At a time when the daily talk at universities is more about employment opportunities for the biologist rather than its vocation, Margalef is a constant reminder of what a scientist should be: someone who questions himself about the whys and wherefores of nature. He has also said and written on more than one occasion that nature should be looked at with the eyes of a child -inquisitive and searching - which do not take anything for granted and question everything. In this respect, it may be said that he is perhaps the archetypal naturalist - in the sense of a scholar and expert on nature in all its facets. We might call him a biologist of the biosphere, as others are scholars of a particular group of insects, plants or the Quaternary.

Margalef's contributions to a discipline that is still not clearly established linking ecology with human problems are also considerable. This is a discipline that goes beyond human ecology and social anthropology and could be defined as the application of ecological ideas to human problems, whether environmental or not. Consider the scope of such a definition (economics, demography, resource conservation and management, pollution, environmental degradation, etc.) and the importance of the basic postulate of Margalef's contribution to this field: man is to be viewed as a part of the biosphere and within a general ecological context. One of his most representative articles on this is "Ecological theory and prediction in the study of the interaction between man and the rest of the biosphere" (1973).

Margalef's clear vision of many human or anthropological problems has turned his lectures or articles into items which are highly sought after by institutions and magazines in the humanities field. Although he frequently despises his "sermons" (as he calls them, by analogy to the religious ones that many people hear but few take seriously), they are valuable and original pieces of thought directed to heterogeneous audiences who deeply appreciate the message delivered, be it ecological or otherwise. Margalef has also taken an active part in the activities of the Institut d'Humanitats de Barcelona, one of whose main objectives is to fill the gap that exists (especially in our country) between sciences and humanities.

This interest is patently clear in his popularizing work in the form of conferences, books or exhibitions for a very wide public. Although the books and articles for encyclopaedias and magazines of a divulgative nature have not been listed in the bibliography of Appendix I, they actually represent a considerable percentage of Margalef's output, characterised by a highly personal style that bears witness to the author's breadth and depth of knowledge and teaching qualities. *Ecología*

(1981) and *L'ecologia* (1985) are but two of Margalef's diverse range of popularizing books which are worthy of mention. His participation in the book *Natura, ús o abús? Llibre blanc de la gestió de la Natura als Països Catalans* (1976[1988]) and in the volume *Sistemes naturals* (1989) of the encyclopaedia *Història Natural dels Països Catalans* was outstanding.

Just in case it is wrongly thought that popularizing ecology is easy, Margalef himself has highlighted the limitations of the ecological discourse as far as leaving important basic matters to one side is concerned: the teaching of these matters is absolutely essential if future generations are to understand the way nature works, and manage its resources better than the present generation. In "Simple facts about life and environment not to forget in preparing schoolbooks for our grandchildren" (1984), to mention but one of his papers on that matter, he lists a series of concepts that must be given priority if ecology is to be made understandable. His advice: "It is necessary to go back to fundamentals - look at nature and state real and interesting problems in a simple and general form, if possible."

This ability to go back to the fundamental and state it in simple, understandable terms, combined with his ability to summarise his encyclopaedic knowledge, have made him a much sought after contributor to books related to his fields of interest, and have made him an expert disseminator of ecological information. Margalef is a charming writer, and his work as plain-science writer is second only to his serious scientific work.

In all his books, scientific or vulgarization articles and lectures, Margalef is always new and original and has the excellent teaching virtue of suggesting and upsetting: suggesting new relationships and general rules on the basis of data which are apparently unrelated; upsetting schemes and clichés which are taken for granted and which should be reformulated. Margalef's classes have never been famous for their clear and succinct construction; they are the classes that students most shy away from, because they can hardly ever take precise notes, maybe because Margalef jumps from one subject to another (or even one discipline to another) or because the listeners must take their time to digest the impact of the revelations, the questions and the paradoxes about nature that are provided at great speed. The great merit of these classes lies in the fact that they awaken the students' emotions and doubts, which unfailingly brings them to ask themselves about the ecological issue that is under consideration instead of taking it as a perfectly established solemn truth, as often happens in the "magisterial" lectures still commonly given in Spanish universities. Rather than attempting to persuade, Margalef attempts to provoke, which means that the student is obliged to think and not just memorise. His books also have this virtue.

Ramon Margalef is well-regarded everywhere as much for his kindness and modesty as for his science. It is difficult to define a boundary between his scientific interests, very broad as they are, and his personal commitment to human culture. The fact that his ideas cover both areas is an index of the breadth and depth of his scientific knowledge and of his own human character. In fact, he sees science as a part of human culture, and in this sense he can also be termed a humanist.

Margalef the man is a very warm and friendly human being; he has been always extremely generous with his time in teaching students and rearing young researchers from many countries, mainly Latin American. No doubt this willingness to help and his warm and continued interest in everyone he meets are the underlying reasons for his having stayed in Spain, although throughout his career he has received many tempting offers from some of the world's most prestigious teaching and research institutions. His attachment to

his roots and the commitment to the idea that his teaching and research work should be undertaken in his own country are but a few more merits that should be emphasised, especially for a scientist of Margalef's calibre.

In summary, Ramon Margalef's work has been marked not only by scientific excellence and brilliant exposition, but also by far-reaching insight and a remarkable degree of personal candour. This Catalan naturalist, one of the finest world scientists of the 20th century, has served, and will continue to serve, as a model for scientific endeavour in the field of aquatic ecology.

REFERENCES not to be found in Appendix I

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# APPENDIX I. SCIENTIFIC PUBLICATIONS OF PROFESSOR RAMON MARGALEF

Papers in scientific reviews and divulgative books are not included.

## 1943

1. Los epibiontes en los animales de agua dulce. *Euclides*, 33, 3 pp.
2. Sobre la ecología de las larvas de algunos culícidos. *Graellsia*, 1: 7-12.
3. Contribución al conocimiento de los diaptómidos (Crustáceos copépodos) de España. *Bol. Real Soc. Esp. Hist. Nat.*, 41: 379-383.

## 1944

4. Datos para la flora algológica de nuestras aguas dulces. *Pub. Inst. Bot. Barcelona*, 4 (1): 130 pp, 22 cuadros y 7 láminas.
5. Notas sobre quironómidos. *Graellsia*, 2: 3-13, 65-76, 165-181; 3: 13-22.
6. Contribución al conocimiento de los crustáceos anfípodos que viven en las aguas dulces y salobres de España. *Bol. Real. Soc. Esp. Hist. Nat.*, 42: 199-209.

## 1945

7. Fitoplancton nerítico de la Costa Brava catalana (Sector de Blanes). Inst. Esp. Estudios Mediterráneo. *Publ. Biol. Mediterránea,* I, 48 pp.
8. Infusorios de las aguas continentales de la provincia de Barcelona. *Bol. Real Soc. Esp. Hist. Nat.*, 43 369- 381.
9. Un curioso tipo de biocenosis dulciacuícola: la fitotélmica. *Euclides*, 5: 398-399.

## 1946

10. Observaciones sobre el régimen alimenticio de varios pequeños animales de agua dulce. *R. Esp. Fisiol.*, 1: 245- 250.
11. Materiales para el estudio de la biología del lago de Bañolas (Gerona). *P. Inst. Biol. Apl.*, 1: 27-78.
12. Sobre dos supuestas protófitas. *Collectanea Botanica*, 1: 49-50.
13. Contribución al conocimiento del género *Platymonas* (Volvocales). *Collectanea Botanica*, 1: 95- 105.
14. Contribución al conocimiento hidrobiológico del país vasco-navarro. Estación de estudios Pirenaicos: *Aportación al estudio de la fauna y flora vasco-navarras (Sierra de Aralar):* 7- 44.
15. Algunos ostrácodos de las aguas continentales del NE de España. *P. Inst. Biol. Apl.*, 2: 89-95.
16. Fitoplancton nerítico estival de Cadaqués (Mediterráneo catalán). *P. Inst. Biol. Apl.*, 2: 89-95.
17. Sobre la morfología, afinidades y ecología de una interesante pleurocapsácea (cianofícea). *P. Inst. Biol. Apl.*, 2: 89- 95.
18. Miscelánea de zoología dulciacuícola. *P. Inst. Biol. Apl., 2: 117-120.*
19. (with M. BASSEDAS) Algunos branquiópodos del NE de España y consideraciones sobre la fauna ibérica de cladóceros. *P. Inst. Biol. Apl.*, 2: 127-148.

## 1947

20. Una oscilatoria notable por la estructura de sus vainas. *An. Jardín Bot. Madrid*, 6: 187-192.
21. Limnosociología. *Monografías de Ciencia Moderna*, 10. 93 pp.
22. Observaciones micropaleontológicas sobre los sedimentos lacustres miocénicos de Libros (Teruel). *Estudios Geológicos*, 5: 171-177.
23. Materiales para una flora de las algas del NE de España. I, Zignemales. *Collectanea Botanica*, 1: 107-121.
24. Observaciones sobre el desarrollo de la vida en pequeños volúmenes de agua dulce y sobre la ecología de las larvas de *Aedes aegypti. P. Inst. Biol. Apl.*, 3: 79-112.
25. Datos zoogeográficas sobre ostracódos de agua dulce de Cataluña y descripción de la nueva especie *Potamocypris pyrenaica. P. Inst. Biol. Apl.*, 3: 163-171.

## 1948

26. Primera nota sobre la biología de las aguas estancadas del bajo Urgel. *Ilerda*, 5, 65 pp.
27. Los métodos para la investigación de las comunidades acuáticas adnadas y especialmente las formadas por organismos microscópicos (perifiton, pecton). *Collectanea Botanica*, 1: 247-259.
28. A new limnological method for the investigation of thin layered epilithic communities. *Trans. Amer. Micr. Soc.*, 67: 153-154.
29. Le phytoplancton estival de la Costa Brava catalane. *Hydrobiologia*, 1: 15-21.
30. Flora, fauna y comunidades bióticas de las aguas

dulces del Pirineo de la Cerdaña. *Monogr. Est. Estud. Pirenaicos*, 11, 226 pp.
31. Estudios sobre la vida en las aguas continentales de la región endorreica manchega. *P. Inst. Biol. Apl.*, 45: 5- 51.
32. Algas de agua dulce de la laguna de Ariguanabo (Isla de Cuba). *P. Inst. Biol. Apl.*, 4: 79-89.
33. Notas sobre algunos rotíferos. *P. Inst. Biol. Apl.*, 4: 136-148.
34. Materiales para una flora de las algas del NE de España, II. *Collectanea Botanica*, 2: 99-130.

1949

35. Miscelánea de zoología dulciacuícola. *P. Inst. Biol. Apl.*, 5: 69-76.
36. Fitoplancton nerítico de la Costa Brava en 1947-48. *P. Inst. Biol. Apl.*, 5: 41-51.
37. Sobre el régimen alimenticio de los animales de agua dulce. *R. esp. Fisiol.*, 4: 307-213.
38. Las asociaciones de algas en las aguas dulces de pequeño volumen del Noreste de España. *Vegetatio*, 1: 258-284.
39. Algunos ciclópidos (Crustáceos copépodos) de Cataluña. *Real. Soc. esp. Hist. Nat.*, tomo 75 aniv.: 177-188.
40. Materiales para una flora de las algas del NE de España, III. *Collectanea Botanica*, 2: 233-250.
41. Datos para la hidrobiología de la Sierra de Guadarrama. *P. Inst. Biol. Apl.*, 6: 5-21.
42. Importancia de la neotenia en la evolución de los crustáceos de agua dulce. *P. Inst. Biol. Apl.*, 6: 41-51.
43. Una aplicación de las series logarítmicas a la fitosociología. *P. Inst. Biol. Apl.*, 6: 63-102.
44. Sobre la ecología de las larvas del mosquito *Aedes mariae*. *P. Inst. Biol. Apl.*, 6: 63-102.

1950

45. Caractères biogéographiques intéressants des biotes des eaux continentales de l'Espagne. *Verh. Int. Ver. theor. ang. Limnol.*, 10: 280-283.
46. Las papilas anales de las larvas de los culícidos y la absorción de tóxicos. *Rev. Esp. Fisiol.*, 5: 251-257.
47. (with M. MASSUTI) *Introducción al estudio del plancton marino*. Patronato Juan de la Cierva. 182 pp.
48. Datos para la hidrobiología de la cordilera cantábrica, especialmente del macizo de los Picos de Europa. *P. Inst. Biol. Apl.*, 7: 37-76.
49. Algunos crustáceos interesantes de las aguas dulces y salobres de España. *P. Inst. Biol. Apl.*, 7: 131-152.
50. Materiales para una flora de las algas del NE de España, IIIb. *Collectanea Botanica*, 2: 273-293.
51. Datos para la hidrobiología del estanque de Montcortés (Provincia de Lérida). *Bol. Real. Soc. Esp. Hist. Nat.*, 48: 209-218.
52. Segunda nota sobre la biología de las aguas estancadas del bajo Urgel. *Ilerda*, 13: 329-375.
53. (with F. PONZ) Actividad fosfatásica de los cladóceros, en particular sobre substancias disueltas en el agua ambiente. *Rev. esp. Fisiol., 6: 227-237.*

1951

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55. Un sincárido del género *Parabathynella* en las Baleares. *P. Inst. Biol. Apl.*, 8: 151-153.
56. La base actual de la biogeografía. *Arbor*, 66/67, 17 pp..
57. Rôle des Entomostracés dans la régéneration des phosphates. *Verh. Inter. Ver. Theor. ang. Limnol.*, 11: 246-247.
58. Ueber die biogeographische Stellung der Binnengewasserlebewelt Spaniens. *Arch. Hydrobiol.*, 45: 304-313.
59. Diversidad de especies en las comunidades naturales. *P. Inst. Biol Apl.*, 9: 83-118.
60. Plancton de las costas de Castellón durante el año 1950. *P. Inst. Biol Apl.*, 9: 49-62.
61. Ciclo anual del fitoplancton marino en la costa NE de la Península Ibérica. *P. Inst. Biol. Apl.*, 9: 83-118.
62. (with J.R. RODA, J.J. GOMEZ, B. ANDREU) Datos para una crítica del significado de la medida vertebral de las poblaciones de la sardina. *P. Inst. Biol. Apl.*, 9: 185-192.
63. Observaciones sobre *Triops* (*Apus*) *cancriformis* de una localidad catalana. *P. Inst. Biol. Apl.*, 9: 247-254.
64. Sobre *Gammarus* interesantes de España. *P. Inst. Biol. Apl.*, 9: 255-269.

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66. Materiales para la hidrobiología de la isla de Menorca. *P. Inst. Biol Apl.*, 11: 5-12.
67. Materiales para una flora de las algas del NE de España, IV. *Collectanea Botanica*, 3: 209-239.
68. Quelques remarques biogéographiques au sujet des crustacés d'eau douce des Baléares. *Vie et Milieu*, suppl. 2: 248-252.
69. Regiones limnológicas de Cataluña y ensayo de sistematización de las asociaciones de algas. *Collectanea Botanica*, 3: 43-67.
70. La vida en las aguas dulces de los alrededores del Santuario de Nuestra Señora de Aránzazu (Guipúzcoa). *Munibe*, 4: 73-108.
71. Une *Jaëra* dans les eaux douces des Baléares, *Jaëra balearica* nov. sp. (Isopoda Asellota). *Hydrobiologia*, 4: 289-213.
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75. Estudios experimentales sobre las modificaciones inducidas por diferentes temperatures en células de clorofíceas. *Publ. Inst. Biol. Apl.*, 12: 5-78.
76. Caracteres ligados a las magnitudes de los organismos y su significado sistemático y evolutivo. *P. Inst. Biol Apl.*, 12: 111-121.
77. (with M. DURAN) Microplancton de Vigo, de octubre de 1951 a septiembre de 1952. *P. Inst. Biol Apl.*, 13: 5-78.
78. Materiales para la hidrobiología de la isla de Mallorca. *P. Inst. Biol. Apl.*, 15: 5-111.
79. Estudio sumario del fitoplancton de la Ría de Vigo (1948-1950). *Bol. Inst. Esp. Oceanogr.*, 47: 1-15.
80. Los crustáceos de las aguas continentales ibéricas. *Instituto Forestal Invest. Exper.*, 243 pp.
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83. Materiales para una flora de las algas del NE de España, IVb. *Collectanea Botanica*, 3: 231-260.

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85. Consideraciones sobre la determinación cuantitativa del fitoplancton por la valoración de pigmentos solubles y los factores que afectan a la relación entre cantidad de pigmento y peso seco. *P. Inst. Biol. Apl.*, 16: 71-84.
86. Un aparato para el cultivo de algas en condiciones regulables. *P. Inst. Biol. Apl.*, 17: 65-69.
87. (with J. HERRERA, J. RODRIGUEZ-RODA & J.J. GOMEZ). Fitoplancton de las costas de Castellón durante el año 1952. *P. Inst. Biol. Apl.*, 17: 131-134.
88. Una técnica de filtración para el estudio cualitativo y cuantitativo del fitoplancton. *P. Inst. Biol. Apl.*, 17: 65-69.
89. Diferencias interanuales en la producción de fitoplancton, 1: 10.
90. (with M. DURAN). Métodos de trabajo en el mar, práctica del laboratorio de Vigo. *Reunión sobre productividad y pesquerías*, I, 32.
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93. Los organismos indicadores en la limnología. *Instituto Forestal Inv. Exper.*, 308 pp.
94. (with J. HERRERA & F. MUÑOZ). Fitoplancton de las costas de Castellón durante el año 1953. *Inv. Pesq.*, 1: 17-29.
95. (with M. DURAN & F. SAIZ). El fitoplancton de la Ría de Vigo, de enero de 1953 a marzo de 1954. *Inv. Pesq.*, 2: 85- 129.
96. Temperature and morphology in freshwater organisms. *Verhandl. intern Ver. theor. agew. Limnol.*, 12: 507-514.
97. Comunidades bióticas de las aguas dulces del noroeste de España. *P. Inst. Biol. Apl.*, 21: 5-85.
98. Contribución al estudio de la fauna de las aguas dulces del Noroeste de España. *P. Inst. Biol. Apl.*, 21: 137- 171.
99. Datos para el estudio de la distribución de los crustáceos en las aguas continentales españolas. *P. Inst. Biol. Apl.*, 21: 173-177.
100. Métodos de trabajo en el mar, laboratorio de Vigo. 15 pp.
101. (with P. ARTE). Experiencias efectuadas con una sonda "Sadir- Carpentier" tipo S. 24 pp.
102. Dinámica de las poblaciones de fitoplancton. Variaciones interanuales en el fitoplancton de Castellón. *II Reunión Productividad y Pesquerías*, 48 pp.

## 1956

103. Materiales para una flora de las algas del NE de España, VI. *Collectanea Botanica*, 4: 319-329.
104. La diversidad de especies en las poblaciones mixtas naturales y en el estudio del dinamismo de las mismas. *Pub. Univ. Barcelona*, T. Hom. F. Pardillo: 229-243.
105. Cultivos experimentales de algas unicelylares. *Inv. Pesq.*, 3: 3-19.
106. (with F. MUÑOZ & J. HERRERA). Fitoplancton de las costas de Castellón durante el año 1954. *Inv. Pesq.*, 3: 75-90.
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111. Paleoecología postglacial de la Ría de Vigo. *Inv. Pesq.*, 5: 89-112.
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113. Estudios hidrobiológicos en los valles de Bohí. (Prov. de Lèrida). *Actes 2ème Congrès Intern. Et. Pyrennés: 87-108.*
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## 1957

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117. La vida en las aguas de elevado residuo salino de la provincia de Zamora. *P. Inst. Biol. Apl.*, 24:

123-137.
118. (with J. HERRERA). Hidrografía y fitoplancton de las costas de Castellón, de julio de 1956 a junio de 1957. *Inv. Pesq.*, 18: 17-44.
119. (with F. MUÑOZ & J. HERRERA). Fitoplancton de las costas de Castellón de enero de 1955 a junio de 1956. *Inv. Pesq.*, 7: 3-31.
120. Los microfósiles del lago miocénico de la Cerdaña como indicadores ecológicos. *Cursillos y Conf. Inst. Lucas Mallada*, 4: 13-17.
121. Paleoecología del lago de la Cerdaña. *P. Inst. Biol. Apl.*, 25: 131-137.
122. La teoría de la información en Ecología. *Mem. Real. Acad. Ciencias Artes Barcelona*, 32: 373-449. (Translated into english and published in *General Systems*, 3).
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124. Un modelo para el estudio de la distribución de organismos de gran dispersabilidad y área de reproducción muy localizada. *Inv. Pesq.*, 7: 117-125.
125. Fitoplancton de las costas de Blanes (Gerona) de agosto de 1952 a junio de 1956. *Inv. Pesq.*, 7: 105-116.
126. Variación local e interanual en la secuencia de poblaciones de fitoplancton de red en las aguas superficiales de la costa mediterránea española. *Inv. Pesq.*, 9: 65-95.
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## 1958

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130. Algunos crustáceos de las agua continentales de España y norte de Africa. *Miscelánea zoológica,* 1: 3-12.
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132. (with B. ANDREU). Componente vertical de los movimientos del agua en la Ría de Vigo y su posible relación con la entrada de la sardina. *Inv. Pesq.*, 11: 105-126.
133. La sedimentación orgánica y la vida en los fondos fangosos de la Ría de Vigo. *Inv. Pesq.*, 11: 67-100.
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135. Materiales para una flora de las algas del NE de España. VIIb, Supl. *Collectanea Botanica*, 5: 535-365.
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## 1959

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158. Velocidad de sedimentación de organismos pasivos del fitoplancton. *Inv. Pesq*, 18: 3-6.
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163. (with J. HERRERA). El nivel del mar en Castellón. *Inv. Pesq.*, 19: 55-63.
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166. (with J. HERRERA). Hidrografía y fitoplancton de las costas de Castellón, de julio de 1958 a junio de 1959. *Inv. Pesq.*, 20: 17-63.
167. Fitoplancton atlántico de las costas de Mauritania y Senegal. *Inv. Pesq.*, 20: 131-143.
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## 1988

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# APPENDIX II. PH. D. THESES DIRECTED BY PROFESSOR RAMON MARGALEF

1971. Dolors Blasco. Acumulación de nitritos en determinados niveles marinos por acción del fitoplancton.
1972. M. Dolors Planas. Composición, ciclo y productividad del fitoplancton del lago de Banyoles.
1973. Joandomènec Ros. Opistobranquios (*Gastropoda: Euthyneura*) del litoral Ibérico: Estudio faunístico y ecológico.
1974. M. Rosa Miracle. Estructura y dinámica de las poblaciones de la comunidad zooplanctónica del lago de Banyoles.
1976. Antonio Cruzado. Afloramiento costero en el Atlántico nororiental. Análisis del ecosistema en sus aspectos de hidrografía y producción primaria.
1976. Marta Estrada. Estudios sobre las poblaciones de organismos acuáticos en medio no uniforme.
1976. Felipe Fernández. Influencia de la luz, temperatura y materia orgánica particulada en la actividad metabólica y en la alimentación de los copépodos planctónicos.
1976. F. Xavier Niell. Estudios sobre la estructura, dinámica y producción del fitobentos intermareal (facies rocosa) de la Ría de Vigo.
1976. Julia Toja. Estudio limnológico comparado de dos embalses con distinto grado de eutrofia (Aracena y La Minilla).
1976. Ferran Vallespinós. Estudio comparado del metabolismo del nitrógeno en bacterias y cianofíceas: relaciones con el ciclo del carbono e importancia ecológica.
1977. Miquel Alcaraz. Ecología, competencia y segregación en especies de copépodos (*Acartia*).
1977. Joan Armengol. Los crustáceos planctónicos en los embalses españoles.
1978. Narcís Prat. Ecología y sistemática de los Quironómidos (*Insecta, Diptera*) de los embalses españoles.
1979. Francesc Amat. Diferenciación y distribución de las poblaciones de *Artemia (Crustacea, Branchiopoda)* de España.
1980. Jordi Flos. Material en suspensió oceànic i la seva distribució en el Mediterrani Occidental.
1981. Francisco A. Comín. Limnología de las lagunas costeras del delta del Ebro: características físico-químicas y fitoplancton de la Encañizada.
1981. Tecla Riera. Variabilitat morfològica de *Tropocyclops* i *Temora*: Aproximació crítica a l'ús generalitzat de la biometria en la taxonomia dels copèpodes.
1983. Carlos A. Gracia. La clorofila en los encinares del Montseny: Interpretación como una optimización del aprovechamiento de la luz.
1983. M. Pilar López. Aguas salinas epicontinentales próximas a la costa mediterránea española: estudio del medio.
1984. Enric Ballesteros. Els vegetals i la zonació litoral: espècies i factors que influeixen en la seva distribució.
1985. Miguel Alonso. Las lagunas de la España peninsular: taxonomía, ecología y distribución de los cladóceros.
1985. Francisco Gómez. Ecología del fitoplancton de la Ría de Pontevedra.
1985. Josep Peñuelas. Briòfits i fanerògames com a invasors de les aigües dolces: distribució, pigments, fonts de carboni i l'obstacle dels espais aeris.
1985. Javier Romero. Estudio ecológico de las fanerógamas marinas de la costa catalana: producción primaria de *Posidonia oceanica* (L.) Delile en las Islas Medes.
1985. Luís Zúñiga. Ecología de los entomostráceos planctónicos de los lagos nord-patagónicos.
1986. Cèlia Marrasé. Experimentos multifactoriales con plancton marino en microcosmos.
1987. Jordi Catalan. Limnologia de l'estany Redó (Pirineu Central). El sistema pelàgic d'un llac profund d'alta muntanya.
1987. Ricardo Génova. Análisis y significado de los anillos de crecimiento en dos especies forestales: *Pinus uncinata* y *Pinus silvestris* en la Península Ibérica.
1987. Emilia Gutiérrez. Dendrocronología de *Fagus silvatica*, *Pinus uncinata* y *P. silvestris* en Catalunya.
1987. Sergi Sabater. Estudi de les poblacions d'algues del riu Ter.
1988. Xavier Tomàs. Diatomeas de las aguas epicontinentales saladas del litoral mediterráneo de la Península Ibérica.
1988. Ricardo Iglesias. Diversidad taxonómica y ataxonómica en poblaciones de insectos: un ejemplo del ecosistema restinga.
1988. Antoni Palau. El embalse de Baserca (Pirineos centrales, Lérida). Estudio limnológico de un embalse nuevo de alta montaña con bombeo.
1989. Olga Delgado. Sistema carbónico-carbonatos en el Mediterráneo noroccidental y relación con las principales comunidades fitobentónicas productoras de carbonatos.
1990. Agustín Lobo. Estudios sobre la organización espacial del bentos marino. Una aproximación a través del análisis de imagen digital y de la modelización.
1990. M. José Gil. Estudios sobre ácaros de aguas continentales españolas.