FILAMENTOUS GREEN ALGAE OF SPAIN: DISTRIBUTION AND ECOLOGY

J. Cambra[1] and M. Aboal[2]

1. Departamento de Biología Vegetal. Facultad de Biología. Universidad de Barcelona. Avgda. Diagonal, 645. Barcelona 08028. Spain.
2. Departamento de Biología Vegetal (Botánica). Facultad de Biología. Universidad de Murcia. Campus de Espinardo. Murcia 30100. Spain.

Keywords: Filament, Green Algae, Flora, Distribution, Ecology, Spain.

ABSTRACT

A survey on the studies of filarnentous green algae in Spain is presented. The main part of the information was produced by Margalef in the 50's. Recently, there is an increasing interest on filarnentous green algae. Data on distribution and ecology are compiled.

INTRODUCTION

The relative importance of macrophytes in benthic communities is much more higher in freshwater than in marine habitats dominated by macroalgae. In epicontinental waters benthic communities are composed mainly of microalgae in close relationship with phanerogamic macrophytes.

Most of the microscopic benthos of freshwater habitats have such a passive role like plankton but they have reduced their losses by sedimentation to zones outside the photic zone. In lakes and especially small ponds, primary production of littoral and benthic algae is twice that of plankton one and the production of macrophytes is higher than both together (MARGALEF, 1983).

Filamentous green algae constitute an important component of algal communities in freshwater habitats. Nevertheless, their enormous morphological plasticity and the difficulty of observing some features have complicated their taxonomy. These and other facts explain the scarcity of data on their ecology.

On a worldwide scale there is a lack of information as regards their geographical distribution and it seems necessary to undertake a taxonomical review of some of these algal groups.

The filament is an excellent adaptative form: the plant grows rapidly in length and can use new volumes of water maintaining the area/volume ratio constant. Branches represent a variation which permit the algae a better use of water in confined spaces and a better control of absorption (MARGALEF, 1983).

A sucession from simple filaments with fast growth to branched filaments with a slower growth can be observed very frequently in freshwater ecosystems (MARGALEF, 1983).

FLORA. DISTRIBUTION.

The most important contribution to our knowledge of Spanish algal flora was made by ALLORGE & ALLORGE (1930), ALLORGE & MANGUIN (1941), BESCANSA (1907, 1908), CABALLERO (1942, 1945, 1947, 1950), GONZALEZ GUERRERO (1927, 1931, 1940a,b, 1942, 1946, 1953, 1960), LEWIN (1888) and MARGALEF (1944,1946a y b, 1947, 1948, 1949a y b, 1950, 1951, 1952a y b, 1953, 1955, 1956, 1957).

A total of 431 filamentous green algae taxa were recorded (ALVAREZ COBELAS, 1983; ALVAREZ COBELAS & GALLARDO, 1986; CAMBRA, 1985).

More recently new reports were presented (CAMBRA, 1987, 1988, 1989 a y b; SABATER, 1989; ABOAL, 1988 a y b, 1991, 1992).

The most frequently cited genus was *Oedogonium* (fig. 1) followed by *Spirogyra* and *Mougeotia* and the most important order is *Zygnematales* (fig. 2).

Lininetica, 8: 213–220 (1992)

Oedogonium prefers softwater rich in humic compounds and iron. In such conditions a relatively high number of species can cohabit without any indication of competition

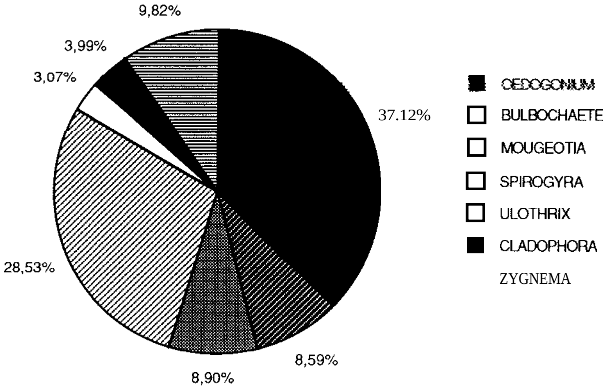

Figure 1. Floristic diversity of filamentous greeii algae in Spain

and with more or less synchronic reproduction. Very often some related forms are collected at thc same site and time, suggesting the possibility of polyploid series. Some experimental data supports this hypothesis (HASITSCHKA-JENTSCHKE, 1960). The *Oedogonium* live mainly as epiphytes on macrophytes.

Spirogyra (and other Zygnematacean taxa) has a wider ecological range (HOSHAW & McCOURT, 1988). It probably prefers softwater but it can also been collected in saltwatcr. Many species are cosmopolit but a great number of them have a more restricted distribution. The existence of autopolyploids was shown several times in the laboratory (HOSHAW *et al.*,1985,1987) and in the field(WANG *et* al., 1986). These polyploids are considered different species in classical monographs. In fact, there is an overestimation of the number of *Spirogyra* species (as in *Oedogonium*). Probably 30% of Spanish *Spirogyra* species are really polyploids. WANG eral., (1986) found a correlation between an altitudinal gradient and the ploidal level. With the data available, it is impossible to test this hypothesis in Spain. Further efforts are necessary to confirm the relationship of morphology and ploidy with ecology in *Spirogyra* and related genera. LEWIS (1980) in studies of many higher plants showed that physiological ranges and ecological niches differ for different ploidal forms of plants.

Ulothrix includes several species with a very simple morphology and rather different physiology and ultrastructure. The most conspicuous species (U. *zonata*) has several physiological races inhabiting very different saprobic conditions.

Sphaeroplea is probably broadly distributed in temporal ponds from arid regions but due to its short life cycle it has been cited very few times.

Cladophoraceae are characterized by multinucleate cells and may form uniseriate (*Rhizoclonium*) or branched (*Cladophora*) filaments. All of them are typical of alkaline waters and support a very diversified community of epiphytes (like *Oedogonium* but unlike *Spirogyra*)

Chaetophoraceae has a very evolved thallus with prostrate and erect portions. The presence of mucilage is relatively frequent Thcy are very common but fairly incospicuous on flowing waters on rocks or macrophytes.

The main contribution to the study of aquatic biocenosis in Spain was undertaken by MARGALEF (1944, 1946, 1947, 1948, 1949c, 1951b, 1952b, 1955 a y b, 1958). He described a total of 40 associations of which 23 were referred to filamentous green algae.

The following paragraphs are devoted to a synthetic approach to the distribution of filamentous algae in Spanish aquatic systems.

Temporary stagnant waters

Temporary stagnant waters (pools, ponds, rice fields, peat-bogs) are the most widespread water system all over Spain. Organisms inhabiting these must survive to periodi-

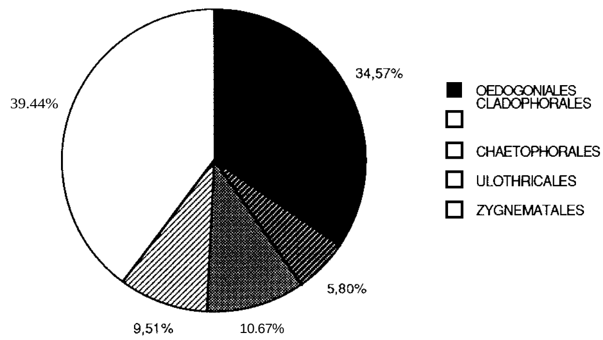

Figure 2. Species numbei ol the main studied orders of Chlorophyta.

cal drought and usually produce durable cells or spores: oospores or zygospores (*Bulbochaete*, *Spirogyra*, *Oedogonium*, *Sphaeroplea*). These are the dominant genera in all kinds of temporary waters.

If we compare the flora of Spain's geographical regions it can be observed that the Atlantic Basin has the highest taxa richness (fig. 3) and the Alpine region is the lowest, althought in this late case, the relatively low number of species recorded is related with the scarcity of data and the difficulty in finding fructified material(indispensable for species identification).

In the Atlantic systems (fig. 4), *Oedogoniaceae* are the doininant group: *Oedogonium* and *Bulbochaete* together represent 63% of the total number of taxa. In these systems, *Oedogoniaceae* are accompanied by many *Tribonema* and Desmids species and constitute a community which is very frequent in Northern Europe (MARGALEF, 1955).

The Mediterranean freshwater systems (fig. 4) are dominated by *Zygnemataceae* (73%).

The algal communities of endorrheic lagoons are similar to the Mediterranean communities, with a great number of *Zygnemataceae*. However, the relative proportion of *Vaucheria* species is higher.

In alpine teniporary waters the percentage of *Zygnemataceae* (i.e. *Zygogonium ericetorum*) is slightly higher than that of *Oedogoniaceae* but they are usually sterile.

Ulothrichales are well represented in peat-bogs and acid waters (i.e. *Binuclearia tectorum*, *Chlorhormidium crenulatum*, *C.mucosum*, *Microspora pachiderma*, *M.amoena*) but much more floristic information is required.

Rice fields are located on the Eastern coast of Spain. Important algal growths of *Sphaeroplea annulina*, almost completely covering the water surface can be observed at the beginning of the cultivation. *Hydrodictyon reticulatum* rnay develop a thallus of several meters. Later on, before harvest, *Cladophora* masses became dominant.

In more permanent waters, which do not dry up in summer, the filamentous masses of *Oedogonium*, *Spirogyra* and others are replaced by *Cladophora fracta* and *C.glomerata v.crassior* mats, in mesotrophic and eutrophic waters (MARGALEF, 1983). In this more stable situation, the macroalgal filaments are covered by many Chaetophoralean epiphytes (*Aphanochaete repens*, *Coleochaete scutata*, *Gloeoplax weberi*, *Protoderma viride*).

In brackish or saline waters (endorrheic or coastal lagoons), algal mats of *Rhizoclonium hieroglyphicum*, *Chaetomorpha sp.pl.*, *Cladophora glomerata var.crassior*, *C.sericea*, *C.vagabunda* are dominant (fig.4). *Zygnematales* and *Oedogoniales* are not frequent (i.e.*Oedogonium capilliforme*, *Spirogyra monserratii*, *S.subsalsa*, *S.micropunctata*).

Flowing waters

In flowing waters the most widespread species is *Cladophora glomerata*, especially in mesotrophic alkaline waters (MARGALEF, 1983), although it can be collected in a very

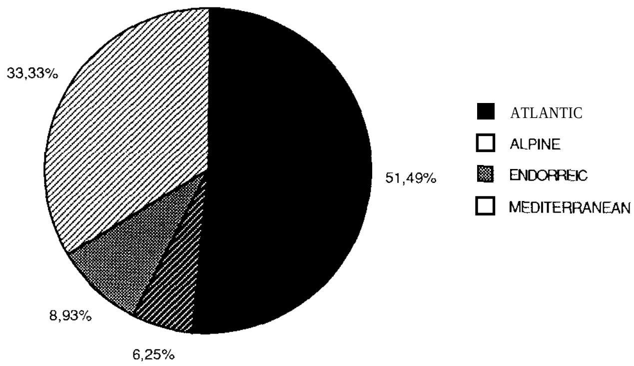

Figure 3. Species number of filamentous algae in several biogeo graphic areas of Spain.

wide ecological range from oligotrophic to heavily organic polluted waters (ABOAL, 1989a; SABATER,1987). Several filamentous green microalgae can live on *Cladophora* cells (*Aphanochaete polychaete*, *Coleochaete orbicularis*, *Microthamnium strictissimum*, *Uronema confervicultum or Protoderma viride*).

Other groups such as *Chaetophorales* and *Ulothrichales* can develop important growths depending on the alkalinity values and water nutrient content (ABOAL. 1987: SABATER, 1982, 1987).

Draparnaldia glomerata and *D.mutabilis* frequently cover the aquatic phanerogams or rocks in the littoral zone of slowly flowing streams with relatively low conductivity and low level of nutrients (ABOAL, 1987, 1989).

Attached to the aquatic phanerogarn roots several species of *Stigeoclonium* can he found in alkaline flowing waters, from oligo-mesotrophic (*S.longipilum*, *S.nanum*, *S.subsecundum*, S.*variabile*) to heavily polluted (*S.tenue*).

The hemispherical lobulated thalli of *Chaetophora* species cover rocks or rnacrophytes in several flow conditions but always in pure alkaline water: *Ch.glomerata* is rnainly epiphytic and *Ch.incrassata* is epilithic. Both can develop a very hard encrustation.

Sorne of these filamentous algae strongly adhered to rocks and are usually intensely encrusted. They constitute a very important and very inconspicuous portion of benthic communities (*Gongrosira*, *Chloroclonium*). Species of *Gongrosira* can inhabit both saltwater and freshwater streams (*G.debaryana*, *G.incrustans*) and can even grow on macroalgae such as *Cladophora* (*G.scourfieldii*). The only known species of *Chlorotylium* (*Ch.cataractarum*) is characteristic of pure fast flowing waters all around the world (ABOAL, 1989c).

Masses of filaments of some *Ulothrix* species can be accumulated in some littoral river ponds (*U.moniliforme, U.oscillarina, U.subtilissima, U.tenerrima, U.zonata)* from oligotrophic to eutrophic waters and from low to high conductivity. Very often these species are entangled with other Ulothrichacean algae such as: *Geminella interrupto, G.minor, G.ordinata* (usually in waters with high nutrient content), *Klebsormidium flaccidum K.subtile* (sometimes in aerial conditions) or *Microspora abbreviata, M.quadrata, M.stagnorum y M.tumidula* (almost always in eutrophic waters), (ABOAL,1988b).

Zygnematacean species are present even in fast flowing riffles (but they are much more diversified in littoral ponds). Very often *Spirogyra, Mougeotia* and *Zygnema* filaments are entangled but *Spirogyra* forms zygospores more frequently. Recent studies have considerably enlarged the distribution of some of these (poorly known) taxa and some new species have been described (ABOAL, 1991, 1992).

Oedogoniaceae, especially *Bulhochaete* species are very common epiphytes on *Chara* but can cover bottom stones too, always in oligotrophic waters. *Oedogonium* prefers phanerogamic macrophytes and littoral zones. This algal group is poorly diversified in alkaline waters and its reproduction is mainly asexual with the very rare formation of oospores (ABOAL, 1989c).

Temporal rivers have some stretches which dry out in the summer months with or without flowing water. In any case,

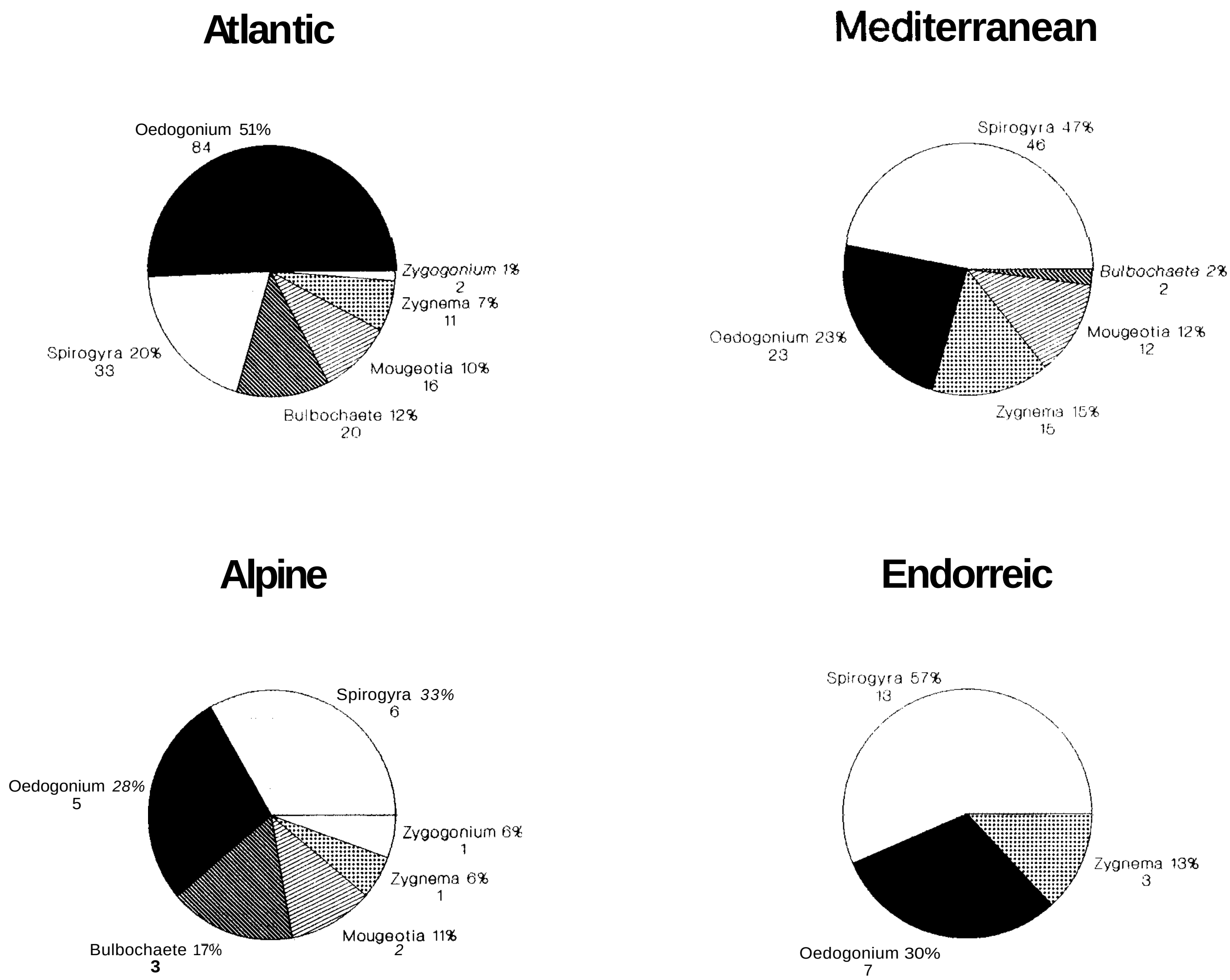

Figure 4. Floristic diversity of spore-producting genus of filamentous algae in several areas of Spain

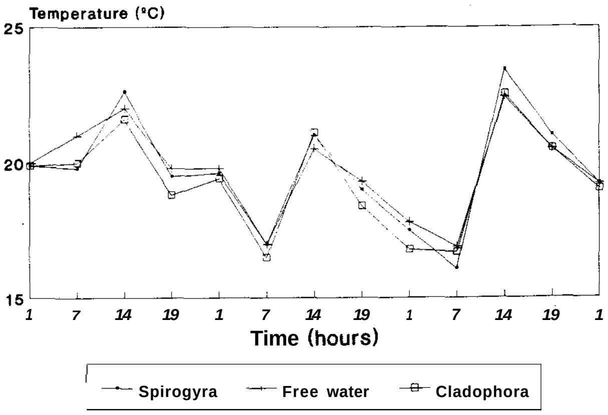

Figure 5. Diurnal three-day changes of temperature water values of Spirogyra and Cladophora.

speed flow is highly reduced in summer and algal communities are closer to those of stagnant waters . The dominance of *Cladophora* and *Vaucheria* is clear at the beginning but later on great algal mat masses are developped with *Hydrodictyon, Enteromorpha, Spirogyra, Zygnema* and *Oedogonium* entangled with macrophytes such as *Lemna*. In these temporal rivers, very hard encrusted *Cladophora* is accumulated in littoral zones.

Saltwater streams are relatively frequent in some Spanish regions (SE region). In these habitats algal flora is clearly dominated by filamentous green algae: *Rhizoclonium hieroglyphicum, Cladophora glomerata* and *Chaetomorpha gracilis* cohabiting with several species of Enteromorpha: *E.flexuosa, E.intestinalis, E.compressa* (ABOAL, 1986).

All available information refers to alkaline rivers of Mediterranean Basin.

Lakes

The littoral of lakes is usally covered by a more or less dense phanerogamic vegetation. Among these populations, except in Alpine lakes, local growths of filamentous algae are frequently observed. They are attached to vascular plants in the early spring and during summer they break away and float (CAMBRA, 1990). However, the species richness of filamentous algae is much lower than in temporary waters.

In Alpine lakes there is little filamentous algae diversity. Occasionally there are local growths of *Binuclearia tectorum, Oedogonium* sp. and especially *Spirogyra* sp. (CAMBRA, 1990). On the other hand, alkaline lakes support an important biomass of *Cladophora fracta* with *Coleochaete scutata, Gloeoplax weberi, Protoderma viride and Rhizoclonium hieroglyphicum.* In such systems, very few species of *Spirogyra* have been recorded (*S.longata, S.majuscula*); they usually appear in early spring and are substituted in early summer by an intense growth of *Cladophora.*

In coastal saltmarshes the chloride concentration reaches very high values (CAMBRA, 1980) determining the composition of filamentous populations. In oligohaline waters *Cladophora glomerata var.crassior* and specially *Rhizoclonium hieroglyphicum* are dominant all year round. They cohabit with *Aphanochaete repens, Epilobium dermaticola, Oedogonium capilliforme, Ulothrix flacca and Uronema africanum.* In mesohaline waters some Ulvophycean such as *Enteromorpha* and *Monostroma* can appear.

ECOLOGY

Our knowlege of filamentous green algae ecology is very scarce and fragmentary.

There are very few data concerning the amount of filaments living in a certain volume of water: 10-1000m/l (MARGALEF, 1983). *Spirogyra* and *Cladophora* may triplicate their own biomass in only three days and even faster during some periods.

Mats of filaments decrease water turbulence. The gas bubbles produced by photosynthesis facilitate the detachment of filaments. These free-floating algae receive a very intense irradiation and become yellow-green. They seem to be fairly active but, in fact, even when their chlorophyll content is lower their net photosynthesis is higher. In laboratory studies (ADRIAN & LEMBI,1991) when the ilumination is reduced they recover their former status. Chlo-

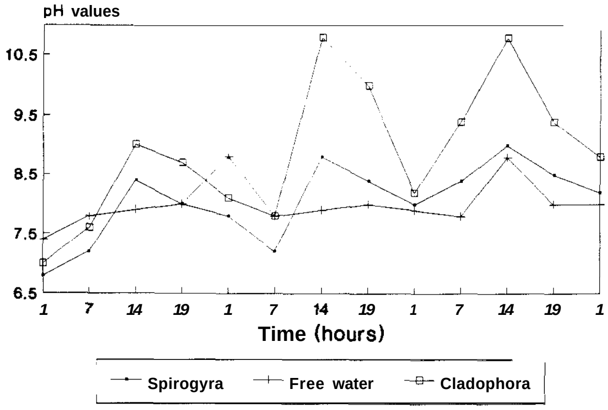

Figure 6. Diurnal three-day changes of pH values of Spirogyra and Cladophora.

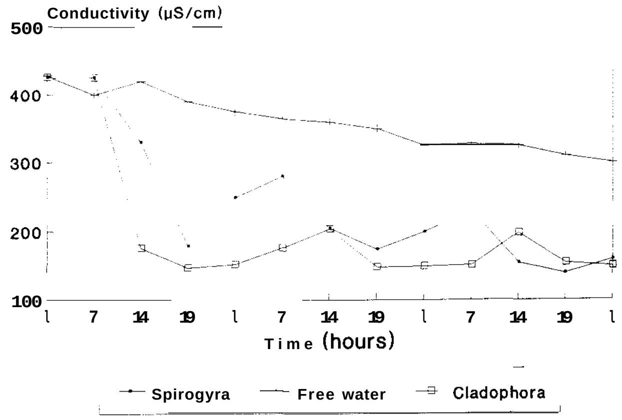

Figure 7. Diurnal three-day changes of conductivity water values of Spirogyra and Cladophoi-a.

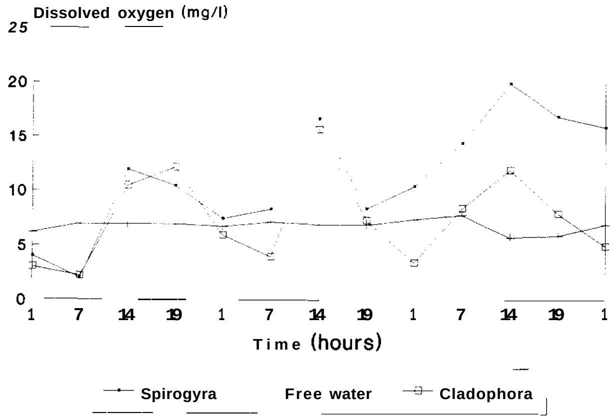

Figure 8. Diurnal three-day changes of dissolved oxygen values of Spirogyra and Cladophora.

rophyll a content of filamentous algae is about 0.5-2.4 % of its dry weight (MARGALEF, 1983) and in *Cladophora* may represent about 112 mg/m^2 (SABATER, 1988). These high values pose a question as regards the significance of algae in the the food chain. Usually it is thought that herbivores prefer to graze Diatoms and other epiphyte microalgae, but the main source of food for some insect larvae and freshwater fishes are *Zygnemataceae*, *Oedogoniaceae* and *Ulothrichales*, at least in Mediterranean temporary rivers (PUIG & ABOAL, inéd. dat.). The exact role of herbivors in the control of populations must be studied.

In stagnant waters these filamentous mats may function by pumping nutrient-rich deep water and transfering warm water horizontally due to the gradient of temperature (0.5-6ºC warmer between filaments than in free water (MARGALEF, 1983). In other situations this variation of teinperature is not observed (fig. 5). On the other hand, algal mats filter light and may absorb up to 99% of incident radiation (MARGALEF, 1983). Below the mats light intensity is very low and conditions ai-e nearly anoxic (CAMBRA & DOMINGUEZ-PLANELLA, 1990).

In a comparative study in stagnant water over a period of three days between water with and without filaments of *Cladophora-Spirogyra* we observed: no variation of temperature (fig. 5) , the highest PH value in the interfilament of *Cladophora* (fig. 6), maximum conductivity for *Spirogyra* earlier in the morning than for *Cladophora* (fig. 7), and a considerable effect of fauna respiration in the dissolved oxygen on *Cladophora* (fig. 8).

In temporary rivers *Cladophora* plays an important role. In Matarraña River(Ebro basin) was not possible to observe important variations of temperature between bare boulder, algal mat surface and below the algal mat. Dissolved oxygen values decrease (even when all of them represent oversaturation) from bare boulders to water below algal mats. The minimal dissolved oxygen values (maximal respiration) extends each time over longer periods from bare boulders to below mats. Moreover, masses of filaments increase oxygen content superficially, not in depth, and gas bubbles are carried away by flow to close-by waters. In late summer in ponds, *Cladophora* masses may reach several meters in length and constitute a free floating mat that remains for different periods of time (never more than a month). At this time, a typical community of epibionts lives on filaments and mats soften environmental conditions: a difference of 10ºC was registered between mat surface and free water (GROSSMAN *et al.*, 1986).

As a conclusion, it can be said that many areas of Spain remain unexplored from the algological point of view even though very interesting findings can be expected in a country characterized by its extremely high environmental diversity. From the ecological point of view , we can only agree with Margalef (MARGALEF, 1983) when he was surprised at the evident incapacity of biologist to make use of the excellent experimental material represented filamentous green algae.

REFERENCES

ABOAL. M.,1986. Flora algal de la Rambla del Tinajón (Río Segura, Murcia, SE de España. *Limnetica*, 2: 103-108.

ABOAL, M., 1987. *Flora algal epicontinental de la Cuenca del Segura, SE de España*. Ph. Doctoral Thesis. Facultad de Biología. Universidad de Murcia.

ABOAL, M., 1988a. *Zygnemataceae* (*Conjugales, Chlorophyceae*) of the River Segura Basin, Southeastern Spain. *Nova Hedwigia*, 47(3-4): 389-402.

ABOAL. M., 1988b. Aportación al conocimiento de las algas del SE de España.VII. Clorofíceas (*Chlorophyceae* Wille in Warming 1884). *Candollea*, 43: 521-548.

ABOAL, M., 1989a. Los poblamientos algales bentónicos del Río Segura y su relación con la calidad del agua. *Candollea*, 44: 199-208.

ABOAL, M., 1989b. Flora algal del Río Benamor (Cuenca del Segura, SE de España). *Limnetica*, 5: 1-11.

ABOAL, M., 1989c. Epilithic algal communities from the River Segura Basin, Southeastern Spain. *Arch. Hydrobiol.*, 106 (1): 113-124.

ABOAL, M., 1991. New records of *Zygnemataceae* (*Zygnemales*, *Chlorophyceae*) from Southeastern Spain. *Nova Hedwigia*, 52 (3-4): 365-373.

ABOAL, M., 1992. A new species of *Zygnema (Zygnematales,)* from Southeastern Spain. *Algological Studies*, 65. (in press).

ADRIAN, H. L. & C. A. LEMBI., 1991. Effects of light and temperature on growth, photosynthesis and chlorophyll content of *Spirogyra. 4th International Phycological Congress*. Durham. North Carolina. USA.

ALVAREZ COBELAS, M.,1984. Catálogo de las algas continentales españolas. III. *Zygophyceae* Widder, 1960. *Collect Bot.*, 15: 17-37.

ALLORGE. V. & P. ALLORGE., 1930. Hétérocontes, Euchlorophycées et Conjuguées de Galice. *Rev. Algol.*, 5: 327-382.

ALLORGE, P. & E. MANGUIN.,1941. Algues d'eau douce des Pyrénées basques. *Bull. Soc. Bot. France*. SS: 159-191

ALVAREZ COBELAS, M. & T. GALLARDO, 1986. Catálogo de las algas continentales españolas. IV. *Chlorophyceae* Wille in Warming 1884, *Prasinophyceae* T. Christensen ex Silva 1980. *Acta. Bot. Malacitana*, 11: 17-38.

BESCANSA. F.,1907. Algunas conjugadas de la provincia de Orense. *Bol. R. Soc. Esp. Hist. Nat., 7*: 65-68.

BESCANSA, F., 1908. Conjugadas para la flora de Galicia. Bol. R. Soc. *Esp. Hist. Nat.*, 8: 234-238.

CABALLERO, F., 1942. Contribución al conocimiento de la flora algológica de España. *An. J. Bot. Madrid*, 3: 299-320.

CABALLERO, F., 1945. Algas de las aguas de Santillana. *An. J. Bot. Madrid*, 5 (2): 345-364.

CABALLERO, F. ,1947. Una *Mougeotia* nueva de Guadalupe. *An. J. Bot. Madrid*, 8: 285-295.

CABALLERO, F., 1950. Algas de Gredos. *An. Inst. Bot. Cavanilles*, 10 (1): 231-260.

CAMBRA, J.,1985. Catalègs de les especies de cianofícies i d'algues continentals y del plancton mari dels Països Catalans. Annex I: 501-522. In: *Historia Natural dels Països Catalans. Plantes Inferiors. X*. LLIMONA (ED.). ENCICLOPEDIA CATALANA S.A.

CAMBRA, J., 1987. Flore et végétation algologiques des eaux épicontinentales de la Réserve Naturelle des Vallées d'Ordesa (Pyrénées Aragonaises). *Candollea*, 42: 475-490.

CAMBRA, J., 1989a. Fresh water algae from the Cape of Creus Peninsula, Catalonia (NE Spain). *Nova Hedwigia*, 49 (3-4): 281-321.

CAMBRA, J., 1989b. Contribución al conocimiento del género *Oedogonium* en España.I. *Acta Bot. Malacitana*, 14: 201-206.

CAMBRA, J.,1990. *Estudi sobre les algues epifítiques en sistemes lacustres*. Tesis Doctoral. Univ. Barcelona.

CAMBRA, J., 1991. Contribució a I'estudi de les algues epifítiques dels estanys de Banyoles, Basturs i Estanya. *Orsis*, 6: 27-44.

CAMBRA, J. & A. DOMINGUEZ-PLANELLA., 1990. Datos para el estudio de las algas filamentosas en arrozales de l'Alt Empordà (Girona, NE de España). *Scientia Gerundensis*, 16(2): 43-53.

GONZALEZ GUERRERO, P. ,1927. Contribución al estudio de las algas y esquizófitas de España. *Trab. Mus. Ciencias*, 22: 1-52.

GONZALEZ GUERRERO, P., 1931. Algunos datos algológicos de la Península Ibérica, Baleares y Marruecos. *Bol. R. Soc. Esp. Hist. Nat.*, 31: 633-639.

GONZALEZ GUERRERO, P., 1940a. Observaciones ficobiológicas en aguas de Valencia. *An. J. Bot. Madrid*, 1: 107-140.

GONZALEZ GUERRERO, P. , 1940b. Novedades biológicas en algas de Cuenca. *An. J. Bot. Madrid, 1*: 107-140.

GONZALEZ GUERRERO, P., 1942. Algas del norte y centro de España. *An. J. Bot. Madrid*, 3: 269-278.

GONZALEZ GUERRERO, P., 1946. Algas invernales gaditanas. *An. J. Bot. Madrid*, 7: 433- 456.

GONZALEZ GUERRERO, P., 1953. Datos estivales de las algas pacenses. *An. Inst. Bot. Cavanilles*, 12: 5-76.

GONZALEZ GUERRERO, P., 1960. Algas de Aragón. *An. Ins. Bot. Cavanilles*, 18: 149-197.

GROSSMAN, G.; LOBON-CERVIA, J; PUIG, M. A. & A. de SOSTOA., 1986. *Relaciones ecológico-ambientales de algunas comunidades de peces del río Mararraña*. Proyecto del Comité conjunto Hispano-Norteamericano de Cooperación científica y técnica. Annual Report 1986.

HASITSCHKA-JENSCHKE, G., 1960. Vergleichende Untersuchungen an haploiden und durch Colchicineinwirkung dipioid gewordenen Stämmen von *Oedogonium cardiacum. Österr. Bor. Zeitsch., 107: 194-211.*

HOSHAW, R. W. & R. M. McCOURT., 1988. The *Zygnemataceae* (*Chlorophyta*): a twenty-year update of research. *Phycologia*, 27(4): 511-548.

HOSHAW, R. W.; WANG, J.C.; McCOURT, R. M. & H. M. HULL., 1985. Ploidal changes in clonal cultures of *Spirogyra communis* and implications for species definition. *Amer. J. Bot.*, 72 (1): 1005-1011.

HOSHAW, R. W., WELLS, C.V. & R. M. McCOURT., 1987. A polyploid species complex in *Spirogyra maxima* (*Chlorophya, Zygnemataceae*): a species with large chromosomes. *J. Phycol.*, 25: 267-273.

LEWIN, M., 1888. Uber Spanische Süsswasseralgen. *Bih. Svensk. Vedensk. Akad. Handl. Avdl.*, 14 (1): 1-24.

LEWIS. W. H., 1980. *Polyploidy: biological relevance.* Plenum Press, New York.

MARGALEF, R. ,1944. Datos para la flora algológica de nuestras aguas dulces. *Publ. Inst. Bot. Barcelona*, 4 (1), 130 pp.

MARGALEF, R., 1946a. Materiales para el estudio del Lago de Bañolas (Gerona). *P. Inst. Biol. Apl.* 1: 27-78.

MARGALEF. R., 1946b. Contribución al conocimiento hidrobiológico del País Vasco-Navarro. Aportación al estudio de la fauna y flora vasco-navarra (Sierra de Aralar). *Inst. Est. Pirenaicos,* 44 pp.

MARGALEF, R., 1947. Materiales para una flora de las algas del NE de España. I. *Zygnematales.* I vol.I, fasc. II, nº 9: 1-21.

MARGALEF, R., 1948. *Flora, fauna y comunidades bióticas de las aguas del Pirineo de la Cerdaña.* Inst. Est. Pirenaicos. 226 pp.

MARGALEF, R.,1949a. Datos para la hidrobiología de la Sierra de Guadarrama. *P. Inst. Biol. Apl.*, 6: 5-21.

MARGALEF, R. ,1949b. Materiales para una flora de las algas del NE de España. III. *Euchlorophyceae. Coll. Bot.*, 2 (2): 234-293.

MARGALEF, R., 1949c. Las asociaciones de algas en las aguas dulces de pequeño volumen del nordeste de España. *Vegetatio,* 1: 258-284.

MARGALEF, R., 1950. Datos para la hidrobiología de la Cordillera Cantábrica, especialmente del Macizo de los Picos de Europa. *P. Inst. Biol. Apl.*, 7: 35-76.

MARGALEF, R., 1951a. Materiales para la hidrobilogía de la isla de Ibiza. *P. Inst. Biol. Apl.*, 8: 9-70.

MARGALEF, R., 1951b. Regiones limnológicas de Cataluña y ensayo de sistematización de las asociaciones de algas. *Collect. Bot.*, vol. 111, fasc. I, nº 2: 43-67.

MARGALEF, R., 1952a. Materiales para la hidrobiología de la isla de Menorca. *P. Inst. Biol. Apl.*, 11: 5-112.

MARGALEF, R., 1952b. *La vida en las aguas dulces de Andorra. Monograf. Inst. Est. Pirenaicos,* 69, 107 pp.

MARGALEF, R., 1953. Materiales para la hidrobiología de las isla de Mallorca. *P. Inst. Biol. Apl.*, 1S: 5-111.

MARGALEF, R., 1955. Comunidades bióticas de las aguas dulces del NO de España. *P. Inst. Biol. Apl.*, 21: 5-85.

MARGALEF, R., 1955. *Los organismos indicadores de la Limnología.* Ministerio de Agricultura Ed. 300pp.

MARGALEF, R., 1956. Materiales para una flora de las algas del NE de España. VII. Suplemento. *Collect. Bot.*, vol. V, fasc. II, nº 2: 87-107.

MARGALEF, R., 1957. Materiales para una flora de las algas del NE de España. VIII. Suplemento. *Collect. Bot.*, vol. V, fasc. II, nº 15: 353-365.

MARGALEF, R., 1958. Trophic typology verus biotic typology, as exemplified in the regional limnology of Northern Spain. *Verh. intern. Verein Limnol.*, 13: 339-349.

MARGALEF, R., 1983. *Limnología.* Omega. 1010 pp.

MARGALEF, R.; PLANAS, M. D.; ARMENGOL, J.; VIDAL, A.; PRAT, N.; GUISSET, A.; TOJA, J. & M. ESTRADA., 1976. *Limnología de los embolses españoles.* MOPU. Madrid. 422 pp.

SABATER, S., 1982. *Estudio de lqa sucesión ecológica de una población algal en l'Avençó (Montseny).* Graduate St. Dissert. Barcelona Univ.

SABATER, S., 1987. *Estudi de les poblacions d'algues del riu Ter.* Ph. Doctoral Thesis. Barcelona Univ.

SABATER, S., 1988. Composición y ciclos de pigmentos clorofílicos en las poblaciones del fitobentos del río Ter durante un periodo de nueve meses. *Oecologia aquatica.*, 9: 61-75.

SABATER, S., 1989. Encrusting algal assemblages in a Meditterranean River Basin. *Arch. Hydrobiol.* 114 (4): 555-573.

WANG, J. CH.; HOSHAW, R. W. & R. M. McCOURT., 1986. A poliploid species complex of *Spirogyra communis* (*Chlorophyta*) occurring in nature. *J. Phycol.*, 22: 102-107.