



Flora and water chemistry in a relictic mire complex: the Sierra Segundera mire area (Zamora, NW Spain)

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Abstract

Chemical variables, algae, bryophytes, and vascular plants were determined in twelve mires located in the plateau of the Sierra Segundera range. All the mires studied are minitrophic in relation to water origin, and oligotrophic poor fens in relation to water chemistry. They were classified into two types: (a) 'slope mires', developed in effluent basins or depressions on slopes, usually small in size and poorly developed, and (b) 'basin mires', formed in closed basins, more developed than the previous type, always including hummocks and hollows, and in some cases sedge swamps in the ponds margins. The Sierra Segundera mire system is one of the better conserved mire complexes in the Iberian Peninsula. Bryophyte and vascular plant communities were similar to those in central and northern Europe, although some Mediterranean taxa tolerating water level variation also exist. Diatomaceae were scarce whilst Cyanophyta were relatively common, which differentiate those mires from northern European ones.

Introduction

Small mire systems are widespread in northern and northwestern Iberian Peninsula, but the biological and chemical nature of these ecosystems is poorly known despite their ecological importance (Margalef, 1955; Simó, 1977; Fernández et al., 1987; Aldasoro et al., 1996). One of the more interesting mire complexes in Spain is the Sierra Segundera mountain range (northwestern Zamora), where more than 20 small lakes and ponds of glacial origin also exist. The first studies in the area were carried out almost fifty years ago (Margalef, 1955), and since then little work has been done.

The aim of the present work is to study the basic chemistry and biological aspects of the different types of mires in the area. We have examined phytoplankton, bryophytes, charophytes and angiosperms in order to classify the mires and to present data for preservation purposes. This study is a continuation of an earlier sur-

vey of northwestern Iberian mire systems (Aldasoro et al., 1996).

Description of sites studied

The mires are situated on the glaciated plateau of the Sierra Segundera mountain range, which includes numerous small basins and valleys. Bedrock consists of acidic orthose-rich gneiss and some granodiorites. The mire complex is fed by groundwater with a very low ionic content due to the low solubility of these rocks. Consequently, mires in the area are minitrophic to some extent, with individual levels depending on the total surface of the drainage area of each mire. Nutrients are well within levels of the poorest peatlands.

Table 1 describes the general features of the mires studied. Sites 1–6 are located on slopes at 1700–2000 m and have small drainage areas. Sites 7–12 are lar-

Table 1. General features of the mires studied

No	Name	Altitude (m)	Total surface (m ²)	Pool surface (m ²)	Max. depth (m)	Hummocks	Sedge swamps	Mire type
1	Truchillas	1950	80	9	0.5	no	no	slope
2	Valdecazares	1800	130	4	0.2	no	no	slope
3	Moncalvo-3	1900	100	15	0.5	no	no	slope
4	Moncalvo-4	1920	150	22	0.5	no	no	slope
5	Puente-Porto	1710	130	54	0.5	no	no	slope
6	Alto Lacillo	1910	114	40	0.6	no	no	slope
7	Padornelo	1730	73000	10800	2.0	no	yes	basin
8	Majadavieja	1620	136300	12100	1.3	yes	yes	basin
9	La Roya	1600	26300	7500	1.6	no	yes	basin
10	Aguas Cernidas	1700	87000	24900	2.5	yes	yes	basin
11	Camposagrado	1690	52600	5000	1.5	no	no	basin
12	La Clara	1590	52500	14000	4.0	yes	yes	basin

ger and lie at lower altitude, 1500–1700 m, in glacial basins filled with morainic sediments.

Annual average temperature at the station located at 1440 m a.s.l. is 5.9 °C and total cumulative yearly rainfall average is 1752 mm. The coldest month is February with a daily average of –2.9 °C and an absolute minimum of –16 °C. The highest temperatures were recorded in July and August when they rise to a mean of 21 °C and a maximum of 32 °C.

Materials and methods

Surface water samples from pools and mires were collected during August 1998. Additional samples were also collected throughout the year in mire 12 to evaluate seasonal changes. Conductivity and pH were measured in the field with a WTW conductivity meter and a WTW pHmeter respectively (corrected for temperature). Alkalinity was also measured in the field by HCl titration with the pHmeter. Chlorophyll samples were extracted with acetone and measured spectrophotometrically. For all other analyses samples were filtered through a Whatman GF/C (~0.7 μm) filter and stored in plastic bottles except for phosphorus where glass bottles were used. Analysis of nutrients, calcium and silicon were made according to Golterman & Clymo (1969), Rodier (1981) and Strickland and Parsons (1965). The phosphomolybdic

acid method was used for phosphate, and total phosphorus was measured after digesting the sample with potassium peroxodisulfate in acid medium at 120 °C and 1.2 atm. For nitrates the samples were reduced in a cadmium column and nitrites were measured using the sulfanilamide method. Dissolved silica was determined with ammonium molybdate and methol, adding oxalic acid to avoid the phosphate interference. Calcium was measured following the methyl-thymol blue (pH 12) method. Water color was measured spectrophotometrically at 380 nm using a 10 cm cell (Alexander & Barsdate, 1971).

A minimum of three algal samples from each site were collected during the summer of 1993, kept in 100 ml plastic bottles and fixed with Lugol. After sedimentation, cells were counted with a Nikon inverted microscope. Fluorescence microscopy was used in some cases to discriminate Cyanophyta and eukaryotic algae. SEM samples were fixed with glutaraldehyde and filtered (Whatman GF/C). Results were expressed as cells/ml. Algal abundance must be used with care due to the variability in frequencies observed at short time intervals as well as between different parts of the mires.

Bryophytes and vascular plants were collected and dried using standard botanical methods. Herbarium vouchers are housed at MA (Royal Botanic Garden at Madrid).

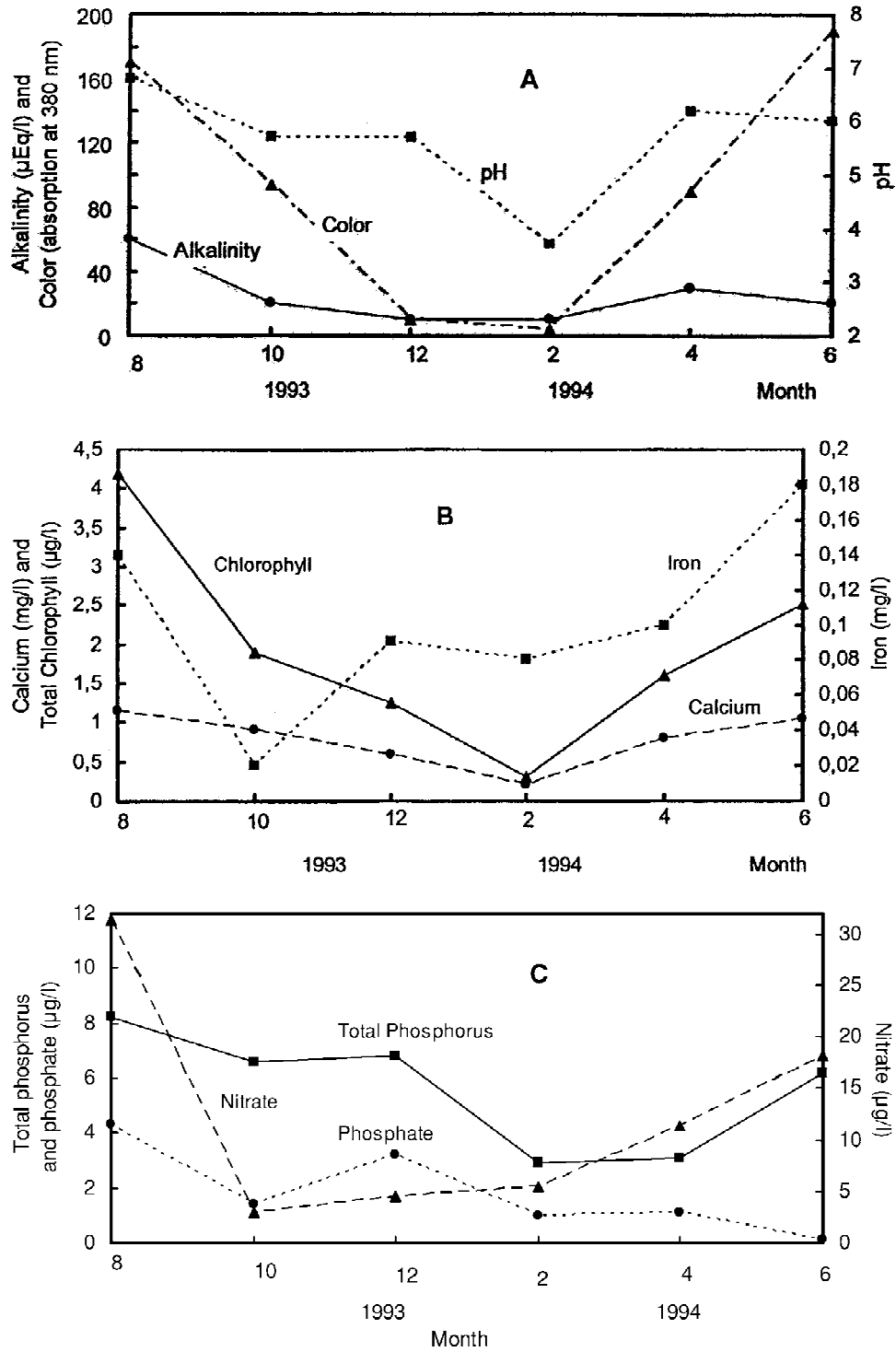


Figure 1. Variation of some values in a 10-month interval (August 1993 – June 1994) in the pool of La Clara mire (n° 12). All values show an increase during the summer months that could be correlated with the higher biological activity associated to the higher summer temperatures. The biological activity comprises both the algal photosynthetic processes and the bacterial respiratory activity. (A) alkalinity ($\mu\text{Eq/l}$), color (absorption at 380 nm), and pH; (B) iron (mg l^{-1}), calcium (mg l^{-1}), and total chlorophyll ($\mu\text{g l}^{-1}$); (C) nitrate ($\mu\text{gN-NO}_3/\text{l}$), phosphate ($\mu\text{gP-PO}_4/\text{l}$), and total phosphorus ($\mu\text{gP/l}$).

Table 2. Chemical features of the mires studied. 1 – Truchillas; 2 – Valdecasares; 3 – Moncalvo³; 4 – Moncalvo⁴; 5 – Puente Porto; 6 – Alto Lacillo; 7 – Padornelo; 8 – Majadavieja; 9 – Roya; 10 – Aguas Cernidas; 11 – Camposagrado; 12a – La Clara, pool and sedge swamps; 12b – La Clara, hollows; 12c – La Clara, hummocks. bl – below limits of detection. nm – not measured

	1	2	3	4	5	6	7	8	9	10	11	12a	12b	12c
Conductivity (S/cm)	15	12	16	17	12	12	7	11	18	18	12	15	24	nm
Alkalinity (Eq/l)	30	80	60	80	40	10	40	90	130	120	30	60	1	nm
pH	4.8	5.2	5.2	5.8	5.6	5.7	6.4	7	7.2	7.1	6.5	6.8	5	3.6
Silicon (mg l ⁻¹)	0.24	0.1	0.49	0.05	0.1	0.03	0.08	0.01	0.36	0.04	0.1	bl	bl	nm
Iron (mg l ⁻¹)	0.11	0.05	0.08	0.05	0.08	0.08	0.23	0.11	0.43	0.18	0.14	0.14	0.04	nm
Ca ⁺⁺ (mg l ⁻¹)	0.92	0.75	0.7	0.96	0.84	0.98	1.17	1.2	1.92	1.5	1.45	1.16	0.1	nm
Nitrate (gN-NO ₃ /l)	14.1	10	18.1	5.7	9.5	9.2	9	39	17.2	14.2	8.9	31.4	3.5	nm
Phosphate (gP-PO ₄ /l)	6.2	9.8	4.7	14.6	9.8	2.7	2.7	1.9	11.2	4.7	3.9	4.3	3.1	nm
N:P atomic ratio	1.59	0.8	4.01	0.32	1.01	0.41	1.92	10.53	3.07	1.40	0.39	8.48	-	nm
Total phosphorus (gP/l)	19.6	27.8	10	39.8	20.8	49.9	10.4	8.2	12.4	22.4	50.8	8.2	8	nm
Chlorophyll (g l ⁻¹)	3	3.2	1	1.2	2.1	4.8	2	11.1	22.1	5.8	4.4	4.2	18.1	nm
Color (absorption at 380 nm)	0.34	0.2	0.14	0.1	0.08	0.32	0.06	0.2	0.48	0.28	0.52	0.17	nm	nm

Results and discussion

Water chemistry

All the mires studied are minerotrophic with no development of ombrotrophic bogs. Mires in the Sierra Segundera system (see Table 2) can be considered as oligotrophic poor fens in the sense of Wheeler & Proctor (2000). We agree with these authors that mire terminology is not always interchangeable among different authors, and thereafter we use the terms **oligo-trophic/eutrophic** in a restricted sense to express the relative availability of nutrients (mainly N and P), and not pH and cations levels. The terms **ombrotrophic** and **minerotrophic** mean, respectively, atmospheric and terrestrial origin of water and nutrients. Finally, the term **bog** defines the mires with pH lower than 5.5, whereas **fen** embraces mires with pH higher than 5.5 (Wheeler & Proctor, 2000). Because all fens studied have very low levels of Ca⁺⁺, conductivity and alkalinity, they have been termed in this study **poor fens**. The higher pH values observed in some of what we call poor fens in relation to bogs could be caused by the high summer temperatures, which could favor a high photosynthetic activity that would increase the pH even under low levels of cations, conductivity, and nutrients (Fig. 1).

The levels of calcium, pH, and alkalinity were usually low, with only minor differences among different mires. Slope mires show lower pH (4.8–5.8) than basin mires, where this variable ranges between 6.4 and 7.2

(Table 2). Some differences could be detected between different parts of each mire, i.e. hollows showing a pH of 5.1, whilst in hummocks it measured 3.6. The observed pH of the pools is slightly higher than in similar environments in northern Europe or America. Tolonen & Hosiainluoma (1978) found values of 3.9 for pools and 3.7 for hollows in Finnish mires, whilst Wells & Zoltai (1985) indicated values of 4.5–5.1 for poor or intermediate fens and 3.8–4.0 for bogs in Canada. Havas (1961) determined a pH value of 5 as the upper limit for bogs, and finally, Eurola & Holappa (1985) and Malmer (1986) stated that values of conductivity <25 μ S, calcium <2 mg l⁻¹, and total phosphorus <50 μ g l⁻¹ were characteristic of oligotrophic mires.

All the mires were relatively poor in nitrate, phosphate, total phosphorus and silicon. Based on the data from mire 12, these variables vary through the year, with the lowest values during the winter and the highest levels during the summer (Fig. 1). N:P atomic ratios were always lower than 16, which indicates N limitation of phytoplanktonic growth (Redfield, 1958). Chlorophyll concentrations were usually moderate even during summer. Water color was higher in basin mires, and usually increased during the summer.

Angiosperm and bryophyte vegetation

The two mire groups have different plant communities: small mires in slopes have few species, whilst the basin mires have several microhabitats differing in species composition (as shown in Table 1).

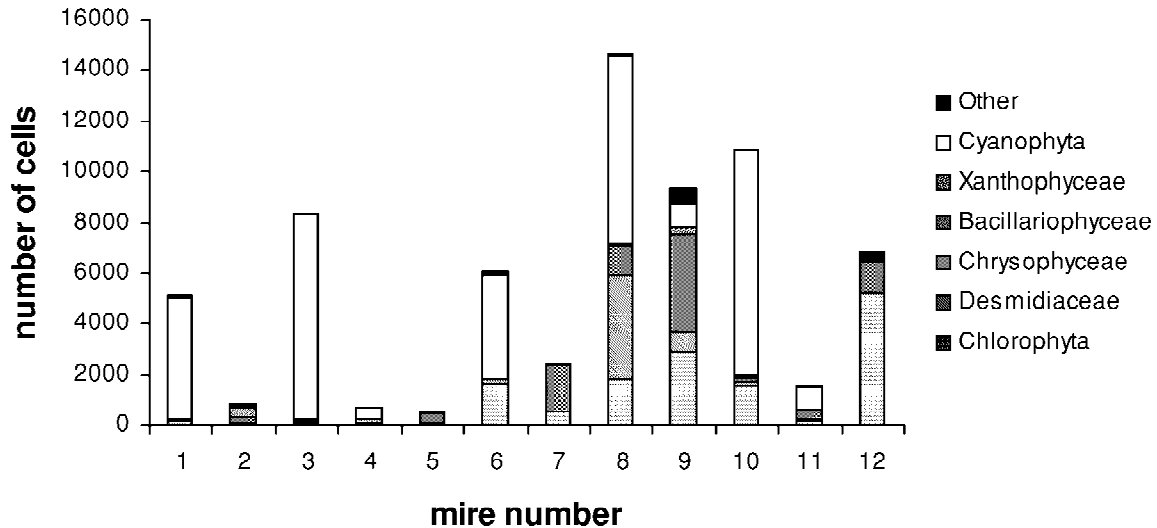


Figure 2. Algal composition of mires studied (1 – Truchillas; 2 – Valdecazares; 3 – Moncalvo³; 4 – Moncalvo⁴; 5 – Puente Porto; 6 – Alto Lacillo; 7 – Padornelo; 8 – Majadavieja; 9 – Roya; 10 – Aguas Cernidas; 11 – Camposagrado; 12a – La Clara, pool and sedge swamps; 12b – La Clara, hollows; 12c – La Clara, hummocks). ‘Chlorophyta’ does not include Desmidiaceae which are treated separately. ‘Other’ combines Euglenophyta, Cryptophyta and Pyrrophyta.

Slope mires (1–5) are characterized by the presence of *Carex curta*, *C. nigra*, *Sphagnum flexuosum*, *S. russowii* and *S. subsecundum*. Occasional intruders from nearby more minerotrophic areas are *Sphagnum denticulatum* and *S. teres*. Floristic composition varied strikingly between different mires, which as a rule have few angiosperm species with few individuals each (Table 6). The small size of these slope mires precludes the development of differentiated microhabitats, and might also result in large trophic differences among different mires.

Basin mires are more complex than slope mires, and further differences could be detected among the mire, pools, and pool shores. The pH and nutrient concentrations are always lower in the mire. No significant differences in chemical composition existed among mires (Table 2). Mires 1–6 are small slope mires whilst mires 7–12 are large and complex basin mires with several differentiated environments which favour higher diversity.

Characteristic species of the basin mires are *Carex limosa*, *Eriophorum angustifolium*, *Menyanthes trifoliata*, *Potentilla palustris*, and *Utricularia minor*. Among mosses, *Sphagnum cuspidatum* and *S. denticulatum* dominate in the pools and the small hollows. Main constituents of carpets are *S. fallax* and *S. papillosum*, whereas in the hummocks dominate species of *Sphagnum* sect. *Acutifolia* like *S. capillifolium* and *S. russowii*. In the center of the pools grow lacus-

trine species such as *Callitriche palustris*, *Isoetes velata*, *Myriophyllum alterniflorum*, *Nitella flexilis*, *Potamogeton natans*, and *Sparganium angustifolium*. Along the shores of the pools sedge meadows develop dominated by *Carex rostrata* where grow some minerotrophic non-mire species grow such as *Antinoria agrostidea*, *Baldellia alpestris*, *Eleocharis acicularis*, *Lythrum portula*, and *Ranunculus peltatus*.

This vegetation pattern is similar to that observed in poor fens in Nordic peatlands. Nevertheless, some species with a Mediterranean mountain distribution such as *Antinoria agrostidea*, *Carex curta*, and *Isoetes velata*, should withstand water table fluctuations in contrast with northern species (Laitinen, 1990). Species such as *Carex limosa* and *Eriophorum angustifolium* are considered characteristic of oligotrophic habitats (Jeglum, 1971; Jankovská & Rybníček, 1988), as are the mosses *Sphagnum cuspidatum*, *S. fallax*, *S. magellanicum*, *S. majus*, *S. russowii*, and *Straminergon stramineum* (Malmer, 1985, 1986; Moen, 1985; Gignac & Vitt, 1990; Gignac et al., 1991). Despite the dominance of oligotrophic taxa, others are usually considered meso-eutrophic, like *Carex nigra*, *C. canescens*, *Menyanthes trifoliata*, *Potentilla palustris*, and, among the mosses, *Sphagnum denticulatum*, *S. teres*, and *Warnstorfia exannulata* (Jeglum, 1971; Horton et al., 1979; Reinikainen et al., 1984). The mixed nature of the vegetation in the basin mires suggests

Table 3. Moss species. Mire numbers as in Table 2

	1	2	3	4	5	6	7	8	9	10	11	12a	12b	12c	12d
<i>Aulacomnium palustre</i> (Hedw.) Schwägr.	-	-	-	-	-	-	+	+	-	+	-	-	+	+	+
<i>Fontinalis antipyretica</i> Hedw.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>Philonotis fontana</i> (Hedw.) Brid.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Polytrichum alpinum</i> Hedw.	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-
<i>P. formosum</i> Hedw.	-	+	-	-	-	-	+	+	+	+	+	-	-	+	-
<i>P. strictum</i> Hedw.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
<i>Scapania undulata</i> (L.) Dum.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Sphagnum angustifolium</i> (Russow) C.E.O. Jensen	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-
<i>S. capillifolium</i> (Ehrh.) Hedw.	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>S. compactum</i> DC.	-	-	+	-	-	-	+	+	+	-	-	-	-	-	-
<i>S. cuspidatum</i> Hoffm.	-	-	-	-	-	-	+	+	-	+	+	-	+	-	-
<i>S. denticulatum</i> Brid.	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
<i>S. fallax</i> (Klinggr.) Klinggr.	-	-	-	-	+	-	+	-	-	-	-	-	+	-	-
<i>S. flexuosum</i> Dozy & Molk.	+	+	+	+	+	+	+	+	+	+	+	-	-	+	-
<i>S. girgenshonii</i> Russow	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
<i>S. magellanicum</i> Brid.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>S. majus</i> (Russow) C.E.O. Jensen subsp. <i>norvegicum</i> Flatberg	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>S. papillosum</i> Lindb.	-	-	-	-	-	+	-	-	+	+	+	-	+	-	-
<i>S. rubellum</i> Wilson	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>S. russowii</i> Warnst.	-	+	+	+	+	+	-	+	+	+	+	-	+	-	-
<i>S. subsecundum</i> Nees	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-
<i>S. subtile</i> (Russow) Warnst	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>S. teres</i> (Schimp.) Ångstr.	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Straminergon stramineum</i> (Brid.) Hedenäs	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>Warnstorfia exannulata</i> (Schimp.) Loeske	-	-	+	+	+	+	-	+	+	+	+	+	+	-	+
<i>Warnstorfia fluitans</i> (Hedw.) Loeske	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-

that these ecosystems are of mixed nature, with an oligotrophic center and mesotrophic margins.

Although all previous taxa might be widespread in peatlands of the northern Iberian Peninsula, they have been rarely reported in the literature. Basin mires in the Sierra Segundera mountain range house rare species seldom or never reported from other Iberian areas. Among these worth mentioning are *Sphagnum majus* subsp. *norvegicum* and *S. subtile*. These reach their southernmost European limit here (Muñoz & Aldasoro, 1995). *Carex limosa*, *C. curta*, *Sphagnum girgenshonii*, and *S. magellanicum* are other rare taxa that have been previously reported from few

localities in the Cantabrian Mountains and Pirineos (Rivas-Martínez & Cantó, 1985; Brugués et al., 1998).

Algal vegetation

Table 5 lists the 230 species of algae identified from the Sierra Segundera mire system. Table 6 shows the species richness for these groups in each mire. The algal flora observed is similar to other European mires and no differences could be established between the more complex systems in northern Europe and these Iberian peatlands, which are at the southernmost limit of mire development in Europe. N:P atomic ratio was significantly correlated with the cell number ($r =$

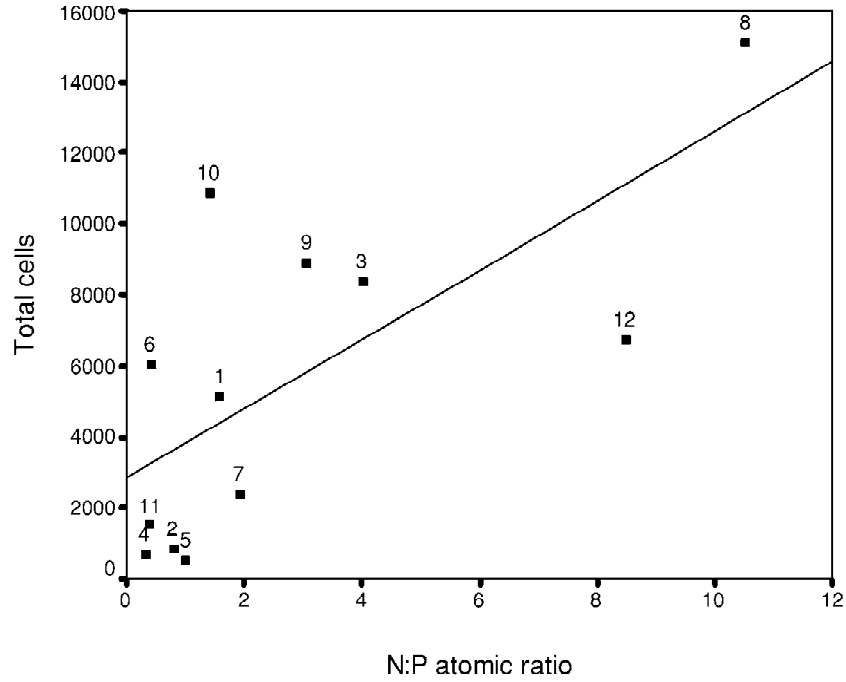


Figure 3. Bivariate correlation plot of total cell number and N:P atomic ratio. Mire numbers like in Figure 2.

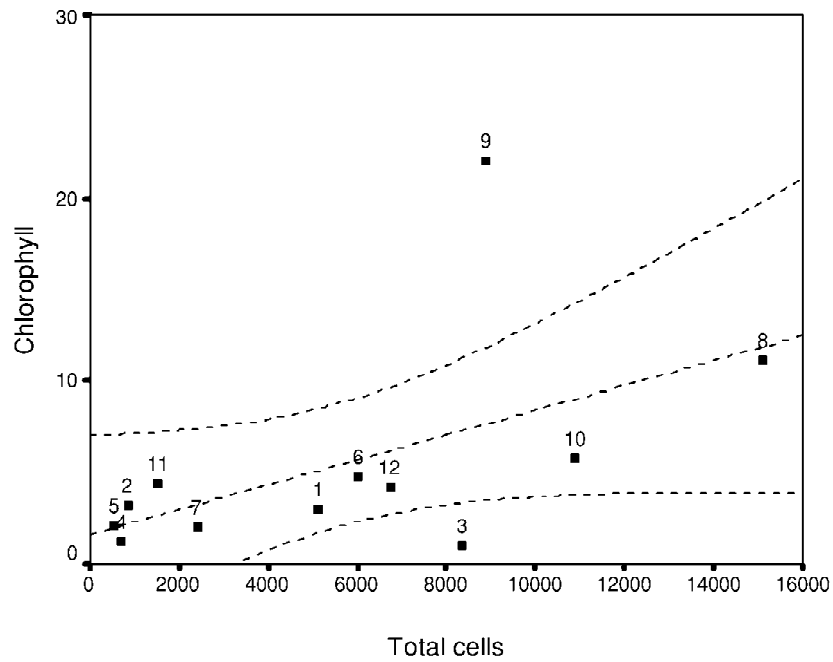


Figure 4. Bivariate correlation plot of chlorophyll concentration and total cell number. Mire no 9 deviates from the rest on the high chlorophyll concentration relative to the cell number observed. High number of the chlorophyll-rich group Chlorophyta (including Desmidiaceae) explains this result. Mire numbers like in Figure 2.

Table 4. Vascular plant and Charophyta species. Mire numbers as in Table 2

	1	2	3	4	5	6	7	8	9	10	11	12a	12b	12c	12d
<i>Nitella flexilis</i> Ag.	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-
<i>Antinoria agrostidea</i> (DC.) Parl.	-	-	-	-	-	-	+	+	+	+	+	+	-	-	+
<i>Baldellia alpestris</i> (Cosson)	-	-	-	-	-	-	+	+	+	+	-	-	-	-	+
Vasc.															
<i>Callitriche palustris</i> L.	-	-	-	+	-	-	+	+	+	-	+	-	-	-	-
<i>Caltha palustris</i> L.	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-
<i>Carex curta</i> Good.	+	+	-	+	-	+	-	-	-	-	-	-	-	-	-
<i>C. echinata</i> Murray	+	+	+	+	+	-	+	+	+	+	+	-	-	-	+
<i>C. limosa</i> L.	-	-	-	-	-	-	-	+	-	+	-	-	-	+	-
<i>C. nigra</i> (L.) Reichard	-	+	-	+	-	+	+	+	+	+	-	-	-	-	+
<i>C. rostrata</i> Stokes	-	-	-	-	-	+	+	+	+	+	+	-	+	+	+
<i>Drosera rotundifolia</i> L.	+	+	+	+	+	+	+	+	+	+	+	-	-	+	-
<i>Epilobium palustre</i> L.	+	+	+	+	-	+	-	-	-	-	-	-	-	-	-
<i>Eryophorum angustifolium</i>	-	-	-	-	-	-	+	+	+	+	+	-	-	+	-
Honckeney															
<i>Isoetes velata</i> A. Braun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Juncus bulbosus</i> L.	-	-	-	-	-	-	+	+	+	+	+	+	+	-	+
<i>J. filiformis</i> L.	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
<i>Lythrum portula</i> (L.) D. A. Webb	-	-	-	-	-	-	+	+	+	+	+	-	-	-	+
<i>Menyanthes trifoliata</i> L.	-	-	-	-	-	-	+	+	+	+	+	-	+	-	-
<i>Myriophyllum alterniflorum</i> DC.	-	-	-	-	-	-	+	-	+	+	+	+	-	-	-
<i>Phleum alpinum</i> L.	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Potamogeton natans</i> L.	-	-	-	-	-	-	-	+	+	-	-	+	-	-	-
<i>P. polygonifolium</i> Pourret	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-
<i>Potentilla palustris</i> (L.) Scop.	-	-	-	-	-	-	+	+	+	+	+	-	+	-	-
<i>Ranunculus peltatus</i> Schrank	-	-	-	-	-	-	-	+	+	+	+	+	-	-	+
<i>Scirpus cespitosus</i> L.	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>S. lacustris</i> L.	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
<i>Sparganium angustifolium</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Michx.															
<i>Utricularia australis</i> R.Br.	-	-	-	-	-	-	+	+	+	+	+	-	+	-	-
<i>U. minor</i> L.	-	-	-	-	-	-	-	+	-	+	-	+	+	-	-
<i>Viola palustris</i> L.	+	+	-	+	+	+	-	+	-	+	-	+	+	-	-

0.701, $p = 0.011$, Fig. 3) which supports the hypothesis of N limitation in phytoplanktonic growth. If all mires are included in the analysis, total cell number is not significantly correlated with chlorophyll concentration ($r = 0.534$, $p = 0.074$, Fig. 4). Mire 9 (La Roya) deviates from the tendency observed with the rest (Fig. 4) due to its richness in groups with large cells high in chlorophyll. If mire 9 is excluded from the analysis, the correlation is significant ($r = 0.752$, $p = 0.008$). The occurrence of nutrient-loving species of Chlorophyta (including Desmidiaceae) in mire 9 is owed to large livestock load with high nutrient income during summer months.

Desmidiaceae are present in low numbers in the mires studied, with numerous species characteristic of poor fens. Desmids are common in peatlands because *Sphagnum* plants remove nutrients from the water, maintaining an oligotrophic environment favorable to this group. There are species typical of hollows, as the members of *Desmidium*, *Gymnozyga* or *Micrasterias*, whilst others are characteristic of pools, such as *Arthrodesmus*, *Closterium*, *Hyalotheca*, and *Onychonema*. Nevertheless, Desmidiaceae are uncommon in hummocks of basin mires and in small slope mires. These data agree with previous results in continental peatlands, where most of the Desmidiaceae

Table 5. Algal taxa (cells/ml). Mire numbers as in Table 2

	1	2	3	4	5	6	7	8	9	10	11	12a	12b	12c
Chlorophyta														
(Desmidiaceae excluded)														
Ankistrodesmus falcatus (Corda) Ralfs.	0	0	0	4.2	0	19	0.5	0	0	36.4	0	18	0	0
A. fusiformis Corda	0	0	0	0	0	0	0	164	15	9.3	21.4	0	0	0
A. gelifactus (Chod.) Bourr.	0	0	18.1	2.1	0	0.7	0	15	4.5	5.7	5.1	14	0	0
Asterococcus limneticus G.M. Smith	0	0	0	1	0	3.8	0	7	3.1	0	0	0	0	0
A. siderogleus (Pasch. & Jah) Nováková	0	0	0	1	0	5.7	0	0	0	0	0	0	0	0
Botryococcus braunii Kütz.	0	0	0	0.2	0	0.7	0	16.1	3	1.9	1.7	1.4	2.5	0
Botryosphaerella sudetica (Lemm.) Silva	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Bulbochaete sp.	0	0	0	0	0	0	0	0	0	0	0	0	42	0
Chlamidocapsa bacillus (Teil.) Fott.	1.3	0	0	0	0	0	0	2.5	0	0	0	1.4	14	0
Chlamidomonas difficilis Pasch.	0	0	0	0	0	0	0	0	0	0	0	0	0	29.1
Chlorella kessleri Fott & Nov.	21.8	0	0	0	7.2	94.5	0	240	201	82.6	47.2	203	36.3	0
Chlorobium lunulatum Hind.	0	0	0	0	0	0	0	0	0	0	10.2	0	0	0
Chloromonas seriata (Pasch.) Gerl. & Ettl.	0	0	0	0	0	0	0	312	0	0	0	0	32.7	381
Coelastrum astroideum De Not.	0	0	0	0	0	0	0	0	0	13.5	0	0	0	0
C. microsporum Näg.	0	0	0	0	0	2.9	0	26	0	0	0	0	0	0
C. pulchrum Schmidle	0	0	0	0	0	0	0	0	0	0.6	0	0.6	0	0
C. reticulatum (Dang.) Senn.	0	0	0	0	0	518	0	0	0	0	0	0	0	0
Crucigenia quadrata Morren	0	0	0	0	0	0	0	0	84.1	0	0.8	1544	3.6	72.7
C. tetrapedia (Kirchn.) W. West & G.S. West	0	0	0	0	0	0	0	36	66	180	0	2066	0	181
Crucigeniella rectangularis (Näg.) Kom	0	0	0	0	0	0	0	0	0	0	2.6	0	40	0
Cylindrocapsa geminella Wolle	0	0	0	0	0	0	0	0	0	0	0	0	1331	0
Dictiosphaerium chlorelloides (Naum.) Kom. & Peim.	0	0	0	0	0	0	0	0	0	68.8	0	0	0	0
D. elongatum Hind.	0	0	0	0	0	0	0	0	0	169.4	0	0	0	0
D. pulchellum Wood	0	0	0	2.2	0	0	0	98.1	58.5	0	0	7.4	5.7	0
D. sphagnale Hind.	7.8	0	0	0	0	24	0	0	0	0	0	0	0	0
D. subsolitarium Van Goor	0	0	0	0	0	0	0	276	0	240	0	0	0	0
Dimorphococcus lunatus A. Br.	0	0	0	0	0	32	0	37	1.3	0	0	0.4	0	0
Eutetramorus fottii (Hind.) Kom.	0	0	0	0	0	0	7.1	0	0	0	0	0	0	0
Gloeotila sp.	0	0	0	0	0	0	0	0	0	0	0	0	340	0
Keratococcus raphidioides (Hansg.) Pasch.	0	0	0	0	0	0	0	0	0	0	4.3	0	0	0
Kirchneriella contorta (Schmidle) Bohl.	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0
K. diana (Bohl.) Comas	0	0	0	0	0.3	0	0	29	3	0	1.1	0.2	0	0
K. microscopica Nyg.	0	0	0	0	0	0	0	0	360	0	0	0	0	400
Monoraphidium contortum (Thur.) Kom. & Legn.	0	0	0	0	0	0	0	61	6	24.3	0	15	0	24.2
Neochloris sp.	0	0	0	0	0	0	0	0	0	132.2	0	287.2	0	0
Oocystis lacustris Chod.	0	0	0	2.1	2.2	29	0	29	370	36.4	0	0	2.8	0
O. submarina Lagerh.	0	0	0	0	0	0	0	0	240	201	0	0	0	0
Oonephris obesa (W. West) Fott	0.04	0	0	0.7	0	3.6	0	4	1.1	0	0	0	2	0
Pandorina morum (O. Müll.) Bory	0	0	0	0.7	0	0.3	0	1.6	1.3	0.2	0.6	0	0	0
Pediastrum boryanum (Turpin) Menegh.	0.04	0	0	1.3	0	0.8	0	0	3.2	0	0	0	0	0
P. tetras (Ehrbg.) Ralfs.	0.6	0	0	8.5	0	144	0.8	6	66	89.3	3.4	158	0	0
Pedinomonas sp.	0	0	0	0	56.3	0	502	200	992	0	0	0	0	0
Pseudosphaerocystis lacustris (Lemm.) Nováková	0	0	0	0	0.2	5.7	0	50.1	0	0	0	0	0	0
Quadrigula closterioides (Bohl.) Printz	0	0	0	0	0	32	0	47	102	10.7	5.1	0	0	0
Radiooccus sp.	0	0	0	0	0	518	0	0	0	35	27.4	287	0	0
Scenedesmus aculeolatus Reinsch.	0	0	0	14.1	0.7	128	4	52	0	59.1	18.8	12	0	0
S. acutiformis Schröd.	92	0	0	0	0	0	0	0	0	0	0	0	0	0
S. corallinus Chod.	0	0	17.1	0	0	0	0	0	0	0	0	0	0	0
S. intermedius Chod.	0	0	0	0	0	0	0	6	0	0	0	0	0	0
S. magnus Meyen.	0	0	0	0	0	28	0	20	66	13.3	0	28	0	0
S. ovalternus Chod.	0	0	0	0	0	32	0	0	0	0.9	0	0	0	0
S. serratus (Corda) Bohl.	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
S. sempervirens Chod.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphaerellopsis sp.	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0
Sphaerocystis schroeteri Chod.	0	0	0	3.5	0	0	0	7	22.5	35	47.1	0	0	0
Tetraedron caudatum (Corda) Hansg.	0	0	0	0	0	0	0	4	15	0	0	542	0	0
T. minimum (A. Br.) Hansg.	0	0	0	0	0	0	0	3.6	0	2.8	0	0	0	0
Treubaria setigera (Arch.) G.M. Smith	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Westella botryoides (W. West) De Wild	0	0	0	0	0	0	0	62	201.2	129.4	0	0	0	0

Table 5. contd.

Chlorophyta (Desmidiaceae)														
Actinotaenium cucurbita (Bréb.) Teil.	0.08	0	0	0	0	0	0	0	0	0	0	0	0.7	0.3
A.cucurbitinum (Biss.) Teil.	0	0	0	0	0	0	0	0.04	0.02	0	0	0	0	0
Arthrodesmus bifidus Bréb.	0	0	0	0	0	0	0	0	111	0	0	0	0	0
A. incus (Bréb.) Hass.	0.24	0	0	0.04	0	0.48	0	0	18	0.16	0	0.24	4	0
A. octocornis Ehrbg.	0	0	0	0	0	0.16	0	2	0	0	0	0	0	0
A. triangularis Lagerh.	0	0	0	0.78	0	0	0	0	3	0	0	3.72	0	0
A. validus W. West & G.S. West	0	0	0	0	0	0	0	0	0.24	0.04	0	0.04	0	0
Closterium acutum Bréb.	41.6	0	0	0	0	1	0	15	25.5	0	0	0	16	0
C. closterioides (Ralfs.) Louis & Peet.	0	0	0	0	0	0.24	0	0	0.04	0	0	0	0	0
C. intermedium Ralfs.	0.04	0	0	0	0	0	0	0	0	0	0	0	0.06	0.05
C. lineatum Ralfs.	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0
C. lunula (Müll.) Nitzsch.	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
C. pronum Bréb.	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0
C. setaceum Ralfs.	0	0	0	0	0	0	0	0.04	0	0.02	0	0	0	0
Cosmarium amoenum Bréb.	0	0	0	0	0	0.12	0	0.16	0.12	0	0.04	0	0.04	0.2
C. bioculatum Bréb.	0	0	0	0	0	0	0	0	3.3	6.4	0	0	0	0
C. connatum Bréb.	0	0	0	0	0	2.92	0	0.48	0	0	0	0	0	0
C. contractum Kirchn.	0	0	0	0	0	0	0.12	0	51.5	0.22	0	0.1	0	0
C. humile (Gay) Nordst.	0	0	0	0.48	0	0.08	0.04	13	16.5	2.1	0.2	0	0	0
C. impressulum Elfvig	0	0	0	0.08	0	0	0	0	0	0	0	0	0.06	0.05
C. margaritifera Menegh.	0	0	0	0	0	0.44	0.04	1.24	0.32	0.32	0.1	0	0	0.2
C. meneghini Bréb.	0	0	0	0	0.04	0	0	0	0	0.08	0	0	0	0
C. moniliforme (Turpin.) Ralfs.	0	0	0	0	0	0	0	1.28	2	0.58	0	0.2	0	0
C. norimbergense Reinsch.	0	0	0	0	0	0	0	0	12.2	0	0	0	0	0
C. ornatum Ralfs.	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0
C. polygonum (Näg.) Archer	0	0	0	0	0	0	0	14	0	0	0	0	0	0
C. pseudoconnatum Nordst.	0	0	0	0	0	0	0	44	0	0	0	0	0	0
C. punctulatum Bréb.	0	0	0	0.2	0.02	0	0	0	0	0.16	0	0	0	0
C. pyramidatum Bréb.	0	0	0	0	0	5.16	0	5.88	1.12	0.04	0.1	0.04	0	0.1
C. quadratum Ralfs.	0	0	0.04	0.24	0	4	0	0	8.8	6.4	0	0.08	0	0
C. rectangulare Grunow.	0	0	0	0	0	0	0	0	0	0.16	0	0	0	0
C. regnellii Wille	0	0	0	0	9.6	20	0	0	2.2	8.6	0	0	0	0
C. subarctoum (Lagerh.) Racib.	0	0	0	1.41	0	0	0	80	0	0	0.8	0	0	0
C. subcostatum Nordst.	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0
C. trilobulatum Reinsch.	0	0	0	0	0	0	0	1.04	0	0	0.7	0	0	0
C. venustum Bréb.	0	0	0	0.22	0	0.08	0	0	0	0.71	0	0	0.08	0
Cosmoecidium constrictum Joshua	0	0	0	0	0	22	0	15	6.6	25	0	0	0	0
C. pusillum Hilse	0	0	0	7.1	9.6	0	0	0	0	0	0	0	0	0
Cylindrocystis brevisonii Menegh.	0.3	44	0	0	0	0	0	0.24	0	0	0	0	0	0.1
Desmidium occidentale W. West & G.S. West	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0
D. quadratum Nordst.	0	0	0	0	0	0	0	0	0	0	0	0	104	0
Euastrum affine Ralfs.	0	0	0	0	0	0	0	0	0	0	0	0	0.84	0
E. ansatum Ehrbg.	0	0	0	0	0	0.08	0	0	0.16	0	0	0	0	0
E. bidentatum Næg.	0	0	0	0	0	0	0	0	0	0.1	0	0	0.5	0.1
E. binale (Turp.) Ehrbg.	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0
E. crassum (Bréb.) Kütz.	0	0	0	0	0	0.08	0	0	0.2	0	0	0	0.5	0
E. denticulatum (Kirchn.) Gay	0	0	0	0	0	3	0	0.04	1.76	0.12	0	0.08	0	0
E. didelta Ralfs.	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
E. dubium Næg.	0	0	0	0	0	0	0	0	0	0	0.1	0	0.04	0
E. elegans (Bréb.) Kütz.	0	0	0	0.1	0	0.08	0	2	0.04	0.04	0	0	0	0.05
E. evolutum (Nordst.) W. West & G.S. West	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0
E. insulare (Wittrock) Roy.	0	0	0.08	2.21	0	0.28	0	9.01	0	0	2.5	0	0	0
E. pectinatum Bréb.	0	0	0	0	0	0	0	0.16	0	0.02	0	0	0	0
E. praemorsum (Nordst.) Schmidle	0	0	0	0	0	0	0	0.04	0	0	0	0	0.08	0
E. subtrilobulatum Först.	0	0	0	0	0	0	0.04	0.08	0	0	0	0	0	0
E. verrucosum Ehrbg.	0	0	0	0	0	0	0	0	0.16	0	0	0	0	0
Gonatozygon aculeatum Hast.	0	0	0	0	0	0	0	0.04	15	0	0.1	0.16	0	0
G. brevisonii De Bary	0	0	0	0.08	0	0	0	1	0	1.4	0	0	0	0
Gymnozyga moniliformis Ehrbg.	0	0	0	0	0	3.36	0	13.7	0	0	0	0	3369	0
Hyalotheca undulata West.	0.44	0	0	0	0	0	0	2912	16.5	0	0	0	0	0
Micrasterias truncata (Corda) Bréb.	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.05
M. rotata (Grev.) Ralfs.	0	0	0	0	0	0	0	0	0	0	0	0	5.5	0.15
Netrium digitus Itzigsh. & Rothe	5.8	0.02	0.04	0	0	0.28	0	0.28	0	0	0.08	0	0	0.15
Onychonema filiforme (Ehrh.) Roy & Biss.	0	0	0	0	0	0	0	943	0	5	0	0	0	0
Pleurotaenium trabecula (Ehrbg.) Næg.	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0
Pehrenbergii (Bréb.) De Bary	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0
Sphaerozosma granulatatum Roy & Biss.	0	0	0	3.53	0	87.1	0	2	126	72.2	0.2	0.52	3.6	0
S.pygmaeum (Cooke) West	0	0	0	0	0	0	0	0	0	5.7	0	0	0	0
S. vertebratum (Bréb.) Ralfs.	0	0	0	0	0	0	0	0	0	10	0	0	0	0
Spondylosium planum (Woile) W. West & G.S.	0	0	0	0	0	5	0	2	66	0	0.1	0	0	0

Table 5. contd.

<i>S. pulchellum</i> Arch.	5.6	0	0	1.4	0	3	0	0	141	3.5	0	2	0	0
<i>S.pygmaeum</i> (Cooke) West	0	0	0	0	0	0	0	0	0	5.7	0	0	0	0
<i>Spirotaenia condensata</i> Bréb.	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0.15
<i>Staurastrum anatinum</i> Cooke & Wills.	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0
<i>S. arachne</i> Ralfs.	0	0	0	0	0	1.72	0	0.08	1.48	0.16	0	0	0	2.5
<i>S.arcticon</i> (Ehrbg.) Lundell.	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0
<i>S. avicula</i> Bréb.	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0
<i>S. brachiatum</i> Ralfs.	0.04	0	0	0	0	5.84	0	2	0.96	0.04	0	0.8	0	0
<i>S. coarctatum</i> Bréb.	0	0	0	0	0	0	0	0	5.56	0.71	0	0.04	0	0
<i>S. connatum</i> (Lund.) Roy & Biss.	0	0	0.04	0.04	0	0	0	4.76	1.5	0.16	0	0.04	0	0
<i>S. dejectum</i> Bréb.	0	0	0	0	0	0	0	0	13.5	0.02	0	0	0	0
<i>S. furcatum</i> (Ehrbg.) Bréb.	0	0	0	0.26	0	1.1	0	0.04	0.4	0	0	0	0	0
<i>S. glabrum</i> (Ehrbg.) Ralfs.	0	0	0	0	0	3.36	0	3	2	0	0	0	0	0
<i>S. gracile</i> Ralfs.	0	0	0	0	0	1.16	0	12	0.2	0.12	0	0	0	0
<i>S. hystrix</i> Ralfs.	7.8	0	0	0	0	0	0	0	0	0	0	0	0.04	0
<i>S. inconspicuum</i> Nordst.	0.8	0	0	0	0	1	0	13	1.1	1.43	0	0	0	0
<i>S. jaculiferum</i> West	0	0	0	0	0	0	0	0	28.5	0	0	0.42	0	0
<i>S. minutissimum</i> Reinsch.	0	0	0	0	0	0	0	0	0	17.1	0	0	0	0
<i>S. orbiculare</i> Ralfs.	0	0	0	0	0	0.16	0	0	0	0	0	0	0	0
<i>S. paradoxum</i> Meyen.	0	0	0	0.3	0	1.04	0	3	1.68	0.08	0	0	0	0
<i>S. polymorphum</i> Bréb.	0	0	0	0	0	0.08	0	0	0.28	0.1	0	0	1.2	0
<i>S. proboscideum</i> (Bréb.) Arch.	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
<i>S. punctulatum</i> Bréb.	0	0	0	0.02	0.26	0.16	0	0.04	0.12	0	0	0	0	0
<i>S. suborbiculare</i> W. West & G.S. West	0	0	0	0	0	0	0	0	0	0.12	0	0	0	0
<i>S. teliferum</i> Ralfs.	0	0	0	0.04	0	0.6	0	2	0.28	0	0	0	0	0
<i>S. tetracerum</i> Ralfs.	0	0	0	0.2	0	6	0	10	126	8.7	1.7	0.24	0	0
<i>S. tumidum</i> Bréb.	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0
<i>S. vestitum</i> Ralfs.	0	0	0	0	0	0	0	0	0	0.46	0	0	0	0
<i>Tetmemorus granulatus</i> (Bréb.) Ralfs.	0	0	0	0	0	0	0	0.04	0.04	0	0	0	8.8	0.1
<i>Xanthidium antilopaeum</i> (Bréb.) Kütz.	0	0	0	0	0	0	0	0.08	0.08	0.06	0	0	0	0
<i>X.armatum</i> (Bréb.) Rabenh.	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0.05
<i>X. concinnum</i> Bréb.	0	0	0	0	0	0	0	0	0	0	0	0	3.6	0
<i>X. cristatum</i> Bréb.	0	0	0	0	0	0	0	0	0	0.12	0	0	0	0
Euglenophyta														
<i>Anisonema</i> sp.	33.6	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ethosiphon polyaulax</i> Skuja	0	0	0	0	0	0	0	0	0	0.2	0	0	0	5.7
<i>Euglena</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	2	0.6
<i>Menoidium falcatum</i> Zach.	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0
<i>Petalomonas pusilla</i> Skuja	0	0	0	0	0	0	0	11	0	0.02	0	0	0	136
<i>P. scutulum</i> Skuja	0	0	0	0	0	0	0	0	0	0	0	0	0	469
<i>Trachelomonas volvocina</i> Eich.	0	0	0	0	0	0	0	0	1.7	1.4	0	0.04	1.2	0
Chrysophyceae														
<i>Bicosoeca alaskana</i> Hill.	0	0	0	5.6	10.4	0	0	0	3.6	0	0	43.6	0	0
<i>Bitrichia ochridana</i> (Fott) Bourelly	0	0	0	0	0	0	0	0	0	2.1	0	0	0	0
<i>Chromulina minuta</i> Doflein	0	0	32.7	0	0	0	0	0	0	0	0	0	0	0
<i>C. sphaerica</i> Doflein	11	102	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dinobryon divergens</i> Imhof.	0	0	0	5.6	10.3	0	0	6.6	2460	132.2	0	53	0	0
<i>Kephyrion planctonicum</i> Hill.	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0
<i>K. rubri-claustri</i> Conrad	0	0	0	0	0	0	0	0	14.5	0	0	12.5	0	0
<i>Lagynion</i> sp.	0	0	0	0	0	0	0	0	0	1.7	54.5	0	0	0
<i>Mallomonas acaroides</i> Perty	0	0	0	0	0	0.1	5.8	0	0	0	0	0	0	0
<i>M. akrokomos</i> Ruttner	0	0	0	0	0	0	116	0	0	0	0	0	0	0
<i>M. sp.</i>	0	0	0	9.1	2.2	0	0.72	0	0	0	3	0	0	0
<i>Monomastix</i> sp.	0	0	0	0	7.2	0	1170	941	366	2.7	367	963	0	0
<i>Ochromonas mutabilis</i> Klebs	0	0	0	0.7	0	0	0	34	0	19.3	0	117.2	0	0
<i>O. nanna</i> Skuja	0	3	0	0	60.7	0	501	309	992	0	0	0	5978	0
<i>O. silvarum</i> Doflein	0	170	0	2.8	283	0	38	225	0	0	32.7	0	0	54.5
<i>O. vagans</i> Doflein	0	0	0	0	0	0	0	134.5	0	0	0	0	0	0
<i>Synura uvella</i> Ehrh.	0	0	0	0	3.6	0	0	2.5	0	0	0.6	0	0	0
Bacillariophyceae														
<i>Aulacoseira ambigua</i> Muller	0	0	0	0	0	0	0	0	0	0.12	0	0	0	0
<i>A. distans</i> (Ehrh.) Kütz.	0	0	14.3	4.9	0.02	0	0	0	0	0	0	0	0	0
<i>Cyclotella meneghiniana</i> Kütz	0	0	0	0	2.1	0	0.08	0	0	0	0	0	0	0
<i>Cymbella gracilis</i> (Rubh.) Cleve	0	0	0	5.6	0	0.5	0.06	4	1.1	2.1	0	0.28	0	0
<i>C. ventricosa</i> Kütz	0	0	0	0	0.06	5	0	0	0	0	0	0	0	0
<i>Eunotia bidentula</i> W. Sm.	0	0	2.1	0	0.74	0	0	0	0	0	0	0	0	0
<i>E. exigua</i> (Bréb.) Grun.	0	325	7.1	0	0	0	0	3	1	4.3	0	0	8	611
<i>E. lunaris</i> (Ehrh.) Grun.	1.6	0	0	2.1	0	0	0.06	0	0	0	0	0	0	0
<i>E. pectinalis</i> (Kütz.) Rabh.	1.6	50	0	0	0	1	1.64	11	4	0.02	3.4	0.24	0	0.9
<i>E. robusta</i> Ralfs.	0.24	0	0	0	0	0	0.04	0	0	0.04	0	0	0	0.8

Table 6. Species richness. Mire numbers as in Table 2

	1	2	3	4	5	6	7	8	9	10	11	12a	12b	12c
Chlorophyta	7	0	2	12	6	21	4	28	24	28	15	18	14	5
Desmidiaceae	12	2	4	22	5	34	4	42	51	47	13	16	24	18
Euglenophyta	1	0	0	0	0	0	0	1	1	4	0	1	2	4
Chrysophyceae	1	2	1	5	8	0	5	8	5	4	4	7	1	1
Bacillariophyceae	4	4	9	10	7	9	12	8	13	8	4	10	7	9
Xanthophyceae	1	0	2	1	1	1	0	1	1	1	1	1	1	2
Cryptophyta	1	0	0	0	1	1	1	2	1	2	2	1	1	0
Pyrrhophyta	0	1	0	1	2	0	1	3	1	2	1	3	0	0
Cyanophyta	11	1	6	7	7	8	2	6	7	8	4	5	12	5
Total Algae	38	10	24	58	37	74	29	99	104	104	44	62	62	44
Bryophytæ	3	12	4	7	9	9	11	9	7	9	7	2	8	4
Vascular plants and Charophyta	6	7	5	10	4	6	15	20	17	18	14	8	7	4

grow commonly in pools or hollows with some nutrient limitation (Coesel, 1981, 1982, 1986; Yung et al., 1986). In the present study, desmid growth appeared to be limited by N. Correlation between desmid cells and N:P atomic ratio was high ($r = 0.718$, $p = 0.0085$), and the richest site in desmids (mire 8) presented the highest nitrate concentration. Conflicting conclusions were found, however, by Sparling & Nalewajko (1970), who stated that base-poor lakes of Ontario had lower numbers of Desmidiaceae than base-rich lakes, and Tassigny (1973), who found that some sedge swamps or other rich meadows have larger numbers of desmids than poor peatlands.

Chlorophyta (excluding Desmidiaceae) can be considered common in the study area, mainly in the basin mires (6, 7, 8, 9, and 12). The bulk of Chlorophyta species are in the genera *Ankistrodesmus*, *Chlorella*, *Chloromonas*, *Crucigenia*, *Dictyosphaerium*, *Kirchneriella*, *Oocystis*, *Pediastrum*, *Pedinomonas*, *Radiococcus*, and *Tetraedron*. Some of these taxa (e.g., *Chlorella*, *Dictyosphaerium*, *Pediastrum*, and *Tetraedron*) could indicate nutrient enrichment in oligotrophic sites under low pH.

Among the Chrysophyceae, the most speciose genera are *Chromulina*, *Dinobryon*, *Monomastix*, and *Ochromonas*. Those mainly occupied the big pools of the basin mires (7, 8, 9, and 12), except *Ochromonas*, which was common in hollows and moss carpets. As with Chlorophyta, Chrysophyceae were rare in hummocks.

Several species of Chlorophyta such as *Crucigenia tetrapedia*, *Ochromonas* spp., *Oocystis lacustris*, *Pedi-*

astrum tetras, and *Tetraedron caudatum*, and Chrysophyceae found in the Sierra Segundera mire system have been reported as common in Scandinavian oligotrophic and polyhumic lakes or pools (Hosiaisuoma, 1975; Sheath & Steinman, 1982; Eloranta, 1986).

Bacillariophyceae (diatoms) are common only in the mires number 2, 4, 12b, and 12c. Among the species that have been reported in the literature as characteristic from fen hollows in several North American and European mires are *Fragilaria intermedia*, *Frustulia rhomboides*, *Nitzschia gracilis*, *Pinnularia viridis*, and *Tabellaria fenestrata* (Hayward, 1957; Fetzmann, 1961; Flensburg & Sparling, 1973; Kingston, 1982). Other species, such as *Eunotia exigua*, inhabit hummocks even in dry conditions, and are considered aerophilous or bryophilous taxa (Foged, 1951; Wuthrich & Matthey, 1978; Kingston, 1982).

Cyanophyta were found abundant in mires 1, 3, 6, 8, 9, 10, 11, and 12, but they were rare in mires 2, 5, and 7. It is not yet fully understood why Cyanophyta colonized some mires but not others in the study area. An explanation could be the high irregularity of annual cycles of Cyanophyta in mires (Hayward, 1957; Duthie, 1965). Consequently, our data should only be considered to depict the Cyanophyta flora in a particular moment of summer growth. The bulk of Cyanophyta cells belonged to the genera *Anabaena*, *Aphanothece*, *Microcystis*, and *Rhabdoderma*, and many of them were found growing on mosses. Our data on Cyanophyta abundance and distribution (Table 5) agree with those of previous authors who also found these taxa living on mosses (Messikommer, 1957; Sheath & Hellebust, 1978; Yung et al.,

1986). In the study area, species of *Aphanocapsa* and *Microcystis* were common in hollows, whereas *Anabaena*, *Aphanothece*, and *Microcystis* were the most important genera in hummocks. *Anabaena* was one of the most abundant genera of Cyanophyta in the Sierra Segundera mire system, and according to previous authors, it may be implicated in the N₂ fixation in peatlands (Granhall & Selander, 1973; Basilier et al., 1978).

The abundance of Cyanophyta seems to contradict our previous statement that the Sierra Segundera mires are mainly oligotrophic, because Cyanophyta have been usually considered to be good indicators of eutrophication. However, our results agree with those by other authors who have found Cyanophyta to be important constituents of oligotrophic environments. High concentrations of Cyanophyta have been indicated from large oligotrophic lakes by Bozniak & Kennedy (1968), Eloranta (1986), Pearsall (1932), and Thomasson (1964) and other authors have found high concentrations of Cyanophyta during the summer in some oligotrophic mires in northern Europe (Flensburg & Malmer, 1970; Flensburg & Sparling, 1973; Eloranta, 1974; Tolonen & Hosiaislouma, 1978). The situation in the Sierra Segundera mire system can be considered analogous to the latter. As shown for the Desmidiaceae, the Cyanophyta are likely N-limited, and despite the high number of Cyanophyta cells, oligotrophy seems justified by the very low values of phosphorus, nitrate and silicon, the low level of chlorophyll, and the vegetation composition.

Cyanophyta are the most important algal group in poor to intermediate mires with high organic matter concentrations showing strongly colored waters. Low light intensity caused by high humic acid content could give to Cyanophyta some ecological advantage over eukaryotic algae. Facultative heterotrophy might be also advantageous to Cyanophyta in waters rich in organic matter but poor in nutrients (Kalff et al., 1975; Stockner & Antia, 1986). Some species have been also reported to assimilate several nitrogenated organic compounds from dissolved organic matter (Antia et al., 1991).

Cryptophyta, Dinophyceae, Euglenophyceae and Xanthophyceae had few species each, but they were widespread in the area. Cryptophyta and Euglenophyceae have been considered characteristic of eutrophic ponds (Round, 1957), but are also present in Danish and Finish humic lakes of oligotrophic nature (Kristiansen, 1959; Ilmavirta, 1980). Their presence can be attributed to the fact that members of these

groups can move actively and reach their optimal light intensity or nutrient concentration, avoiding unfavorable areas of the ponds. Euglenophyceae especially common in hummocks were *Petalomonas pusilla*, *P. scutellum*, and *Nephrodiella semilunaris*. Along with Euglenophyceae, another group common in the hummocks was Xanthophyceae, a fact already known from North American and European mires (Kristiansen, 1959; Tarapchak, 1972).

Conclusions

Mires in the Sierra Segundera mountain range can be separated into two types which differ in plant composition and complexity. Slope mires are smaller and less diverse than basin mires, which besides their large area, are more complex, with several differentiated microhabitats which harbour a higher number of species. Significant differences were detected in the plant composition of mire expanse, pools, and the pool shores in the latter type.

Despite the observed differences between the two types in which mires in the area can be classified, all of them are, regarding water supply, minerotrophic, and no ombrotrophic bogs develop in the area. Based on the chemical nature of the mires, (Table 2), they are considered as oligotrophic poor fens.

Vascular plant and bryophyte communities are similar to those of poor fens in Nordic peatlands except for the occurrence of some Mediterranean species able to withstand water table fluctuations.

The algal flora in the Sierra Segundera system is similar to northern European mires despite the simplicity of those Iberian systems, which represent the southernmost limit of mire development in Europe.

N:P atomic ratios were lower than 16, and were significantly correlated with cell numbers in all mires. Both results indicate a N limitation in the phytoplanktonic growth in the studied mire system, specially for groups such as Desmidiaceae and Cyanophyta. Our claim on the oligotrophy of those mires is based on chemical data, specially the very low values of phosphorus, nitrate and silicon, as well as the vegetation composition.

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