E.Ü. Su Ürünleri Dergisi 2002
E.U. Journal of Fisheries & Aquatic Sciences 2002
Cilt/Volume 19, Sayı/Issue (1-2): 247 – 258

ISSN 1300 - 1590
http://jfas.ege.edu.tr/

Invertebrate Grazer - Epiphytic Algae Interactions on Submerged Macrophytes in a Mesotrophic Turkish Lake

Meriç Albay, Güler Aykulu

Istanbul University, Faculty of Fisheries, Ordu Cad. No: 200, 34470 Laleli, Istanbul, Turkey.

Özet: ***Bir mesotrofik Türk gölünde su altı makrofitleri üzerinde omurgasız grazer -epifitik alg ilişkisi.*** İznik gölü'nün litoral bölgesinden toplanan *Potamogeton pectinatus* L. ve *Potamogeton perfoliatus* L. perifitonunda bulunan epifitik alglerle omurgasız hayvanlar arasındaki ilişkiler Mayıs 1993 - Kasım 1994 tarihleri arasında incelendi. Perifitonda bazı omurgasızlar ile epifitik algler arasında yakın bir ilişki gözlemlendi; *P. perfoliatus* üzerinde nematod sayısı artarken saplı (stalked) ve tüp içinde yaşayan diyatom yoğunluğunda azalma gözlendi. Rotiferlerin prostrate diyatomlar üzerindeki baskısının yanında *cocconeis* tipi diyatomeler üzerinde de rotifer ve ciliata gruplarının beklenmedik baskısı gözlemlendi. *P. pectinatus* üzerinde yaşayan epifitik alg ve omurgasızların taksonomik kompozisyonu *P. perfoliatus'un* perifiton topluluğuna benzemesine rağmen bu gruplar arasındaki ilişki önemli derecede farklılıklar gösterdi; Erect diyatomlar üzerinde nematod ve rotiferlerin zayıf negatif etkisi, saplı diyatomeler üzerinde ciliata ve rotifera grubunun baskısı ve *cocconeis* tipi diyatomeler üzerinde ciliata grubunun baskısı kaydedildi. Diğer omurgasız gruplar perifitonda çok nadir bulundukları için epifitik alglerle önemli bir ilişki bulunamadı. Su sıcaklığı, yüksek pH, ışık ve su kalitesinin yanı sıra makrofitlerin yapısı epifitik alg kolonizasyonu ve bunların omurgasızlar tarafından tüketilmesini etkiledi.

Anahtar kelimeler: *Potamogeton pectinatus, P. perfoliatus,* İznik gölü, perifiton, saplı diyatome, *cocconeis* tipi diyatome,

Abstract: Invertebrate - epiphytic algae interaction in the periphyton of *Potamogeton pectinatus* L. and *Potamogeton perfoliatus* L. collected from the littoral of Lake İznik was investigated between May 1993 - November 1994. A close relationship was observed between some invertebrates and algae in the periphyton. A decrease was observed in stalked and tubes diatom density whilst nematodes in *Potamogeton perfoliatus* periphyton community increased. An unexpected negative effect of Rotifers and Ciliates on erect and *cocconeis* type diatoms were recorded in addition to Rotifers pressure on prostrate diatoms. Although the taxonomic composition of epiphytic algae and invertebrates of *Potamogeton pectinatus* was similar to that of *P. perfoliatus,* interaction between these groups differed significantly. A weak negative effect of nematodes and Rotifers on erect diatoms was found besides Ciliates and Rotifers pressure on stalked diatoms and distinct influences were found between Ciliates and *cocconeis* type diatoms. Since other invertebrate groups were scarce in both periphyton communities, no significant interaction with epiphytic algae was found. In addition to the effects of water temperature, high pH, light, water quality and structure of the macrophytes significantly affected the colonization of the epiphytic algae and their grazing by the invertebrates.

Key words: *Potamogeton pectinatus, P. perfoliatus,* Iznik Lake, periphyton, stalked diatoms, *cocconeis* type diatoms.

Introduction

Preliminary investigations were carried out on the epiphytic algae, revealed list of the species and frequency of some dominant taxa in Turkish freshwaters (Yildiz, 1987; Şen and Aksakal, 1988; Obalı *et al.*, 1989). So far, interactions between algae and invertebrates in the periphyton have been neglected in Turkey whilst these interactions have been investigated by several scientists (Hunter, 1980; Underwood and Thomas, 1990; Walton *et al*., 1995). As it is well known, herbivores play a central role in periphyton dynamics. Invertebrates are known to have a grazing effect on the community structure and biomass development of epiphytic algae in the periphyton (eg. Hann, 1991; McCormick *et al*., 1994). Cattaneo et al., (1998) indicated that the positive relationship between epiphyton and macroinvertebrate abundance suggests a role for epiphyton as a food source directly for the epiphytic fauna and indirectly to fish and water fowl. In general, while grazing activity increases the productivity in freshwater and marine planktonic systems (Lamberti and Resh, 1983) grazing on attached algae in littoral region often gives rise to decreased productivity (Cuker, 1983).

The aim of the present study was to investigate invertebrate-epiphytic algae interactions and to reveal community structure, seasonal changes in the periphyton on two annual macrophytes; *Potamogeton pectinatus* L. and *P. perfoliatus* L. growing in the littoral zone of the L. Iznik.

Study Site

L. İznik is located in the Marmara region of Turkey (latitude N 40° 30' 00" - 40° 23' 30", longitude. E 29° 2' 30" - 29° 42' 50") and is a hard wafer Jake with a surface area of 308 km^2 (Fig. 1) and a maximum depth of 65 m (Budakoğlu and Bürküt 1995). The lake is the fifth biggest in Turkey, surrounded by agricultural lands, orchards, several villages and two towns, one of which is Iznik (Niceae).

The lake receives partially treated sewages and agricultural wastes, including pesticides and fertilizers. In recent years, several algal blooms were observed in the lake and hundreds of fish -mainly carp- died. However, an unpopular fish species, *Atherina hepsetus* L., increased drastically.

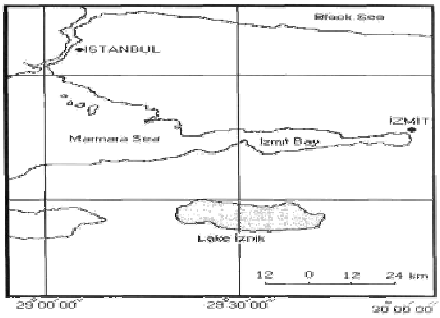

Figure 1. Location of the Iznik lake

Materials and Methods

Four sampling sites were selected in the littoral region of Lake Iznik. Macrophytes were taken at fortnightly from July 1993 to November 1994. Representative samples of *P. pectinatus* and *P. perfoliatus* were collected for the analysis of epiphytic algae and invertebrates. For each sampling occasion, three macrophytes were taken from each site. No sampling was done during winter and early spring since macrophytes were absent. In the laboratory, stems and leaves were scraped with a scalpel and epiphytes were collected in 1 L recipients. And than 100 ml subsamples were taken. From these subsamples, 2 - 5 ml aliquots were fixed with lugol's iodine for algal counting. 350-600 organisms were counted using an inverted microscope per count. The relative abundance of epiphytic algae was assessed on a counting basis using an inverted microscope. Non - diatom taxa were identified according to Prescott (1961), Pestalozzi (1969), Komarek and Fott

(1983). Komarek and Anagnostidis (1986), Anagnostidis and Komarek (1988). In most cases, some of the common filamentous taxa (e.g. *Oedogonium* spp., *Stigeoclonium* sp.) could not be identified to species level because many of the essential diagnostic characteristics were not present. Diatom identifications were based on Patrick and Reimer (1966, 1975) and Hustedt (1985). Some diatom species identifications were confirmed by electron microscopy. After the withdrawal of the 100 ml subsample, invertebrates were concentrated by filtering the final suspension through a 100 jam mesh net and preserved in 8% formalin. Invertebrates were counted and identified to species when possible. For identifications, Scourfield and Harding (1966), Koste (1978), Pennak (1978), Ward and Whiple (1966) and Sahin (1991) were used.

Water depth, which was changed between 20 cm - 250 cm, and temperature were measured along transect. Chemical parameters were measured according to the respective methods; Technicon Industrial Methods and Standard Methods (APHA - AWWA - WPCF 1989). Dissolved oxygen, conductivity, temperature and Secchi depth were measured on site.

Seasonal difference in periphytic biomass among the stations were evaluated with Duncan's Post Hoc Tests within the analysis of variance (ANOVA) design of SPSS 9.0® for Windows (Chicago, IL, USA). t- test were applied to test for differences in epiphytic biomass resulting from pressure of epiphytic algae to algae and epiphytic grazers to algae. Significance was evaluated at the $p<0.05$ and $p<0.01$ level for analysis. For cluster analysis Systat was used (Systat version 5.03 Copyright, 1991 SYSTAT, Inc). For this purpose dominant epiphytic algae were grouped as prostrate, adnate - stalked, erect, *cocconeis* type diatoms; chlorococcal and filamentous chlorophyt and dominant invertebrates were grouped as ciliates, nematodes and rotifers.

Results

At the sampling station during July, August, September, October and November 1993 and June, July, August, September, October and November 1994, the following average physical and chemical parameters were measured: water temperature, 21.4°C (range 13 - 27; n = 40; SE= 4.17); conductivity, 1020 µS cm^{-1} (range 990 - 1050; n = 20; SE = 17.73); pH, 9.09 (range 8.9 - 9.3; n = 16; SE = 0.18); Total Phosphorous (TP), 21.01 µg 1^{-1} (range 12 - 37.1; n = 16; SE = 6.88); Total Nitrogen (TN), 522 µg 1^{-1} (range 140 - 873; n = 16; SE = 174.1); carbonate, 56.75 mg 1^{-1} (range 45 -72; n = 20; SE = 6.43); bicarbonate, 397.8 mg 1^{-1} (range 342 - 460; n = 20; SE = 28.4).

The seasonal pattern of epiphytic algal richness during the study period in 1993 showed different growth pattern than *P. perfoliatus* (t- test, $P<0.01$). The relative proportion of major taxonomic groups is shown in Figure 1. The maximum numbers of cells were observed in late June and mid August 1993. During September and October 1993, very small increases and decreases were recorded in numbers of epiphytic algae however, a considerable decline was occurred in mid November 1993, coinciding with the start of *P. pectinatus* decay. This pattern differed in 1994, presumably due to a higher solar radiation and long dry season.

While diatoms, which were the dominant group with 68 taxa in the epiphytic community, made up max. 77.6% in 1993, and 92.3% in 1994 of the periphyton. It was observed that loosely attached species (primarily *Gomphonema* spp., *Cymbella* spp. and *Fragilaria* spp.) grew two times higher than adnate species on *P. pectinatus* during the study.

On the first sampling in June 1993, diatoms comprised 60.1 and 67.3% of the total cell numbers at all sites. *Fragilaria vaucheriae* (Kütz.) Peters., *F. construens var. venter, Cocconeis placentula* Ehr. accounted for 10 - 25% of the diatoms. This range declined to 8-15% in August and September at all stations. *F. vaucheria* and adnate *C. placentula, Navicula viridula* (Kütz.) Kütz., *Gomphonema angustatum* (Kütz.) Rabh. and *Cymbella prostrata* (Beick) Cl. were prominent diatoms during October and November 1993 and they comprised 18% of the total diatom cells. First peak in 1994 was recorded in June at Station 3 on new shoots. At that time, adnate and loosely attached species grew equally on the macrophytes. *F. vaucheria, Epithemia sorex* Kütz., *Rhoicosphenia curvata* (Kütz.) Grun., *Cymbella minuta var. silesiaca* (Bl. ex Rabh.) Rein, and *Cymbella pediculus* Ehr. grew equally but this trend did not continue throughout the summer and cell numbers declined in all stations. A last but big peak was recorded in late September and diatoms accounted for 92.3% of the periphyton. Percent composition of selected important species in the periphyton is shown at Figure 3.

Chlorophyta and Cyanophyta were the other main groups in the epiphytic flora and during the summer months in 1993 and 1994 we found high amount of filamentous and chlorococcal chlorophytes. *Scenedesmus quadricauda* (Turp.) Breb., *Oedogonium* spp., *Pediastrum boryanum* (Turp.) Meneg., epiphytic flora on *P. pectinatus. Spirogyra Weberii* Kuetz., *Tedraedron muticum* (A. Br.) Hans., *Ulothrix cylindricum* Presch. and *Mougeotia* sp. were observed not continuously but when they appeared, they grew luxuriantly.

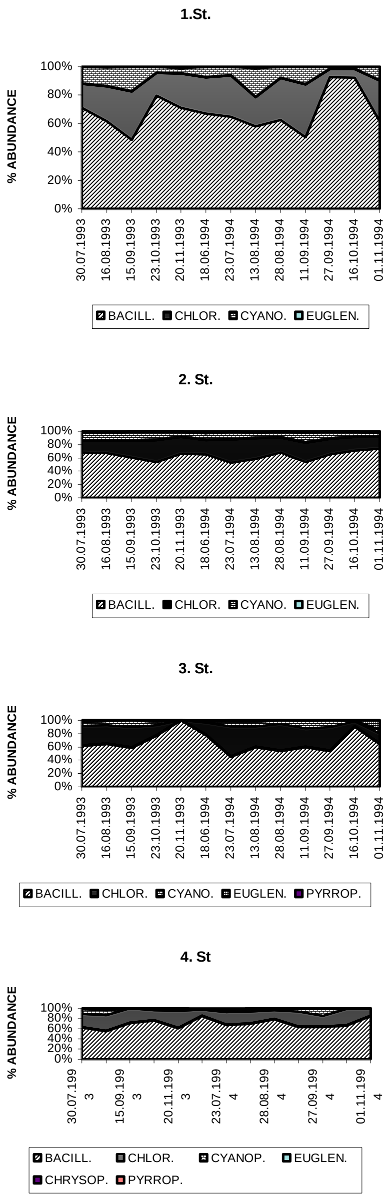

Figure 2. Relative proportion of the total epiphytic algal biomass accounted for by the major groups of algae on *P. pectinatus* (Abbreviation: Euglen = Euglenophyta; Cyano = Cyanophyta; Chlor = Chlorophyta; Bacil = Bacillariophyta; Pyrop = Pyrrophyta).

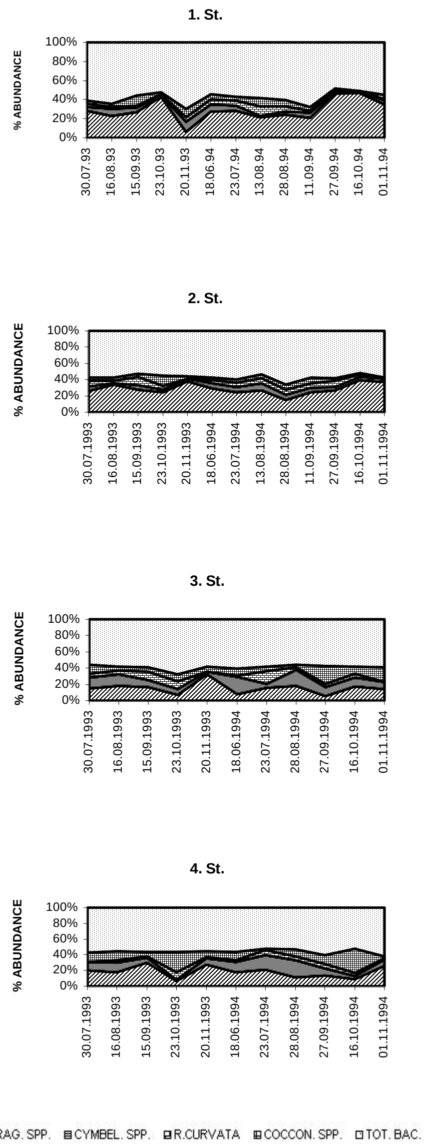

Figure 3. Percent composition of some important diatoms on *P. pectinatus* (Abbreviation: Tot. Bac = Total Bacillariophyta; Coccon. spp = *Cocconeis* spp; Cymbel= *Cymbella* spp; Frag. spp = *Fragilaria* spp.).

Cyanophytes were always present but they never exceed 15 % of the periphyton. Like chlorophytes, cyanophytes such as *Merismopedia glauca* (Ehr.) Naegeli and *Gomphosphaeria* sp. increased in summer months and they showed a modest correlation each other(r=0.6, P<0.01).

Euglenophytes, Dynoflagellates and Chrysophytes were the small groups and they constituted%2.5,%1.2 and 0.6 of the total, respectively. Euglenophytes (mainly *Phacus* sp, and *Euglena acus* Ehr.) grew Stations 2, 3 and 4, however they considerably abundant at Station 3 where received nutrient rich waters from two factories and sewage waters of Orhangazi. Apart from the Station 2, Dinoflagellates were found at all stations. The observed relatively high dynoflagellates cells at Station 3 in late June 1994 were mainly *Glenodinium Gymnodinium* Penard and *Peridinium cinctum* (Muel.) Ehr.

Chrysophyceae was represented only one species and observed only at Station 4 and were represented by only one species

Among the invertebrates, ciliates were the dominant group with 6 taxa, which made up 3.7% of the periphyton, whilst Nematoda, Rotifera, Trichoptera, Turbellaria and Hydracarina contributed with 4, 4, 1, 1, 1 taxa respectively. The ratio between epiphytic algae and invertebrates was 8:1.

Beginning from late spring to mid summer in 1993 and 1994, we found relatively small numbers of ciliates were recorded at all stations. *Oxytricha* sp. and *Tetrahymena* sp. were exclusively increased in late summer to at the end of the October 1993 and 1994. During this period, Ciliates and Cyanophytes -mainly *Oscillatoria formosa* Bory and *Merismopedia glauca* (Ehr.) Naegeli- showed a modest negative correlation (r= -0.4 ; P<0.05) and Chlorophytes decreased slightly in numbers.

The subdominant invertebrate group on *P. pectinatus* were nematods. They consisted 2.5% of the total species and were represented by 4 taxa. Nematoda showed two small peaks in late summer and in mid autumn like ciliates. *Anonchus* sp. was the main species which grew at Station 1 and 2. While we did not found any correlation among the Nematoda and epiphytic algae a weak negative correlation was found between the Nematoda and diatoms ($r = -0.2$; $p<0.05$). Other subdominant invertebrate group was Rotifera. The members of this group increased considerably in early summer. *Lecane* sp. and *Lophocharis* sp. were the pioneer species, showed negative correlation with diatoms ($r= -0.5$; $P<0.01$) and positive correlation with Cyanophytes ($r= 0.36$; $p<0.05$).

160 algal taxa were identified on *P. perfoliatus.* Diatoms were the dominant group (Figure 4), ranged 38 - 92.1% with 75 taxa. Although seasonal patterns of abundances of diatoms were similar at station 2, 3, and 4, significantly high amount of diatoms were found at station 1 ($p<0.05$). Loosly attached and adnate species grew equally in numbers on *P. perfoliatus. G. angustatum, R. curvata, E. sorex, F. construens* var. *venter, F. vaucheriae, C. placentula, C. minuta* var. *silesiaca* were the dominant species and they accounted for 40% of the total epiphytic flora in late spring and autumn (Figure 5). During summer months in 1993, most of those species changed their place with chlorococcal, desmids, and filamentous chlorophytes, eg. *S. quadricauda, P. boryanum, C. formulosum, Oedogonium* sp., *Spirogyra* sp. at Station 2 and with some Cyanophyt such as *M. glauca* and *Oscillatoria tenuis* C.A. Ag. at Station 2 and 3 where members of the Cyanophyta considerably increased compared to the other stations ($p<0.05$). During these months, Chlorophytes and Cyanophytes comprised 4 to 30% and 1 to 10% of the total epiphytic algal density respectively.

The other epiphytic algal groups, Euglenophyta and Pyrrophyta, were represented with 1.3% each, were recorded in very small numbers in periphyton occasionally. Euglenophytes were recorded in periphyton only at Station 3.

Periphyton was dominated by diatoms at nearly all stations in June 1994 and this trend did not differ until at the end of the year. In addition to dominant species, eg. *G. angustatum, R. curvata, E. sorex, F. contruens* var. *venter, F. vaucheria, C. placentula* and *C. minuta* var. *silesiaca*, some species eg. *Fragilaria brevistriata* Grun., *F. capucina, Synedra ulna* (Nitzs) Ehr., *Epithemia adnata* Breb., *C. pediculus* and *C. tumida* reached the high numbers at the beginning of summer months. Seasonal fluctuation of these species showed different grow pattern at all sites particularly at Station 1. While these species accounted for 48 - 78% of periphyton at the Station 1, which receives wastewater and sewage water from town of Iznik, this range decreased to 28 - 58% at the Station 2, 3 and 4.

Chlorophytes were the subdominant group in the periphyton of *P. perfoliatus*. Filamentous and chlorococcal chlorophytes, eg. *Oedogonium* spp., and *Scenedesmus* spp. were the master species. They reached the maximum numbers in mid August to late September 1993, accounted for 30 - 35% of total chlorophyte numbers at station 1 and 2. *Cladophora* sp., *Spirogyra* spp., *P. boryanum, P. simplex* and *Cosmarium* spp. were found in high numbers in the periphyton, occasionally.

Semiqu-antitative analysis of the invertebrate grazer community on *P. perfoliatus* demonstrated that ciliates and rotifers were the dominant groups among the invertebrates. Their seasonal changes showed similar pattern in both 1993 and 1994. *Oxytricha* sp., *Vorticella* sp. and *Pleurotricha* sp. were the important species from Ciliates and these species showed adverse relationship with diatoms (r= -0.7; P<0.01).

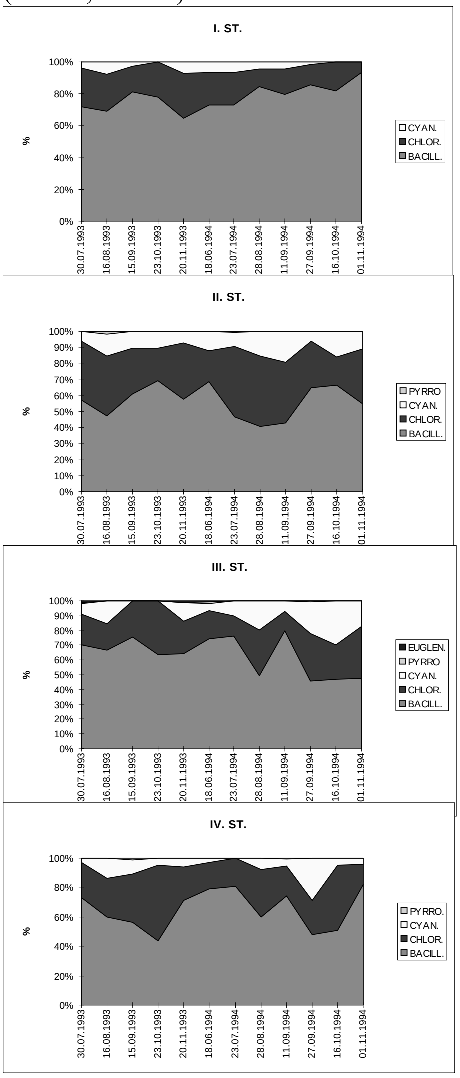

Figure 4. Relative proportion of the total epiphytic algal biomass accounted for by the major groups of algae on *P. perfoliatus* (Abbreviations as for figure 2).

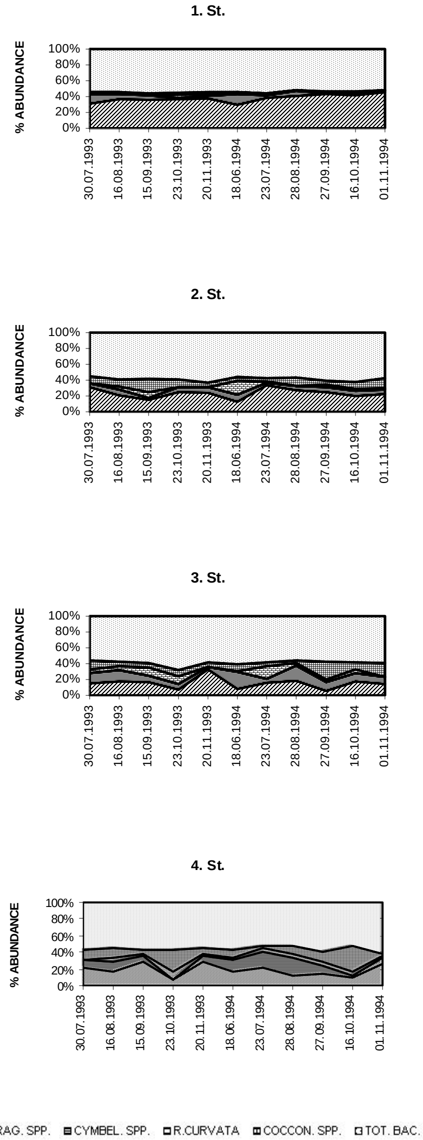

Figure 5. Percent composition of some important diatoms on *P. perfoliatus* (Abbreviations as for figure 3).

From the rotifers, *Lophocharis* sp. was the important species and was found at all sites except Station 3. In general, rotifers showed adverse relationship with diatoms (r= -0.5; P<0.01) and positive correlation with Cyanophytes (r= 0.4; P<0.05).

Nematodes was the subdominant group on *P. perfoliatus*. Maximum peak was found in mid- spring 1993 to 1994. *Anonchus* sp. was found at all stations. We did not observe any significant correlation between Nematoda and epiphytic algae except Cyanophyt. Surprisingly, we found very strong negative correlation between Nematodes and Cyanophytes (r= -0.9 ; P<0.01).

Other invertebrate groups on *P. perfoliatus* were Copepoda, Diptera, Turbellaria, Trichoptera, made up the remainder with 1 taxon each, were not significant in the periphyton. They were recorded few cases during the investigation. The ratio of epiphytic algae to the invertebrates was 7.4 : 1.

Discussion

Elsewhere, plant species and their architecture and of plant density have strong effects on the development of epiphytic organisms (Cattaneo & Kalf, 1980; Cattaneo et al., 1988). Rychkova (1989) states that epiphytic algal biomass is largely eliminated by changes in the water action, which mainly detach the loosely attached species, as was observed especially after wind stress.

In our cases a general decrease was observed on periphytic diatoms particularly in summer and early spring on *P. pectinatus* and *P. perfoliatus*. Aykulu (1982) stated that high daylight intensity inhibited diatom development, while Wetzel (1983) emphasized that the joint effect of light and temperatures altered species composition. When diatom increase was limited by some various factors in summer and early autumn, chlorococcal and filamentous chlorophytes, including some planktonic and periphytic species, such as *Scenedesmus* spp., *Pediastrum* spp., *Oedogonium* spp., *Spirogyra* spp., *Mougeotia* spp. and some Cyanophytes such as *Anabaena* spp., *M. glauca,* reached considerable numbers. As Bouvy *et al*., (1997) pointed out that periphyton and phytoplankton may exchange organisms and compete for nutrients. Similar results were found by Müller (1996) who recorded high numbers of filamentous chlorophytes (*Oedogonium* spp., *Spirogyra* sp. and *Mougeotia* sp.) in a shallow German lake. It is worthwhile the point out that when *Anabaena* reached to high numbers in periphyton Secchii depth decreased to 0.8 m in L. Iznik. Romo and Galanti (1998) described that among the abiotic factors light could be one of the main variables structuring epiphytic communities along the vertical axis of *Trapa natans*. Similarly, Mjelde and Faafeng (1997) stated that light might be limiting factor for epiphyton where the mean seasonal secchi disc transparency is lover than 0.5 m in lake Hellesjovatn.

The other point is that the loosly attached species grew two times more than adnate species on *P. pectinatus* (p<0.01). Some planktonic and tycoplanktonic species were encountered on *P. perfoliatus*'s periphyton, occasionally. The dendogram resulting from clustering of the correlation matrix of the selected epiphytic algal abundances on *P. perfoliatus* and *P. pectinatus* are shown in Figure (6) and (7) respectively. Some desmids, chlorococcal and filamentous chlorophytes; *Cosmarium ornatum* Rafs, *C. formulosum, Slaurastrum planktonicum* Teiling., *P. boryanum, S. quadricauda, Oocystis crassa* Witt, and *Oedogonium* spp., some cyanophytes; mainly *Anabaena* sp. and *Gleotricha* sp., and one centric diatom; *C. meneghiniana* grew luxuriantly from mid summer to early autumn.

Table 1. The pairwise correlation coefficients among the selected epiphytic algae and invertebrates on *P. pectinatus* and *P. perfoliatus* (Abbreviations: *P. per.= P. perfoliatus; P. pec.= P. pectinatus;* Stal= Stalked; Pros= Prostrate; Cocc.= *Cocconies* type diatoms; Fla= Filamentous green algae; Nem= Nematoda; Rot= Rotifera and Cla= Ciliata

		Pros-Erect	*Cocc*-Stal	Nema-Erect	Nema-Stal	Rot-Erect	Rot-Stal	Rot-Pros	Rot-*Cocc*	Rot-Nema	Cla-Erect	Cla-Stal	Cla-*Cocc*	Cla-Nema	Fla-Stal	Fla-Cocc	Fla-Nema
P. per	r	.44	-.8	.42	-.57	-.51	.6	-.61	-.73	-.53	-.59	.5	-.51	-.6	-.53	.71	.52
P. pec		.06	.69	-.29	.29	-.43	-.34	.04	-.08	-.33	.27	-.3	-.61	-.19	.43	.33	.54

The invertebrate assemblages were found to be rather similar on *P. pectinatus* and *P. perfoliatus* but their grazing effects on epiphytic algae varied, significantly. Grazing effects of invertebrates on periphyton and macrophytes has been already recognized by many workers (Walton et. al., 1995; Van Dijk, 1993; Jacobsen and Send - Jensen, 1995). There are numerous biotic and abiotic factor which affect the size of grazing. Admittedly, we consider that approximately 300 tons crayfish *(Astacus leptodactylus leptodactylus* Esch.) have been catched from L. İznik every year (N. Gulec pers.com.). However, it is not still clear that how much herbivory was performed by this species. Jacobsen and Send-Jensen (1995) recorded that invertebrate herbivory is common on the submerged *P. perfoliatus* in Danish freshwaters and only one of the twenty eight populations showed no sign of herbivory.

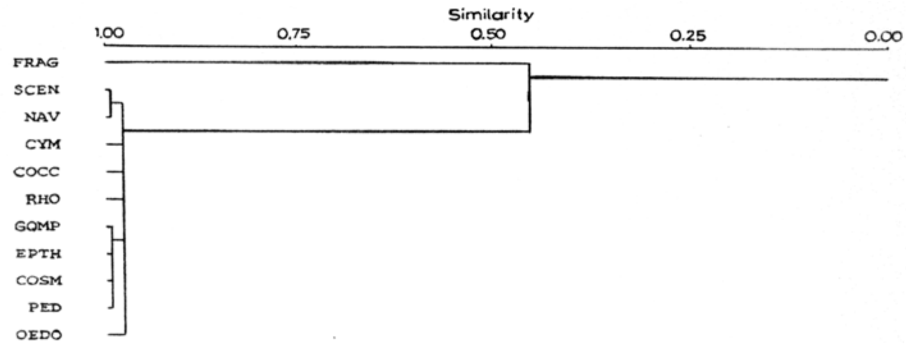

Figure 6. Dendogram resulting from clustering or the correlation matrix of the selected epiphytic algal abundances on *P. perfoliatus* (Abbreviation: Frag=; *Fragiluria* spp.; Scerv *Scenedesmns* spp.: Cymb= *Cvmbella* spp.; Rho= *Rhoicosphenia curvuta:* Ped= *Pcdiusirum* spp.: Cosm= *Cosmarium* spp.; Cocc^{r}-= *Cocconeis* spp.; Epth— *Epithcmia* spp.: Oedo- *Oedogonium* spp.: Gomp= *Gomphonema* spp.: Na\~ *Navicula* spp.

Nematoda (primarily *Anonchus* sp. and *Microlaimus* sp.) increased no changes were observed on the abundance of filamentous green, blue - green algae and diatoms erect, prostrate and *cocconeis* type, however, significant decreases were recorded in chlorococcal chlorophyts and stalked diatoms. Contrary to Nematoda, other dominant invertebrate groups, Rotifera (primarily *Lophocharis* sp.) and Ciliate (primarily *Oxytricha* sp. and *Pleurotricha* sp.) showed adverse relationship with epiphytic algae and prostrate diatoms (primarily *C.*

placentula, C pediculus, Navicula capitata (Kütz.) Kütz. and *Navicula cryptocephala* Ktitz.). Members of Copepodes, Diptera, Hydracarina, Trichoptera and Turbellaria were found occasionally in the periphyton, never reached to a level that change the structure of the community.

Invertebrate - epiphytic algae interaction showed notable differences than those on *Potamogeton perfoliatus* during the study period. A weak negative effect of Nematods (primarily *Anonchus* sp.) and Rotifers (primarily *Lophocharis* sp. and *Philodina* sp.) on erect diatoms (primarily *F. brevistriata, F. capucina, F. construens var. venter* and *R. curvata).* While ciliates and rotifers had pressure on stalked diatoms (primarily *C. cistula, C. lanceolata, C. prostrata, C. tumida G. olivaceum* and *G herculeana)* and distinct influences were found between ciliates (primarily *Oxytricha* sp. and *Tetrahymena* sp.) and *Cocconeis* type diatoms *(Cocconeis scutellum* Ehr. *C pediculus,* and C. *placentula).* The overall relationship among the epiphytic algae and invertebrates on *P. pectinatus* and *P. perfoliatus* are shown at Table 1. It is understood that although periphyton community was affected from various physical, chemical and biological factors; among these, three factors were observed more characteristics than others in Iznik Lake. One of them was fertilizer; each year approximately 10 000 tones fertilizer are used for agricultural activity. The other factors were pH and conductivity; relatively high pH (average 9.09) and conductivity (average 10020 ($\mu S\ cm^{-1}$) were measured. Therefore, organisms, which prefer alkalic waters, were found in addition to *C. placentula, C. pediculus, C. prostrata, C. minuta, E. adnata, E. sorex, E. turgiga, F. brevistriata, F. capucina, N. cryptocephala, N. capucina, R. curvata* and *R. gibba* in the periphyton of both macrophytes. *C. placentula, E. sorex, E. adnata* and *R. gibba* do not need special requirements reach high numbers environments which is especially true for *C. placentula* (Hofmann, 1994; Müller, 1999).

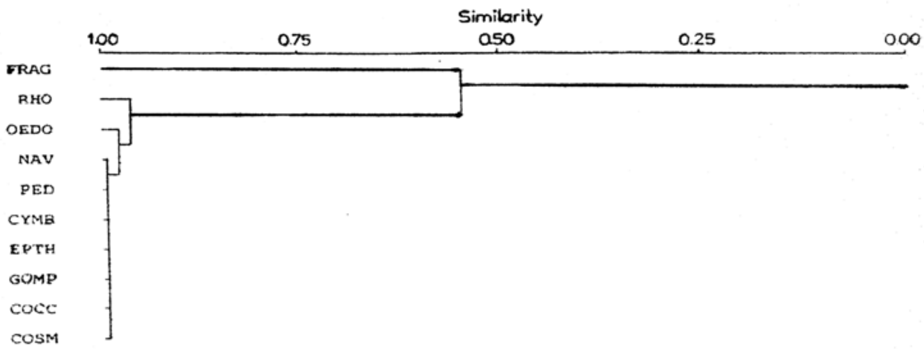

Figure 7. Dendogram resulting from clustering of the correlation matrix of the selected epiphytic algal abundances on *P. pectinatus* (Abbreviation: Frag= *Fragilaria* spp.; Scen= *Scenedesmus* spp.; Cymb= *Cymbella* spp.; Rho= *Rhoicosphenia curvata;* Ped= *Pediastrum* spp.; Cosm= *Cosmarium* spp.; Cocc= *Cocconeis* spp.; Epth= *Epithemia* spp.; *Oedogonium* spp.; Gomp= *Gomphonema* spp.; Nav= *Navicula* spp.

Results showed that plant architecture and their position in the littoral region clearly affected the epiphytic algal colonization and their consumption by invertebrates in addition to physical, chemical and biological effects. Cattaneo *et al.* (1998) stated that submerged plants provide a well illuminated substratum in the water column and submerged stems and extended aquatic roots trap detritus that could enrich the epiphyton. It was also concluded that morphological difference between *P. perfoliatus* and *P. pectinatus* affected grazing size on epiphytic algae. Jacobsen and Send - Jensen (1995) revealed that herbivory on a given plant species depends on the food plant and the food choice of the herbivore.

As fresh submerged macrophytes are used as habitat by many invertebrate (Iversen *et al.* 1985), which is very important factor for crayfish *(A. leptodactylus leptodaclylus* Esch.) in Iznik Lake, and provide a large potential food resource. It is crucial that further study has to be done understanding interaction between invertebrates and epiphytic algae.

References

Anagnostidis, K. and Komarek, J. (1988) Modern approach to the classification system of Cyanophytes, 3. Oscillatoriales. Arch. Hydrobiol. 80, 1 - 4; 327 - 472.

APHA-AWWA-WPCF (1989) Standart Methods for the Examination of Water and Wastewater. 17th ed., American Public Health Association, Washington, DC.

Aykulu, G. (1982) The Epipelic Algal Flora of the River Avon. Br. Phycol. J. 17; 27-38.

Bouvy, M., Arfi, R. and Troussellier, M. (1997) Taxonomic characterization of pelagic and Periphytic heterotrophic bacteria isolated from the tropical Ebrie Lagoon Cote d' Ivoire. Arch. Hydrobiol. 140: 3: 393 - 409.

Budakoğlu, M. and Bürküt, Y. (1995) Trend Surface and Cluster Analysis of Iznik Lake Surface Water. The V. Symposium on Mining Chemistry, 7-10 November, Istanbul.

Cattaneo, A. and Kalff, J. (1980) The relative contribution of aquatic macrophytes and their epiphytes to the production of macrophytes bed. Limnol. Oceanogr. 25: 280 289.

Cattaneo, A., Galanti, G., Gentinetta, S. and Romo, S. (1998) Epiphytic algae and macroinvertebrates on submerged and floating - leaved macrophytes in an Italian lake. Freshwater Biology, 39, 725 - 740.

Cuker, B. E. (1983) Graning and nutrient interactions in controlling the activity and composition of the epilithic algal community of the arctic lake.Limno. and Oceonog. 28:133-141.

Hann, B. J. (1991) Invertebrate Grazer - Periphyton Interactions in a Eutrophic Marsh Pond. Freshwater Biology 26, 87-96.

Hofmann, G. (1994) Aufwuchs-Diatoomen in Seen und Ihre Eignung als Indikatoren der Trophie: Bibl. Diotomol., 30: 241pp

Hunter, R. D. (1980) Effects of Grazing on the Quantity and Quality of Freshwater Aufwuchs. Hydrobiologia, Norman 69, 251-259.

Hustedt, F. (1985) The Pennate Diatoms. Koeltz Scientific Books Koenigstein. Suplement by G. Jensen. ISBN 3-87429-246-0

Jakobsen D. and Jensen, K.S. (1995) Variability of invertebrate herbivory on the submerged macrophyte *Potamogeton perfoliatus.* Freshwater Biology 34: 357 - 365.

Koste, W. (1978) Rotatoria, I. Textband. ISBN 3 443 390 714.

Koste, W. (1978) Rotatoria, II. Tofelband. ISBN 3 443 390 722.

Komarek, J. and Fott, B. (1983) Das phytoplankton des Süsswassers. Chlorophyceae, Chlorococcales. In. Huber -Pestalozzi. ISBN 3 510 40023 2.

Komarek, J. and Anagnostidis, K. (1986) Modern approach to the classification system of Cyanophytes, 2. Chroococcales, Arch. Hydrobiol. Suppl. 73, 2; 157 - 226.

Lamberti, G. A. and Resh, V. H. (1983). Stream periphyton and insect herbivores:

an experimental study of grazing by a caddisfly population. Ecology, 64: 75-81.

McKormick, P.V., Louie, D. and Cairns, J. J. (1994) Longitudinal Effects of Herbivory on Lotic Periphyton Assemblages. Freshwater Biology, 31, 201-212.

Mjelde, M. and Faafeng, B. A. (1997) *Ceratophyllum demersum* hampers phytoplankton development in some small Norwegian lakes over a wide range of phosphorus concentrations and geographical latitude. Freshwater Biology, 37: 355 - 365.

Müller, U. (1996) Production rates of epiphytic algae in an eutrophic lake. Hydrobiologia 330:37-45.

Müller, U. (1999) The vertical zonation of adpressed diatomed diatcnx and ohytic algae on *Phragmites australis.* Eur. J. Phycol. 34 : 487-496. Obah, O., Gonulol, A. and Dere, S. (1989) Algal Flora in the Littoral Zone of Lake Mogan.

19 May University, Journal of Science 1(3): 33-53.

Patrick, R. and Reimer, C.W. (1966) The Diatoms of the United States, Vol. 1. The Academy of Natural Sciences of Philadelphia.

Patrick, R. and Reimer, C.W. (1975) The Diatoms of the United States, Vol. 2. Part 1, The Academy of Natural Sciences of Philadelphia.

Pennak, R. W. (1978) Freshwater Invertebrates of the United States 2nd Ed. John Willey and Sons Inc.

Pestalozzi, G. H. (1969) Das phytoplankton des Susswassers, Euglenophyceen. 4. Teil, Band XVI.

Prescot, G. W. (1961) Algae of Western Great Lake Area. Brown Comp. Prob. Dubeque Iowa.

Romo, S. and Galanti, G. (1998) Vertical and seasonal distribution of epiphytic algae on water chestnut (*Trapa natans*). Arch. Hydrobiol. 141; 4: 483-504.

Rychkova, M. A. (1989) Role of water mass dynamics information of epiphytic algae communities in a lake. Hydrobiological Journal. 25; (3): 157 - 191.

Scourfield, D. J. and Harding, J. P. (1966) A key to the British Freshwater Cladocera. Freshwater Biological Association Sci. Publ. No:5 Third Ed.

Sokal, R. R. and Rohlf, F. J. (1981) Biometry. 2nd edition W.H. Freeman and Co., San

Francisko, CA.

Şahin, Y. (1991) Potamofauna of Turkey TUBITAK, Basic Sci. Res. Group. Project No: TBAG 869 VE VHAG-347, TBAG 669, TBAG-792 (in Turkish).

Şen, B. and Aksakal, M. (1988) The seasonal changes and density of epiphytic algae population on *Potamogeton* sp. and *Nasturtium qfficinale* in Kirkgozeler (in turkish).

IX. National Biology Congres, 21-23 September Vol. 3; Sivas , Turkey. ,

Underwood, G. J. C. and Thomas, J. D. (1990) Grazing Interactions Between Pulmonate Snails and Epiphytic Algae and Bacteria. Freshwater Biology, 23, 505-522.

Van Dijk, G.M. (1993) Dynamics and attenuation characteristics of periphyton upon artifical substratum under various light conditions and some additional observation on periphyton upon *Potamogeton pectinatus.* Hydrobiologia, 252; 143-161.

Walton, S. P., Welch, E. B. and Horner, R. R. (1995) Stream Periphyton Response to Grazing and Changes in Phosphorus Concentration. Hydrobiologia 302: 31-46.

Ward, H. B. and Whipple, G. C. (1966) Freshwater Biology. Second Ed. Edited by Edmanson. Univ. Of Washington.

Wetzel, G. R. (1983) Limnology, Second Ed. Saunders College Pub. Philadelphia.

Yıldız, K. (1987) A study on algal assemblage of Altınapa Dam Lake and its outlet Cumhuriyet University, Journal of Science, 5; 191 - 207.