

Colonisation and growth of epiphytic algal communities on *Potamogeton perfoliatus* under two different light regimes

MUNIRA SULTANA

TAKASHI ASaeda†

JAGATH MANATUNGE

ABDURAHMAN ABLIMIT

Department of Environmental Science and
Human Engineering
Saitama University
255 Shimo-okubo
Saitama-shi, Saitama
Japan 338–8570
email: asaeda@post.saitama-u.ac.jp

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INTRODUCTION

Epiphytic algae are an important constituent of the autotrophic community of a macrophyte-oriented aquatic ecosystem (Wetzel 1990). Epiphyton are significant primary producers that fix carbon (Cattaneo & Kalff 1979) and uptake essential nutrients from the water column, thereby making these nutrients accessible at higher trophic levels (e.g., consumption of biofilm by invertebrates) (Vadeboncoeur & Steinman 2002). Even though epiphytic algae are very important components of the pelagic-benthic part of lentic ecosystems for both nutrient cycles and food-webs, their ecology has been subject to relatively little investigation (Müller 1994). Furthermore, many scientists have only drawn comparisons of the effects of naturally growing and artificially made macrophytes on epiphyton (Cattaneo & Kalff 1978; Goldsborough & Hickman 1991) or periphyton on other substrates (Brown 1976; van Dijk 1993). Most research related to the epiphytic algae is based on seasonal trends of their macrophytic hosts (Bowker & Denny 1980; Jacobs & Noten 1980; Goldsborough & Robinson 1985; Müller 1994; Shamsudin & Sleight 1995; Galanti & Romo 1997). Several biotic and abiotic factors can influence epiphytic growth such as the macrophyte host (Cattaneo & Kalff 1979), grazers (Cattaneo 1990), nutrient availability (Phillips et al. 1978), and temperature (Wetzel 1964). Light is also an important factor in epiphytic growth (Müller 1999). But in most of the light-related studies, the effect of different light levels was tested for periphyton using artificial substrates (i.e., McIntire & Phinney 1965; Hudon & Bourget 1983; Bothwell 1988). It has been suggested that periphyton communities respond to changing light regimes by exhibiting different species composition and cell abundance in artificial substrates including glass slides (Hudon & Bourget 1983).

Abstract The composition and distribution of epiphytic algae on *Potamogeton perfoliatus* were studied in a controlled laboratory environment over 84 days under two light conditions. The study was based on a 2 × 2 factorial design with two light conditions (high and low, 200 and 80 $\mu\text{E m}^{-2} \text{s}^{-1}$) and two different plant parts (apical and basal). In both light conditions, the community consisted of 18 taxa (under nine genera) of Bacillariophyceae. *Amphora lineolata*, *Cocconeis placentula*, and *Diatoma hiemale* were the most common and abundant species. The total algal density was significantly higher in the high light condition and on the basal plant part than in the low light condition and on the apical plant part. At termination of the experiment, basal plant parts exhibited a more uniform crust of epiphytic algae consisting of c. 95% *C. placentula* whereas the apical plant parts expressed a more mosaic community (under both light conditions).

† Author for correspondence.

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Information about the ecology of the periphyton on an artificial substrate may reveal little about the real scenario of succession, distribution, physiology, and production of epiphytic algae on macrophytic surfaces (Wetzel 1975). Moreover, a mesocosm study or field observation under natural conditions cannot always reveal the true critical factor because more than one factor can function at the same time. As it is not possible to control all of the influential biotic and abiotic factors during an observation period in the natural environment, it is often difficult to concentrate on any one factor without understanding the other influencing factors. Only in a laboratory based experimental study is it possible to closely observe a segment of a natural community, examine it under simplified and controlled conditions, and thereby hypothesise on how single or multiple factors may influence the growth (McIntire & Phinney 1965).

In previous studies, field or laboratory, it seems that although light is a key factor influencing epiphytic algal growth (Round 1961), there is very little information about the effects of different light intensities on the species composition and distribution of epiphytic algae on different parts of plants. Only van Dijk (1993) performed a laboratory experiment with the submerged macrophyte *Potamogeton pectinatus* L. under four light conditions. The experiment was performed for a short period of only 3 weeks. The composition and distribution of the epiphytic community developed on *P. pectinatus* was not analysed. In the present study, we examined the epiphytic algal composition, colonisation, and distribution on the submerged macrophyte *P. perfoliatus* under two light conditions for 12 weeks (84 days) in the laboratory. *P. perfoliatus* is a very common submerged macrophyte in many water bodies in Japan (e.g., Kobayashi 2001) and some other parts in the world (e.g., Kemp et al. 1986) and provides a large surface area for attachment of epiphytic algae because of its broader leaves. We hypothesised that: (1) the epiphytic community in the two light conditions would differ completely in their size, structure, or range of tolerance to light intensity; and (2) the composition of the epiphytic community would differ on different plant parts. We assumed that this would be because of the effect of light availability and plant age or both. The information provided in our study may be usefully applied to improve the trophic status of many water bodies through the management of submerged macrophyte communities.

MATERIALS AND METHODS

Experimental design and set-up

The experiment was conducted for 84 days between August and December 2002. The set-up consisted of six glass aquaria (1.6 m × 0.8 m × 0.8 m) with two light conditions, each with three replicates: plants with high light and epiphytic algae (HLE) and plants with low light and epiphytic algae (LLE).

Potamogeton perfoliatus were collected from a commercial source. Single shoots (10 cm long at the apical part) were planted in individual plastic pots (diam. 7 cm, depth 15 cm) filled with a sediment suitable for the growth of *P. perfoliatus*. The composition of the sediment was 74% sand, 20% silt, and 6% clay particles (with 1% organic carbon), a composition similar to that used by Kemp et al. (1986) for experimental beds of *P. perfoliatus*. Sediment was autoclaved before use to avoid the introduction of undesirable seeds or spores. Seventy-five pots (each planted with a single shoot) were then transferred to each of the six aquaria filled with dechlorinated tap water. The experiment was conducted using dechlorinated tap water instead of natural lake water because natural water contains many living organisms which can interfere with the epiphytic algal growth on the plant leaf surface either by increasing water turbidity (e.g., phytoplankton) or grazing the epiphytic algae (e.g., zooplankton and invertebrates). However, similar amounts of nutrients were given to mimic growth conditions of *P. perfoliatus* in its natural habitat (nutrient addition is described later). During the first 4 weeks, the plants were maintained with the same nutrient (described later), light ($200 \mu\text{E m}^{-2} \text{s}^{-1}$), and temperature (25°C) conditions for acclimation to the new environment.

Two light conditions were selected: $200 \mu\text{E m}^{-2} \text{s}^{-1}$ as the high light condition and $80 \mu\text{E m}^{-2} \text{s}^{-1}$ (40% of the high light) as the low light condition, at 1 cm below the water surface. Hootsmans & Vermaat (1994) used the high light level ($200 \mu\text{E m}^{-2} \text{s}^{-1}$) in their growth experiment on *Potamogeton pectinatus*. Light was provided by white fluorescent bulbs, and reducing the number of bulbs created the low light level. Light transmission was measured at each 5 cm depth in all of the aquaria horizontally and vertically on days 0, 42, and 84. Mean values were then calculated in the top half (from 5 cm below water surface to the middle of the aquaria) occupied by apical plant parts and in the bottom half (from the middle of the aquaria to sediment surface of the pots) occupied by basal plant parts. A 14-h photoperiod

and 25°C temperature were maintained for all aquaria. Water in all tanks was bubbled continuously with air to provide mixing and to minimise CO₂ limitation and O₂ inhibition (Kemp et al. 1986). The CO₂ concentration of the water in the aquaria was as described by Nielsen & Sand-Jensen (1990), by supplying CO₂ from the outside. All aquaria were covered with thick black screens to maintain a proper and uniform light condition throughout the aquaria.

Nutrient addition

Commercial fertilisers in the form of ammonium sulfate, potassium nitrate, and di-ammonium phosphate containing equal amounts of NO₃⁻, NH₄⁺, and phosphorus (P) were added to the aquaria at a concentration of 38 µmol N litre⁻¹ day⁻¹ or 19 µmol P litre⁻¹ day⁻¹, which was similar to that used by Neundorfer & Kemp (1993) for *P. perfoliatus*. In addition, a commercially available micronutrient solution, Tetra flora prideTM, which is normally used for aquarium plants, was added to maintain sufficient concentrations of micronutrients in the water. Water was fully changed and replenished every week to avoid shading effects created by phytoplankton.

Epiphytic algal seed

Attached epiphytic algal spores on the plant segments were the only source of epiphytic algae, developed later on the experimental *P. perfoliatus*.

Sampling and laboratory analyses

To study the quality and quantity of epiphytic algae, plant leaves were collected from two different plant parts (i.e., apical and basal) on days 14, 28, 42, 70, and 84. On each sampling day, all the selected main shoots were divided crosswise into two equal parts depending on the level of light received. The top part was taken as the apical part and the other as the basal part. Fifteen leaves were collected from each part of the plant separately and gently scraped with a soft toothbrush to remove epiphytic algae as described by Pan et al. (2000). This removal procedure is effective for both loosely and firmly attached epiphytic algae. Microscopic observation of *P. perfoliatus* leaves after algae removal showed that only a very small proportion of epiphytic algae were left on the surface. The algal suspension removed from the leaves was fixed in 2% neutral glutaraldehyde for identification and enumeration.

Epiphytic diatom identification and counting

To identify and count the diatoms, five leaves from each of the apical and basal plant parts with their

coating intact were boiled for 1 h in a solution of sulfuric acid and potassium dichromate (3:1 ratio) to remove organic matter from the diatom frustules. After rinsing in distilled water, the cleaned diatom frustules were mounted in Hyrax. Standard traverses across the slide were made and every cell seen at 1000× magnification was identified (using a 100× oil immersion objective) until at least 500 cells were counted. No distinction was made between living cells and dead frustules. Taxonomic identification of the epiphytic algae was performed following Patrick & Reimer (1975), Krammer & Bertalot (1986), and Ueno (1986). The conventional criteria of frustules size, shape, and ornamentation were used for identification of the diatom. The valve view was mainly used for this purpose. Rarely observed taxa were not considered for counting.

The structure of the epiphytic algal community was characterised by: (1) the number of taxa and; (2) the relative abundance of each, which was determined by counting the cells of each species.

Scanning electron microscopy

Five intact leaves from the apical and basal parts were immediately preserved in cold (4°C) 5% phosphate-buffered glutaraldehyde for scanning electron microscopy (SEM). First, leaves were prepared for SEM by cutting them into 1-cm² pieces. Then, the leaf pieces were dehydrated in a graded ethanol series (30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100%, allowing 10 min at each concentration), critical point dried, separately silver (Au)-coated, and examined with a Hitachi S 4100 SEM at 15 kV. Epiphytic algal density was expressed as units per area of leaf surface. The leaf surface area of the plant was measured with a leaf area meter (AAM-7, Hayashi Denkoh, Japan).

Statistical analyses

All data were checked for the assumptions of normality distribution and homogeneity before statistical analyses. Total epiphytic algal density and development of most abundant taxa were analysed by three-way ANOVA with sampling time, light condition, and plant part (i.e., apical or basal part) as the main factors. If a significant difference was found in the light condition and in the two plant parts, the effects were tested again using one-way ANOVA. All ANOVAs were performed using STATISTICA (version 5).

RESULTS

Species composition of the epiphytic algal community

The epiphytic algal community on the leaves of *P. perfoliatus* was composed of only members of the Bacillariophyceae in both of the high and low light conditions. A total of 18 species belonging to 9 genera were recorded in the entire experimental period (data not shown). *Amphora lineolata* Ehr., *Cocconeis placentula* (Ehr.) Cleve, and *Diatoma hiemale* (Lyngb.) Heiberg. were the most common and abundant species throughout the experiment in both light conditions and in both apical and basal plant parts. *Eunotia pectinalis* (Kütz.) Rabh. was also present throughout the entire experimental period in both light conditions and on both apical and basal plant parts but with a very small population. Some taxa, at a density too low to count, were only identified. In this category, *Amphora veneta* Kütz., *Cymbella cymbiformis* Kütz., *Cymbella sinuata* Greg., *Gomphonema constrictum* Ehr., *Melosira solida* Eulenstein, *Navicula salinarum* Grun., and *Nitzschia hungarica* Grun. were recorded only in the high light condition. On the other hand, *Eunotia veneris* (Kütz.) O. Müll and *Navicula tuscula* Ehr. were found only in the low light condition.

Light profile in different parts of plant

Mean values of percentage of transmitted light were always significantly higher in apical than in basal parts of plants under both light conditions (one-way ANOVA, $F = 4.19$, d.f. = 1, $P < 0.05$) (Fig. 1). Initially it was c. 85% and 78% of the light supplied at the apical and basal parts of the plants for both light conditions. However, on day 84, it decreased

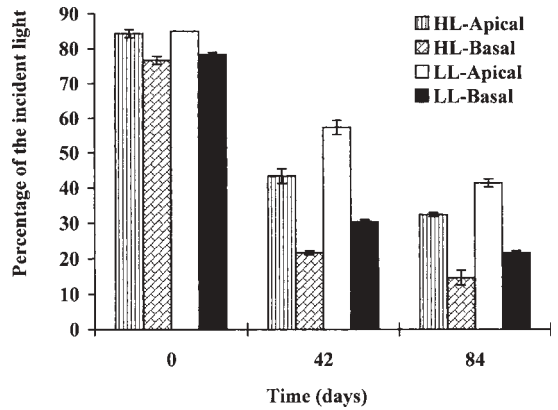


Fig. 1 Profile of transmitted light on different parts of the experimental *Potamogeton perfoliatus*. Vertical bars indicate \pm SD ($n = 3$). (HL, high light; LL, low light.)

in all the treatments and reached 32% for apical and 14% for basal parts under high light conditions. Whereas it was 41% of the provided light at apical and 21% for basal parts of the plants under low light conditions (Fig. 1).

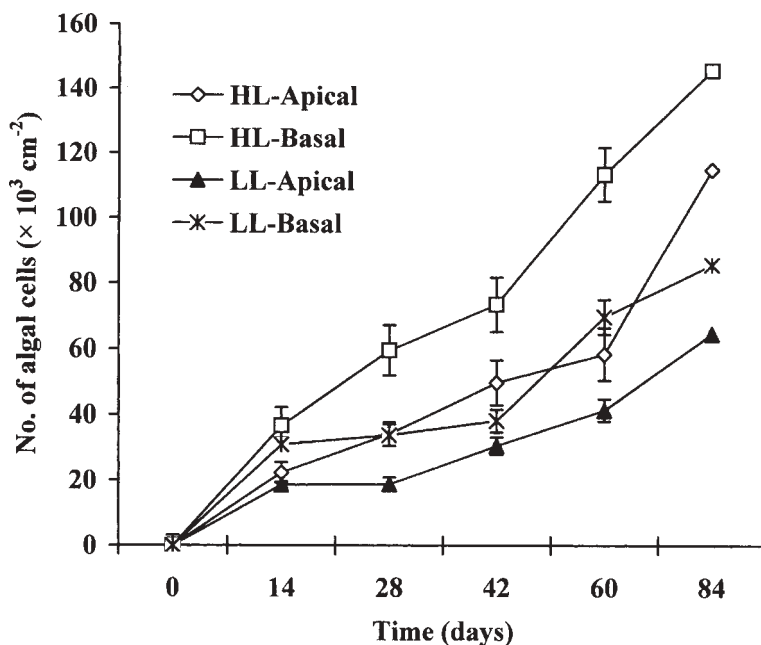
Density of the epiphytic algal population

Three-way ANOVA showed significant differences in the total epiphytic algal density with time, between the two light conditions and between the two plant parts (Table 1). The algal density increased with time (Fig. 2). On day 14, under high light conditions, the algal density was 22.33×10^3 and 36.61×10^3 cells cm^{-2} in the apical (HL-apical) and in the basal plant part (HL-basal), respectively, whereas the algal density was 18.55×10^3 and 30.91×10^3 cells cm^{-2}

Table 1 Results of three-way ANOVA testing the effects of time (T), light (L), and plant part (P) in the abundance of epiphytic algae on *Potamogeton perfoliatus* (F values are given and significant effects are denoted as: ^a, 0.001; ^b, 0.01; ^c, at 0.05 probability level).

Variables:	Source of variation						
	T	L	P	L×P	T×P	T×P	T×L×P
Total epiphytic algal density (cells $\times 10^3 \text{ cm}^{-2}$)	9.25 ^a	9.62 ^b	6.88 ^b	0.84	0.32	0.52	0.053
Abundant taxa							
<i>Cocconeis placentula</i> (cells $\times 10^3 \text{ cm}^{-2}$)	345.72 ^a	530.42 ^a	736.25 ^a	5.20 ^b	96.02 ^a	30.53 ^a	3.46 ^c
<i>Diatoma hiemale</i> (cells $\times 10^3 \text{ cm}^{-2}$)	74.14 ^a	16.65 ^a	11.98 ^b	33.27 ^a	67.18 ^a	28.93 ^a	5.10 ^b
<i>Amphora lineolata</i> (cells $\times 10^3 \text{ cm}^{-2}$)	124.73 ^a	52.73 ^a	1.02	51.08 ^a	80.24 ^a	11.8 ^b	10.84 ^a

Fig. 2 Total epiphytic algal density on *Potamogeton perfoliatus* leaves in the apical and basal plant parts in high (HL) and low light (LL) conditions during the experimental period. Vertical bars indicate \pm SD ($n = 3$).



in the apical (LL-apical) and basal plant parts (LL-basal), respectively, under low light conditions (Fig. 2). Considering light levels only, significant differences were observed in the epiphytic algal density between the high and low light conditions (one-way ANOVA, $F = 8.50$, d.f. = 1, $P < 0.01$). Maximum algal density always occurred on day 84 (Fig. 2). It was 114.82×10^3 cells cm^{-2} in the apical plant part and 145.66×10^3 cells cm^{-2} in the basal part under high light conditions. In contrast, under low light conditions, the algal density was 64.61×10^3 cells cm^{-2} in the apical and 85.53×10^3 cells cm^{-2} in the basal plant parts, respectively (Fig. 2). On day 84, the algal density was 44% higher in the apical plant part under high light than low light and 42% higher in the basal part under high light conditions than in the apical plant part under low light conditions. The epiphytic algal density was significantly higher in the basal plant part than the apical part under both light conditions (one-way ANOVA, $F = 5.68$, d.f. = 1, $P < 0.001$).

Relative abundance of the epiphytic community

Cocconeis placentula dominated throughout the entire experimental period in both apical and basal plant parts under high light conditions. In the apical plant part, the percentage of *C. placentula* population was 94% on day 14, and it declined to 45% on day 84 (Fig. 3A). *A. lineolata* and *D. hiemale* comprised

31% and 24% respectively, of the epiphytic algal community (Fig. 3A). SEM showed a mosaic community of the above-mentioned three taxa (photograph is not presented) on day 84. However, in the basal plant part, *C. placentula* ranged between 74% and 92% of the total algal cell density and combined with two other abundant species, *A. lineolata* (between 3% and 11%) and *D. hiemale* (between 3% and 14%) until day 70 (Fig. 3B), but on day 84, *C. placentula* accounted for 96% dominance (Fig 3B). SEM pictures corroborated the high and more-or-less homogeneous colonisation of the epiphytic community by *C. placentula* in the basal part under high light conditions. *C. placentula* was also dominant under low light conditions and occupied the bulk of the entire experimental period in both the apical and basal plant parts except on day 14 (Fig. 3C,D). On day 14, *D. hiemale* (abundance 55%) led the community on the apical plant part under low light conditions. On day 84, the epiphytic algal community of both apical (*C. placentula* 46%, *A. lineolata* 22%, *D. hiemale* 32%) and basal (*C. placentula* 92%, *A. lineolata* 4%, *D. hiemale* 4%) plant parts exhibited the same community architecture with low abundance. The density of the other species was negligible.

Development of the most abundant taxa

Cocconeis placentula was the most abundant taxa in the epiphytic community on the *P. perfoliatus* leaves.

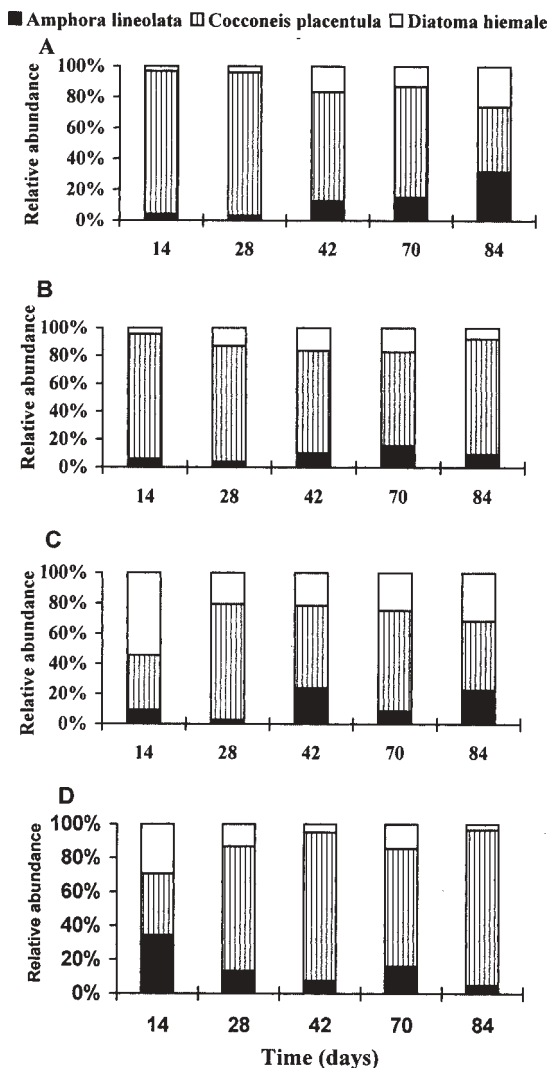


Fig. 3 Relative abundance of different epiphytic algal taxa on the: **A**, apical plant part in high light condition; **B**, basal plant part in high light condition; **C**, apical plant part in low light condition; and **D**, basal plant part in low light condition.

There were significant variations observed in the population of *C. placentula* during the sampling time, between the two light conditions, between apical and basal plant parts, and among all combinations of their interactions (three-way ANOVA, Table 1). This indicates that different temporal patterns of the colonisation of *C. placentula* on *P. perfoliatus* leaves transpired in both light conditions and both plant parts with time. The population of *C.*

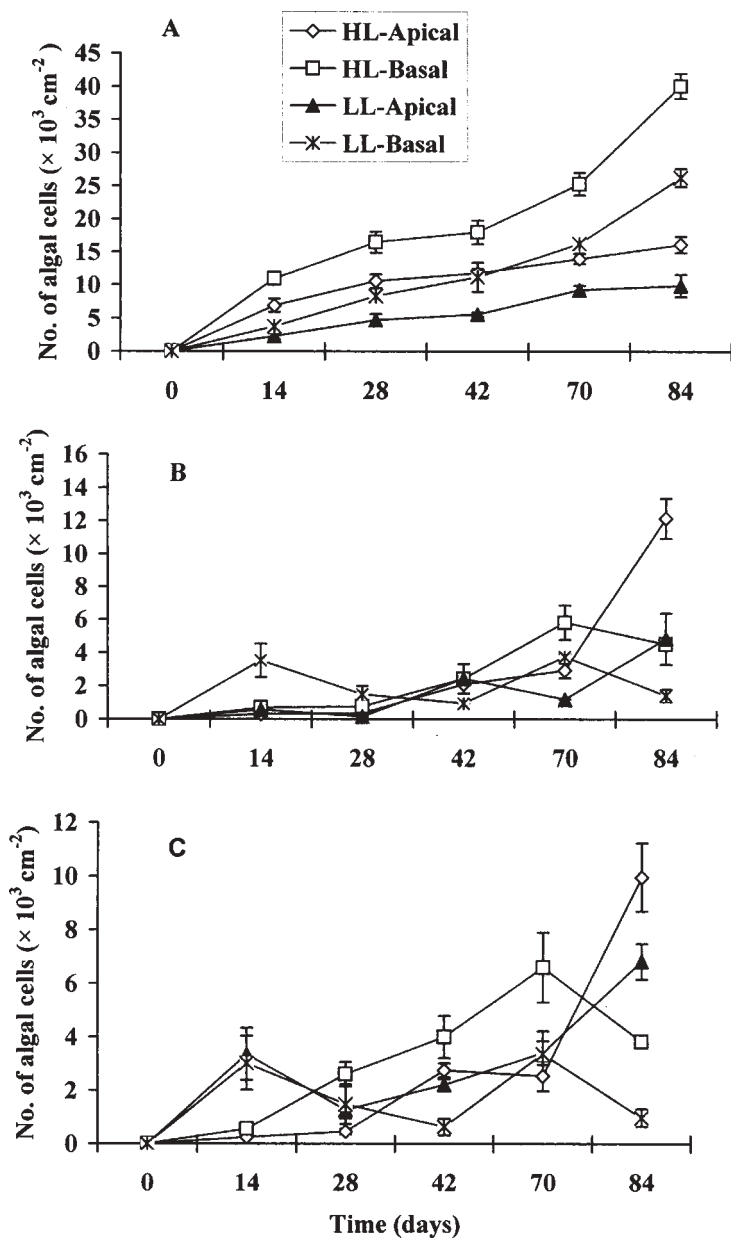
placentula showed a significant tendency to increase throughout the experimental period in both light conditions and on both plant parts (Fig. 4A) (one-way ANOVA, $F = 10.82$, d.f. = 4, $P < 0.001$). The cell density was significantly higher under high than low light conditions (one-way ANOVA, $F = 11.79$, d.f. = 1, $P < 0.01$) and higher on the basal plant part than on the apical plant part (one-way ANOVA, $F = 17.77$, d.f. = 1, $P < 0.001$). The other two abundant taxa, *A. lineolata* and *D. hiemale*, showed fluctuating affinity throughout the experimental period (Fig. 4B,C). Three-way ANOVA showed significant differences in the *D. hiemale* population with the three variables, time, light, and plant part and among all combinations of their interactions (Table 1). The *A. lineolata* population expressed the same phenomena except in the two plant parts, i.e., apical and basal plant parts. There was no significant difference observed in the *A. lineolata* population between apical and basal plant parts (Table 1). Under high light conditions, after a small growth from day 14 to day 28, *A. lineolata* declined on day 42 in the apical plant parts. Afterwards, it increased slowly until day 70, then sharply to a peak on day 84 (Fig. 4B), but in the basal plant part, it tended to increase until day 70 and thereafter declined until day 84 (Fig. 4B). Under low light conditions, it fluctuated in number on both the apical and basal plant parts until day 70 (Fig. 4B). On day 84, it sharply increased on the apical part and decreased in the basal part (Fig. 4B).

The *D. hiemale* population showed fluctuating density on the apical plant part in both light conditions and on the basal plant part under low light conditions until day 70 (Fig. 4C). Thereafter, *D. hiemale* sharply increased on the apical plant part (both high and low light conditions) and decreased on the basal plant part in the low light conditions on day 84 (Fig. 4C). In contrast, under high light conditions the species *D. hiemale* tended to increase until day 70 on the basal plant part and thereafter sharply declined on day 84 (Fig. 4C).

DISCUSSION

Compared to field investigations, laboratory analyses have seldom been performed to determine the structure and abundance of epiphytic algae on plants. Thus, comparison with data from other studies is quite difficult. In our present study, we observed only taxa of the class Bacillariophyceae as the epiphytic algal community in both light

Fig. 4 Colonisation rhythm of epiphytic algae: **A**, *Cocconeis placentula*; **B**, *Amphora lineolata*; and **C**, *Diatoma hiemale* during the experimental period on *Potamogeton perfoliatus* leaves. Vertical bars indicate \pm SD ($n = 3$). (HL, high light; LL, low light.)



conditions during the entire experimental period. This result differs from the epiphytic algal community observed under natural conditions by Bowker & Denny (1980), Goldsborough & Hickman (1991), Müller (1994), Tesolín & Tell (1996), and Cattaneo et al. (1998). In all the above-mentioned studies, it is obvious that the members of Bacillariophyceae are the most important structural component of the epiphytic community. In addition

to Bacillariophyceae, the previous studies reported members of Cyanophyta, Chlorophyta and, sometimes, Euglenophyta (i.e., Bowker & Denny 1980; Tesolín & Tell 1996) and other algae classes. Furthermore, in our present study, we identified only 18 taxa from the Bacillariophyceae group whereas all the above-mentioned studies identified a higher number of taxa from the different algae classes (i.e., Tesolín & Tell 1996, identified in total 136 algal taxa

consisting of 57 Bacillariophyceae, 31 Chlorophyceae, 31 Cyanophyceae, 13 Tribophyceae, and 4 Euglenophyceae). We hypothesise some reasons for the relatively lower species richness in our present study. First, the epiphytic algal community that developed was established by plant segments bearing algal propagules on the experimental *P. perfoliatus* leaves. We assume that only obligate epiphytic algal propagules were introduced with the leaves of *P. perfoliatus* segments from their natural habitat. Second, we used dechlorinated tap water for the experiment, and the water was completely changed once a week during the experimental period to avoid shading effects on the plants by phytoplankton. Therefore, the observed epiphytic algae were fully dependent on *P. perfoliatus* leaves; they were neither water-borne nor from the phytoplankton community. Moreover, the concentration of nutrients in the water affects the epiphytic community (Cattaneo 1987). We observed that *P. perfoliatus* is a low-nutrient inhabiting species (unpubl. data). We assume naturally low nutrient-affinitive organisms grow as the epiphytic community on *P. perfoliatus*. Epiphytic filamentous algae of the groups Cyanophyceae and Chlorophyceae prefer a comparatively nutrient-rich environment (Wuhrmann & Eichenberger 1975; Elwood et al. 1981). Wuhrmann & Eichenberger (1975) observed a significant biomass increase and shift from diatoms to filamentous algae with more nitrate and phosphorus enrichment of ground water in outdoor channels of Zurich. Thus, the comparatively low nutrient status of the water in the present study, rather than that of a eutrophied water body, may be another important reason for the lower species richness of the epiphytic community.

The density of the epiphytic algae increased with time under both light conditions. The algal density was significantly higher under high light than low light conditions. The findings of Hudon & Bourget (1983), who observed the maximum abundance of diatom cells in high light (in normal daylight at 1 m depth: 1600 cells mm⁻²) than in low light intensity (in a shaded panel at 5 m depth: 22 cells mm⁻²) supports the observations of the present study. They immersed glass slides as a substrate for epibenthos diatom communities in the St. Lawrence Estuary, Quebec.

Previous research examined epiphytic algal community development on different parts of the plant (e.g., Galanti & Romo 1997). The structure of the community in different parts of the plant is different for several reasons, i.e., shading created by plants parts, attenuation of light with water depth.

Alternatively, the basal plant part is older than the apical plant part. In the present study, significantly higher algal density was observed in the basal part than in the apical part. This observation is in agreement with Ballantine (1979) who observed heavier epiphyte growth in the older portion of the plant than in the younger portion. Blindow (1987) reported that there were no significant differences in total epiphyton densities among different macrophytes parts. Nevertheless, many taxa were more abundant on younger plant parts than on older ones. In our study, the apical part showed more species richness than the basal part under high light conditions on day 84, but under low light conditions, the number of taxa was the same on both plant parts.

Cocconeis placentula has been identified as an abundant epiphytic algal species in several previous studies (Troeger 1978; Bowker & Denny 1980; Shamsudin & Sleight 1995). In the present study too, it was observed that *C. placentula* was the most abundant epiphytic algae on the experimental *P. perfoliatus* plants. It formed a crust on the leaf surface and was always accompanied by *D. hiemale* and *A. lineolata* in both light conditions and on both the apical and basal parts, but their densities differed according to tolerances to different light levels and different plant parts during the colonisation time. Only a few authors report *Diatoma* spp. (i.e., Shamsudin & Sleight 1995) and *A. lineolata* (i.e., Troeger 1978; Jacobs & Noten 1980; Cattaneo et al. 1998) as members of the epiphytic community, although very little is known of their ecological requirements. Hudon & Bourget (1983) also reported *Cocconeis* spp. and *Amphora* spp. colonisation with different densities in different light intensities (normal daylight and shade condition). Actually, *C. placentula* can be regarded as a pioneer coloniser of the epiphytic community (Sieburth & Thomas 1973; Müller 1999). It may be a species that is tolerant of a wide range of light variations (Hudon & Bourget 1983) and it shows no preference for any host species and is abundant on a great variety of macrophytes (Müller 1999). Tippet (1971) reported that *C. placentula* preferred a low light intensity to high light. Our present study showed the density was higher under high than low light conditions, and it was 45% on the apical part (younger plant part, where transmitted light intensity was relatively higher than for the basal parts) under both light conditions on day 84, whereas it occupied a 95% share on the basal plant part under both light conditions (where transmitted light intensity was relatively lower than for the apical parts of the

plants). In this study, *C. placentula* was most abundant on young macrophytic leaves and least numerous on old leaves. On day 84, we observed a mosaic community that consisted of *C. placentula*, *D. hiemale*, and *A. lineolata* on the apical part of the plant. We suppose that this is a result of the effect of light, and also relates to the age of the plant. This was observed under both light conditions. The newly formed apical plant part somehow limits the growth of *C. placentula* and favours the growth of *D. hiemale* and *A. lineolata*.

We expected the epiphytic algal community species to differ in structure, size, or light tolerance as our first hypothesis. We observed more-or-less similar algal compositions (in the abundant taxa) in both light conditions, although their sizes (densities) were different. We think our reported taxa are wide light- and low nutrient-tolerant epiphytic algal species. Our first hypothesis is thus partially accepted, and the second hypothesis was proven by the end of the experiment (day 84). On day 84, the apical plant part expressed a mosaic epiphytic algal community, but the basal part expressed a more homogenous community with 95% *C. placentula*. A more interesting observation is the presence of only diatom taxa as the epiphytic community. For existing reasons, further study with phytoplankton, natural water, and more nutrients is needed.

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