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STUDIES ON PHOTOSYNTHETIC RATES AND SPECIES COMPOSITION OF AN EPILITHIC PERIPHYTON COMMUNITY IN A STREAM AT FRESNO, CALIFORNIA

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Abstract

An epilithic periphyton community showed significant seasonal changes in species composition, abundance, and photosynthetic rates in a slow-flowing, manmade stream. Blue green algae were dominant during summer, diatoms were dominant during spring and winter, and green algae dominated the community during fall. The highest photosynthetic rates were found in winter with 24°C as the optimum temperatures for production in all seasons.

Introduction

The structure and organization of the periphyton community alongwith the role of periphyton in community dynamics has become a focus of interest for many fresh water biologists. Benthic communities in streams have a high specific diversity and are confined to specific ranges of physical environments (Fiance, 1978; Vannole & Sweeney, 1980), they grow where flow is reduced or they are firmly attached to the substratum. Various ecologists have studied the energetics of lotic systems (Hynes, 1963; Fisher & Likens, 1973; Cummins, 1974; Cushing & Wolf, 1982). Work on primary production of periphyton has been done by Bott (1981), Revsbech *et al.* (1981) and Brown (1985). The factors which control primary productivity of periphyton communities are temperature (Phinney & Mcintire, 1965); light (Malone, 1977; Chang, 1981); nutrients and carbon dioxide (Bott, 1981). Experiments were carried out to study the seasonal changes in the structure and composition of an epilithic periphyton community in a slow flowing stream and to measure the productive capabilities of the community as a function of structure and season.

Materials and Methods

The study site chosen was a small stream about 4.5m wide and 0.6m deep in Woodward Park at Fresno, California (USA). Sampling area was a ripple area where flow of water is relatively slow (Aliya, 1986). In April, July, October, 1985 and January, 1986 algae were collected with the stream water in jars and stored overnight in referigerator in the laboratory. All animals were removed from the sample. Algal genera were identified

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using a compound light microscope. Live material was identified upto generic level which were characterized as dominant, abundant and rare.

Photosynthetic rates of algal samples were measured with Gilson respirometer. The algae were removed from the refrigerator, brought to room temperature and put into 12 respirometer flasks. Ten ml of the stream water was added to each flask. Two flasks with 10 ml of distilled water in each were used as control. Six flasks with algae were covered with aluminium foil to prevent light and photosynthesis. The other six flasks were left uncovered to measure net algal photosynthesis. Experiments were run at 15, 24 and 35°C. Samples were run for 2 h at each temperature with a one h equilibration period between runs to allow pressure and solubility changes to occur. Observations were taken at 15-min. intervals and were recorded in µl of oxygen. After the last run, algae from each flask were removed by filteration through a buchner funnel and weighed. The algae were then dried in an oven overnight at 105°C. The dry weight of the algae was then estimated. The photosynthetic rates of all the different samples was calculated in µl of O_2 /mg/h dry wt. at three different temperatures.

Results

There was a marked seasonal change in temperatures, air temperature ranged from 18 to 32°C and water temperature ranged from 15 to 27°C during the 1-year period. The pH of samples varied from 8 to 9.5 indicating the alkaline nature of the stream with the highest pH observed in spring (Table 1).

Although very little variation in the genera of algae occured from season to season, but a marked difference was seen in the dominance, abundance and rareness of the genera. Fourteen different genera of algae observed, were representatives of Chlorophyta, Cyanophyta, and Bacillariophyta (Table 2). *Cladophora* was the only macroscopic filamentous green alga found in the community which was dominant during fall and became rare towards the summer. *Cladophora* was often seen heavily coated by another microscopic green alga, *Characium* and the diatoms. *Ocillatoria, Anabaina, Chroococcus*

Table 1. Air and water temperatures, and pH readings at the time of sampling.

	Temperature °C		
Season	Water	Air	pH
Spring	20	23	9.5
Summer	27	32	9
Fall	18	20	8
Winter	15	18	8

Table 2. List of algae found during spring, summer, fall and winter.

Genus	Spring	Summer	Fall	Winter
Cyanophyta				
Anabaina sp.	–	+++	+	+
Chroococcus sp.	–	++	+	+
Oscillatoria sp.	+	+++	+	+
Chlorophyta				
Cladophora sp.	++	+	+++	++
Cosmarium sp.	+	–	+	+
Characium sp.	+	+	++	+
Dictyosphaerium sp.	+	–	–	–
Pediastrum sp.	++	++	++	++
Scenedesmus sp.	+	++	++	+
Thamniochaete sp.	+	–	–	+
Bacillariophyta				
Achnanthes sp.	+++	+	++	+++
Cyclotella sp.	+	–	+	++
Fragillaria sp.	–	+	+	++
Pinnularia sp.	++	–	++	+
No. of Genera	11	9	12	13
No. of dominant Genera	1	2	1	1

–Absent (0 %), +Rare (29% or below), ++Abundant (30-59%), +++Dominant (60% or above)

were dominant during summer and formed mats over the rocks in the stream. Diatoms formed a large part of the community. The most common diatom genus found was *Achnanthes*. Diatoms were dominant during the colder months but decreased in abundance towards the summer. The community structrure as a whole changed markedly from season to season, although the various genera were the same. Every season exhibited an abundant or dominant genus (Table 2).

The photosynthetic capabilities of the community were considerably different during the four seasons of the year. They were also significantly different at different temperatures within the same season with highest photosynthetic rates observed during the winter (Table 3) with lowest production in summer. There were marked differences in photosynthesis at various temperatures even within the same season. The optimum temperature for production during all four seasons was 24°C. Winter and fall samples did not show

Table 3. Net and gross productivity of periphyton as a function of season and temperature.

Season	Temperature °C	Photosynthetic Rates µl O_2/mg/h Net	Gross
Spring	15	7.77	6.82
	24	12.94	9.92
	35	4.2	0.31
Summer	15	4.02	2.52
	24	8.15	5.38
	35	0.64	-2.75
Fall	15	14	10.09
	24	29.6	12.71
	35	—	—
Winter	15	17.96	0.79
	24	37	19.7
	35	—	—

All measurements expressed as µl 0_2/mg/h dry wt., measured by Gilson respirometery.

any production at all at 35°C. The highest recorded net photosynthsis in winter was at 24°C, the lowest recorded net photosynthesis was seen in summer at 35°C.

Discussion

The Woodward Park stream periphyton community showed seasonal changes in dominance, abundance and rareness of genera. In general, the pattern of seasonal change was similar to patterns reported from previous studies of stream periphyton, (Hynes 1970; Fogg *et al.*, 1973; Round, 1973; Gibson, 1975; Moore, 1976, 1978; Round, 1981; Sze, 1986). Three genera of blue-green algae (*Anabaina, Chroococcus and Oscillatoria*) were dominant in the summer season. Although they were present in the other three seasons, they were no longer dominant. These results agree with previous reports (Hynes, 1970; Fogg *et al*, 1973; Round 1973-1981; Gibson, 1975; Moore, 1976; Darley, 1982) that blue-green algae are maximally abundant during the warmer months. Possibly their ability to withstand high temperatures (30-35°C) allows them to outcompete all other groups of algae during the hot summer season.

Diatoms, in contrast, were dominant during the spring and winter. The genus most frequently found was *Achnanthes* as was reported by Hynes (1970). Although present all year, they reach their peak in winter and spring. Hynes (1970) also found that some of the spring diatoms may become dominant again during the fall. However, this phenomenon did not occur during the present study. Douglas (1958) reported increases in diatom populations in May and June (British Isles), but attributed those peaks to the dry weather that occurs in those regions at that time of the year. He also studied *Achnanthes* in detail and found it to be the most common diatom in streams.

The green alga *Cladophora* dominated the community during the fall and was abundant all the year except during the summer when it occured in a very young growing state. *Cladophora glomerata* is a common inhabitant of flowing water systems all over the world and is the most abundant filamentous alga found in streams. *Cladophora* filaments have a nonmucilagenous wall which became densely coated throughout its growth with other epiphytic algae (diatoms and *Characium*). Round (1973) found diatoms, small green algae, and blue-green algae to be commonly epiphytic on *Cladophora* (in streams and rivers). Different authors have reported conflicting seasons of maximum abundance for *Cladophora*. Round (1973, 1981) found *Cladophora* abundance peaks in spring and summer. Sze (1986), however, recorded spring and fall as the greatest growth seasons for *Cladophora*.

Community productivity also showed marked seasonal changes. Highest net photosynthetic rates occurred in winter, lowest rates occurred in summer. This does not agree with previous work on periphyton productivity. Most workers (Hynes, 1970; Bott, 1981; Round, 1981; Darley, 1982) found that production rates reached their peak in summer, declined as temperatures decreased, and became lowest in winter. There are important differences between the study site and the type of stream ecosystems that are usually described in the literature. For example, most stream research is based on high elevation streams that are very low in nutrients and are usually covered by snow during winter. The current study, however, is based upon a low elevation, manmade California stream in a region of moderate winter temperature and light intensity. These conditions should support higher productivity rates in winter as compared to mountain streams.

These observations, however, do not explain why the Woodward Park stream attained its highest production rates during winter. Since light and temperature conditions are more favourable during summer, the ony plausible explanation seems to be nutrient quality. The Woodward Park stream receives water from a nutrient-rich duck pond. During the period of summer stratification, it is likely that most nutrients would sink to the bottom, leaving the surface layer of the pond depleted of nutrients. The water pumped into the stream comes from the upper layer of the pond. If this water became nutrient depleted, it could be the cause of low productivity during summer. Bott (1981) underlines the importance of nutrients in stream communities, since changes in nutrient availability could alter the productive capabilities of the community drastically.

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