

Seasonal Relationship Between Southern Naiad and Associated Periphyton

ERNESTO LASSO DE LA VEGA, J. R. CASSANI AND H. ALLAIRE¹

ABSTRACT

Periphyton growing on southern naiad (*Najas guadalupensis* (Sprengel) Magnus) were collected monthly to determine the relationship between southern naiad and its associated periphyton in south Florida. Periphyton biomass was determined indirectly by measuring the chlorophyll *a* of cells after separation from apical portions of the macrophyte and reported as mg chlorophyll *a* per g DW of macrophyte. The periphyton biomass, composed mainly of Cyanophyceae and Bacillariophyceae, changed seasonally depending on

light intensity ($r = -0.72$, $p < 0.01$), temperature ($r = 0.54$, $p = 0.05$) and water nutrients (O-PO₄ $r = 0.58$, $p < 0.05$). A significant inverse relationship between periphyton and southern naiad biomass ($r = -0.77$, $p < 0.01$) was found. The shading caused by periphyton appears to promote the seasonal senescence of southern naiad, which releases nutrients and subsequently stimulates further periphyton growth.

Key words: epiphytes, *Najas guadalupensis*, senescence, seasonality, light attenuation.

INTRODUCTION

The native submerged macrophyte southern naiad causes restricted recreational use and water flow in many of south-west Florida lakes and canals (Blackburn and Weldon 1964,

¹Research Biologist, Resource Manager and Aquatic Biologist, respectively, Biological Control Section, Lee County Hyacinth Control District, P. O. Box 06005, Fort Myers, FL 33906.

Lawson 1991). Ecological studies of southern naiad are lacking and the information that is available is largely restricted to its distribution and taxonomy (Haynes 1977, 1979; Lowden 1986). Martin *et al.* (1970) studied the relationship of nutritional and environmental factors that affect the growth of macrophytes of the genus *Najas* but little information concerning the life history and seasonal growth requirements of southern naiad has been published.

The relationship between macrophytes and associated periphyton has been studied intensively in species other than *Najas* spp. (Allanson 1973, Cattaneo and Kalff 1978, Blindow 1987). The effect that periphyton have on macrophytes is controversial. Two such controversial ideas include periphyton inhibitory effect on macrophytes and periphyton proliferation as a result of metabolite "leakage" from macrophytes (Rejmankova 1989).

Light intensity, temperature (Barko *et al.* 1984) and nutrient availability (Landers 1982) play an important role in regulating macrophyte seasonality. We believe these environmental factors affect periphyton as well.

The objective of this study is to describe the seasonal periodicity and community composition of a periphyton community associated with southern naiad and the potential significance of this periphyton community on the seasonality of the host macrophyte.

MATERIAL AND METHODS

The study area was located in a sparsely populated area of the city of Cape Coral, FL, latitude 26°37'N and longitude 81°57'W. The study site was a man-made freshwater reservoir with a surface area of 6.5 ha and a maximum depth of 3 m.

Periphyton associated with southern naiad were collected monthly from April 1991 to May 1992. Six samples were taken from randomly selected sites using SCUBA equipment. Apical portions (approx. 25 cm) of southern naiad were carefully placed inside 2-L wide-mouth glass containers under water. Samples were analyzed the same day of collection at the laboratory. Jars containing the samples were slowly drained by siphoning with plastic tubing. FAA solution (500 ml of ethanol, 350 ml of water, 100 ml of formalin and 50 ml of glacial acetic acid) was added (approx. 250 ml) to the glass container. The loss of cell metabolites, due to the use of FAA solution, can occur and reported values for chlorophyll *a* may be conservative. This was inevitable in order to remove and to preserve the material for enumeration and identification. Removal of the periphyton was accomplished by a combination of agitation and acid hydrolysis of the mucilage-like adhering structures (Gough and Woelkerling 1976). After 1 min of vigorous shaking, "clean"

macrophyte material was removed, dried in an oven for 24 hr at 105C and weighed on an analytical balance. Microscopic inspection of southern naiad leaves and stems revealed less than an estimated 1% of the periphyton remaining after the extraction process. Loose periphyton in solution was collected in a graduated cylinder and diluted to 500 ml with deionized water. Aliquots of 100 ml were used to determine chlorophyll *a*, following APHA (1989) methodology. Periphyton biomass was expressed as mg of chlorophyll *a* per g of dry macrophyte (mg Chl *a*/g DW). Additional aliquots of 30 ml were kept in vials for enumeration and identification. A Palmer counting cell was used as a counting chamber to determine percentages of the following algal groups: coccoid blue-green, filamentous blue-green, coccoid green, filamentous green, centric diatoms and pennate diatoms.

Southern naiad biomass was estimated monthly from April 1991 to May 1992 by means of a 0.1-m² drop-and-cut-type sampler. Thirty samples were collected from random locations, sorted according to species, rinsed of adhering periphyton and oven-dried at 105C for dry weight determination.

The water column was sampled with a Kemmerer water sampler at two deep-water stations and the results of these analyses were averaged. Samples were analyzed for turbidity, chlorophyll *a*, ortho-phosphate and nitrates following the methodologies described in APHA (1989). Turbidity was measured using a HF Scientific Inc., Model DRT-100B turbidimeter and expressed as Nephelometric Turbidity Units (NTU). Chlorophyll *a* was determined by spectrophotometry after acetone extraction. Ortho-phosphates were determined by the ascorbic acid method and nitrates were determined by the cadmium reduction method. Irradiance, measured at 0.5-m intervals with a LI-COR, Model LI-1000 Data Logger, was averaged and expressed as $\mu\text{E}/\text{m}^2/\text{s}$.

Multiple regression analysis (SPSS) (Norusis 1986) was used to compare potential statistical relationships between the dependent variable periphyton biomass and the independent variables southern naiad biomass, light intensity, temperature and ortho-phosphate.

RESULTS AND DISCUSSION

Monthly estimates of southern naiad biomass indicate a seasonal pattern, having the highest value in June (98.0 g/m² DW) and declining to the lowest value in August (0.3 g/m² DW) (Figure 1). Seasonal changes in associated periphyton biomass demonstrate a significant inverse relationship ($r = -0.77$, $p < 0.01$) with southern naiad biomass.

Periphyton community composition was dominated numerically by filamentous blue-green algae (Cyanophyceae) from July through October when periphyton biomass reached

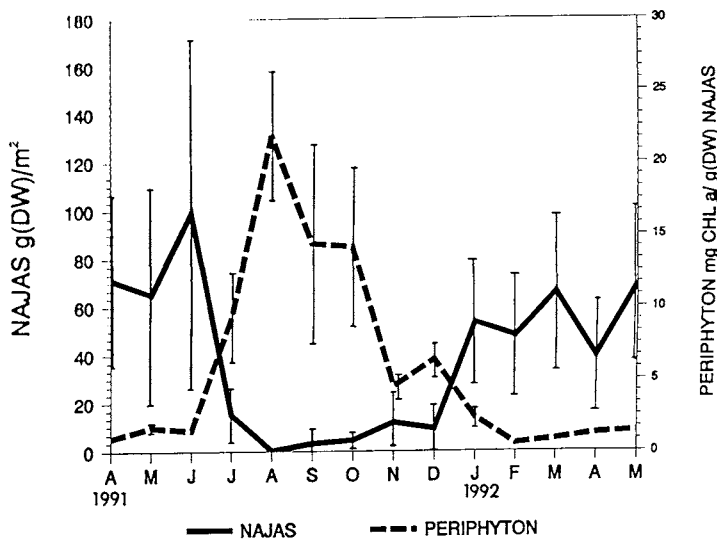


Figure 1. Average southern naiad biomass (n = 30) and associated periphyton biomass (n = 6) collected monthly from April 1991 to May 1992.

its maximum density (21.8 mg Chl *a*/g DW Najas) (Figure 2). A subsequent shift to dominance by diatoms (Bacillariophyceae) occurred from November through February after periphyton biomass declined. Dominance by diatoms also occurred during June 1991 (56%) although periphyton biomass is lower than when filamentous blue-green algae were dominant. Barko *et al.* (1988) reported similar algal succession where species composition shifted from diatoms and green algae in the early summer to blue-green and green filamentous algae in late summer and autumn. In our study,

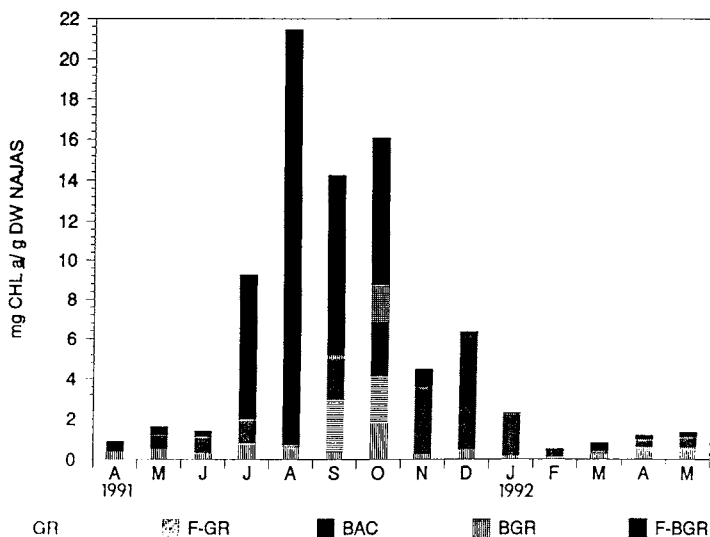


Figure 2. Periphyton community composition associated with southern naiad. GR = coccoid green algae, F-GR = filamentous green algae, BAC = Bacillariophyceae, BGR = coccoid blue-green algae, F-BGR = filamentous blue-green algae.

the period of dominance by filamentous blue-green algae could be characterized by relatively low water transparency and warmer temperatures (Table 1). Average light intensity was inversely related to periphyton biomass ($r = -0.72$, $p < 0.01$). Water column phytoplankton, as measured by chlorophyll *a*, and turbidity were primary factors regulating light availability (Table 1). Beer *et al.* (1986) found that at reduced light and high temperature, blue-green algae tend to compete more effectively than other algal groups.

The periphyton proliferation could be interpreted as the result of the natural senescence of the macrophyte, thereby increasing nutrient availability from the decaying material to the periphyton (Burkholder and Wetzel 1990). Another interpretation is that periphyton promotes senescence of the macrophyte by reducing light availability (Sand-Jensen and Sondergaard 1981, Bulthuis and Woelkerling 1983).

Rejmankova (1989) reviewed several studies suggesting two prevailing theories relating the effect of light attenuation on macrophyte photosynthesis. In the first theory, the density of periphyton causes a shading effect suppressing macrophyte photosynthesis. However, in the second theory, the shading effect does not suppress macrophytes substantially because older leaves, which developed the most dense periphyton, are not as photosynthetically active as new leaves. Periphyton biomass, as reported in our study, was collected from apical portions and was considered relatively dense. For this reason, we believe periphyton may have a significant shading effect on southern naiad.

Periphyton extract nutrients from the water column in contrast to most macrophytes that derive their nitrogen and phosphorus primarily from the sediments (Barko and Smart 1980, 1981). As a result, periphyton and macrophytes are not competing for nitrogen and phosphorus from the same source. In general, relatively high phosphorus concentrations promote phytoplankton proliferation which decreases water transparency and subsequently reduces light available to macrophytes. Similarly, ortho-phosphate was present in relatively high concentrations (May 1991) before the macrophyte decline (Table 1), which may have accounted for the increase in phytoplankton and the decrease in light. Consequently, southern naiad biomass starts to decline and phosphorus levels increase further in August stimulating periphyton growth. Landers (1982) reported that the annual dieback of eurasian water milfoil (*Myriophyllum spicatum* L.) results in a seasonal increase of water column nutrients with subsequent increases in periphyton and phytoplankton.

A somewhat different temporal pattern for nitrate concentrations was evident. When periphyton biomass declined (October through November 1991), nitrate concentrations in the water column increased (Table 1). The increase of nitrates may be related to the release of inorganic nitrogen compounds

TABLE 1. AVERAGE PHYSICAL AND CHEMICAL WATER QUALITY PARAMETERS DETERMINED AT THE STUDY SITE, AN ARTIFICIAL RESERVOIR IN CAPE CORAL, FL.

Month	Light intensity ($\mu\text{E}/\text{m}^2/\text{s}$)	Turbidity (NTU)	mg Chl <i>a</i> /m ³	$\mu\text{g O-PO}_4/\text{l}$	$\mu\text{g NO}_3\text{-N}/\text{l}$	Temperature C
Apr 1991	337	0.6	3.0	1	1	26
May	394	1.1	6.2	6	3	28
Jun	295	1.2	5.6	2	5	29
Jul	132	2.0	22.6	5	1	29
Aug	163	0.8	3.7	6	3	30
Sep	288	1.0	4.7	4	4	29
Oct	268	0.7	3.0	2	18	26
Nov	262	0.8	3.3	2	55	21
Dec	314	1.0	2.8	4	46	19
Jan 1992	331	0.8	2.9	2	2	18
Feb	377	0.9	1.6	2	1	19
Mar	442	0.5	1.5	1	0	21
Apr	459	0.8	3.0	2	0	22
May	424	0.7	1.9	1	2	26

from senescing periphyton, especially the blue-green algae component, which was declining during this period (Figure 2). It has been reported that filamentous blue-green algae can release inorganic nitrogen compounds, such as ammonium, under unfavorable conditions (Zimmermann 1989). During this same period, average water temperatures declined from 25.6C to 21.1C (Table 1), and may have contributed to the decline of periphyton biomass, as indicated by the statistical relationship between temperature and periphyton ($r = 0.54$, $p = 0.05$). Bushong and Bachmann (1989) reported that water temperature was an important factor in controlling periphyton growth rates and that nutrients seldom limit the growth of attached algal communities.

The grazing effect on periphyton by gastropods has been reported (Hunter 1980) to significantly affect the productivity of "aufwuchs." However, we suspect that in this case, macroinvertebrates had an insignificant effect on periphyton abundance since none were observed on the leaves and stems of southern naiad when sampled.

In conclusion, it appears that a combination of two cause-and-effect interactions contribute to southern naiad seasonality. Increasing periphyton abundance, responding to seasonal patterns in light availability, water temperature and nutrients, may be largely responsible for declines in associated southern naiad through shading. Concomitantly, nutrients in the water column increase as southern naiad tissue senesces, stimulating further periphyton growth.

ACKNOWLEDGMENTS

We thank John Hunt and Craig Curtis for assisting with sample collection and Betsy Sanford for the preparation of the manuscript and tables.

LITERATURE CITED

- Allanson, B. R. 1973. The fine structure of the periphyton of *Chara* sp. and *Potamogeton natans* from Wytham Pond, Oxford, and its significance to the macrophyte-periphyton metabolic model of R. G. Wetzel and H. L. Allen. *Freshwater Biol.* 3:535-542.
- American Public Health Association, American Water Works Association and Water Pollution Control Federation. 1989. *Standard Methods for the Examination of Water and Wastewater*, 17th ed. APHA, Washington, D. C. 1467 pp.
- Barko, J. W. and R. M. Smart. 1980. Mobilization of sediment phosphorus by submersed freshwater macrophytes. *Freshwater Biol.* 10:229-238.
- Barko, J. W. and R. M. Smart. 1981. Sediment-based nutrition of submersed macrophytes. *Aquat. Bot.* 10:339-352.
- Barko, J. W., D. G. Hardin and M. S. Matthews. 1984. Interactive Influences of Light and Temperature on the Growth and Morphology of Submersed Freshwater Macrophytes. Technical Report A-84-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Barko, J. W., G. L. Godshalk, V. Carter and N. B. Rybicki. 1988. Effects of Submersed Aquatic Macrophytes on Physical and Chemical Properties of Surrounding Water. Technical Report A-88-11, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Beer, S., W. Spencer and G. Bowers. 1986. Photosynthesis and growth of the filamentous blue-green alga *Lyngbya birgei* in relation to its environment. *J. Aquat. Plant Manage.* 24:61-65.

- Blackburn, R. D. and L. W. Weldon. 1964. Control of southern naiad in Florida drainage and irrigation channels. *Weeds*. 12(4):295-298.
- Blindow, I. 1987. The composition and density of epiphyton on several species of submerged macrophytes - The neutral substrate hypothesis tested. *Aquat. Bot.* 29:157-168.
- Bulthuis, D. A. and W. J. Woelkerling. 1983. Biomass accumulation and shading effects of epiphytes on leaves of the seagrass *Heterozostera tasmanica* in Victoria Australia. *Aquat. Bot.* 16(2):137-148.
- Burkholder, J. M. and R. G. Wetzel. 1990. Epiphytic alkaline phosphatase on natural and artificial plants in an oligotrophic lake: Re-evaluation of the role of macrophytes as a phosphorus source for epiphytes. *Limnol. Oceanogr.* 35(3):736-747.
- Bushong, S. J. and R. W. Bachmann. 1989. In situ nutrient enrichment experiments with periphyton in agricultural streams. *Hydrobiologia*. 178(1):1-10.
- Cattaneo, A. and J. Kalf. 1978. Seasonal changes in the epiphyte community of natural and artificial macrophytes in Lake Memphremagog (Que. & Vt.). *Hydrobiologia*. 60(2):135-144.
- Gough, S. B. and W. J. Woelkerling. 1976. On the removal and quantification of algal aufwuchs from macrophyte hosts. *Hydrobiologia*. 48(3):203-207.
- Haynes, R. R. 1977. The Najadaceae in the Southeastern United States. *Journal of the Arnold Arboretum*. 58(2):161-170.
- Haynes, R. R. 1979. Revision of North and Central American *Najas* (Najadaceae). *SIDA*. 8(1):34-56.
- Hunter, R. D. 1980. Effects of grazing on the quantity and quality of fresh water aufwuchs. *Hydrobiologia*. 69(3):251-260.
- Landers, D. H. 1982. Effects of naturally senescing aquatic macrophytes on nutrient chemistry and chlorophyll *a* of surrounding waters. *Limnol. Oceanogr.* 27(3):428-439.
- Lawson, P. 1991. Southern naiad - A neglected native. *Aquatics*. 13(4):4-6.
- Lowden, R. M. 1986. Taxonomy of the genus *Najas* L. (Najadaceae) in the neotropics. *Aquat. Bot.* 24(2):147-184.
- Martin, J. B., B. N. Bradford and H.G. Kennedy. 1970. Relationship of Nutritional and Environmental Factors to Selected Rotted Aquatic Macrophytes; Part I. Factors Affecting Growth of *Najas* in Pickwick Reservoir. National Fertilizer Development Center, TVA, Muscle Shoals, AL. pp 7-14.
- Norusis, M. J. 1986. SPSS/PC+ for the IBM PC/XT/AT. SPSS Inc., Chicago, IL.
- Rejmankova, E. 1989. Review of Senescence as an Important Factor Determining the Relationship Among Aquatic Plants, Their Epiphytes, and Pathogens. Miscellaneous Paper A-89-3. US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Sand-Jensen, K. and M. Sondergaard. 1981. Phytoplankton and epiphyte development and their shading effect on submerged macrophytes in lakes of different nutrient status. *Int. Rev. Gesamten Hydrobiol.* 66(4):529-552.
- Zimmermann, C. F. 1989. Nitrogen and phosphorus uptake and release by the blue-green alga *Microcoleus lyngbyaceus*. *J. Aquat. Plant Manage.* 27:49-51.