Acta Biol. Venez., Vol. 19(4):1-8
Diciembre, 1999

GROWTH OF TROPICAL HELOPHYTE *ECHINOCHLOA POLYSTACHYA* (H.B.K.) HITCHCOCK IN JURUMIRIM RESERVOIR (SÃO PAULO, BRAZIL)

CRECIMIENTO DE LA HELOFITA TROPICAL *ECHINOCHLOA POLYSTACHYA* (H.B.K.) HITCHCOCK EN LA REPRESA DE JURUMIRIM (SÃO PAULO, BRASIL)

Marcelo Luiz Martins Pompêo, Viviane Moschini-Carlos & Raoul Henry

Departamento de Zoologia - Instituto de Biociências, UNESP, C.P. 510, 18618-000 - Botucatu - SP - Brasil, e-mail: vivimarc@uol.com.br

RESUMEN

El crecimiento de la macrófita emergente *Echinochloa polystachya* (H.B.K.) Hitchcock, en la desembocadura del río Paranapanema, en la Represa de Jurumirim, São Paulo, Brasil, se estudió durante un año midiendo periódicamente las hojas e internudos vivos. Se estimó la tasa absoluta de crecimiento (AGR) y la tasa relativa (RGR), asi como la producción de materia seca durante dos periodos de observación. El RGR determinado el observación dos fue mayor (0.0146 g g/día) do que en el observación uno (0.0039 g g/día). Su grande crecimiento alcanzó 2 cm/dia como estrategia para evitar el ahogamiento del tallo, en especial durante la época de inundación. *E. polystachya* mostró un modelo de crecimiento que sugiere la utilización de recursos para un rápido crecimiento longitudinal del tallo.

ABSTRACT

The growth of emergent macrophyte *Echinochloa polystachya* (H.B.K.) Hitchcock in the mouth of Paranapanema River at Jurumirim Reservoir (São Paulo, Brazil) was studied during one year, throughout periodical measurements of living blades and internodes. Two observations were carried to estimate the absolute (AGR) and relative growth rate (RGR) and dry matter productivity. The RGR determined in observation two (0.0146 g g/day) was biggest than in observation one (0.0039 g g/day). Its bigger growth attained 2 cm/day, to avoid the stem being drown, particularly at the time of rising water. *E. polystachya* showed a growth pattern that suggests allocation of resources for a rapid stem elongation.

Palabras clave: macrófito, *Echinochloa polystachya*, crecimiento, producción

Keywords: macrophyte, *Echinochloa polystachya*, growth, production

INTRODUCTION.

In the early phase of limnological studies, there were few works on aquatic macrophytes because of the methodological difficulties (Esteves & Menezes, 1992). However, various methods have been used to determine their primary productivity (Howard-Williams, 1978; Howard-Williams et al., 1982; Esteves & Menezes, 1992). Some of those methods have used destructive sampling, potentially harmful to vegetation. Using linear relations or allometric functions (e.g. area and volume, weight and number of structural units) is the methodology to estimate the living plant growth without damage (Benincasa, 1986). Primary productivity, for example, could simply be estimated by successive measurements of living plant parts, using regression equations that relate length with dry weight. Studies using non-destructive sampling, as in periodical samplings of living plants, are useful for the application of demographic and growth techniques (Coutinho, 1989).

The growth of aquatic macrophytes is very closely to hydrological cycle (Junk & Piedade, 1997). Many species present growth in the water rise period, for example, emergent plants, while anothers grow in the water low time (Piedade *et al.*, 1991; Junk & Piedade, 1997; Luciano & Henry, 1998; Pinho *et al.*, 1998).

The aim of the present work is to relate with hydrological cycle the growth of living plants and the dry material production of an emergent macrophyte *Echinochloa polystachya* (Poaceae) in a tropical reservoir.

MATERIALS AND METHODS.

Study Area. Jurumirim Reservoir is the first one of Paranapanema River cascade reservoirs (São Paulo State, Brazil). The climatological characteristics of the studied region included a period with high air temperature and precipitation, from October 1993 to March 1994, and a dry season from August and September 1993 and April to July 1994, with low air temperature and precipitation (Pompêo *et al.*, 1997). Rooted in the marginal region of Paranapanema River's mouth, at Jurumirim Reservoir (23º 27' - 23º 29' S and 48º 39' - 48º 36' W), E. polystachya dominated the ecotone region between land and water, according to Russo (1996), covering 160 ha. The stems of this grass can extend for about 15 m and are projected towards the limnetic region, with 5 to 8 leaf blades above water. Below the water surface, stem nodes with adventitious roots up to 50cm long and senescent leaf blades and sheaths were observed (Pompêo & Henry, 1996).

Observations. The first one observation (observation 1) lasted 150 days (from August 1993 to January 1994) and the second one (observation 2) 137 days (from February to July, 1994). Six and four stems were labeled, respectively, in the first and second observation. With the drowning and disappearance of first stems labeled in observation 1, due to rising water, occurred between January and February 1993, were necessary labeled new stems.

The observational design involved the choice of individual stems a periodical labeling and measurements of the internodes (length and diameter) and leaf blades (length and width). Simple linear regressions were used to relate dependent biometric variables to its respective dry weight. For the leaf blades, the following equation was used (Pompêo & Henry, 1996): $DW_{bl} = (Abl - 7.782)/123.94$ ($r = 0.97$; $P<0.01$), where DW_{bl} is the leaf blade dry weight and Abl is the surface area ($Abl = 0.631.L.W$, in which L is length and W is width). For the internodes, the following equation was used: $DW_e = 0.108.V_e + 0.469$ ($r = 0.90$; $P<0.01$), where DW_e is the internodes dry weight and V_e is the volume ($V_e = \pi.(D/2)^2.L$, in which D is diameter and L is length).

For each observation, the number of live and dead leaf blades was counted (Coutinho, 1989) and the absolute (AGR) and relative growth rates (RGR) were calculated (Benincasa, 1986). To measure the stem's primary productivity, chosen was the equation proposed by Ricker (1946, 1958): $P\ (gDW\ m^{-2}/day) = \{(\ln W_2 - \ln W_1).(B_1 + B_2)/2\}/(t_2 - t_1)$, where P is the primary productivity; B_1 and B_2 are the monthly mean biomass (gDW/m) determined at *E. polystachya* stand (Pompêo, 1996); W_1 and W_2 are the dry weight determined by regression equation on two successive sampling (times t_1 and t_2).

According Pompêo (1996), the seasonal variation in biomass of *E. polystachya* was unimodal, with greater biomass from November 1993 to April 1994. The average biomass was 1,933.7 (479.5 gDW/m2, with a variation along the year from 1,149.0 to 2,755.9 gDW/m2. The annual variation of aerial green biomass, aerial and aquatic detritus suggest that the main growth period of *E. polystachya* was from December 1993 to May 1994, with peak between February to March 1994. The data indicate that this macrophyte is adapted to water level variation.

RÉSULTS

Direct field observations showed that leaf blades of *E. polystachya* remain photosynthetically active for about one month. After that, leaves form the aerial detritus, and later the aquatic ones. At the time of rising water, they are directly transformed into aquatic detritus, due to the drowning of the still photosynthetically active leaves.

During the observation 1, a slight reduction of leaf blade number occurred in October 1993. Later, a increase of leaf blade number was observed at the beginning November 1993 (Fig. 1). During observation 2, leaf blade number increased and "peaked" at the beginning of April 1994. Next, a decrease in leaf blade number was observed until July 1994. For two observations, the live and dead leaf blade numbers showed a similar pattern of variation, showing that living blades are continually being replaced along the year.

Stem length, internode number, leaf blade and total dry weight of the plants obtained during observation 1 and 2 are shown in Fig. 2. Comparing the observations 1 and 2, the smallest gain in weight was recorded in observation 1. Thus, smallest AGR, RGR and dry weight production were found in observation 1 (Fig. 3). Higher initial leaf blade dry weight was found in observation 2 than in observation 1, and an increase in dry weight occurred until the 45th day (Fig. 2, IIc). Later, a weight loss was observed, due to the

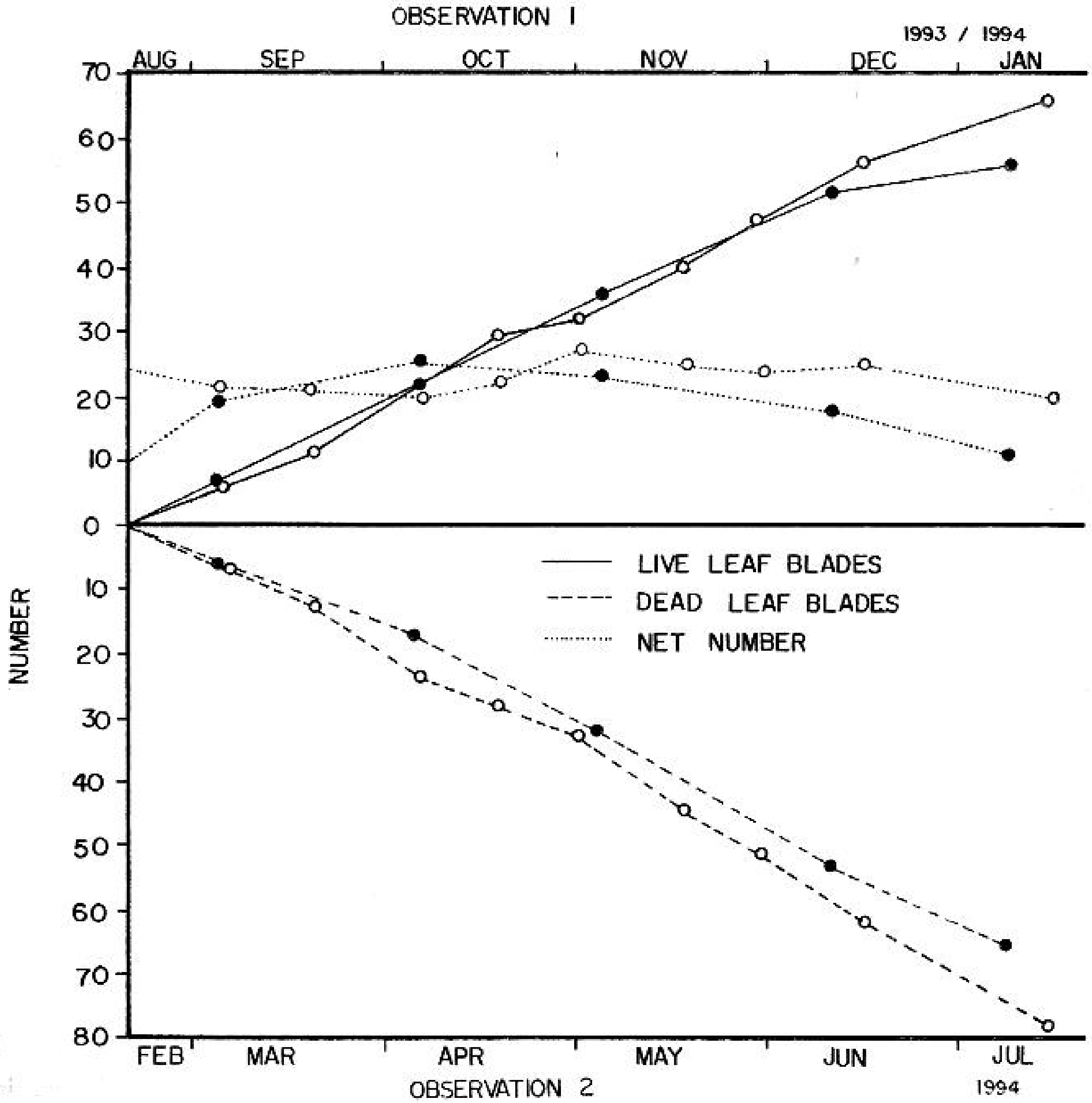

Figure 1. Cumulative number of live (birth-rate) and dead (mortality) blades, and net number of live blades of *E. polystachya* present in month during observation 1 (O - from August 1993 to January 1994) and observation 2 (O - from February 1994 to July 1994).

decreasing in the number of live blades (Fig. 1). Further on, a diminution of live leaf blade biomass was recorded. A reduction AGR, RGR and dry material production (Fig. 3) also could be observed from the 45th day. Comparing the mean initial and final biomass values, *E. polystachya* presented a gain of 0.0787 and 0.4064 gDW/day, with a growth in length corresponding to 0.53 and 1.99 cm/day, respectively, for observations 1 and 2. Therefore, during observation 2 occurred the bigger and faster growth in length and total stem dry weight, in spite of the smaller number of internodes observed. The internodes reached maximum length during observation 2. The difference observed in leaf blade dry weight between the experiments was attributed to higher leaf blade length verified in observation 2 that in observation 1.

AGR, RGR and dry material production values showed no significant variation during the period in observation 1 (Fig. 3).

Considering the growth rates found in observation 1, mean dry weight annual material production would be infered how 8.4 tDW/ha. When growth rates found during the observation 2 are used, production would present a significant increase, attained 108.7 tDW/ha.

DISCUSSION.

RGR determined for *E. polystachya* at Jurumirim Reservoir, are inferior to other studies (Table 1), except to *Eichhornia azurea* (leaves and rhizomes). Growth rate in length observed in this work is smaller comparatively with the values determinate by Piedade (1993), also for *E. polystachya* (4 cm/day), but upper the values determinate for *Phragmites australis* (Cav.) Trin, Ex Steudel (0.91 cm/day) and *Phalaris arundinaceae* L. (0.7 cm/day) (Ho, 1979a,b). Differences found could be attributed to differential growth of plants, the structure of the studied plant, its physiological state and year period. The growth is also influenced by nutritional state. Macrophytes growing in lakes with high nutrient contents develop better and faster than the ones in lakes with lower nutrient contents (HO, 1979a, b).

The highest RGR observed in individual analysis of stems of *E. polystachya* studied in observation 1 was 0.0322 g g/d, and in the observation 2, was 0.0708 g g/d. Considering these rates, it would be necessary 21.5 days (observation 1) and 9.8 days (observation 2) to reach the doubling time in *E. polystachya*, respectively. The values determinate in this work in the observation 2 are higher than verified to others aquatic macrophytes. According Junk & Piedade (1997), the rooted plants grow mainly vertical manner, while that the floated plants, how *Salvinia auriculata*, *Pistia stratiotes* and *Eichhornia crassipes*, grow by horizontal manner. This can be the explanation about the differences showed between the doubling time (Table 2).

The unequivocal differences on the production estimations from these two observations suggest a variation in the growth rates. *E. polystachya* is well adapted to the water level variations that occur in the Paranapanema River mouth, and present a annual production of 25 tDW ha/year (Pompêo, 1996). There is a synchronism between the total, live biomass and nutrient stock variations with water level rise. In the Amazon region *E. polystachya* is also adapted to water level variation, and it grow vigorously during the period of rising water level (10 m) (Piedade *et al.*, 1991; Piedade, 1993).

Thus, the differences observed during observation 2, when compared to observation 1, promoted an increment on leaf photosynthetic activity and a bigger vegetative growth. Probably, the strategy for resource allocation is to stimulate a fast elongation, as it was observed in the initial phase of observation 2, to avoid the stem drowning during the period of water level rise.

Probably, the combination of factors gives *E. polystachya* the ability for occupying and remaining in the Paranapanema River mouth. The identification of the effects of environmental factors on morphology and vegetative growth is possible through experimental works under controlled conditions. In the field, these factors act in combination and in a synergistic way over the plant development (Coutinho, 1989). The presence of *E.*

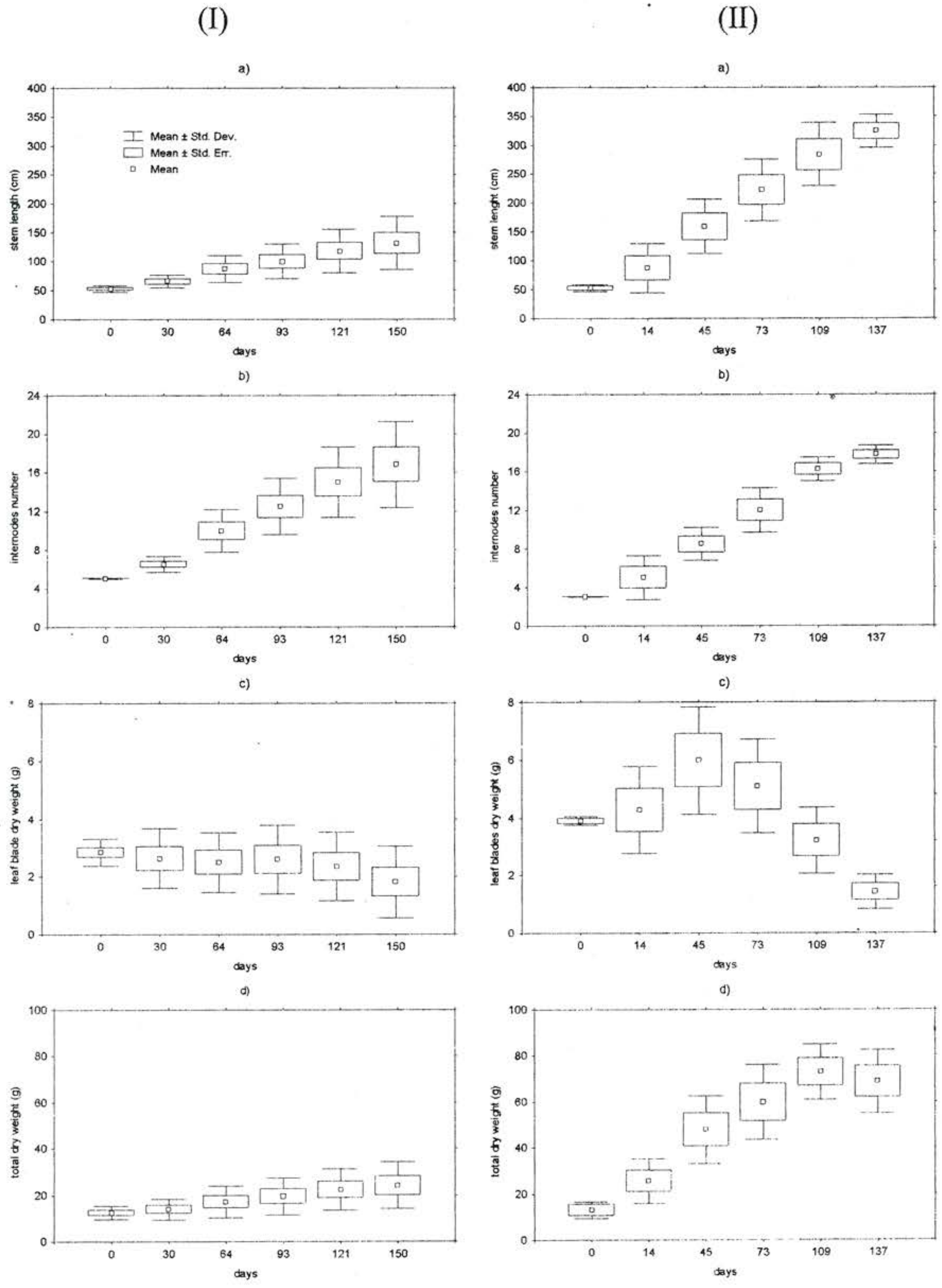

Figure 2. Growth of *E. polystachya* during observation 1 (I) and 2 (II) - a) stem length, b) internode number, c) leaf blade dry weight and d) total dry weight (leaf blades + internodes).

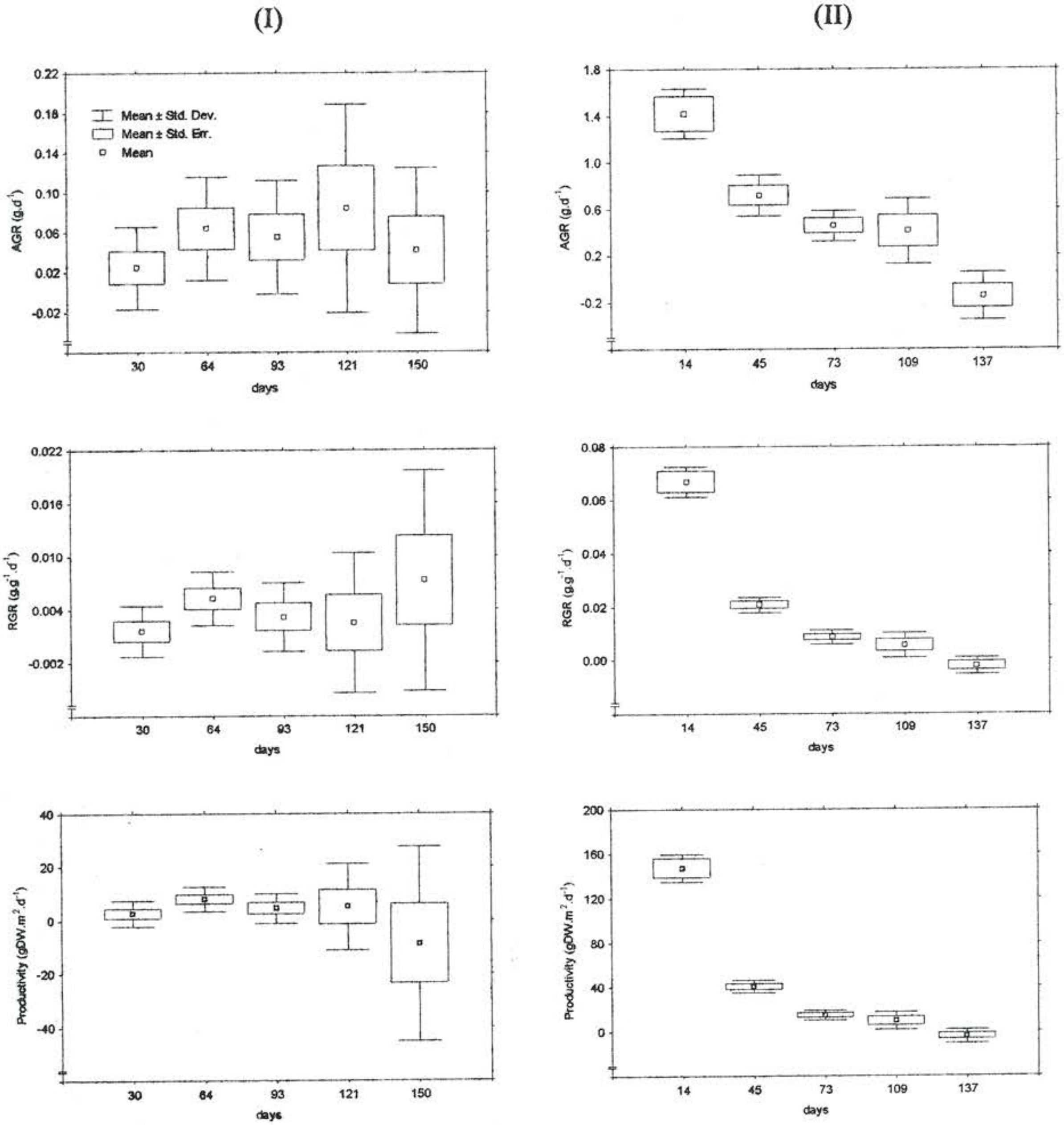

Figure 3. Absolute (AGR) and relative growth rates (RGR) and primary productivity of *E. polystachya* during the observation 1 (I) and 2 (II).

Table 1. **Relative growth rates (RGR) of different macrophytes in some tropical ecosystems.**

plant	fraction	Site	RGR - g g/day	author
Eichhornia azurea (Swartz) Kunth	leaves	Lagoon of Infernão – Brazil	0.0065 to 0.0232	1
	rhizome	Lagoon of Infernão – Brazil	0.0 to 0.0276	1
	leaves	Lake Dom Helvécio - Brazil	0.0813	2
	leaves	Lake Jacaré – Brazil	0.0659	2
	leaves	Lake Carioca – Brazil	0.0592	2
Eichhornia crassipes (Mart.) Solms	-	Lake Castanho – Brazil	0.074	4
Pistia stratiotes L.	-	Lake Castanho – Brazil	0.088	4
Salvinia auriculata Aubert	-	Lake Castanho – Brazil	0.096	4
Nasturtium officinale R. Br.	all plant	Whangamata Stream - New Zealand	0.0046 to 0.0569	3
E. polystachya	blade+stem	Jurumirim Reservoir – Brazil	0.0039(1) and 0.0146(2)	5

1 - COUTINHO (1989);
2 - IKUSIMA and GENTIL (1987) - Vale do Rio Doce lakes - Minas Gerais State, Brazil;
3 - HOWARD-WILLIAMS *et al.* (1982), included vegetal parts lost during the growth;
4 - JUNK and HOWARD-WILLIAMS (1984);
5 - this work - (1) observation 1 and (2) observation 2.

Table 2. Doubling time (days) for some aquatic macrophytes.

macrophyte	site	doubling time	References
S. auriculata	Lake Castanho (Brazil)	7.2	JUNK and HOWARD-WILLIAMS (1984)
P. stratiotes	Lake Castanho (Brazil)	7.9	JUNK and HOWARD-WILLIAMS (1984)
E. crassipes	Lake Castanho (Brazil)	9.4	JUNK and HOWARD-WILLIAMS (1984)
E. polystachya	Paranapanema River	9.8$^{(1)}$ and 21.5$^{(2)}$	this work

(1) - observation 1
(2) - observation 2

polystachya in the littoral areas of Paranapanema River mouth can be in part explain by resource allocation for quick elongation and the resistance of rooted stem to water forces, with suggested by Piedade *et al.* (1991) for *E. polystachya* in the Amazon region.

ACKNOWLEDGMENTS.

This research was supported by FAPESP (Procs. 91/0612-5, 92/2886-8). We are grateful to H.A. Rodrigues and M.P.F. de Oliveira for the assistance in the field and laboratory works, and to M.S.R. Ibañez for the English manuscript reading.

REFERENCES.

BENINCASA, M.M.P.
1986. Análise de crescimento de plantas (noções básicas). Jaboticabal, FUNEP, 42pp.

COUTINHO, M.E.
1989. Ecologia populacional de Eichhornia azurea (Kunth) e sua participação na dinâmica da vegetação aquática da Lagoa do Infernão - SP. M.Sc. Thesis, São Carlos, UFSCar, 145pp.

ESTEVES, F.A. & C.F.S. MENEZES
1992. Productivity and organic carbon release in a tropical aquatic macrophyte: Utricularia breviscapa Griseb. *Internation Journal of Ecology and Environmental Sciences,* 18: 55-61.

HO, Y.B.
1979a. Growth, chlorophyll and mineral nutrient studies on Phalaris arundinaceae L. in three Scottish lochs. *Hydrobiologia,* 61(3): 33-43.

——— 1979b. Shoot development and production studies of Phragmites australis (Cav.) Trin. ex Steudel in Scottish lochs. *Hydrobiologia,* 63(3): 215-222.

HOWARD-WILLIAMS, C.
1978. Growth and production of aquatic macrophytes in a south temperate saline lake. *Verh. Internat. Limnol.* Verein., 20: 1153-1158.

HOWARD-WILLIAMS, C., J. DAVIES, & S. PICKMERE
1982. The dynamics of growth, the effects of changing area and nitrate uptake by watercress Nasturtium officinale R.BR. in a New Zealand stream. *Journal of Applied Ecology,* 19: 589-601.

JUNK, W.J. & C. HOWARD-WILLIAMS
1984. Ecology of aquatic macrophytes in Amazonia. p. 269-293. In Sioli, H. (ed.) *The Amazon: Limnology and landscape ecology of a mighty tropical river and its basin.* Dordrecht: Dr. W. Junk Publishers.

JUNK, W.J. & M.T.F. PIEDADE
1993. Biomass and primary production of herbaceous plant communities and the Amazon floodplain. *Hydrobiologia,* 263: 155-162.

——— 1997. Plant life in the floodplain with special reference to herbaceous plants. *Ecological Studies,* 126: 147-185.

LUCIANO, S.C. & R. HENRY
1998. Biomass of *Eicchornia azurea* Kunth. and Brachiaria arecta Stent. in lower Taquari River, Jurumirim Reservoir, São Paulo, Brazil. *Verh. Internat. Limnol. Verein.,* 26: 1857-1861.

PIEDADE, M.T.F.
1993. Biologia e ecologia de *Echinochloa polystachya* (H.B.K.) Hitchcock (Gramineae = Poaceae), capim semi-aquático da várzea amazônica. *Acta Limnologica Brasiliensia* 7: 173-185.

PIEDADE, M.T.F., W.J. JUNK & S.P. LONG
1991. The productivity of the C4 grass *Echinochloa polystachya* on the Amazon floodplain. *Ecology* 72: 1456-1463.

PINHO, J.S., C.J. DA SILVA & I. BIANCHINI JR.
1998. Análise do crescimento da macrófita aquática *Pontederia lanceolata* em área alagável do Pantanal Mato-Grossense, Brasil. Revista Brasileira de Biologia 58(2): 287-300.

POMPÊO, M.L.M.
1996. Ecologia de *Echinochloa polystachya* (H.B.K.) Hitchcock na represa de Jurumirim (zona de dezembocadura do rio Paranapanema - SP). Ph.D Thesis, São Carlos, USP, 150 p.

POMPÊO, M.L.M. & R. HENRY
1996. Biometria de lâminas foliares e entrenós caulinares da macrófita aquática *Echinochloa polystachya* (H.B.K.) Hitchcock na zona de desembocadura do rio Paranapanema da represa de Jurumirim, SP. *Naturalia,* 21: 147-157.

POMPÊO, M.L.M., R. HENRY, V. MOSCHINI-CARLOS & C.R. PADOVANI
1997. A influência da macrófita aquática *Echinochloa polystachya* (H.B.K.) Hitchcock nas características físicas e químicas da água na zona de desembocadura do rio Paranapanema na represa de Jurumirim - SP. *Revista Brasileira de Ecologia,* 1: 44-53.

RICKER, W.E.
1946. Production and utilization of fish populations. *Ecological Monographs,* 16: 373-391.

———
1958. *Handbook of computations for biological statistics of fish populations.* (Bulletin. n0 119) Fisheries Research Board of Canada, Ottawa, 300pp.

RUSSO, E.H.R.
1996. Aplicação de sensores na identificação de plantas aquáticas nos rios Taquari e Paranapanema. Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq, Brazil, 103 pp (report).