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Periphyton biomass on artificial substrates during the summer and winter

Biomassa de perifíton em substratos artificiais durante o verão e inverno

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ABSTRACT

This study evaluated the periphyton production on artificial substrates considering it as a source of low cost live food for fish. Blades of artificial substrates such as wood, black plastic, acrylic, fiberglass, ceramics and glass (all with 144cm^2 blades, 24 for each substrate) were submerged 20.0cm below the water column for 35 days in the winter and 42 days in the summer. The blades were randomly installed in 200m^3 pond and evaluated for the biomass production at different phases during the summer and winter. Four blades of each substrate were collected weekly, and the periphytic community was carefully scraped with a spatula and fixed in 4% formaldehyde. The periphytic biomass productivity was evaluated by artificial substrate area and per day. The results evidenced the characteristic periodicity in periphyton biomass production and a significant variability in the collect period and season in the different artificial substrates used. Ceramic and wood showed the best results in the summer while wood showed the best results in the winter. The priphyton biomass productions differ among periods, substrates and seasons. Wood and ceramics could be indicated for periphyton biomass production in either winter or summer.

Key words: *microorganisms-food, hatchery, periphyton, phytoplankton.*

RESUMO

O estudo objetivou avaliar a produção de perifíton em susbtratos artificiais, considerando-o como fonte de alimento vivo de baixo custo para peixes. Foram submergidos substratos artificiais como madeira, plástico preto, acrílico, fibra de vidro, cerâmica e vidro (24 lâminas de cada substrato com 144cm²), 20cm abaixo da coluna de água por um período de 35 dias no inverno e no verão. As lâminas foram instaladas em um viveiro de 20m³, em delineamento inteiramente casualizado, e foi avaliada a produção de biomassa em diferentes fases durante o inverno e o verão. Foram coletadas semanalmente quatro laminas de cada substrato e a comunidade perifítica foi cuidadosamente raspada com espátula e fixada em formaldeido a 4,0%. Foi avaliada a produtividade em biomassa por área e por dia dos substratos artificiais. Os resultados evidenciaram característica periodicidade na produção de biomassa perifítica e uma significante variabilidade nos períodos e nas estações de coleta nos diferentes substratos artificiais utilizados. Cerâmica e madeira apresentaram os melhores resultados no verão, enquanto a madeira apresentou melhores resultados no inverno. A produção de biomassa perifítica difere entre períodos, substratos e estações. Madeira e cerâmica podem ser indicados para a produção de biomassa perifítica tanto no inverno quanto no verão.

Palavras-chave: *microorganismos-alimento, larvicultura, perifiton, fitoplâncton.*

INTRODUCTION

The periphytic community displays clear temporal and spatial heterogeneity, showing variations in their composition, biomass and productivity (KHATOON et al., 2007; GUARIENTO et al., 2009). Understanding this heterogeneity is important because the microorganisms involved are the base of the food chain in many lotic systems (FINK e VON-ELERT, 2006; RICHARD et al., 2009). These microorganisms serve as reducers and nutrient processors (LOCK et al., 1984) in addition to providing a habitat for a variety of other organisms

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(UDDIN et al., 2007). Beyond to serve as food source for many aquatic organism (UDDIN et al., 2007; FELISBERTO & RODRIGUES, 2010), its importance as food source has been related for youth fish in rearing cages and laboratories (TAKAMI et al., 1997; ASADUZZAMAN et al., 2009).

The periphytic organisms constitute an important food source for many other aquatic organisms (UDDIN et al., 2007; FELISBERTO & RODRIGUES, 2010). The importance of periphytic organisms as feed for young fish has been reported (TAKAMI et al., 1997; ASADUZZAMAN et al., 2009) such as laboratory food sources or culture systems.

The development of the periphyton dependents on the hydrological periods (LEANDRINI et al., 2008), water temperature and the concentration of nutrients, primarily nitrogen and phosphorus (MCCORMICK et al., 2001; FELISBERTO & RODRIGUES, 2010) and the substrates availability that allow its fixation and development. The utilization of substrates to increase the surface area for the fixation of periphytic communities increases the availability of food in the environment for the fish. This contributes to greater survival and development rates in the larvae population and can bring major benefits for the hatchery of native species. Therefore, the present study evaluated the periphytic biomass production using different types of artificial substrates during the summer and winter.

MATERIAL AND METHODS

The study was conducted in a fish farm located within the municipality of Toledo/PR-Brazil. Two experiments were established using different artificial substrates for the production of periphyton in fish tanks, one in the summer and one in the winter. The substrates used were fiberglass, acrylic, wood, ceramics, clear glass, and black plastic fixed on wooden blades placed in sub-surface water. Twenty-four blades of each material, measuring 144cm^2, were randomly installed in a nursery with approximately 200m^3 in volume and 1.0m deep. These blades remained submerged in the water (20cm deep) for 42 and 35 days in the summer and winter, respectively.

Four blades of each material were collected weekly, scraped and the organisms collected were stored in plastic bottles with 4% formalin. The samples were analyzed for wet and dry weight of the biomass collected in the Aquaculture Laboratory of UNIOESTE at the Toledo/PR Campus following the methodology presented by ESTEVES (1998). The productivity per area (final weight - initial weight/ substrates area) and per day (weight gain/substrates area/day) was evaluated for each substrate through the average wet and dry weight of the periphyton produced. The nursery used for the experiments was fertilized with organic fertilizer (swine manure) in the same proportion (0.03% of the water volume) in the two experiments (summer and winter). Physical and chemical water parameters, such as dissolved oxygen (8.25±1.26mg.L^{-1} in summer and 6.74±1.80mg.L^{-1} in winter), pH (7.43±0.41 in summer and 6.98±0.47 in winter), and electrical conductivity (23.47±3.53µS.cm^{-1} in summer and 31.02±10.86µS.cm^{-1} in winter) were measured weekly using portable electronic equipments and the water transparency was measured with a Secchi disc (58.33±17.22cm in summer and 100% in winter). The water temperature (26.83±3.71ºC in summer and 18.94±4.60ºC in winter) was measured twice daily, in the mornings and afternoons.

The obtained data were subjected to homogeneity and normality tests, and analysis of variance. The Tukey’s multiple comparison test was applied when significant average differences were observed. The data was analyzed using the SAS-Statistic Analysis System (SAS, 2004).

RESULTS AND DISCUSSION

A significant variation in the periphytic biomass was observed among the different artificial substrates used. The biomass produced in the summer surpassed the biomass produced in the winter (Table 1). This production increases with time during the summer while during the winter it remained virtually constant. These results demonstrated that the periphytic biomass is highly dependent on the temperature and photoperiod, being the temperatures higher in the summer and the days longer with greater incidence and intensity of light that influenced in periphytic biomass.

The periodicity of the evaluations revealed that the periphytic biomass production differed significantly between the summer and winter (the ceramics in summer and acrylic in winter), which was already observed in the first sampling (Figure 1). Significant variations related to the sampling period and between the used substrates and seasons were also observed (Table 2 and Table 3). These results are directly related to the structure of the substrate used, its opacity, transparency, and type of surface, as porous or smooth. A fluctuation in productivity was recorded during the summer between the substrates;

Table 1 - Periphytic biomass on different artificial substrates in the summer and winter seasons.

		Substrates							
		Fiberglass	Acrylic	Wood	Ceramics	Glass	Black P.	CV	p
Wet weight (g)	Summer	2.77bc	2.49d	2.97a	2.77ab	2.57cd	2.84ab	8.13	<0.0001
	Winter	2.00	2.03	2.12	2.14	2.20	1.97	14.70	<0.1398
Dry weight (g)	Summer	0.12a	0.07c	0.13a	0.13a	0.09b	0.12a	15.96	<0.0001
	Winter	0.069c	0.076abc	0.091ab	0.073bc	0.067c	0.095a	27.78	<0.0100
Production (mg cm^{-2} day^{-1})	Summer	0.034ab	0.026c	0.037a	0.039a	0.029bc	0.034ab	19.67	<0.0001
	Winter	0.033	0.035	0.043	0.035	0.033	0.043	32.51	<0.1243
Ashes weight (g)	Summer	0.110	0.045	0.119	0.088	0.093	0.077	89.94	<0.8044
	Winter	0.022bc	0.033b	0.050a	0.033b	0.017c	0.063a	21.23	<0.0001

In each line, values followed by the same letter are not significantly different according to Tukey's test (P<0.05).

the highest productivity observed was in fiberglass substrates fourteen days after submersion in the water column (Table 2). Wood, acrylic, glass, and black plastic did not differ significantly in productivity when compared to ceramics in the first sampling event while fiberglass presented similar productivity only 21 days after submersion. The substrates with greater permeability, opacity, and adherence presented faster responses towards the periphytic biomass production when compared to the more transparent and smooth substrates. This behavior was steady over the experimental period, when the wood and ceramics substrates presented better productivity performances in periphyton wet and dry weight, respectively.

The best productivity rates in the winter were observed in the first sampling on this season; the remaining samplings presented high fluctuations levels in the productivity rates. These responses clearly demonstrated the relationship between the productivity rate and the type of substrate, which was also observed in the results from the summer season which directly influences the Periphytic biomass production. Although fiberglass did not demonstrate to be the best substrate for periphytic biomass production in the summer (Table 2; Table 3 and Figure 1), it presented faster responses compared to the other artificial substrates. Its production was not sustained throughout the experimental period, while wood and ceramics presented the best results after 21 days of submersion. Regardless of the substrate used, it was observed a cumulative increase in the periphytic biomass production in all substrates in the summer period. The spatial sequence which is presented by the periphyton community (FRANÇA et al., 2011) and its relationship with the substrates available for development (PELLEGRINI and FERRAGUT, 2012) can be influenced in the composition and, therefore, in the periphytic community biomass.

In the winter, the cumulative periphytic biomass remained virtually constant. Black plastic presented the greatest periphytic biomass in the first four collections, however, in the last collection, wood presented the highest average cumulative production (P<0.05). It was still observed during the winter that the black plastic and wood substrates presented the best cumulative periphyton production results, highlighting the differences between the substrate's performances in the summer and winter. These differences are closely related to climatic conditions, such as temperature, photoperiod, and the rainy season (GUARIENTO et al., 2009; FRANÇA et al., 2011) which altogether interfere directly in the predominance of species (FELISBERTO & ROFDRIGUES, 2010), and hence, their favorable habitat conditions (PELLEGRINI & FERRAGUT, 2012). The periphytic biomass is directly related to the characteristics and composition of the substrate used for their development (ZHANG et al., 2012), the water flow (PELLEGRINI & FERRAGUT., 2012), the brightness, physical, and chemical characteristics of the water (AZIM et al., 2002) such as the concentration of chemical compounds (FELISBERTO & RODRIGUES, 2010).

The periphytic community contributes significantly in the food supply for aquatic organisms (ASADUZZAMAN et al., 2009; FRANÇA et al., 2011). It can be an important source of low cost food for these animals (UDDIN et al., 2007) and is ecologically appropriate because it does not generate pollution and serves as an indicator of the water quality.

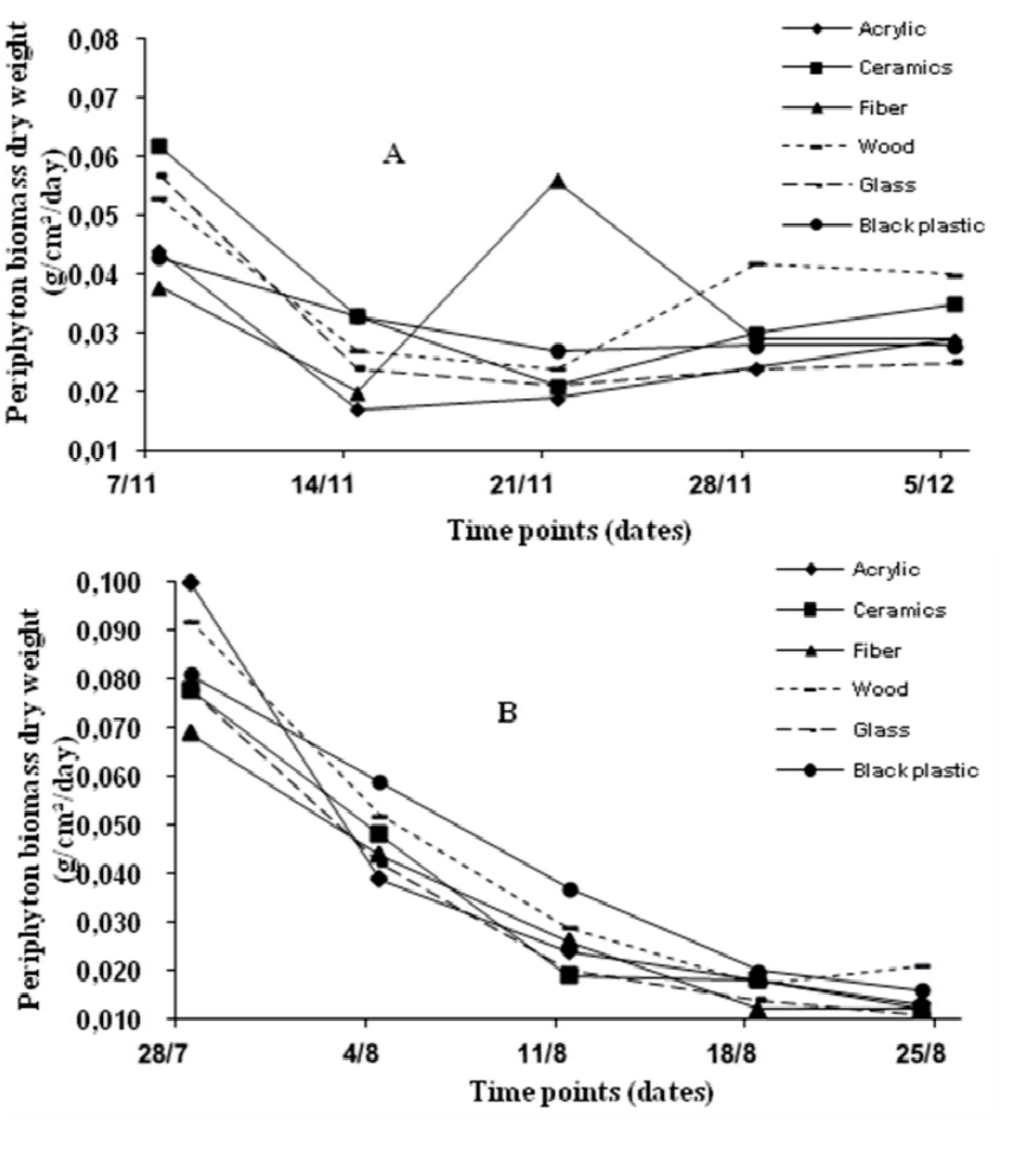

Figure 1 - Periphyton biomass production on different substrates evaluated by day and by area during the summer (A) and winter (B) season.

A trend of reduction in the periphytic biomass production at the end of the winter period was observed for all substrate types. This condition may be related to changes in the predominant species attached to the substrates that has an influence in the species throughout its development (PELLEGRINI & FERRAGUT, 2012). Since the species in the periphytic community were not evaluated, it is only assumed that the changes in species occurred along the experiment. It was observed that the temperature oscillated from 12.7°C at the start of the experiment to 24.0°C in the final stage of the evaluation during the winter period, showing a steady gradual increase throughout the experiment.

The productivity per area and per day in the different evaluated substrates presented gradual reduction in the winter period (Figure 1). The data from the winter period showed that the productivity rates followed a polynomial curve, corroborating with the results presented by SAND-JENSEN (1983). This author stated that the periphyton development presents three phases in the colonization process:

Table 2 - Biomass and productivity of periphyton performance during the summer and winter on different artificial substrates.

Period (in days)	Parameters	Station	---Substrates---						
			Fiberglass	Acrylic	Wood	Ceramics	Glass	Black Plastic	CV
07	Wet weight (g)	Summer	2.28±0.04	2.31±0.05	2.40±0.14	2.39±0.05	2.55±0.16	2.36±0.09	4.23
		Winter	1.50±0.44	1.19±0.82	1.99±0.24	1.86±0.18	1.80±0.22	1.06±0.72	30.43
	Dry weight (g)	Summer	0.038±0.004	0.04±0.004	0.05±0.02	0.06±0.01	0.06±0.01	0.04±0.01	21.72
		Winter	0.070±0.024	0.10±0.04A	0.09±0.03	0.08±0.01	0.08±0.01	0.08±0.02	27.16
	Productivity (mg cm^{-2} day^{-1})	Summer	0.038±0.004	0.04±0.004	0.05±0.02	0.06±0.01	0.06±0.01	0.04±0.005	21.73
		Winter	0.069±0.024	0.10±0.04A	0.09±0.03	0.08±0.01	0.08±0.006	0.08±0.02	27.16
14	Wet weight (g)	Summer	2.69±0.33	2.47±0.13	2.53±0.18	2.27±0.02	2.65±0.14	2.42±0.09	7.06
		Winter	1.76±0.21	1.87±0.24	1.52±0.66	1.93±0.16	2.21±0.15	2.08±0.22	17.10
	Dry weight (g)	Summer	0.039±0.001	0.03±0.002	0.05±0.008	0.07±0.005	0.05±0.01	0.07±0.03	26.43
		Winter	0.088±0.022	0.08±0.02	0.10±0.03	0.10±0.003	0.08±0.02	0.12±0.02	24.00
	Productivity (mg cm^{-2} day^{-1})	Summer	0.020±0.0007	0.02±0.001	0.03±0.004	0.03±0.002	0.02±0.007	0.03±0.01	26.43
		Winter	0.044±0.011	0.04±0.009	0.05±0.02	0.05±0.002	0.04±0.01	0.06±0.01	24.00
21	Wet weight (g)	Summer	2.69±0.17	2.61±0.32	2.83±0.32	2.40±0.04	2.39±0.16	2.69±0.16	8.44
		Winter	2.30±0.16	2.07±0.22	2.21±0.31	2.32±0.22	2.31±0.08	2.45±0.17	9.02
	Dry weight (g)	Summer	0.17±0.04	0.06±0.007	0.07±0.02	0.06±0.01	0.06±0.01	0.08±0.01	25.00
		Winter	0.08±0.01	0.07±0.008	0.09±0.03	0.06±0.001	0.06±0.02	0.11±0.05	32.89
	Productivity (mg cm^{-2} day^{-1})	Summer	0.06±0.01	0.02±0.002	0.02±0.006	0.02±0.004	0.02±0.004	0.03±0.003	25.00
		Winter	0.03±0.004	0.02±0.003A	0.03±0.01	0.02±0.003	0.02±0.007	0.04±0.02	32.89
28	Wet weight (g)	Summer	2.75±0.21	2.35±0.12	3.00±0.19	2.67±0.12	2.63±0.16	2.80±0.16	6.06
		Winter	2.28±0.31	2.34±0.11	2.49±0.06	2.38±0.10	2.37±0.07	2.07±0.34	8.62
	Dry weight (g)	Summer	0.18±0.02	0.10±0.01	0.17±0.02	0.12±0.01	0.10±0.02	0.11±0.009	12.62
		Winter	0.05±0.01	0.07±0.01	0.07±0.02	0.07±0.02	0.05±0.01	0.08±0.02	23.81
	Productivity (mg cm^{-2} day^{-1})	Summer	0.03±0.004	0.02±0.003	0.04±0.005	0.03±0.002	0.02±0.004	0.03±0.002	12.62
		Winter	0.012±0,003	0.02±0.003	0.02±0.004	0.02±0.004	0.01±0.003	0.02±0.004	23.81
35	Wet weight (g)	Summer	2.98±0.21	2.78±0.25	3.42±0.20	2.80±0.22	2.55±0.15	2.71±0.34	8.14
		Winter	2.15±0.22	2.45±0.09	2.52±0.12	2.23±0.28	2.28±0.37	2.21±0.14	9.99
	Dry weight (g)	Summer	0.15±0.002	0.15±0.003	0.20±0.02	0.18±0.02	0.12±0.02	0.14±0.02	10.69
		Winter	0.06±0.02	0.06±0.02	0.10±0.02	0.06±0.01	0.06±0.03	0.08±0.02	29.84
	Productivity (mg cm^{-2} day^{-1})	Summer	0.03±0.003	0.03±0.0004	0.04±0.003	0.04±0.004	0.02±0.003	0.03±0.004	10.69
		Winter	0.01±0.004	0,01±0.003B	0.02±0.004	0.01±0.002	0.01±0.005	0.02±0.004	29.84
42	Wet weight (g)	Summer	3.24±0.41	-	3.66±0.51	4.06±0.35	-	3.84±0.33	10.76
	Dry weight (g)	Summer	0.212±0.01	-	0.21±0.02	0.30±0.03	-	0.28±0.01	11.61
	Productivity (mg cm^{-2} day^{-1})	Summer	0.035±0.003	-	0.04±0.003	0.05±0.005	-	0.05±0.002	11.61

* The date were subjected to homogeneity and normality by the ANOVA one-way, two-way or three-way test (substrate, station and period). The Tukey's multiple comparison test was applied when significant differences were observed between the averages;

Table 3 - interaction between analyzed variable of periphytic biomass.

Variable	Effect	p
Wet weight (g)	Substrates	<0.01
	period	<0.01
	station	<0.01
	Substrates*period	<0.01
	Substrates*station	<0.01
	Period*station	<0.01
	Substrates*period*station	<0.01
Dry weight (g)	Substrates	<0.01
	period	<0.01
	station	<0.01
	Substrates*period	<0.01
	Substrates*station	<0.01
	Period*station	<0.01
	Substrates*period*station	<0.01
Productivity (mg cm^{-2} day^{-1})	Substrates	<0.01
	period	<0.01
	station	<0.01
	Substrates*period	<0.01
	Substrates*station	<0.01
	Period*station	<0.01
	Substrates*period*station	>0.05

The date was subjected to homogeneity and normality by the ANOVA one-way, two-way or three-way test (substrate, station and period). The Tukey's multiple comparison test was applied when significant differences were observed between the averages; *Rows representing the variable and effect different in statistic analysis (P>0.05) of one-way, two-way or three-way; columns representing the variable and summer and winter effect seasons for (P>0.05).

the initial phase (characterized by a rapid growth, exponential or linear, reflecting a biomass increase), the stationary phase (the biofilm reaches a constant level), and the secondary phase (characterized by a decline in the biomass).

A differentiated productive behavior was also observed between summer and winter. When the artificial substrates were compared, wood and ceramic stood out during the summer showing periphytic biomass of 1.397 and 1.232mg cm^{-2} respectively. The variation observed between these two artificial substrates in the course of the experiment was probably due to their high porosity. In the winter, a stronger development of the periphytic community in wood and black plastic was observed showing 0.742 and 0.560mg cm^{-2} of production, respectively. The overall results showed that the studied substrates presented different rates of primary productivity, dependent on the material surface, water temperature, and photoperiod (KHATOON et al., 2007; GUARIENTO et al., 2009; FELISBERTO & RODRIGUES, 2010).

These results demonstrated that the use of these substrates is of great importance for the production of organisms as a source of food. The physical and chemical parameters presented expressive variations. The average temperatures in the two experiments were 26.83±3.71 and 18.94±4.60ºC for the summer and winter, respectively. Different substrate behaviors were observed in the results from the two studied seasons indicating that the water temperature may have favored a larger biomass production in the summer than in the winter, perhaps also enhanced by a more favorable photoperiod and less water transparency. These parameters showed the greater presence of microorganisms in the water column in the summer when compared to the winter. The high rates of electrical conductivity and dissolved oxygen and less transparency in the summer demonstrated that there was greater photosynthetic activity in this period. It is important to evaluate the productive potential of each substrate by studying the communities of microorganisms and the species colonizing these substrates, their relationships with climatic conditions such as temperature and photoperiod, and species of choice to be cultivated before choosing the substrate.

CONCLUSION

The priphyton biomass productions differ among periods, substrates and seasons. Wood and ceramics could be indicated for periphyton biomass production in either winter or summer.

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