Changes in root morphology of anchored water hyacinth *Eichhornia azurea* (Sw.) Kunth (Pontederiaceae) in a perennial bay of *Pantanal*, Brazil

Alterações na morfologia de camalote *Eichhornia azurea* (Sw.) Kunth (Pontederiaceae) em uma baía perene do Pantanal, Brasil

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Abstract

In this study it was evaluated changes in situ in root and leaves of *Eicchornia azurea*, an invasive macrophyte of worldwide reservoirs, in a gradient of organic matter provided by allochthonous and autochthonous sources at *Medalha* bay, *Pantanal,* Brazil. The results showed that the greater the distance of riparian vegetation and sediment, the greater length, dry weight of roots and lower the distance between their insertions. The leaves did not present dry weight differences in the gradient. It was conclude that these macrophytes optimize the root morphology to absorb nutrients along a gradient of organic matter.

Key words: *E. azurea;* aquatic macrophytes; phenotypic plasticity.

Resumo

Nós avaliamos alterações *in situ* em raízes e folhas de *Eicchornia azurea*, macrófita invasora de reservatórios no mundo todo, em um gradiente de matéria orgânica formado por fontes autóctones e alóctones na Baía da Medalha, Pantanal, Brasil. Quanto maior a distância da mata ripária e do sedimento, maior o comprimento, peso seco das raízes e menor a distância entre suas inserções. As folhas não apresentaram pesos secos diferentes ao longo do gradiente. Provavelmente estas

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macrófitas otimizam a morfologia das suas raízes para absorção de nutrientes ao longo de um gradiente de matéria orgânica.

Palavras-chave: *E. azurea;* macrófitas aquáticas; plasticidade fenotípica.

Introduction

In lentics environments, the main autochthonous sources of nutrients are the detritus (generated by decomposition processes) and sediment; alochtonous are provided by lotic effluents (i.e. rivers, streams) and organic matter by riparian and leaching processes (TUNDISI; MATSUMURA-TUNDISI, 2008). So there is a complex dynamic involving different nutrient source, with intrinsic and extrinsic availability as well as organisms utilizing these resources (BARNES, MANN 1991).

The lentic coastal zones are considered an ecotone between terrestrial vegetation and pelagic zone (JORGENSEN, 1980). It´s the main biological metabolic zone in aquatic systems, due high interaction between sediment and water column, nutrient contribution provided by riparian and high incidence of aquatic macrophytes (WETZEL, 2001). Aquatic macrophytes are the most important organisms of nutrient dynamics in shallow lentics (WETZEL, 2001). Due to huge biomass, macrophytes detritus are the main autochthonous nutrient sources in these systems (PIECZYNSKA, 1993).

In floating macrophytes, the roots are the first via of nutrient assimilation (i.e. nitrogen and phosphate). These nutrients are mainly provided by the nutritional gradient between water column and sediment (BRISTOW; WHITCOMBE 1971). The roots development and operation are affected by these nutritional gradients (HAUSER et al., 1995; LYNCH, 1995). Consequently, these nutritional gradient influences the plant ramets size, number of leaves, and root complexity, as well as its ability to exploit and acquire resources (DONG; DE KROON, 1994). There are not studies involving changes in macrophytes in different nutritional gradients at Pantanal region, which represents the larger wetland in the world, with an outstanding seasonality due to overflow fluxes (SILVA; ABDON, 1998).

Water hyacinth (*Eichhornia azurea* (Sw.) Kunth, Pontederiaceae) is one of the main native aquatic plants in Pantanal. It's perennial, with floating rhizomes and anchored at the surrounding substrate (POTT; POTT, 2000). Weevaluate *in situ* morphological root and leaves parameters of *E. azurea* in an environmental gradient of organic matter. We hypothesized that as higher the riparian distance and a most deep water column (i.e. farthest from the main alochtonous and autocthonous organic matter fonts), increases the root structural complexity.

Material and Methods

Pantanal, the largest wetlands in the world (160,000 km^2), comprises an extensive alluvial plain along the central region of South America, with numerous perennial and ephemeral lagoons (CUNHA; FISHER, 2009). The meandric lagoons of Pantanal, with depth ranging from a few centimeters to 2m, are regionally called bays and often covered by aquatic plants

(PRANCE; SCHALLER, 1982). Our study was conducted in a meandric lagoon called Medal bay (UTM 498,7835; 4.3 ha in area) (CARVALHO et al., 2003), located in the sub-region of the Miranda and Abobral Pantanal (SILVA; ABDON, 1998) during dry season (October). This perennial bay flooded annually by the Miranda river, has a great amount of organic matter and clay sediment. The Medal bay presents dense riparian and an *E. azurea* population, arranged like a belt, around all the edge of the lagoon. In dry season, the main allochthonous nutrient source is particulate organic matter from the riparian; the sediment and macrophyte debris are the main autochthonous nutrient sources.

We divide the *E. azurea* belt in three sampling zones, according the distance with the riparian and size of water column: (a) between 1 to 5m distance from the riparian and between 0.3 to 0.5m water column deep, (b) between 10 to 15m distance from the riparian and between 0.8 to 1.0m water column deep, (c) >20m distance from the riparian and between 1.5 to 1.8 m water column deep. In each sampling zone, we collected 30 ramet fragments, totalizing 90 ramet fragments. A ramet fragment was considered as a ramet with flowers and three nodes, in which inserted three leaves and three roots. We measured the distance among the root insertions and the root length. After 48h drying (60 °C±5), we weighted the roots and leaves. To standardize the ramets age at the different sampling zones, we collected mature reproductively ramets (i.e. flower presence) and leaves with the same size.

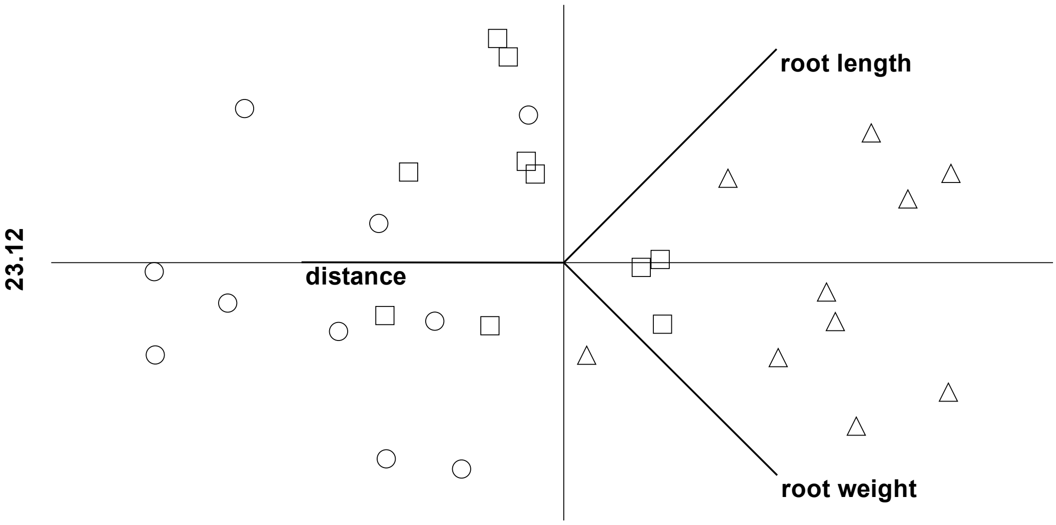
We considered a sampling unit as the average value of three randomized ramets of the same sampling zone (a, b and c), totalizing 30 sampling units. To visualize the differences among root parameters of different riparian zones, we used a Principal Component Analysis and dispersion graphics. All analyses were performed by the software PAST, v.2.11 (HAMMER et al., 2001). To verify significant differences between sampling zones, we applied Mann-Whitney pairwise and Bonferroni correlation test with 0.01 of significance according Shapiro-Wilk normality test (ZAR, 1999).

Results and Discussion

The leaves did not differed significantly comparing the three sampling zones (F = 1.031, *P* = 0.3702). The parameters used in the roots description (PCA components, Figure 1) had good explanation on the distribution of the samplings (89.24%). Roots structures showed a gradient according the distance from the riparian (Figure 2). As far as the distance of the riparian, macrophytes presented higher roots length and dry weight as well as shorter distances between the root insertions (Figure 1 and Figure 2). The ramets closer to riparian (a) presented differences between the farthest ramets (c) for all parameters evaluated (Table 1). The intermediate position ramets (b), presents differences between the farthest ramets (3) for roots insertion distances and root dry weight, but didn´t present differences between closer ramets (a). About the root length, the intermediate ramets (b) present differences between closer ramets (a), however presented no differences between farthest ramets (c).

In this study we attempted to standardize the age of ramets and intraspecific competition in different sampling zones, important variables in studies involving population (GATSUK et al., 1980; MONY et

Figure 1 - Principal Component Analysis (PCA) and the distance between the root insertions, root length and root dry weight of *Eichhornia azurea* in different sample zones



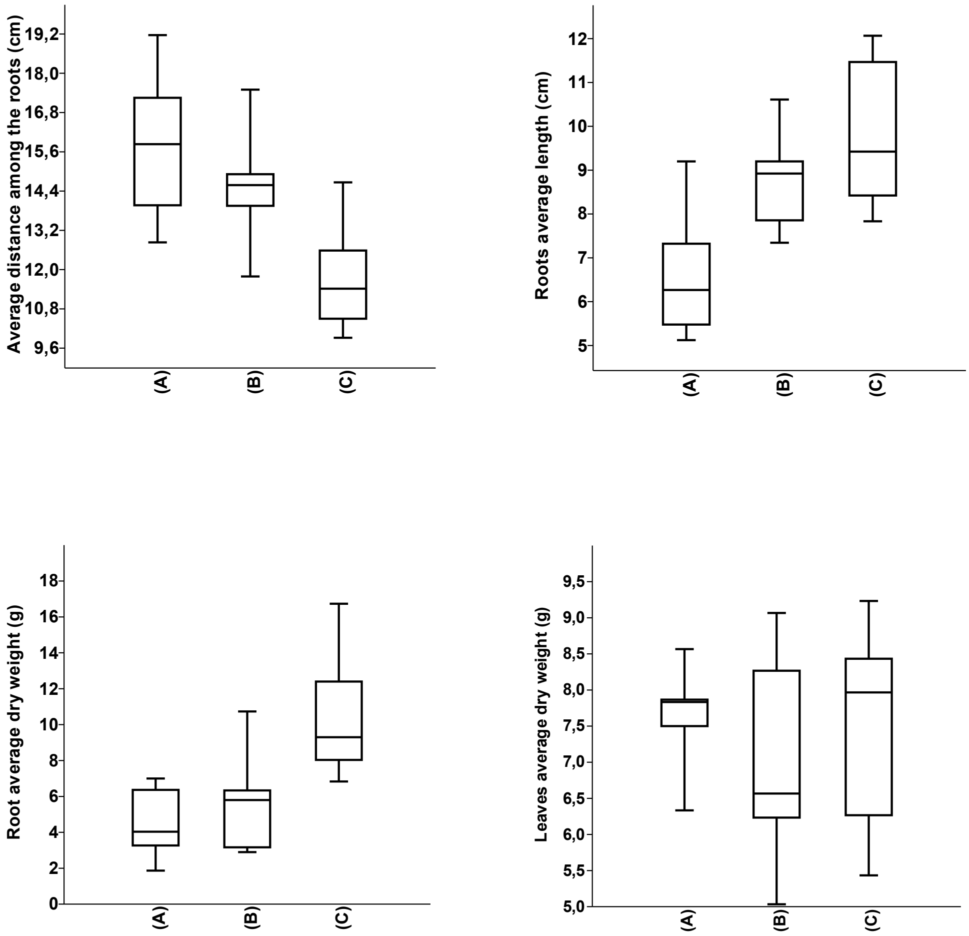
Source: Castro, W. A. C. et al. (2015).

Note: ○ = Samples collected among 1-5m from the riparian and 0.3-0.5m of water column; □ = among 10-15m from the riparian and 0.8-1m water column and Δ = more than 20m from the riparian and among 1.5-1.8m water column.

al., 2007). For aquatic macrophytes, different developmental stages presents differential development of vegetative structures (CARR et al., 1997). Thus, we standardized the collection method exploiting mature ramets (presence of flowers) to standardize its age. The lack of differences about dry weight of leaves indicates the same photosynthetic potential (DICKERMAN et al., 1986) of different sampling zones ramets. According Tundisi and Matsumura-Tundisi (2008), as closer the riparian vegetation and lower water column, higher nutrient availability. So the only variable controlling these macrophytes root development was the gradient of organic matter, provided by the relationship between the riparian (allochthonous source) and sediment (autochthonous source).

The availability of nutrients affects not only the biomass, but the ramet morphology as a whole (PIQUERAS et al., 1999), mainly the length of stolons (CAIN, 1994), and branching frequency (DONG; DE KROON, 1994). However, the main root structural changes are related to the morphological plasticity of structures for resource acquisition (DE KROON; HUTCHINGS, 1995). When nutrient availability decreased, the root architecture changed to optimize nutrient absorption. The roots become larger, both in length and mass, in order to increase the exposure for nutrient assimilation. The distance between root insertions decreases, suggesting a higher density and therefore higher number of roots per stolon.

Figure 2 - Boxplot with root parameters and leaves of *Eichhornia azurea* (A) between 1 and 5 m from the riparian and 0.5 m water column, (B) between 10 and 15m from the riparian and 1m water column and (C) more than 20m from the riparian and more than 1.5 m water column



Source: Castro, W. A. C. et al. (2015).

Table 1 - Significances (*P* values) of a Mann - Whitney test with Bonferroni correction comparing root architecture parameters of *Eichhornia azurea* for different riparian distances (Rd)

	Distance among insertions		Root length		Dry weight	
Rd	10 - 15m	> 20m	10 - 15m	> 20m	10 - 15m	> 20m
1 - 5m	0.2896	0.0015	0.0019	< 0.0001	0.7336	0.0002
10 - 15m	-	0.004	-	0.1041	-	0.0017

Source: Castro, W. A. C. et al. (2015).

Final Considerations

Eicchornia. azurea has been considered a problem in reservoirs in Brazil (FERNANDEZ et al., 1993). Its growth is enhanced by eutrophication (THOMAZ, BINI, 1998). The mechanical and chemical control of this species is often inefficient and expensive (TSNSW, 2009) as well as the use of biological control, with limited success (CARAUTA et al., 1991). The biology of other species ofthe same genus *Eicchornia crassipes* (Mart.) Solms (Pontederiaceae) is already well studied, but more studies are needed to understand the development of *E. azurea*, particularly as the morphological plasticity *in situ*. These mechanistic studies are important to understand the invasion processes to foment its efficient management.

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