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Aquatic macrophytes in floodplain areas of the community of São José, in the municipality of Benjamin Constant, Amazonas, Brazil

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ABSTRACT

Aquatic macrophytes are vascular plants that commonly occupy floodplain and wetland areas. They play an extremely important role in the functioning of the ecosystems in which they occur, being able to establish a strong connection between the aquatic system and the terrestrial environment that surrounds it. Considering that the Amazon presents a great diversity of these plant species, we conducted a field survey to assess the macrophyte species composition in the São José community, located at the municipality of Benjamin Constant, state of Amazonas, Brazil. Specimen collection, exsiccates and photographic records were done in order to assess the number of families and species found, and also to illustrate and describe the aquatic macrophyte species according to their morphology, to classify them according to their growth form and identify what morphological structures are responsible for their adaptation in their aquatic environments. 36 species belonging to 24 families were identified. Thus, the research here conducted obtained sufficient amount of data for the future production of an illustrated guide to aquatic macrophytes of the study area and to initiate further studies in the river Solimões, providing informations about this group of plants.

Keywords: Growth form; Adaptive structures; aquatic herbaceous; Araceae; Macrophytic organisms.

Macrófitas aquáticas em áreas de várzea da comunidade de São José, no município de Benjamin Constant, Amazonas, Brasil

RESUMO

Macrófitas aquáticas são plantas vasculares que normalmente ocupam áreas alagadas e úmidas. Elas desempenham um papel extremamente importante no funcionamento dos ecossistemas em que ocorrem, sendo capazes de estabelecer uma conexão forte entre o sistema aquático e o ambiente terrestre que o rodeia. Considerando que a Amazônia apresenta uma grande diversidade dessas espécies de plantas, foi realizado um levantamento de campo para avaliar a composição de espécies de macrófitas na Comunidade de São José, localizada no município de Benjamin Constant, estado do Amazonas, Brasil. Coleta de amostras, exsicatas e registros fotográficos foram feitos para avaliar o número de famílias e espécies encontradas e também para ilustrar e descrever as espécies de macrófitas aquáticas, de acordo com sua morfologia, classificá-las de acordo com sua forma de crescimento e identificar que estruturas morfológicas são responsáveis pela sua adaptação aos ambientes aquáticos. 36 espécies pertencentes a 24 famílias foram identificadas. Assim, a pesquisa aqui realizada relata uma quantidade suficiente de dados para a produção futura de um guia ilustrado para macrófitas aquáticas da área de estudo e para dar início a outros estudos no Rio Solimões, fornecendo informações sobre este grupo de plantas.

Palavras-chave: Formas de crescimento, Estruturas adaptativas, herbáceas aquáticas, Araceae, Organismos macrofíticos.

Introduction

Brazil has the largest hydrographic network in the world, with aquatic ecosystems (fluvial, permanent or temporary lakes) of great representativeness among Brazilian ecosystems. The vegetation associated with them comprises not only the hydrophytes themselves, but also plants that are periodically submerged at different levels or those that border these environments, such as amphibian species (CERVI et al., 2009).

Aquatic macrophytes are organisms that are present in all types of water, even in low wealth or biomass. And they must remain there, for they are fundamental, for the metabolism of ecosystems, for nutrient cycling and energy flow, for example. This should not be exterminated as pests for the sole purpose of "clean" and free of potential problems, such as the large growth of macrophytes consequences of this growth (POMPÊO, 2017).

The aquatic macrophytes present great adaptability and ecological amplitude, being found in the shallows and shallow areas of rivers, lakes and reservoirs, but also in waterfalls and fitotelmos, in the coastal regions, in fresh, salty and brackish water (ESTEVES; SUZUKI, 2010), or in altered environments, such as in lagoons from the coal mining pit or in mining tailings dams.

Aquatic macrophytes are vascular plants that occupy wetlands and floodplain areas. These plants can grow in fresh (rivers, lakes, ponds, swamps, streams, etc.), brackish (estuaries), and even salt water environments. Irgang; Gastal (1996) classified the aquatic macrophytes in the following growth forms: 1- submerged; 2- free submerged; 3- floating leaved; 4- free floating; 5- emergent; 6- amphibious; 7- epiphyte (PIEDADE et al., 2010).

For Trindade et al. (2010) the ecological groups can be distributed in an organized way and parallel to the margin, forming a distribution gradient towards the interior of the lake, beginning with the emergent macrophytes, passing through floating leaves to rooted submersibles. In most cases, however, environmental factors such as turbidity of water and wind, favor the heterogeneous growth of different groups.

Although there are many studies on these plants in Brazil (POMPÊO, 2017; TRINDADE, 2010; ARAÚJO et al., 2012),

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the northern region, more specifically the Upper Solimões River, presents a lack of investigations in this area. In addition, this region presents a great diversity of plant species, and for this reason, there is a need to investigate and survey what macrophyte species are colonizing and adapting to the hydrological cycle of Solimões River and how these non-native species are causing negative and/or positive effects to this ecosystem.

The Amazon biome is characterized by having the largest river system on Earth, consisting of an immense number of rivers, streams, waterfalls and lakes. As far as the Amazon is concerned, it presents a hydrographic basin with a wide variety of continental aquatic systems that are distinguished from each other by presenting very peculiar physical, chemical and biological characteristics. All this diversity makes the region an environment with great potential for the development and deepening of limnological studies (PIEDADE, 2010).

In the Amazon, a wide variety of macrophytes can be found in the floodplain areas. These areas are flooded by rivers of muddy water such as the Solimões River, among others, always rich in nutrients and with neutral pH. These characteristics are considered essential for the good growth and propagation of many species of these vegetables in the region.

The macrophyte species richness of the community was assessed to obtain information about these plants. Thus, a survey of the aquatic macrophyte population of the São José community was conducted, where plant samples were collected for further identification. Considering this context, the areas of aquatic macrophytes considered important that inhabit the Amazon basin, have been suffering considerable modifications this investigation aimed at assessing the aquatic macrophyte diversity in the community of São José, located in the municipality of Benjamin Constant-AM.

Material and Methods

Study area

This Project was developed at the riverside community of São José (Figure 1), located in the Aramaçá island, at the left bank of Solimões river, around 1800 meters along the arm of the Paraná river, and at 65 meters above sea level (ASSIS, 2010), belonging to the municipality of Benjamin Constant, in the region of the River Solimões – Amazonas. It has the following geographic coordinates: 04º24 '25.8 "South and 070º02' 42.0" West; being the study area located in solid ground, in the municipality of Benjamin Constant, state of Amazonas, Brazil.

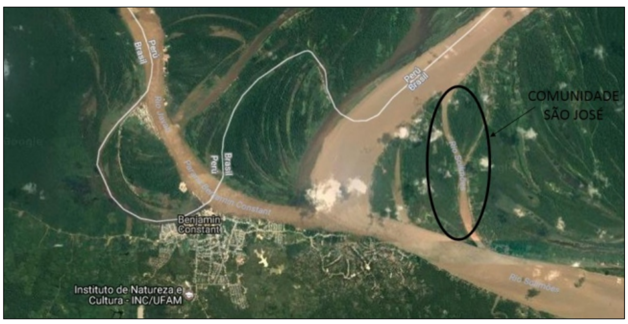

Figure 1. Satellite image of the community of São José. **Source:** Google, 2017

Benjamin Constant is a municipality of the state of Amazonas, located at the banks of Solimões river, which is an Andean white water river, presenting nutrient rich waters, with relatively neutral pH and high electrical conductivity due to the high concentration of ions (SIOLI, 1968), thus being considered a proper environment for the development of aquatic macrophytes.

The climate of the region is tropical humid or super-humid (according to the classification of Köppen), that is, without dry season, with average annual temperature of 25.7 ° C and average annual rainfall of 2,810 mm. The rainfall of the driest month is 120 mm, with higher rainfall concentrated in the months of December to April (LEOPOLDO et al., 1987).

The biome is composed of dense ombrophilous forests with emergent canopy, sheltering lowland and alluvial areas, which indicates fertility for agroforestry and biodiversity use (MESORREGIÃO DO ALTO SOLIMÕES, 2017). It is noteworthy that this study was carried out in a dense and closed ombrophilous forest, being divided into two areas, primary and secondary forest.

Data collection procedures

Four collections were carried out, covering the months of March to July, 2018. During the first stage of the collection, a survey of the floodplain areas of the study site was carried out, evaluating the diversity of macrophyte species occurring in the region. After the survey, the collection of plants visible to the naked eye was done randomly.

The floristic survey was conducted during the floodplain season, from to period. Specimens were collected and stored in bags with water to avoid desiccation. The growth forms were recorded in field, following the Irgang et al. (1984) classification system. This system classifies the species according to their ecological groups as: emergent; floating leaved; submerged; free submerged; free floating (COOK, 1999). This classification is frequently used by researchers of this area (COOK et al., 1974; POTT; POTT, 2000; HENRY-SILVA et al., 2005; PAZ; BOVE, 2007; PIVARI et al., 2008).

Vegetative and reproductive structures were photographed before pressing and drying. The species were identified using specialized literature or by specialist doctor researcher Jefferson da Cruz in aquatic macrophytes of the Federal University of Amazonas (UFAM), and identification guides (POTT; POTT, 2000; PIEDADE et al., 2018), describing the plant specimens according to their morphology.

Every external adaptive structure visible to the naked eye used by the plants for floating and/or attachment to substrates was described using identification keys. The identification of the structures helped us to understand how each species adapted to the aquatic environment.

After the illustration, identification and description, duplicates of all the exams were done and sent to the Herbarium of the Federal University of Amazonas (HUAM) for identification. Duplicates, plaques and their descriptions are deposited in the Botanical Laboratory of the Institute of Nature and Culture for educational purposes and subsequent research. The identification of the taxa was comparison of the collected material, with the aid of specialized bibliography and consultation of specialists. The classification of phanerogamic botanical families was based on in Souza; Lorenzi (2012) and in APG III (2009).

Results and Discussion

Survey of aquatic macrophytes

During the survey, we found 43 specimens in the floodplain areas of the São José community. We recorded 36 species, included to 24 families and 33 genera, described in the Table 1.

As shown in the Table 1, the most representative families (in relation to the number of species) were Araceae (six species/six genera), Cyperaceae (three/two), totaling eight genera, followed by Nymphaeaceae (two/two), Poaceae (two/two); Pontederiaceae (two/two), Lentibulariaceae (two/one), Onagraceae (two/one), and, also totaling eight genera. The other seventeen families presented only one species.

Table 1. Representative families the aquatic macrophytes and growth form of the São José community.

Families	Species	Growth Form
Alismataceae	*Limnocharis flava* (L.) Buchenau	Emerging
Amaranthaceae	*Alternanthera aquatica* (D. Parodi) Chodat	Fixed floating or floating free emerged
Araceae	*Lemna valdiviana* Phil.	Floating free emerged
	Montrichardia linifera (Arruda) Schott	Emerging
	Pistia stratiotes L.	Free float
	Spirodela intermedia W. Koch	Floating free emerged
	Urospatha sagittifolia (Rudge) Schott	Emerging
	Wolffiella oblonga (Phil.) Hegelm.	Free float underwater
Araliaceae	*Hydrocotyle verticillata* Thunb.	Fixed floating or floating free emerged
Asteraceae	*Eclipta prostrata* (L.) L.	Amphibian
Azollaceae	*Azolla filiculoides* Lam.	Floating free emerged
Ceratophullaceae	*Ceratophyllum muricatum* Cham.	Free float underwater
Commelinaceae	*Commelina longicaulis* Jacq.	Free float, amphibian or emerging
Convolvulaceae	*Ipomoea aquatica* Forssk.	Emerging, amphibian
Cyperaceae	*Cyperus luzulae* (L.) Retz.	Emerging, amphibian
	Cyperus odoratus L.	Emerging, amphibian
	Eleocharis cf. acutangula (Roxb.) Schult.	Emerging, amphibian
Euriocaulaceae	*Tonina fluitans* Aubl.	Fixed underwater or emerging
Fabaceae	*Neptunia oleracea* Lour.	Emerging, amphibian or free float
Hydrocharitaceae	*Limnobium laevigatum* (Humb. & Bonpl. ex Willd.) Heine	Floating free emerged
Lentibulariaceae	*Utricularia foliosa* L.	Free float underwater
	U. gibba L.	Free float underwater
Marsileaceae	*Marsilea clotophora* D. M. Johnson	Fixed floating or floating free emerged
Nymphaeaceae	*Nymphaea amazonun* Mart. & Zucc.	Fixed with floating leafs
	Victoria amazonica (Poepp.) J.E. Sowerby	Fixed with floating leafs
Onagraceae	*Ludwigia helmintorrhiza* (Mart.) H. Hara	Free float emerged
	Ludwigia leptocarpa (Nutt.) H. Hara	Emerging, amphibian or fixed underwater
Parkeriaceae	*Ceratopteris pteridoides* (Hook.) Hieron.	Floating free emerged
Phyllanthaceae	*Phyllanthus fluitans* Benth. ex Müll Arg.	Floating free emerged
Poaceae	*Gynerium sagittatum* (Aubl.) P. Beauv.	Amphibian, emerging
	Oryza grandiglumis (Döll) Prod.	Emerging
Polygonaceae	*Polygonum acuminatum* Kunth	Fixed floating, amphibian or floating free emerged
Pontederiaceae	*Eichhornia crassipes* (Mart.) Solms	Floating free emerged
	Pontederia rotundifolia L. f.	Floating free emerged
Ricciaceae	*Ricciocarpos natans* (L.) Corda	Floating free emerged
Salviniaceae	*Salvinia auriculata* Aubl.	Floating free emerged

In most of the work done with aquatic macrophytes, including Irgang et al., (1984), Brandão et al., (1989), Pott et al., (1989), Pedralli et al., (1993a) e (1993b), Pott; Pott (2000), França et al., (2003), Matias et al., (2003), Tavares (2003), Delello (2008), the Cyperaceae and/or Araceae families appear among the three main families in relation to specific wealth.

The species collected and identified from the Araceae family were *Montrichardia linifera* (Arruda) Schott, *Pistia stratiotes* L. *Urospatha sagittifolia* (Rudge) Schott and according to the identifications of Pott & Pott, 2000, these plants have as main characteristics the presence of a spadix, with uni or bisexual flowers, implied by a spathe, both supported on a long or short peduncle. The rest of the species are very small plants and have inconspicuous inflorescences, being generally found sterile in the field. The Araceae family is currently divided into nine subfamilies and is represented by 125 genera and approximately 3.550 species (BOYCE; CROAT, 2011), with cosmopolitan distribution. In Brazil it occurs throughout the national territory with 36 genera and 488 species (COELHO, 2006, 2014).

During the survey, an abundance of individuals from the Cyperaceae family was noted, namely: *Cyperus luzulae* (L.) Retz. *C. odoratus* L. and *Eleocharis* cf. *acutangula (Roxb.) Schult.*

That for Pivari et al. (2008) the marked presence of representatives of this family in aquatic springs suggests recent changes in the location and the development of floating islands, possibly related to anthropic processes. The studied watercourse works as a fluvial transport route for the local population, and, in addition, in front of the houses, small ports are made to dock the boats and which are also used for personal hygiene of the residents, thus there are anthropic actions in the region.

Cyperaceae is a cosmopolitan family composed of more than 5.000 species distributed in 104 genera (GOETGHEBEUR, 1998). Although family species are often associated with wetlands, such as river banks and water bodies, they also occur in more drained environments, such as hilltops, in addition to being an important floristic and ecological element in the successional composition of areas subject to anthropic action. In Brazil, between 600 and 700 species of the family occur, distributed in approximately 44 genera (LUCEÑO et al. 1997).

The representativeness of these families might be due to their high number of species, with an estimated 5000 species of Cyperaceae and more than 10.000 species of Araceae (IRGANG et al., 1984; BRANDÃO et al., 1989; POTT et al., 1989; WATSON; DLLWITZ, 1992; PEDRALLI et al., 1993; GOETGHEBEUR, 1998; POTT; POTT, 2000; FRANÇA et al., 2003; MATIAS et al., 2003; TAVARES, 2003; DELELLO, 2008). It is aslo estimated that 30 and 9% of their genera, respectively, have aquatic species (COOK, 1999; RUTISHAUSER, 2010). In addition, plants of these families have a complex underground system formed by rhizomes and tubers, with some species also presenting underground stolons, which allows vegetative propagation, and consequently, representing ecologically competitive species (GOETGHEBEUR, 1998).

The remaining families did not present a high diversity, but they still have a significant representation in respect to the total number of species found.

Classification of the aquatic macrophytes according to their growth form:

In the present study, we could identify six of the seven macrophyte growth forms proposed by Irgang; Gastal (1996).

1. The submerged form grows completely under water and is attached to a substrate. An example of a species collected belonging to this class is *Tonina fluitans* Aubl. According to Scremin-Dias (1999), the submerged macrophytes have usually thin leaves lacking most of their lamina, presenting only a few layers of cells, which have homogeneous shape, and with many air spaces. The leaf shape represents an important morphological adaptation of this growth form to minimize mechanical damage by water.

2. Free submerged – a submerged macrophyte that is not attached to any substrate and floats free next to the water surface, and in some cases, with the inflorescences above the waterline: *Ceratophyllum muricatum* Cham. (Ceratophyllaceae); *Utricularia foliosa* L. and *U. gibba* L. (Lentibulariaceae); *Wolffiella oblonga* (Phil.) Hegelm. (Araceae) are examples of free submerged macrophytes collected in this study. According to Scremin-Dias (1999) this group of macrophytes presents the same characteristics as the submerged macrophytes, but with undeveloped rhizoids that float in the water column.

3. Floating leaved - plants that have a root system attached to a substrate and with leaves floating on the water surface and flowers above the waterline: *Nymphaea amazonum* Mart. & Zucc. (Nymphaeaceae); *Victoria amazonica* (Poepp.) J.E. Sowerby (Nymphaeaceae) are examples of floating leaved macrophytes found. This group lives in regions protected against wind because are subjected to mechanical stress above the waterline, such as water and wind movements (SCREMIN-DIAS, 1999).

4. Free floating – plants that float on the surface, with only roots and stolons submerged: *Pistia stratiotes* L., *Lemna valdiviana* Phil and *Spirodela intermedia* W. Koch. (Araceae); *Azolla filiculoides* Lam. (Azollaceae); *Limnobium laevigatum* (Humb. & Bonpl. ex Willd.) Heine (Hydrocharitaceae); *Ludwigia helmintorrhiza* (Mart.) H. Hara (Onagraceae); *Ceratopteris pteridoides* (Hook.) Hieron. (Parkeriaceae); *Phyllanthus fluitans* Benth. ex Müll. Arg. (Phyllanthaceae); *Eichhornia crassipes* (Mart.) Solms and *Pontederia rotundifolia* L. f (Pontederiaceae); *Ricciocarpos natans* (L.) Corda (Ricciaceae); *Salvinia auriculata* Aubl. (Salviniaceae).

5. Amphibious – plants usually anchored in saturated soils. These plants may complete their life cycle in the water, but do not follow the rise in the water level (BARROS, 2009). They have vegetative adaptations to certain degrees of floodplain, such as the aerenchyma and/or lenticels at the base of the aerial stems or rhizomes; formation of adventitious roots, aerenchymas on the roots or even pneumatophores.

These species may have fruits and/or seeds adapted to water dispersal, as well as resistance to extreme floodplain, maintaining a viable seed bank. The amphibious species recordedin this study was *Eclipta prostrata* (L.) L. (Asteraceae). Macrophytes presenting these growth forms are usually located on river banks, tolerate dry periods and are associated to humid environments, remaining in shallow areas next to the margins (SPONCHIADO, 2008; BARROS, 2009).

According to Sponchiado (2008), the amphibious macrophytes are capable to properly live in both floodplain areas and terrestrial environments, normally changing their aquatic morphology when the water level drops.

6. Emergent – Plants attached to the soil that grow as the water level rises. They are sometimes released from the substrate and become emergent free floating, especially at the peak of the floodplain season and/or at the beginning of the low water period. During the investigation, the emergent macrophytes recorded were: *Limnocharis flava* (L.) Buchenau (Alismataceae); *Montrichardia linifera* (Arruda) Schott *and Urospatha sagittifolia* (Rudge) Schott (Araceae); and *Oryza grandiglumis* (Doll) Prod. (Poaceae).

Costa-Neto et al. (2007) state that the predominance of emergent macrophytes is a consequence of an abundance of water, nutrients, solar radiation, and a proper temperature, which are factors that control their population growth.

Usually, the number of amphibious and emergent macrophyte species is greater than those for other growth forms. This might be explained by their adaptation to both terrestrial and aquatic environments (IRGANG; GASTAL, 1996), however, this statement disagrees with the present survey, where the number of free floating emerged species was the greatest of all growth forms.

It is believed that the emergent free floating species are abundant due to their capacity to complete their life cycle, i.e., their morphological structures enable a better adaptation to various periods of Solimões river, making them more resistant to this environment than the other growth forms. However, further investigations are necessary to prove this hypothesis.

7. Epiphyte – plants that grow on the surface of other aquatic plants. No species presenting this growth form were found in the area investigated. The species previously described presented only one growth form, however, there are species presenting up to three different growth forms. This phenomenon occurs because the colonization of macrophytes varies according to the depth of water sources and/or rivers (ARAÚJO et al., 2012).

Araújo et al. (2012) also state that as the water input increases, so does the thalweg depth, causing a substitution by growth forms such as floating leaved, free floating and submerged. The representativeness of emergent and amphibious species is explained by the adaptation of these growth forms to ecotonal habitats. In addition, in wet seasons, the rise in the water level temporarily incorportates the plants on river banks into the floodplain area.

Habitat condition, especially at the water level, causes a species to present more than one growth form. Thus, the species *Alternanthera aquatica* (D. Parod) Chodat, *Hydrocotyle verticillata* Thunb. and *Marsilea clotophora* D. M. Johnson presented two growth forms, adapting to the hydrological cycle: floating leaved when the water level rises and free floating when the water level drops.

The species *Tonina fluitans* Aubl. spends most of its life cycle as rooted submerged. As the water level drops, however, they switch to emergent forms, thus allowing for their reproduction.

We also reported the species: *Ipomea aquatica* Forssk., *Cyperus luzulae* (L.) Retz., *C. odoratus* L., *Eleocharis* cf. *acutangula* (Roxb.) Schult. and *Gynerium sagittatum* (Aubl.) P. Beauv., in both emergent and amphibious forms following the rise of the water level and tolerating long periods of flooding.

At the beginning of the rise in water levels, *Ludwigia leptocarpa* (Nutt.) H. Hara was found in three growth forms: emergent; amphibious, when the water level rose due to the floodplain periods, with only the reproductive structures above the water; and submerged in the floodplain period, being completed covered by water.

During the dry period, the species *Commelina longicaulis* Jacq., *Neptunia oleracea* Lour. and *Polygonum acuminatum* Kunth appeared as amphibious, and, as the water level rose, they remained attached to the soil, resisting to floodplain periods.

Morphological structures that macrophytes use to adapt to aquatic environments

In order to adapt to aquatic environments, macrophytes evolved some anatomical and physiological traits. For the following species: *Pistia stratiotes* L.; *Neptunia oleracea* Lour.; *Ludwigia helmintorrhiza* (Mart.) H. Hara; *Ludwigia leptocarpa* (Nutt.) H. Hara; *Limnobium laevigatum* (Humb. & Bonpl. ex Willd.) Heine; *Victoria amazonica* (Poepp.) J.E. Sowerby; *Ceratopteris pteridoides* (Hook.) Hieron.; *Eichhornia crassipes* (Mart.) Solms; *Ricciocarpos natans* (L.) Corda, the presence of the aerenchyma was reported. We observed this tissue in the roots, stems, and leaves, being used by these plants for floating, respiration and protecting them against the infiltration of water inside the stems. The aerenchyma may be distributed on roots, stems and leaves, contributing to gas exchanges in the whole plant and mechanical resistance for the submerged parts, in addition to enable plants to float in the water (SCREMIN-DIAS, 1999).

Aerenchyma refers to plant tissues presenting air spaces in their anatomical structures designated to perform gas exchanges and develops from roots and aerial parts of species living in wetlands and in some species of dry environments of harsh conditions (SCATENA; SCREMIN-DIAS, 2003).

Also called aerial parenchyma, the function of this tissue is to store air between its cells. Its main feature is the numerous intercellular spaces or gaps, where air is stored. The aerenchyma is common in aquatic plants, but can be found in plants that grow in soils that are susceptible to flooding (SCATENA; SCREMIN-DIAS, 2003).

The adventitious root is another adaptation of plants to aquatic environments. In this survey, this structure was observed in the following species: *Alternanthera aquatica* (D. Parodi) Chodat; *Hydrocotyle verticillata* Thunb. *Azolla filiculoides* Lam.; *Ipomoea aquatica* Forssk.; *Neptunia oleracea* Lour.; *Limnobium laevigatum* (Humb. & Bonpl. ex Willd.) Heine; *Marsilea clotophora* D. M. Johnson; *Ceratopteris pteridoides* (Hook.) Hieron.; *Phyllanthus fluitans* Benth. Ex Müll. Arg.; *Eichhornia crassipes* (Mart.) Solms; *Pontederia rotundifolia* L. f.

According to Vidal and Vidal (2000), adventitious roots are those that do not originate from the embryo radicle or the main root axis formed by it. They can originate from the aerial parts, such as stems, leaves or underground stems.

In most of the species, we could not observe adaptive structures that could have contributed to their survival in the aquatic environments. Probably, these plants present anatomical structures and physiological traits that make them adapt to this environment.

During the reflux period, the macrophyte abundance was decreasing as the water level dropped. Thus, at the dry period, only a few plants were found in the study area. Some surviving macrophytes switch their growth forms in response to low water levels (e.g. soil rooting). However, most of the species reported in this study were no longer found in their vegetative or reproductive forms. We hypothesize that the end of the reproductive cycle coincided with the low water period, and thus, the seeds generated remained dormant until favorable conditions are restored.

Conclusions

The floristic survey of the macrophytes of the community of São José, in the municipality of Benjamin Constant, Amazonas provided a list of species, an indispensable factor in the conservation of littleknown taxa. The general observations allowed us to conclude that macrophytes can adapt to environmental heterogeneity, with complex ecological relationships throughout their life cycles.

Because this survey was conducted only in part of the Upper Solimões community, further investigations are necessary to assess the macrophyte diversity in other areas in order to better understand their species richness in this region.

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