Sustentabilidade International Scientific Journal

Special Edition Forest Week

Characterization of the aquatic vegetation of an Amazonian lake of the Ariaú river, Amazonas, Brazil

Chiara Lubich[a]*, Flora Magdaline Benitez Romero[b], Maria Anete Leite Rubim[c]

Received: **04/03/2025**
Reviewed: **06/03/2025**
Accepted: **06/03/2025**
Published: **07/03/2025**

Citação: Lubich, C., Romero, F. M. B., Rubim, M. A. L. (2024). Characterization of the aquatic vegetation of an Amazonian lake of the Ariaú river, Amazonas, Brazil, *v. 1, n. 3*. DOI://https.doi.org.10.70336/sust.2024.v1.17236

ISSN ONLINE: 2966-280X

[a] Programa de Pós-Graduação em Ciência Animal e Recursos Pesqueiros, Faculdade de Ciências Agrárias, Universidade Federal de Amazonas, Manaus, Amazonas, CEP 69067-375, Brazil; lubichchiara@gmail.com;

[b] Departamento de Ciências Florestais, Faculdade de Ciências Agrárias, Universidade Federal de Amazonas, Manaus, Amazonas, CEP 69067-375; magdaline.romero@inpa.gov.br

[c] Departamento de Ciências Pesqueiras, Faculdade de Ciências Agrárias, Universidade Federal de Amazonas, Manaus, Amazonas, CEP 69067-375; aneterubim@gmail.com@gmail.com

*Corresponding author: lubichchiara@gmail.com

Abstract: The shores of a whitewater lake tend to be colonized by dense aquatic vegetation, in which various biological forms of vegetation can be found. This study aimed to characterize the composition of the aquatic vegetation of an Amazonian lake located in the Ariaú River basin, Amazonas, Brazil. The samples were taken during the high-water period and, for analysis of the composition, the specimens were identified in the Limnology Laboratory of the Federal University of Amazonas. A total of 15 species distributed in 12 families and 15 genera were recorded, and the families with the highest occurrence were Poaceae, Polygonaceae and Salviniaceae. Three biological forms were identified, emergent being the form with the highest occurrence. Our results can serve to better understand the bioecology of aquatic herbaceous species and their relationship with the environment, but we also emphasize the importance of future studies that take into account environmental variables.

Keywords: Diversity, Biological form, Aquatic macrophyte, Zonation, Amazon basin.

1. Introduction

Lakes in general are composed of compartments and, according to Esteves and Caliman (2011), among the compartments of a lake, we can mention the shore, which corresponds to the part that is in direct contact with the terrestrial ecosystem, and is, therefore, strongly influenced by it. Junk et al., (1989) named this region ATTZ: aquatic terrestrial transition zones due to the variation of the hydrological cycle that causes temporary periods of high water and low water in the marginal forest.

According to Reynolds (2008), the shore is home to a high diversity of different organisms, especially in the period of high water, when new compartments are formed due to the emergence of banks of aquatic macrophytes and flooded litter, making the environment more heterogeneous. The author cites that, in this region, there is a complex food chain, with organisms that contribute significantly to the flow/cycling interaction of nutrients.

In this region, all trophic levels of an ecosystem can be found, but its main characteristic is the dense colonization of aquatic vegetation (Esteves and Caliman, 2011; Piedade et al., 2010), also known as herbaceous vegetation. In the Amazon basin, these plants colonize extensive areas with greater diversity in white water environments such as the Solimoes/Amazon River, while in black water environments like the Negro River, their occurrence is limited due to factors such as acidity and low nutrient levels (Junk and Piedade, 1993; Lopes et al., 2014; Rubim and Castilho, 2021), although they may also occur to a lesser extent in streams with these characteristics (Rubim, 2022; Rubim et al., 2022).

The environments connected by the two distinct systems, (Solimões and Negro rivers) such as the Ariaú River (Pinto and Luchiari, 2017), lack information regarding the composition of aquatic vegetation. Thus, the main objective of this study is to fill this gap by characterizing the coastal region where the greatest diversities of aquatic vegetation are found during the high-water period when these exhibit the highest occurrence records.

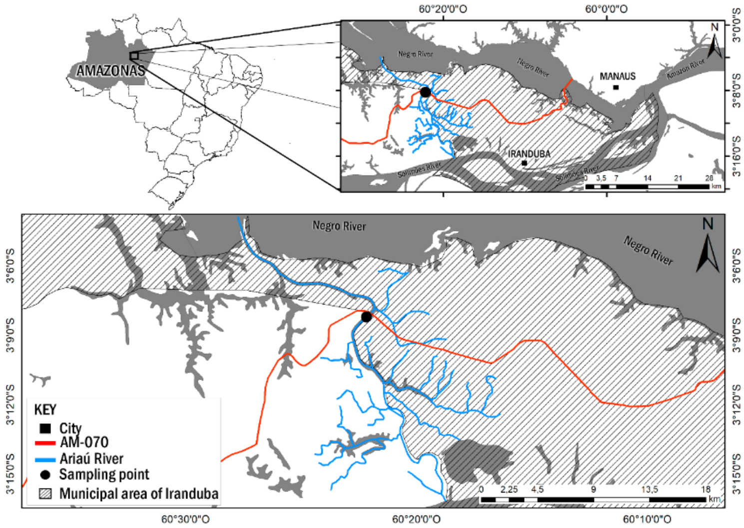
2. Materials and Methods

Study area

This study was conducted in a lake on the right bank of the Ariaú River, located in the rural area of the municipality of Iranduba, at KM 34 of the AM-070 Manoel Urbano highway, approximately 50 km from the capital of the state of Amazonas, Manaus (Figure 1).

The Ariaú River is a tributary of the Negro River. However, according to Silva et al. (2011), this system presents the typical characteristics of whitewater rivers since the Ariaú River connects two of the largest and most important river systems in the world, the Negro River upstream and the Solimões River downstream (Pinto and Luchiari, 2017). Thus, this region presents distinct characteristics and environments in some points due to the presence of floodplain and terra-firme environments (Pinto and Luchiari, 2017). The lake in which the study was conducted is directly influenced by the dynamics of the flood pulse of the Negro and Solimões Rivers (Franzinelli and Igreja, 2002).

Figure 1. Study area and hydrographic distribution of the Ariaú River, Amazonas.



Font: The authors.

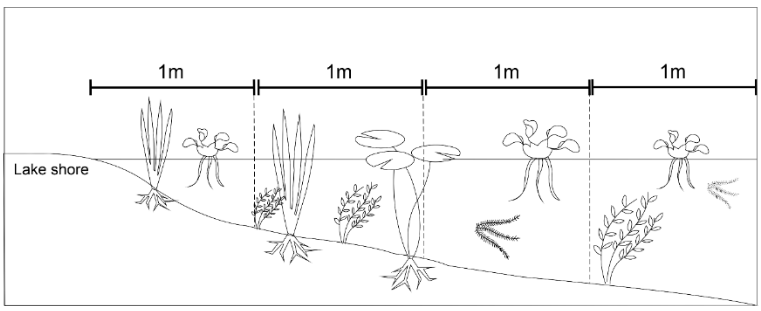
Data collection

The collections were carried out in the period from March 14 to March 16, 2016, coinciding with the high-water period in the region (Bittencourt and Amadio, 2007). The characterization of the shore was carried out with the verification of the occurrence of vegetation from the shore to the total distance of 10 meters towards the center of the lake. Each meter was defined as a category, that is, one meter made up Category 1, two meters made up Category 2 and so on until the end of the tenth category with 10 meters. Thus, at each meter, the identification of the species that were within this area was carried out, as well as taking depth measurements (Figure 2).

In this region, different types of aquatic herbaceous can be found (for example: emergent and free-floating). The species were identified with the help of experts and specialized literature (Pott and Pott, 2000), and the classification of the respective biological forms was carried out following the classification of Pott and Pott (2000).

Figure 2. Collection scheme for characterization of the shore in a lake of the Ariaú River.

Statistical analysis



Font: The authors.

Statistical analysis

ISSN ONLINE: 2966-280X

A regression was performed to evaluate distance (length categories) vs. depth. In order to describe the spatial organization of the species composition between the length categories (1-10) sampled. The succession of biological forms in a lake of the Ariaú River, i.e., the distribution of biological forms along the distance (meters) gradient, was assessed using a generic graph (Magnusson and Baccaro, 2013).

Non-metric multidimensional scaling (NMDS) ordination were constructed using Jaccard's measure of distance (Manly, 1994). The distortion of the ordination relative to the original data matrix was determined by stress. According to Rohlf (2000), values of "stress" of around 0.2 correspond to regular fit; while, values around 0.1 indicate a good fit, and a value equal to 0 indicates a perfect fit.

Simple regression (having as the independent variable the distance from the shore to the center of the lake and dependent variable the variable depth) and NMDS were performed using the vegan package (Oksanen et al., 2019) on R software version 4.0.2 (R Core Team, 2020).

3. Results

We identified 12 families, 15 genera and 15 species of aquatic herbaceous plants (Table 1, Figure 3). The families with the highest occurrence were Poaceae, Polygonaceae and Salviniaceae, which occurred in the length categories seven, six and four, respectively (Table 1 and Figure 4). Three biological forms were identified, emergent being the one with the highest occurrence (N=19) (Figure 5).

The emergent biological form was present in all categories of measured distances (1-10) (Figure 6). From four to nine meters, there was the joint presence of emergent and free-floating plants. While, fixed-floating forms were present only at 10 meters (Figure 6).

Linear regression showed that the distance from the shore to the center of the lake (length categories, 1-10) explains approximately 96.3% of the depth variation (residual standard error = 0.5823, r2 = 0.963, F = 235.3, p-value = 3.239e-07). Therefore, as the distance from the shore towards the center of the lake increases, there tends to be an increase in the depth of the lake.

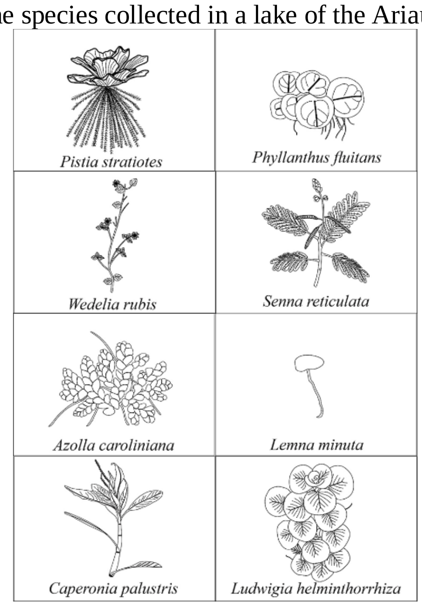
Table 1. List of aquatic herbaceous plants found on the shores of an Amazonian lake of the Ariaú River. * Total distance of 10 m, from the shore to the center of the lake.

	Taxonomy	Biological Forms	Place of occurrence	
			Distance (m)*	**Depth (m)**
Araceae	*Pistia stratiotes* L.	Floating (free)	5	1.7
Asteraceae	*Wedelia rubis* (Baker) H. Rob.	Emergent	2; 3 and 4	0.68; 0.93 and 1.25
Azollaceae	*Azolla caroliniana* Willd.	Floating (free)	7	2.38
Euphorbiaceae	*Caperonia palustris* (L.) A.St.-Hil.	Emergent	4	1.25
Euphorbiaceae	*Phyllanthus fluitans* Bentham ex Müeller	Floating (free)	7 and 8	2.38 and 2.41
Fabaceae/ Leguminosae	*Senna reticulata* (Willd.) H.S. Irwin and Barneby	Emergent	5	1.7
Lemnaceae	*Lemna minuta* Kunth.	Floating (free)	6; 7 and 8	2.07; 2.38 and 2.41
Onagraceae	*Ludwigia helminthorrhiza* (Mart.) Hara	Floating (free)	6,7 and 9	2.07; 2.38 and 2.52
Parkeriaceae	*Ceratopteris pteridoides* (*Hook*.) Hieron	Floating (free)	8	2.41
Poaceae	*Oryza glumaepatula* Steud.	Emergent	6	2.07
Poaceae	*Paspalum fasciculatum* Willd. ex Flügge	Emergent	1 to 7	0.40; 0.68; 0.93; 1.25; 1.70; 2.07 and 2.38

Polygonaceae	*Polygonum hispidum* Kunth	Emergent	3; 6; 7; 8; 9 and 10	0.93; 2.07; 2.38; 2.41; 2.52 and 2.76
Pontederiaceae	*Eichhornia crassipes* (Mart.) SolmsLaubach	Floating (free)	8	2.41
Pontederiaceae	*Pontederia rotundifolia* L.f	Floating (fixed)	10	2.76
Salviniaceae	*Salvinia auriculata* Aubl.	Floating (free)	4; 5; 6 and 8	1.25; 1.70; 2.07 and 2.41

Font: The authors.

Figure 3. Illustration of the species collected in a lake of the Ariaú River, Amazonas, Brazil.



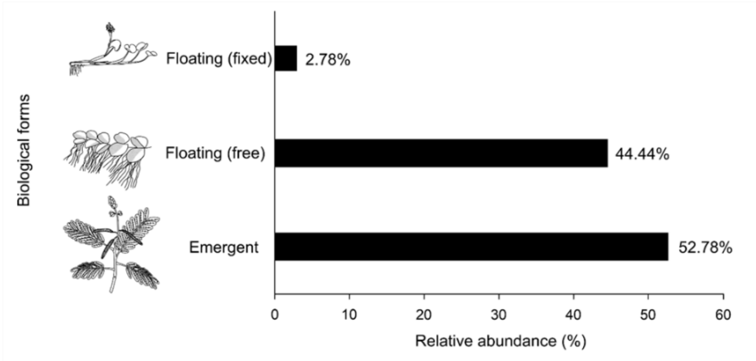
Font: The authors

Figure 4. Relative frequency of occurrence of the aquatic herbaceous families of a lake of the Ariaú River, Amazonas. AR= Araceae, AS= Asteraceae, AZ= Azollaceae, EU= Euphorbiaceae, FA= Fabaceae, LE= Lemnaceae, ON= Onagraceae, PA= Parkeriaceae, PO= Poaceae, PY= Polygonaceae, PT= Pontederiaceae and SA= Salviniaceae.

Font: The authors

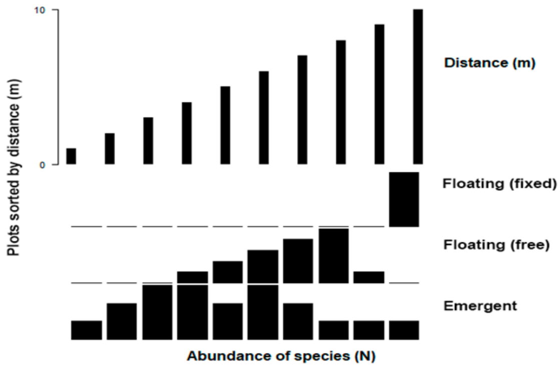
ISSN ONLINE: 2966-280X

Figure 5. Relative abundance (%) of the biological forms found in a lake of the Ariaú River, Amazonas.



Font: The authors

Figure 6. Numerical frequency of occurrences of biological forms as a function of the distances measured from the shore to the center of the lake of the Ariaú River.

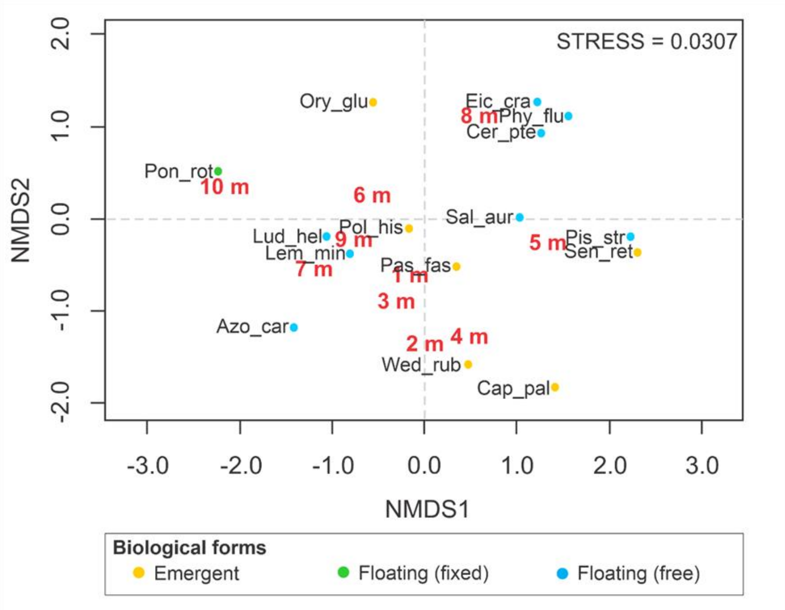


Font: The Authors

The results of the analyses of the ordination (NMDS) based on the presence and absence data (Jaccard distance) indicate a distribution gradient of the species. The second axis was able to capture most of the variations of the original data on the presence and absence of aquatic herbaceous plants, as indicated by the configuration of the Kruskal stress values (stress=0.0307). Along axis 2 (vertical), the pattern generated shows a separation of the species as a function of the distance from the shore, in which, in the lower part, there was a greater association of species emergent biological forms (*Polygonum hispidum*, *Paspalum fasciculatum*, *Wedelia rubis*, *Caperonia palustres* and *Senna reticulata*) and free-floating forms (*Ludwigia helmintorriza*, *Lemna minuta*, *Azolla caroliniana*, *Salvinia auriculata* and *Pistia stratiotes*) with distance categories 1 – 5, 7, and 9. While, in the upper part, there was the presence of the three emergent (with one representant: *Oryza glumaepatula*), free-floating (*Eichornia crassipes*, *Phyllanthus fluitans*, *Ceratopteris pteridoides*) and fixed-floating (such as *Pontederia rotundifolia*) biological forms with association of distance categories 6, 8 and 10 (Figure 7).

ISSN ONLINE: 2966-280X

Figure 7. Ordination analysis of the presence of species according to distance categories (1-10) in a lake of the Ariaú River, Amazonas, Brazil.



Font: The Authors.

4. Discussion

Aquatic herbaceous plants are distributed in all portions of a lake. Junk & Piedade (1993) inventoried the diversity of aquatic herbaceous plants in a region near Manaus and identified 64 families, 182 genera and 388 species. Of the 64 families and 182 genera that Junk and Piedade encountered, 12 families, and all 15 genera were observed in our study. However, when observed in terms of species, Junk and Piedade found 388 species and in our study only nine species were found in the studied lake. The absent species were Wedelia rubis, Azolla caroliniana, Senna reticulata, Lemna minuta, Oryza glumaepatula and Polygonum hispidum.

The richness values of the families were similar to those of lakes in the western Amazon region (Pinheiro & Jardim, 2015), of the Puraquequara River basin, a tributary of the left bank of the Amazon River, near Manaus (Soares et al., 2020), Lake Trevo located southwest of Boa Vista (Neves, 2007) and the Monjolinho River basin in São Paulo (Viana, 2005), with values ranging from 13 to 17 families. However, the data found for lakes in the states of Amapá (Neto et al., 2007) and Macapá (Thomaz et al., 2004) were inferior, with 68 and 44 families. Soares et al. (2020) cite that environmental characteristics, in other words, a healthy/natural or anthropized/altered environment, can influence the composition of the community of these plants, which may be reflected in these differences that were found.

The predominance of the Poaceae family has been previously reported for areas of the Amazon floodplain (Junk & Piedade, 1993), such as in the Puraquequara River basin (Soares et al., 2020), the basins of the Fortaleza stream, a tributary of the Curiaú River, in the state of Amapá (Thomaz et al., 2004) and for the Pantanal (Pott, 2007), since it is one of the families with the largest number of species (Neto et al., 2007; Bove et al., 2003; Junk & Piedade, 1993).

As for the biological form, according to Thomaz & Esteves (2011), the herbaceous plants can be distributed in an organized form depending on the margin, thus having a zoning of emergent species in the shallower places and the submerged rooted species in deeper places, and the other forms will be distributed between these two extremes. Our results indicate this zoning pattern, since, in general, the emergent species present greater occurrences near the margins and at lower depths; while fixed-floating herbaceous plants were present only in the category of 10 meters.

Therefore, the organization pattern proposed by Thomaz & Esteves (2011) was found for the studied lake; however, in order to come to a concrete conclusion, environmental variables must be taken into account, and can be investigated in the future. The studied lake did not present great depths, (the greatest depth was of 2.76 meters), which is a factor that implies the development of biological forms of aquatic herbaceous species, allied to other abiotic factors such as wind and turbidity, among others (Thomaz and Esteves, 2011).

The prevalence of emergent forms has already been recorded in the Puraquequara River, near Manaus (Soares et al., 2020), since species of this biological form propagate and grow rapidly, mainly through stolons, which consequently give rise to a new plant. This phenomenon has already been observed in lakes in other Brazilian states such as in the state of Ceará (Araújo et al., 2012; Matias et al., 2003), Rio Grande do Norte (Meyer & Franceschinelli, 2011), Mato Grosso do Sul (Catian et al., 2012), Macapá (Thomaz et al., 2004), Amapá (Neto et al., 2007), Bahia (França et al., 2010) and Tocantins (Xavier et al., 2012).

The distribution and presence of herbaceous plants on the shores of lakes may indicate a classic example of zoning; however, other factors must be investigated to determine this phenomenon (Esteves & Caliman, 2011). A comprehensive approach in the investigation of aquatic ecosystems should carefully consider both biotic and abiotic factors. This is due to the fact that in certain areas of the shore, dense colonization by aquatic vegetation is observed, which, when combined with relevant abiotic factors, plays a key role in supporting the various trophic levels within the aquatic ecosystem (Esteves & Caliman, 2011; Pinheiro & Jardim, 2015).

5. Conclusion

The families with the highest occurrence were Poaceae, Polygonaceae and Salviniaceae. In general, as the distance from the shore towards the center of the lake increases, there tends to be an increase in the depth of the lake. The emergent forms were present in all the length and depth categories evaluated, which demonstrates a strong adaptation of some species due to the low water depth.

Our results may serve to better understand the bioecology of aquatic herbaceous species and the health of the environment, since the distribution of an herbaceous species is strongly influenced by biotic factors, and their presence and absence may be indicative of anthropization. Therefore, we emphasize the importance of future studies that take into account the environmental variables, since the interaction between these elements plays a crucial role in maintaining and sustaining the different trophic levels present in aquatic ecosystems.

Author Contributions: Conceptualization, C.L. and M.A.L.R.; formal analysis, C.L.; investigation, C.L. and M.A.L.R; supervision, M.A.L.R. and F.M.B.R.; writing—original draft, C.L.; writing—review and editing, C.L., M.A.L.R. and F.M.B.R.. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: Universidade Federal do Amazonas.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

Araújo, E. S., Sabino, J. H. F., Cotarelli, V. M., Siqueira-Filho, J. A., & Campelo, M. J. A. (2012). Riqueza e diversidade de macrófitas aquáticas em mananciais da Caatinga. *Diálogos and Ciência*, 32(1), 229-234.

Bove, C.P., Gil, A.S.B., Moreira, C.B., & Anjos, R.F.B. (2003). Hidrófitas fanerogâmicas de ecossistemas aquáticos temporários da planície costeira do estado do Rio de Janeiro, Brasil. *Acta Botanica Brasilica* 17:119-135.

Catian, G., Leme, F. M., Francener, A., De Carvalho, F. S., Galletti, V.S., Pott, A., Pott, V. J., Scremin-Dias, & Damasceno-Junior, G.A. (2012). Macrophyte structure in lotic-lentic habitats from Brazilian Pantanal. *Oecologia Australis*, 16(4), 782-796.

Esteves, F.A. & Caliman, A. (2011). Águas continentais: características do meio, compartimentos e suas comunidades. In: F.A. Esteves, ed. *Fundamentos de limnologia*. Rio de Janeiro: Interciência, pp. 113-118. 2011.

França, F., Melo, E. D., Góes Neto, A., Araújo, D., Bezerra, M. G., Ramos, H. M., Castros, I. & Gomes, D. (2003). Flora vascular de açudes de uma região do semi-árido da Bahia, Brasil. *Acta Botanica Brasilica*, 17(4), 549-559.

Oksanen, J., Guillaume Blanchet, F., Friendly, M., Kindt, R., Legendre, P., Mcglinn, D., Minchin, P.R., O'hara, R.B., Simpson, G.L., Solymos, P., Stevens, M., Szoecs, E. & Wagner, H. (2019). *vegan: Community Ecology Package*. R package version 2.5-6. https://CRAN.R-project.org/package=vegan

JUNK, W. J., AND PIEDADE, M. T. (1993). Herbaceous plants of the Amazon floodplain near Manaus: Species diversity and adaptations to the flood pulse. *Amazoniana: Limnologia et Oecologia Regionalis Systematis Fluminis Amazonas*, 12(3/4), 467-484.

ISSN ONLINE: 2966-280X

Junk, W. J., Bayley, P.B. & Sparks, R.E. (1989). The flood pulse concept in river - floodplain systems, Pp. 110-127. In: D. P. Dodge, D. P. (Ed.). *Proceedings of the International Large River Symposium. Canadian Special Publications of Fisheries and Aquatic Science*, 106. 1989.

Lopes, A.; Wittmann, F.; Schongart, J.; & Piedade, M. T. F. (2014). Herbaceous aquatic plants in six igapó flooplains in central Amazonia: generic composition and diversity. *Revista Geografia Acadêmica*, v. 8, p. 5-1.

Magnusson, W.E. & Baccaro, F.B. (2023). *Explorando padrões em dados ecológicos com técnicas multivariadas*. Manaus: EDUA - Editora da Universidade Federal do Amazonas, 140p.

Matias, L. Q.; Amado, E. R.; & Nunes, E. P. (2003). Macrófitas aquáticas da lagoa de Jijoca de Jericoacoara, Ceará, Brasil. *Acta Botânica Brasílica*, v. 17, n. 4, p. 623-63.

Meyer, S. T., & Franceschinelli, E. V. (2011). Influência de variáveis limnológicas sobre a comunidade das macrófitas aquáticas em rios e lagoas da Cadeia do Espinhaço, Minas Gerais, Brasil. Rodriguésia, 62(4), 743-758..

Neto, S. V. C., Senna, C. D. S. F., Tostes, L. D. C. L., & Da Silva, S. R. M. (2007). Macrófitas aquáticas das regiões dos lagos do Amapá, Brasil. *Revista Brasileira de Biociências*, 5(S2), 618-620.

Neves, M.A. (2007). *Composição, riqueza e variação espaço temporal de macrófitas aquáticas do lago do Trevo, município de Boa vista*. Dissertação de Mestrado, Universidade Federal de Roraima, Roraima.

Piedade, M.T.F., Junk, W.J., D'angelo, S.A., Wittmann, F., Schoengart, J., & Lopes, A. (2010). Aquatic herbaceous plants of the Amazon floodplains: state of the art and research needed. *Acta Limnologica Brasiliensia*, 2: 165-17.

Pinheiro, M. D. N. M., & Jardim, M. A. G. (2015). Composição florística e formas biológicas de macrófitas aquáticas em lagos da Amazônia Ocidental, Roraima, Brasil. *Biota Amazônia* (Biote Amazonie, Biota Amazonia, Amazonian Biota), 5(3), 23-27.

Pinto, W. H. A., & Luchiari, A. (2017). Uso das imagens SAR R99B para mapeamento geomorfológico do canal do Ariaú no município de Iranduba-AM. *Revista de Geografia* (Recife), 34(1).

Pott, V. J. & Pott (2000). *A. Plantas aquáticas do Pantanal*. Embrapa: Brasíli.

Pott, V.J. (2007). *Plantas aquáticas do pantanal e da alta bacia*. Congresso de Ecologia do Brasil (CEB), 1–3, 2007.

R Core Team. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. URL: https://www.R-project.org/.

Reynolds, C.S. (2008). A changing paradigma of pelagic food webs. *International Review of Hydrobiology*, v. 93, n. 4-5, p. 517- 531. DOI: 10.1002/iroh.200711026

Rubim, M. A. L. (2022). Plantas aquáticas. In: *Fauna e Flora do Campus da Universidade Federal do Amazonas: a maior biodiversidade urbana do Brasil*. Claudia Guerra Monteiro et al.,Org. Editora da Universidade Federal do Amazonas.

Rubim, M.A.L. & Castillo, J.M. (2021). Distribuição de macrófitas aquáticas em águas brancas e pretas na bacia do rio Solimões/Amazonas. In: *Recurso Água: Tecnologias e pesquisas para o uso e a conservação de ecossistemas aquáticos*. Daniel C. V. R. Silva et al. Org. São Carlos, SP, Ed. Cubo.

Rubim, M. A. L., Lima, R. M. S., Lubich, C. & Costa, S. B. (2022). Mácrofitas aquáticas nos igarapés do fragmento florestal do Campus da UFAM. In: *Fragmento Florestal do Campus da UFAM: olhares diversos para o verde*. Maria Anete Leite Rubim e Maria Silvia de Mendonça, Org. Editora da Universidade Federal do Amazonas.

Silva, M. S. R., Cunha, H. B., Miranda, S. A., Miranda, G.P., & Pascoaloto, D. (2011). Química das águas de superfície dos rios da Bacia Amazônica: uma contribuição para classificação de acordo com seus usos preponderantes. *XIX Simpósio Brasileiro de Recursos Hídricos*.

Soares, L.S.G., Oliveira, Z.S. & Rubim, M.A.L. (2020). Composição e diversidade de macrófitas aquáticas. In: Puraquequara em Mosaico: Histórias, vidas e recursos naturais. Maria Anete Leite Rubim e Lídia Rochedo Feraz, Org. Editora da Universidade Federal do Amazonas, 307p.

Thomaz, D. O., Costa Neto, S.V., & Tostes, L.C.L. (2004). Inventário florístico das ressacas das bacias do igarapé da Fortaleza e do rio Curiaú. In: Takiyama, L. R.; Silva, A. Q. (Orgs.). *Diagnóstico de ressacas do Estado do Amapá: Bacias do igarapé da Fortaleza e do rio Curiaú*. Macapá: GEA/SETEC/IEPA. p.13-32.

Thomaz, S.M. & Esteves, F.A. (2011). Comunidade de Macrófitas Aquáticas. In Esteves, Fa., org. *Fundamentos de limnologia*. 3ed. Rio de Janeiro: Interciência. p. 259-281.

Viana, S.M. (2005). Riqueza e distribuição de macrófitas aquáticas no ri Monjolinho e tributários (São Carlos, SP) e análise de sua relação com as variáveis físicas e químicas. Dissertação de Mestrado, Universidade de São Paulo, São Carlos. DOI: 10.11606/D.18.2005.tde-16112005-105845.

Xavier, L. R. C. C., Araújo, T. O., Nascimento, P. R. F., A. & Pereira, S. M. B. (2012). Floristic surveys of aquatic macrophytes in reservoirs in the Agreste zone of Pernambuco State, Brazil. *Brazilian Journal of Botany*, 35(4), 313-318, 2012.