

Original article

Aquatic vegetation of the Caribbean wetlands I: Submerged, free-floating, and rooted floating-leaved

Vegetación acuática de las ciénagas del Caribe I: sumergida, flotante y flotante-enraizada

J. Orlando Rangel-Ch.^{1,*}, Denise Cortés-C.², Yennifer García³

¹ Instituto de Ciencias naturales. U. Nacional de Colombia, Bogotá, Colombia

² Universidad Nacional Abierta y a Distancia, Bogotá, Colombia

³ Fundación Natura, Bogotá, Colombia

Abstract

We present a phytosociological classification of the submerged, free-floating, and rooted floating-leaved aquatic vegetation of the hydric series in the Colombian Caribbean, based on its floristic composition and structural aspects. The vegetation surveys were conducted during both the rainy season (high water levels) and the dry season (low water levels); electrical conductivity and pH were also measured. The most diverse group was rooted floating-leaved vegetation, specifically the class *Pontederio azureae-Paspaletea repentis*, which included two orders, three alliances, and 34 associations. In the free-floating group, the classes *Lemnetea minoris* and *Pistio stratiotis-Pontederietea crassipedis* were identified with two orders, two alliances, and twelve associations, and in submerged vegetation, the class *Cabombo-Nymphaeetea* was found with one order, two alliances, and five associations. One class, two orders, five alliances, and 30 associations are newly described syntaxa. Species richness, community structure, and changes associated with the filling and drawdown cycle of the wetlands are consistent with the patterns reported for wetland environments of Central and South America and the Caribbean. The extent (cover) of the floating and rooted floating-leaved groups was greater during periods of rising waters, when they covered almost the entire water surface of the wetlands. In general, the floristic composition and structural aspects of the submerged, free-floating, and rooted floating-leaved vegetation in the Caribbean resemble those of similar environments in Central America, Mexico, the Antilles, and sectors of the Brazilian Pantanal, the Chaco, and the “savannas” of Bolivia and Paraguay.

Keywords: Aquatic vegetation; Caribbean region; phytosociology; wetlands; floristic composition.

Resumen

Se presenta la clasificación fitosociológica de la vegetación acuática sumergida, flotante libre y flotante enraizada de la serie hídrica del Caribe colombiano con base en su composición florística y en aspectos de la estructura. Los inventarios o censos se realizaron tanto en épocas lluviosas (columna de agua alta en las ciénagas) como en épocas secas (columna de agua baja), y, además, se midieron la conductividad eléctrica y el pH. El grupo más diverso fue el de la vegetación enraizada-flotante, con la clase *Pontederio azureae-Paspaletea repentis*, que incluyó dos órdenes, tres alianzas y 34 asociaciones, en tanto que en el grupo flotante libre se diferenciaron las clases *Lemnetea minoris* y *Pistio stratiotis-Pontederietea crassipedis*, con dos órdenes, dos alianzas y doce asociaciones; en la vegetación sumergida se caracterizó la clase *Cabombo-Nymphaeetea*, con un orden, dos alianzas y cinco asociaciones. Se reportan como novedades sintaxonómicas una clase, dos órdenes, cinco alianzas y 30 asociaciones. La riqueza, aspectos de la estructura comunitaria y los cambios asociados con el ciclo de llenado y vaciado de las ciénagas siguen los patrones mencionados en los ambientes cenagosos de Centroamérica, Suramérica y el Caribe. La extensión (cubrimiento) de los grupos flotantes y la vegetación enraizada-flotante fue mayor

Citation: Rangel-Ch. JO, et al. Aquatic vegetation of the Caribbean wetlands I: Submerged, free-floating, and rooted floating-leaved. Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales. 2026 Oct 2. doi: <https://doi.org/10.18257/raccefyn.4131>

Editor: Gerardo Antonio Aymard
Corredor

***Corresponding author:**
J. Orlando Rangel-Ch.;
jorangelc@unal.edu.co

Received: June 11, 2026

Accepted: August 28, 2026

Published on line: October 2, 2026



This is an open access article distributed under the terms of the Creative Commons Attribution License.

durante los períodos de aguas en ascenso, cuando cubren la casi totalidad de los espejos de agua de las ciénagas. En general, la composición florística y los aspectos de la estructura de la vegetación sumergida, flotante y enraizada del Caribe se asemeja a la de ambientes similares de Centroamérica, México, las Antillas y sectores del Pantanal Brasileiro, el Chaco y las “sabanas” de Bolivia y Paraguay.

Palabras clave: vegetación acuática; región Caribe; fitosociología; humedales; composición florística.

Introduction

In tropical lowland wetlands (0–1000 m), vegetation zonation, rooting or anchoring patterns in relation to water depth, and surface cover are determined by hydrological conditions, wetland area, river or channel inflows, and runoff or groundwater inputs. These conditions vary with rainfall seasonality and the duration of the flooding or high-water period (**Rangel-Ch.**, 2010). The Colombian Caribbean includes extensive plains that receive discharges from large river systems such as the Magdalena and Cauca, which cross much of the Colombian territory, and from regional rivers such as the Sinú, San Jorge, and Cesar. Under this influence, vast portions of the territory are occupied by wetlands, swamps, and small lagoons that generate varied microhabitats suitable for the development of the different types of vegetation characteristic of freshwater hydric series (**Rial**, 2013).

Aquatic vegetation and patterns of floristic richness in tropical regions neighboring Colombia have been documented in several studies. **Lindeman** (1953) described the coastal vegetation of Suriname; studies of plant communities in the Venezuelan Llanos include those by **Castroviejo and López** (1985), **Susach-C.** (1989), **Galán-de Mera et al.** (2006), and **Galán-de Mera and Linares-Perea** (2008). In Brazil, studies include those by **Frey** (1995), **Navarro and Maldonado** (2005) for the Pantanal region, and **Bolós et al.** (1991) in the state of Paraná. Other relevant studies include those by **Reyes and Acosta** (2007) on the Río Cauto wetland in Cuba and **Moreno-C. et al.** (2010) on the central coastal plain of Veracruz, Mexico.

In Colombia, **Rangel-Ch.** (2004) and **Vera et al.** (2019a, 2019b) described communities associated with fluvial-lacustrine systems and floodplains of the biogeographic Chocó and the Orinoquía, respectively. In the department of Córdoba, in the Caribbean, relevant studies include those by **Cataño et al.** (2008) and **Rangel-Ch.** (2010); by **Rangel-Ch. and Arellano** (2008) and **Schmidt-Mumm and Janauer** (2014) in the department of Cesar, and by **Pozo-G. et al.** (2022) in the department of Atlántico.

Here, we address key questions such as patterns of species richness and diversity among vegetation types along the aquatic succession, and their chorological (distributional) relationships. We also examine the influence of river discharge on the organization of plant assemblages in terms of floristic composition and structural attributes, ranging from submerged aquatic vegetation and free-floating vegetation to rooted-emergent vegetation in the transition zone toward swamp and floodplain environments. The classification is based on the phytosociological characterization of vegetation units using floristic composition and species dominance (percentage cover).

Study area

In their classification of the four first-order geomorphological units of the Colombian Caribbean, **Vergara and Velasco** (1901) included the alluvial plains and wetlands (*ciénagas*) associated with the Sinú, San Jorge, Cauca, Magdalena, Ranchería, and Cesar rivers. Geological, geomorphological, and sedimentological aspects of most of these environments are presented in **Lazala and Parra** (2010a, 2010b) and **Jaramillo et al.** (2013). **Jaramillo et al.** (2012) classified wetlands according to their functioning and hydrodynamic connectivity as follows: wetlands associated with major rivers; wetlands influenced by the Caribbean Sea; and closed or inland wetlands that receive water by gravity from the surrounding terrain but have no connectivity with rivers or the sea. Within this wide variety of wetland environments, different types of vegetation occur, ranging from submerged rooted aquatic vegetation to floodplain vegetation, whose characterization and

phytosociological description are the focus of this study. The main wetland systems of the Caribbean region in the departments of Cesar, Magdalena, Atlántico, Sucre, and Córdoba were included in the study. **Table 1S**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>, shows the sites where the detailed vegetation surveys were carried out.

Methodology

Field phase

Vegetation surveys (inventories, detailed censuses) were carried out, considering the filling and drawdown cycle of the wetlands during several field campaigns in 2006, 2007, 2012, 2013, and 2014, according to the precipitation regimes in each locality. Sampling areas ranged from 4 to 16 m². The methodology followed the recommendations in **Rangel-Ch. and Velásquez** (1997), and the following data were recorded: survey area, geographic location (coordinates), relative cover (%) of the species, and measurements of physicochemical water parameters (conductivity, dissolved solids, depth, pH, and temperature). Botanical specimens collected for taxonomic identification were catalogued under the collection numbers of Denisse Cortés (DC) and Orlando Rangel (OR) and were deposited in the National Herbarium of Colombia (COL). Field data were organized in Microsoft Excel spreadsheets, including taxonomic information and species covered by the survey for subsequent processing.

We followed the aquatic-plant zonation scheme described in several studies (**Rangel & Aguirre**, 1983; **Sculthorpe**, 1985; **Velásquez**, 1994; **Rial**, 2000), which includes the following categories (groups): submerged, free-floating, rooted-emergent, swamp, exposed-shore, and alluvial-plain vegetation.

The definition of the vegetation units was based on the Braun-Blanquet phytosociological approach (**Braun-Blanquet**, 1979). The automated TWINSPAN method was used with the PC-ORD program to generate the basic phytosociological matrix, and the classification was subsequently refined manually. Cover values (%) were used in the floristic composition tables of the vegetation units. The names of the resulting phytosociological categories were assigned following the International Code of Phytosociological Nomenclature (**Weber et al.**, 2000, official translation by **Izco and Del Arco**, 2003). The placement of the resulting associations within the syntaxonomic hierarchy (higher categories: class, order, and alliance) was determined based on their affinity with the species reported by **Bolós et al.** (1991), **Borhidi** (1991), **Galán-de Mera** (1995, 2014), and **Galán-de Mera and Vicente-Orellana** (2006). In several cases, the assignment was difficult given the absence of detailed inventories in the references mentioned above.

We described each vegetation unit based on physiognomic traits and the dominance of characteristic species. Measurements of water characteristics (pH, electrical conductivity, and surface temperature) are reported where available. For classes, we reported geographic distributions by department, and we included the municipalities, nearby areas, and wetland names for the associations (**Table 2S**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>).

The codes of the surveys shown in the phytosociological tables refer to the locality or department where we conducted them, as follows: Sucre (SU), Córdoba (C), Magdalena (MG), Juncal-Baquero system (J-B), Doña María-Musanda (M-M), Morales (MO), Congo (CO), Costillas-Sahaya (CT), Zapatosa (ZPT), Mata de Palma, and La Pachita (MP-PCH), all in the department of Cesar. The inventories with OR code were carried out by **Rangel-Ch.** (2010) in the wetlands of Córdoba.

Results

Submerged vegetation

Class *Cabombo-Nymphaeetea* Borhidi & Del Risco in Borhidi, Muñiz & Del Risco (1979) 1983. **Order** *Utricularietalia folioso-juncea* Borhidi, 1996. **Alliance** *Utricularion folioso-juncea* Borhidi 1996 (**Table 1**).

Physiognomy and composition: Communities of submerged aquatic plants and emergent plants.

Syntaxonomy: the Caribbean communities have few species, which complicated their local phytosociological classification. The Caribbean phytocoenoses were assigned to the class *Cabombo-Nymphaeetea* Borhidi & Del Risco in Borhidi, Muñoz & Del Risco (1979) 1983, and not to *Potamogetonetea* Klika in Klika & Novák 1941.

Distribution: Department of Córdoba, municipalities of Santa Cruz de Lorica and Pueblo Nuevo. Department of Sucre, municipalities of San Marcos, San Benito Abad, and Caimito.

Association *Ceratophyllo demersi-Utricularietum foliosae* ass. nov. Rangel & Cortés, in this contribution (Table 1A). **Typus:** PD 1

Physiognomy and composition: Dense assemblages in which the dominant characteristic species were *Ceratophyllum demersum*, *Utricularia foliosa*, and *Cabomba aquatica*. *Najas arguta* appeared as a companion species in wetlands of the San Jorge River (clear waters).

Ecology: during the rainy season, the conductivity ranged from 23 to 86 $\mu\text{S}/\text{cm}$, and the average pH was 6.2. Distribution: see Table 2S, <https://raccefn.co/index.php/raccefn/article/view/4131/5424>.

Table 1. Floristic composition of the Class Cabombo-Nymphaeetea and subordinate units.

Season	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W			
Cond. (µS/cm)	23	23	23	86	23	23	23	68,7	68,7	-	-	-	-	-	-	-	-	-	86	-	-	-	40	-	32	10		
pH	6	6	6	6,3	6	6	6	6,7	6,7	-	-	-	-	-	-	-	-	-	6,3	-	-	-	6,97	-	6,96	9,0		
Plot (m2)	4	4	4	4	4	4	4	4	4	-	-	-	-	-	-	-	-	-	4	-	-	-	4	-	4	4		
Plot number A	Ct 4	PD 1	Respaldo 2	Chopo	Respaldo 3	Respaldo 4	El Coco 2	Bañó 2	Bañó 4	Paloma (P1)	Negro 1	PB 1	Ct 1	Ct 3	Ar 1	Guayabal 1	Respaldo 1	Bañó 5	Guayabal 2	Pr 2	Pr 3	Charco pescao 2	Charco pescao 4	Charco pescao 6	Charco pescao 7	SU- 96B		
Class <i>Cabombo-Nymphaeetea</i> , Order <i>Utricularietalia folioso-juncea</i> , Alliance <i>Utricularion folioso-juncea</i>																												
Association	<i>Ceratophylli demersi-Utricularietum foliosae</i>																		<i>Utricularietum foliosae</i>									
Species	Cover (%)																											
<i>Utricularia foliosa</i>	60	50	20	10	15	5	15	15	20	50	20	20	10	10	10	50	25	10	10	10	10	10	60	50	60	70		
<i>C. demersum</i>	20	15	5	3	3	3	3	3	5	30	10	10	3	15	5	15												
<i>Cabomba aquatica</i>	15	10	5	2	2	2	2	2	5				2			10												
<i>Najas arguta</i>													5	5	10	10	25											
<i>Tonina fluviatilis</i>																			1	2								

Season	W	W	W	W	W	W	W	D	D	D	D	D
Cond. ($\mu\text{S}/\text{cm}$)	10	10	10	10	10	10	11	40	40	40	40	40
pH	9,07	9,64	8,68	8,3	-	9,07	8,34	10,9	10,9	10,9	10,9	10,9
Plot (m2)	9	9	9	9	9	9	9	9	9	9	9	9
Plot number B	SU- 100C	SU- 99C	SU- 97C	SU- 106C	SU- 114B	SU- 103B	SU- 107B	SU- 186.5C	SU- 187.1C	SU- 187.2C	SU- 187.4C	SU- 186.3C
Community Cabomba caroliniana												
Species	Cover (%)											
<i>Cabomba caroliniana</i>	30	20	70	3	55	40	50	30	70	30	80	10

:- No measurement; rainy season (W), dry season (D).

Association *Utricularietum foliosae* Borhidi, 1991 (Table 1A)

Composition: *Utricularia foliosa* was the characteristic and dominant species; *Paepalanthus (Tonina) fluviatilis* was found sporadically.

Ecology: It was found exclusively in the rainy season, in sectors with high water-column transparency (0.5-1 m); the conductivity ranged from 10 to 86 $\mu\text{S}/\text{cm}$, and the average pH was 7.3.

Community of *Cabomba caroliniana* (Table 1B)

Composition: monospecific community of *Cabomba caroliniana*.

Ecology: It was recorded both in the dry season and in the rainy season. Water pH ranged from 8 to 11 (with an average of 9.7); conductivity had a minimum of 10 $\mu\text{S}/\text{cm}$ in the rainy season and 40 $\mu\text{S}/\text{cm}$ in the dry season, with an average of 23 $\mu\text{S}/\text{cm}$.

Alliance *Najo argutae-Ceratophyllion demersi* all. nov. Rangel & Cortés, in this contribution: **Table 3S**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Physiognomy and composition: Submerged herbaceous stands with a clear dominance of *Ceratophyllum demersum*, accompanied by *Najas arguta* and sporadically *Lemna aequinoctialis*.

Ecology: it is found in wetlands with clear waters, in sectors with good transparency in the water column; in contrast, in wetlands with dark waters (brown color), high dissolved solids concentrations may prevent its establishment.

Distribution: Department of Córdoba, municipalities of Santa Cruz de Lorica and Pueblo Nuevo. Department of Cesar, municipality of La Loma. Department of Sucre, municipalities of San Marcos, San Benito Abad, and Caimito.

Association *Ceratophyllo demersi-Najadetum argutae* Cortés & Rangel 2023 (Table 3S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>).

Physiognomy and composition: Dense assemblages dominated by *Najas arguta* and *Ceratophyllum demersum*.

Ecology: it is rooted in sectors with depths of up to 3 m and an average conductivity of 52.3 $\mu\text{S}/\text{cm}$.

Association *Ceratophylletum demersi* (Soó, 1927) Hild. 1956 (Table 3S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>).

Physiognomy and composition: Monospecific community of *Ceratophyllum demersum*.

Ecology: it is rooted at depths greater than 2 m, but reaches its maximum development in the dry season at sites where the water layer is less than 70 cm. The average conductivity was 184 $\mu\text{S}/\text{cm}$, and the pH ranged between 6 and 14.

Free-floating vegetation

This group includes the plant communities that are permanently found in the water body without being rooted to the substrate. Their distribution within the open-water area, as well as their cover, varies throughout the filling and drawdown cycle of the wetlands.

Class *Lemnetea minoris* R. Tx. ex O. Bolòs & Masclans 1955 (Table 4S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>).

Physiognomy and composition: This class comprises several types of floating vegetation (pleustophytic) dominated by *Lemna minor* and *Lemna aequinoctialis*, which occur in lowland wetlands and small lagoons. Elsewhere, *Ricciocarpus natans*, *Spirodela intermedia*, *Spirodela polyrhiza*, and species of *Wolffia* and *Wolffiella* are reported as associated species.

Ecology: It occurs in wetlands and swampy pools.

Distribution: Department of Magdalena, municipality of Concordia. Department of Córdoba, municipalities of Santa Cruz de Lorica and Ayapel. Department of Cesar, municipalities of San Martín, La Gloria, Barrancas de Lebrija, Gamarra, and Chiriguana. Department of Sucre, municipality of San Benito Abad.

Order *Lemnetalia aequinoctialis* Schwabe-Braun et R. Tx. 1981 (Table 4S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>).

Physiognomy, composition, and ecology: floating vegetation in wetlands and swampy pools dominated by *Lemna aequinoctialis*; associated species include *Salvinia auriculata*, *Pistia stratiotes* and *Pontederia (Eichhornia) crassipes*.

Alliance *Lemnion minoris-aequinoctialis* all. nov. Rangel & Cortés, in this contribution: **Table 4S**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Typus: *Pontederio crassipedis-Lemnetum aequinoctialis*

Physiognomy and composition: Floating mats dominated by *Lemna aequinoctialis* and *Lemna minor*.

Ecology: It occurs in shallow swamp pools whose trophic state is strongly influenced by water movement and the presence of pollutant and nutrient inputs (particularly nitrogen). The following communities were documented in the Caribbean wetlands (stages of trophic succession):

Community of *Lemna minor* and *Lemna aequinoctialis* (Table 4S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Floating mats dominated by *Lemna aequinoctialis*, with cover close to 60% of the sampling area; *Lemna minor* appeared as a companion species (15% cover); *Salvinia auriculata* occurred sporadically.

Ecology: It occurs in highly eutrophic swampy areas with very shallow water. This community predominates during the rainy season with conductivity values between 25 and 36 $\mu\text{S}/\text{cm}$; in the dry season, conductivity increases up to 160 $\mu\text{S}/\text{cm}$; the pH varied between 7 and 8. Distribution: see **Table 2S** (A-B), <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Community of *Lemna aequinoctialis* and *Pistia stratiotes* (Table 4S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Floating mats dominated by *Lemna aequinoctialis* and *Pistia stratiotes*; *Lemna minor* and *Salvinia auriculata* appeared as companion species.

Ecology: In shallow pools; it constitutes an intermediate stage in species richness and trophic status within the floating vegetation of the wetlands. It predominates in the rainy season with conductivity values between 38 and 47 $\mu\text{S}/\text{cm}$; the pH varied from 7 to 7.3.

Association *Pontederio crassipedis-Lemnetum aequinoctialis* ass. nov. Rangel & Cortés in this contribution: **Table 4S**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus:** C- 39

Physiognomy and composition: Floating mats dominated by *Lemna aequinoctialis* and *Pontederia crassipes*. *Pistia stratiotes*, *Salvinia auriculata*, and *Lemna minor* occurred as companion species.

Ecology: In shallow pools; as mentioned for the previous community, it is associated with an intermediate stage in species richness and trophic status. It predominates in the rainy season with conductivity values between 11 and 79 $\mu\text{S}/\text{cm}$, with a maximum value of 147 $\mu\text{S}/\text{cm}$, and in the dry season with a value of 155 $\mu\text{S}/\text{cm}$; the pH varied from 6.7 to 8.

Community of *Wolffiella* aff. *lingulata* (Table 4S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Floating mats dominated by *Lemna aequinoctialis* and *Pontederia crassipes*. *Wolffiella* aff. *lingulata* appears as a distinct species with high cover values. Other associated species are *Lemna minor*, *Pistia stratiotes*, and *Salvinia auriculata*.

Syntaxonomy: This community was initially treated as the *Lemno aequinoctialis-Wolffielletum lingulatae* Landolt 1999 association. Galán-de Mera *et al.* (2024) deemed this an invalid name and proposed the *Lemnetum aequinoctialis* association instead, whose description includes *Azolla caroliniana*, *Lemna aequinoctialis*, *L. valdiviana*, *Ricciocarpus natans*, *Wolffiella lingulata*, and *Wolffiella oblonga*. Although there is no floristic composition table, a simple comparison allows us to conclude that the Caribbean community is a different phytocoenosis from the one proposed by Galán-de Mera *et al.* (2024) for Peru.

Ecology: It occurs in swampy pools; it is the final stage of trophic succession. It was recorded during the dry season in shallow-water pools with depths not exceeding 50 cm. Water conductivity ranged between 30 and 35 $\mu\text{S}/\text{cm}$, and the pH was slightly alkaline, with an average of 8.

Class *Pistio stratiotis-Pontederietea crassipedis* O. Bolòs et al. 1991

Order *Pistio stratiotis-Pontederietalia crassipedis* O. Bolòs et al. 1991 (Table 5S A-B, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Mats of floating plants dominated by *Pontederia crassipes*, *Pistia stratiotes*, and *Salvinia auriculata*.

Ecology: It occurs in wetlands and swampy areas that retain open water. In some localities, evidence of human disturbance is apparent, with wastewater discharge and organic-matter inputs from livestock and agricultural activities.

Distribution: Department of Córdoba, municipalities of Santa Cruz de Lorica and Pueblo Nuevo. Department of Cesar, municipalities of La Gloria, Barrancas de Lebríja, Pelaya, San Martín, Chimichagua, and La Loma. Department of Sucre, municipalities of San Marcos, San Benito Abad, and Caimito. Department of Magdalena, municipalities of Concordia and Zapayán.

Alliance *Pistio stratiotis-Pontederion crassipedis* O. Bolòs, Cervi & Hatschbach 1991 (Table 5S A-B, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Floating mats dominated by *Pontederia (Eichhornia) crassipes*, *Pistia stratiotes*, and *Salvinia auriculata*.

Ecology: It is found in most wetlands during both the rainy and dry seasons; evidence of eutrophication is observed at some sites.

Association *Salvinio auriculatae-Pontederietum crassipedis* ass. nov. Rangel & Cortés, in this contribution: Table 5S A, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus: MG-21 (department of Magdalena)**

Physiognomy and composition: Mats dominated by *Pontederia crassipes*, *Pistia stratiotes*, and *Salvinia auriculata*.

Ecology: Its cover increases during the rainy season; the pH ranged from 7 to 11, and the electrical conductivity ranged from 4 to 39 $\mu\text{S}/\text{cm}$. Distribution: see Table 2S (A-B), <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Association *Limnobia laevigati-Pontederietum crassipedis* ass. nov. Rangel & Cortés, in this contribution: Table 5S A, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus: C-81. 2A (department of Córdoba)**

Physiognomy and composition: Mats dominated by *Limnobia laevigatum* and *Pontederia crassipes*; *Pistia stratiotes* appears as a companion species.

Ecology: It occurs in wetlands and swampy sectors, especially in the dry season. The pH ranged from 10 to 12, and the average electrical conductivity was 249 $\mu\text{S}/\text{cm}$.

Association *Ricciocarpo natantis-Pontederietum crassipedis* ass. nov. Rangel & Cortés, in this contribution: Table 5S A, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus: Canal 1**

Physiognomy and composition: Mats dominated by *Pontederia crassipes*, *Pistia stratiotes*, and *Ricciocarpus natans*.

Ecology: It occurs along the margins of wetlands associated with the Sinú and San Jorge rivers.

Association *Pontederietum crassipedis* Samek & Moncada 1971, amended by Rangel & Cortés in this contribution: Table 5S B, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>

Physiognomy and composition: Mats dominated exclusively by *Pontederia crassipes*.

Ecology: In the rainy season, it expands and covers much of the water surface in some wetlands. Electrical conductivity varied between 85 and 225 $\mu\text{S}/\text{cm}$, and the pH between 7 and 8.2.

Association *Pontederietum azureae* Borhidi, Muñiz & Del Risco 1983 (Table 5S B, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Mats dominated by *Pontederia azurea* and *Pontederia crassipes*; *Pistia stratiotes* and *Lemna minor* appear as associated species.

Ecology: It occurs in the wetlands of Córdoba. Distribution: see Table 2S (A-B), <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Community of *Pistia stratiotes* and *Pontederia crassipes* (Table 5S C, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Mats dominated by *Pistia stratiotes* and *Pontederia crassipes*.

Ecology: It occurs along wetland margins. In four locations (departments of Sucre, Córdoba, and Magdalena), during the dry season, conductivity values ranged from 40 to 169 $\mu\text{S}/\text{cm}$, and the pH ranged from 7.95 to 11.3. Distribution: see Table 2S (A-B), <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Community of *Lemna minor* and *Pontederia crassipes*, Table 5SC, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Physiognomy and composition: Floating mats dominated by *Lemna minor* and *Pontederia crassipes*; associated species included *Pistia stratiotes*, *Ricciocarpus natans*, and *Lemna aequinoctialis*; *Spirogyra* sp. occurred sporadically.

Ecology: It occurs along wetland margins in brown-colored waters (influenced by the Sinú River).

Association *Pistio stratiotis-Salvinietum auriculatae* ass. nov. Rangel & Cortés, in this contribution: Table 6S A, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus:** SU-178. 1A (department of Sucre)

Physiognomy and composition: Mats dominated by *Pistia stratiotes* and *Salvinia auriculata*; *Limnobium laevigatum* appeared as a companion species.

Ecology: In wetlands and pools with marked signs of eutrophication.

Syntaxonomy: In sites with stagnant and highly eutrophic waters, the mats of *Salvinia auriculata* and *Pistia stratiotes* are included in the class *Pistio stratiotis-Pontederietea crassipedis*, in the order *Pistio stratiotis-Pontederietalia crassipedis*, and in the alliance *Pistio stratiotes-Pontederion crassipedis*, even though *Pontederia crassipes* and *Pontederia azurea* were not found in the field surveys.

Mixed communities: rooted floating-leaved

Class *Pontederio azureae-Paspaletea repentis* cl. nov. Rangel & Cortés, in this contribution: Table 6S B, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus:** *Ludwigia helminthorrhizae-Pontederietalia azureae*

Physiognomy and composition: Herbaceous stands with emergent rooted species associated with assemblages of *Pontederia azurea*.

Ecology: It occurs in permanent open-water areas and in seasonally inundated swamps. It includes two orders, *Ludwigia helminthorrhizae-Pontederietalia azureae* and *Ludwigia helminthorrhizae-Paspaletea repentis*. Its distribution is restricted to wetlands of the Caribbean and the Colombian Orinoquia.

Syntaxonomic note: **Galán-de Mera and Vicente-Orellana** (2006) included the alliance *Eichhornion azureae* Borhidi & Muñiz in Borhidi, Muñiz & Del Risco 1979 ex Galán de Mera & Navarro 1992 in the order *Pistio stratiotis-Eichhornietalia crassipedis* Bolòs, Cervi & Hatschbach 1991 and in the class *Pistio stratiotis-Eichhornietea crassipedis* Bolòs, Cervi & Hatschbach 1991. **Cortés** (2017) included vegetation units dominated by *Pontederia azurea* from the Caribbean wetlands in the aforementioned syntaxonomic scheme. In this study, we defined the new units based on their floristic composition, with special emphasis on the predominance of *Pontederia azurea* and the absence of *Pontederia crassipes*.

Distribution: Department of Córdoba, municipalities of Ayapel, Chimá, Pueblo Nuevo, San Bernardo del Viento, and Santa Cruz de Lorica. Department of Cesar, municipalities

of La Gloria, Barrancas de Lebrija, Gamarra, Pelaya, Chimichagua, La Loma, and San Martín. Department of Sucre, municipalities of San Marcos, San Benito Abad, and Caimito. Department of Magdalena, municipalities of Concordia and Zapayán.

Order *Ludwigia helminthorrhizae-Pontederietalia azureae* ord. nov. Rangel & Cortés, in this contribution: **Table 6S B**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>

Typus: *Ludwigia helminthorrhizae-Pontederion azureae* all. nov. Rangel & Cortés, in this contribution: **Table 6S B**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus: *Neptunio oleraceae-Pontederietum azureae***

Physiognomy and composition: Mixed herbaceous stands dominated by *Pontederia azurea* (pleustophyte) and *Hymenachne amplexicaulis* (rooted). Associated species include *Ipomoea aquatica* and *Ludwigia helminthorrhiza*.

Ecology: These stands occur in open-water areas and swamps, depending on the rainy-dry cycle. The dominant species is common in transition zones because of its amphibious habit and is commonly found in eutrophic sites.

Association *Marsileo minutae-Pontederietum azureae* ass. nov. Rangel & Cortés, in this contribution: **Table 6S B**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus: SU-172. 1B**

Physiognomy and composition: Mats dominated by *Pontederia azurea* and *Marsilea minuta*. *Ipomoea aquatica*, *Ipomoea trifida*, *Ludwigia helminthorrhiza*, and *Cyperus odoratus* also occur.

Ecology: It occurs on wetland margins in shallow sectors. Its cover increases from the end of the rainy season to the beginning of the dry season. **Distribution:** see **Table 2S (A-B)**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Association *Aeschynomeno rudis-Pontederietum azureae* ass. nov. Rangel & Cortés, in this contribution: **Table 6SB**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus: SU-140. 5B**

Physiognomy and composition: Mixed herbaceous stands dominated by *Pontederia azurea* (pleustophyte) and *Aeschynomene rudis* (rooted); *Hymenachne amplexicaulis* and *Ludwigia helminthorrhiza* also appear.

Ecology: It occurs in swampy areas and along wetland margins. It extends its cover during the rainy period, when it penetrates the water surface.

Association *Ludwigia helminthorrhizae-Pontederietum azureae* ass. nov. Rangel & Cortés, in this contribution: **Table 6S B**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus: SU-149.1B**

Physiognomy and composition: Mixed herbaceous stands dominated by *Pontederia azurea* (pleustophyte) and *Ludwigia helminthorrhiza* (rooted); *Hymenachne amplexicaulis* also appears.

Ecology: It occurs along wetland shores.

Association *Pontederio azureae-Echinochloetum polystachyae* ass. nov. Rangel & Cortés, in this contribution: **Table 6S B**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus: MO-DC. 23**

Physiognomy and composition: Mixed herbaceous stands dominated by *Echinochloa polystachya*, a species that is associated with *Pontederia azurea* during the high-water season. Other associated species were *Funastrum (Sarcostemma) glaucum* and *Odontadenia macranta*.

Ecology: It occurs on wetland margins and expands in the rainy season.

Community of *Pontederia azurea* and *Paspalum repens* (Table 6S B, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>).

Physiognomy and composition: Mixed herbaceous stands dominated by *Pontederia azurea* (pleustophyte) and *Paspalum repens* (rooted).

Ecology: It occurs on wetland margins at sites with clear evidence of human disturbance. In both seasons, the pH ranged from 8 to 11, and the conductivity from 3 to 155 µS/cm.

Ecology: It occurs along wetland margins up to 1.5 m in depth. Water pH was 8, and conductivity was 31 $\mu\text{S}/\text{cm}$.

Association *Pontederio azureae-Nymphaeetum pulchellae* ass. nov. Rangel & Cortés, in this contribution: **Table 2. *Typus*:** C-05. 6

Physiognomy and composition: Herbaceous stand dominated by *Nymphaea pulchella* (rooted aquatic), with *Pontederia azurea* appearing as an associated species.

Ecology: It occurs in sectors less than 2 m deep. The pH was 7.7, and the conductivity was 27 $\mu\text{S}/\text{cm}$. It is uncommon.

Association *Pontederio azureae-Marsileetum vestitae* ass. nov. Rangel & Cortés, in this contribution: **Table 2. *Typus*:** SU-184. 3B

Physiognomy and composition: Herbaceous stand dominated by *Marsilea vestita* (rooted aquatic), with *Pontederia azurea* and *Ipomoea aquatica* appearing as associated species. *Ludwigia sedioides* appears as a companion species.

Ecology: It occurs on wetland margins, especially in the dry season (low water levels).

Association *Pontederio azureae-Nymphaeetum amplae* ass. nov. Rangel & Cortés, in this contribution: **Table 2. *Typus*:** C-33

Physiognomy and composition: Herbaceous stand dominated by *Nymphaea ampla* (rooted aquatic), with *Pontederia azurea* and *Luziola subintegra* appearing as associated species.

Ecology: It occurs on wetland margins; pH varied between 6.9 (rainy season) and 14 (dry season), and the conductivity between 32 and 46 $\mu\text{S}/\text{cm}$ in the rainy season and between 197 and 397 $\mu\text{S}/\text{cm}$ in the dry season.

Association *Pontederio azureae-Nymphaeetum novogranatensis* ass. nov. Rangel & Cortés, in this contribution: **Table 2. *Typus*:** M. M-DC. 47

Physiognomy and composition: Herbaceous stand dominated by *Nymphaea novogranatensis* (rooted aquatic), with *Pontederia azurea*, *Persicaria hispida*, and *Cyperus blepharoleptos* appearing as associated species.

Ecology: It occurs on wetland margins, with vigorous growth during the rainy season at sites from 1 to 2 m deep. The pH was 6.9, and the conductivity was 190 $\mu\text{S}/\text{cm}$.

Community of *Hydrocotyle umbellata* (Table 2)

Physiognomy and composition: Herbaceous stand dominated by *Hydrocotyle umbellata* (rooted aquatic), with *Pontederia azurea* and *Ludwigia helminthorrhiza* appearing as associated species.

Ecology: It occurs on wetland margins, in shallow sites. The pH was 10.

Association *Pontederio azureae-Nymphoideetum indicae* ass. nov. Rangel & Cortés, in this contribution: **Table 2. *Typus*:** SU-75B

Physiognomy and composition: Herbaceous stand dominated by *Nymphoides indica* (rooted aquatic), with *Pontederia azurea*, *Ludwigia helminthorrhiza*, and *Ludwigia sedioides* appearing as associated species.

Ecology: It occurs on wetland margins, with better development during the rainy season. The pH was 7.4, and the conductivity was 37 $\mu\text{S}/\text{cm}$.

Association *Pontederio azureae-Hymenachnetum amplexicaulis* ass. nov. Rangel & Cortés, in this contribution: **Table 3A. *Typus*:** SU-158. 1

Physiognomy and composition: Mixed herbaceous stands dominated by *Hymenachne amplexicaulis* (rooted) and *Pontederia azurea* (pleustophyte). *Ludwigia helminthorrhiza*, *Neptunia oleracea*, *Marsilea minuta*, *Mikania* sp., *Ipomoea subrevoluta*, *Nymphaea novogranatensis*, and *Luziola subintegra* also appear.

Ecology: It occurs on wetland margins and in swampy areas, with greater cover during the dry season; pH varied from 6.8 to 11, and the conductivity ranged from 7 to 69 $\mu\text{S}/\text{cm}$.

Association *Pontederio azureae-Luzioletum subintegrae* ass. nov. Rangel & Cortés, in this contribution: **Table 3A. *Typus*:** C-18. 2

Physiognomy and composition: Mixed herbaceous stands dominated by *Luziola subintegra* (rooted) and *Pontederia azurea* (pleustophyte); companion species include *Ludwigia helminthorrhiza*, *Neptunia oleracea*, *Hydrocotyle umbellata*, and *Louisiella elephantipes*.

Ecology: It occurs on wetland margins, especially during low-water periods; pH varied from 7 (rainy season) to 13 (dry season), and the conductivity ranged from 18 $\mu\text{S}/\text{cm}$ (rainy season) to 204 $\mu\text{S}/\text{cm}$ (dry season).

Association *Marsileo vestitae-Ipomoeetum aquaticae* ass. nov. Rangel & Cortés, in this contribution: **Table 3B. *Typus*:** SU1 36. 2

Physiognomy and composition: Rooted herbaceous stands dominated by *Ipomoea aquatica* and *Marsilea vestita*; associated species include *Pontederia azurea* and *Ludwigia helminthorrhiza*.

Ecology: It occurs on wetland margins, especially during low-water periods; when the water level increases, it expands inward, taking advantage of its hollow stems. The pH was 11, and the conductivity varied from 39 to 42 $\mu\text{S}/\text{cm}$.

Association *Pontederio azureae-Ipomoeetum aquaticae* ass. nov. Rangel & Cortés, in this contribution: **Table 3B. *Typus*:** C-57.4 A

Physiognomy and composition: Mixed herbaceous stands dominated by *Pontederia azurea* (pleustophyte) and *Ipomoea aquatica* (rooted). *Nymphoides indica*, *Cyperus polystachyos*, *Echinochloa polystachya*, and *Persicaria hispida* also appear sporadically.

Ecology: It occurs on wetland margins and expands inward as the water column increases; pH varied from 7.2 to 11.1 (dry season) and from 6.7 to 8.8 (rainy season); conductivity ranged from 28 to 55.4 $\mu\text{S}/\text{cm}$ (dry season) and from 8 to 45 $\mu\text{S}/\text{cm}$ (rainy season).

Order *Ludwigia helminthorrhizae-Paspaletalia repentis* ord. nov. Rangel & Cortés, in this contribution: **Table 7S**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. ***Typus*:** *Neptunia oleraceae-Paspalion repentis*

Physiognomy and composition: Mixed herbaceous stands dominated by *Paspalum repens* and *Ludwigia helminthorrhiza*; *Pontederia azurea* and *Marsilea minuta* are associated with them, but not frequently and with low cover.

Ecology: It occurs along wetland margins and in swampy areas. Changes in the water column level associated with rainfall seasonality condition the extent and cover of the dominant species; in the rainy season, pH varied from 6.3 to 8.2, and the conductivity ranged from 14 to 90 $\mu\text{S}/\text{cm}$ and in the low-water period, the pH varied from 8.2 and 9.1, and the conductivity from 37 to 60 $\mu\text{S}/\text{cm}$.

Alliance *Paspalo repentis-Ludwigia helminthorrhizae* all. nov. Rangel & Cortés, in this contribution: **Table 7S**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. ***Typus*:** *Ludwigia sedioides-Marsileetum vestitae*

Physiognomy and composition: Mixed herbaceous stands dominated by *Paspalum repens* and *Ludwigia helminthorrhiza*; associated species include *Neptunia oleracea* and *Cyperus blepharoleptos*.

Ecology: It occurs on wetland margins and in swampy pools; it expands considerably during the rainy season; pH ranged from 7 to 11 in the dry season and from 6 to 9 in the wet season. Conductivity ranged from 4 to 90 $\mu\text{S}/\text{cm}$ in the wet season, with one exceptional value of 128 $\mu\text{S}/\text{cm}$, and from 31 to 64 $\mu\text{S}/\text{cm}$ in the dry season.

Association *Ludwigia sedioides-Marsileetum vestitae* ass. nov. Rangel & Cortés, in this contribution: **Table 7S**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. ***Typus*:** SU6 5

Physiognomy and composition: Rooted herbaceous stands dominated by *Marsilea vestita* and *Ludwigia sedioides*; associated species include *Paspalum repens*, *Neptunia oleracea*, *Hymenachne amplexicaulis*, *Ipomoea aquatica*, and *Ludwigia helminthorrhiza*. *Luziola spruceana*, *Caperonia palustris*, *Nymphaea nouchali*, and *Ludwigia erecta* may be found sporadically.

Ecology: It occurs on wetland margins and in swampy pools; pH varied from 6 to 11, and the conductivity ranged from 4 to 34 $\mu\text{S}/\text{cm}$, with an exceptional value of 86 $\mu\text{S}/\text{cm}$. Distribution: see **Table 2S (A-B)**, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Table 3. Floristic composition of the Class Pontederio azureae-Paspaletea repentis and other subordinate units (B).

Season	D	D	D	D	D	D	D	D	D	D	D	W	W	D	D	W	W	D	D	D	D	D	D	D	D
Cond. (µS/cm)	40	40	40	40	-	40	33	69	69	40	40	7	6	69	0,7	9	18	27	4	51	44	44	204	-	204
pH	10,2	10,2	10,2	10,9	-	10,9	11	11,2	11,2	10,9	10,2	7,89	6,81	11,2	11	8	7,01	7,67	10,2	7,95	7,95	7,95	12,6	-	12,6
Plot (m2)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Plot number A	SU- 162.1	SU- 160.1	SU- 169.3	SU- 185.1	SU- 157.3	SU- 186.2	SU- 178.2	SU- 154.6	SU- 156.1	SU- 185.4	SU- 158.1	SU- 118	SU- 70	SU- 155.1	SU- 155.2B	SU- 59B	C- 18.2	C- 05.2	SU- 166.2	MG- 33	MG- 34	MG- 36	C- 82.10	C- 80.3	C- 83.3
	Class <i>Pontederio azureae-Paspaletea repentis</i> , Order <i>Ludwigio helminthorrhizae-Pontederietalia azureae</i> , Alliance <i>Ludwigio helminthorrhizae-Pontederion azureae</i>																								
Association	<i>Pontederio azureae-Hymenachnetum amplexicaulis</i>															<i>Pontederio azureae-Luzioletum subintegrae</i>									
Species	Cover (%)																								
<i>Pontederia azurea</i>	15				10	30	25	20	20	20	10	5				70	60	10	30	10	20	40	20	20	20
<i>Ludwigia helminthorrhiza</i>	25				10								5												
<i>Neptunia oleracea</i>	5															5									
<i>Hymenachne amplexicaulis</i>	60	100	100	10	15	10	60	70	80	10	40	60	10	70	10	20									
<i>Marsilea minuta</i>	2 2																								
<i>Ipomoea subrevoluta</i>	10 30																								
<i>Luziola subintegra</i>	20 30 70															60	70	70	80	80	60	60	70	60	
Other species																									
<i>Nymphaea novogranatensis</i> (SU- 186.2; 5); <i>Mikania</i> sp. (SU- 155.1; 5); <i>Louisiella elephantipes</i> (C- 18.2; 10); <i>Hydrocotyle umbellata</i> (C- 83.3; 15)																									

Season	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	W	W	W	W	
Cond. (µS/cm)	-	-	39	39	42	-	-	-	-	-	-	40	-	-	55,4	30	28	-	-	42	42	40	40	40	40	-	8	10	45	-
pH	-	-	11,1	11,1	11,1	-	-	-	-	-	-	10,2	-	-	9,2	7,2	7,2	-	-	11,1	11,1	10,2	10,2	10,2	10,2	-	8,52	8,63	7,47	-
Plot (m2)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Plot number B	SU1 36.1	SU1 36.2	SU1 74.2	SU1 74.1	SU1 75.3	SU1 41.7	C63. 8	C63. 9	SU1 36.3	SU1 41.4	C58.4	SU1 63.1	C63. 7	C59. 1	COR.102	ZPT. DC63	ZPT. DC67	SU1 42.1	SU1 42.2	SU1 75.1	SU1 75.2	SU1 61.1	SU1 63.4	SU1 63.6	SU1 65.1	SU1 5	SU1 28	SU102	C44	SU1 16
Association	Marsileo vestitae-Ipomoeetum aquaticae						Com. Ipomoea aquatica																							
Species	Cover (%)																													
Pontederia azurea	20	20	5																											
Paspalum repens	5																													
Marsilea vestita		10	5	20	20	15																								
Ipomoea aquatica	70	50	10	60	50	30	60	80	80	10	80	10	90	10	5	10	10	5	8	70	40	70	20	30	20	5	80	5	15	20
Nymphoides indica							5 1																							
Cyperus polystachyos							5 20																							
Other species																														
Ludwigia herlminthorrhiza (SU1 74.1; 0,5); Caperonia palustris (C63. 9; 20); Echinochloa polystachya (SU1 63.1; 3)																														

-: No measurement; rainy season (W), dry season (D).

Association *Ludwigia peploides-Paspaleum repens* ass. nov. Rangel & Cortés, in this contribution: **Table 4. *Typus*:** C. OR14

Physiognomy and composition: Mixed herbaceous stands dominated by *Paspalum repens* and *Ludwigia peploides*; associated species include *Pontederia azurea*, *Neptunia oleracea*, *Nymphoides indica*, *Marsilea vestita*, *Ipomoea aquatic*, and *Nymphaea ampla*.

Ecology: It occurs on wetland margins and in swampy pools during the rainy season; pH varied from 6.3 to 8.8, and the conductivity ranged from 14 to 91 $\mu\text{S}/\text{cm}$.

Community of *Ludwigia helminthorrhiza* and *Paspalum repens* (Table 4)

Physiognomy and composition: Rooted herbaceous stands dominated by *Paspalum repens* and *Ludwigia helminthorrhiza*. *Marsilea polycarpa*, *Cyperus blepharoleptos*, and *Ludwigia peploides* appear sporadically.

Ecology: It occurs on wetland margins; pH varied from 6.9 to 8.2, and the conductivity ranged from 13 to 90 $\mu\text{S}/\text{cm}$.

Association *Ludwigia helminthorrhizae-Nymphoideetum indicae* ass. nov. Rangel & Cortés, in this contribution: **Table 5. *Typus*:** ZPT. DC-68

Physiognomy and composition: Herbaceous stands dominated by *Ludwigia helminthorrhiza* and *Nymphoides indica*; associated species include *Marsilea minuta*, *Nymphaea ampla*, *Hymenachne amplexicaulis*, *Nymphaea pulchella*, *Cyperus blepharoleptos*, and *Nymphaea novogranatensis*.

Ecology: It occurs on wetland margins and in shallow pools; pH varied from 6.7 to 8, and the conductivity ranged from 8 to 69 $\mu\text{S}/\text{cm}$.

Class, order, and alliance not assigned

This vegetation has floristic affinities to the rooted floating-leaved group, although the absence of *Pontederia azurea* from the surveys precludes assignment to that group.

Table 4. Floristic composition of the Class *Pontederia azureae-Paspaletea repentis* and other subordinate units (D).

Season	W	W	W	W	W	W	W	W	W	W	-	-	-	-	-	-	-	-	-	-	-	W	W	W	W	W	-	-													
Cond. (µS/cm)	68,7	86	86	86	13,6	13,6	13,6	86	86	91,1	-	-	-	-	-	-	-	-	-	-	-	90	12,8	30	-	13	-	-													
pH	6,7	6,3	6,3	6,3	6,5	6,5	6,5	6,3	6,3	8,8	-	-	-	-	-	-	-	-	-	-	-	6,9	7,3	7,64	7,6	8,15	-	-													
Plot (m2)	9	9	9	9	9	9	9	9	9	9	-	-	-	-	-	-	-	-	-	-	-	9	9	9	9	9	-	-													
Plot number	CO R.38	C-OR. 11	COR.9	CO R.14	CO R.61	CO R.54	COR.60	COR.2	COR.3	CO R.72	Pr 4	Pr 6	Pr 5	Pr 7	Pr 12	Pr 11	Guayabal 3	Pr 10	Pr 1	Paloma (P1)	Yuyos	Respaldo 3	R.Ñ. 1	M. MDC.48	JBD C.58	SU2 2	ZPT OR.8	SU4 8	Pr 15	Pr 14											
Class <i>Pontederia azureae-Paspaletea repentis</i> , Order <i>Ludwigio helminthorrhizae-Paspaleitalia repentis</i>																																									
Alliance	<i>Neptunio oleraceae-Paspalion repentis</i>																					<i>Undefined</i>																			
Association	<i>Ludwigio peploides-Paspaletum repentis</i>																					<i>Ludwigio helminthorrhizae-Paspaletum repentis</i>																			
Species	Cover (%)																																								
<i>Pontederia azurea</i>																														5											
<i>Paspalum repens</i>	80	95	95	40	30	50	60	90	20	20	50	15	60	60	10	5	80	5	50	20	20	9	90	60	70	50	70	20	15	5											
<i>Cyperus blepharoleptos</i>												2	5		5		10	1															10								
<i>Marsilea polycarpa</i>																						5																		40	65
<i>Ludwigia helminthorrhiza</i>																10	20											10	10	1	20	10	10	10							
<i>Ludwigia peploides</i>	5	1	1	1	1	2	10	1	2	3	25	15	10	10	10	10	5	5	2	2	2	2	1																		
<i>Nymphoides indica</i>	1	0,5							1															1																	
<i>Neptunia oleracea</i>	2	1	0,5	1	2						3																														
Other species																																									
<i>Marsilea vestita</i> (CO R.14; 10); <i>Marsilea quadrifolia</i> (Pr 6; 70); <i>Phytolacca rivinoides</i> (Guayabal 3; 5); <i>Ipomoea aquatica</i> (CO R.14; 1); <i>Ipomoea aquatica</i> (CO R.14; 1); <i>Ludwigia sedioides</i> (Respaldo 3; 10); <i>Nymphaea ampla</i> (CO R.14; 1)																																									

-. No measurement; rainy season (W), dry season (D).

Association *Nelumbetum luteae* Borhidi 1991 (Table 8S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Herbaceous stands dominated by *Nelumbo lutea*; *Paspalum repens* and *Luziola subintegra* are found sporadically.

Ecology: It occurs on wetland margins up to 1.5 m deep. In the study area, its presence was restricted to the department of Magdalena, in sectors with a pH of 8 and conductivity ranging from 30 to 32 $\mu\text{S}/\text{cm}$. Distribution: see Table 2S (A-B), <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>.

Community of *Nymphaea novogranatensis* (Table 8S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Herbaceous stands dominated by *Nymphaea novogranatensis*; associated species include *Ludwigia sedioides*, *Paspalum repens*, *Hymenachne amplexicaulis*, *Hydrocotyle umbellata*, and *Nymphoides indica*.

Ecology: It occurs on wetland margins and in swampy pools; pH varied from 6 to 8, and the conductivity ranged from 23 to 86 $\mu\text{S}/\text{cm}$.

Community of *Nymphaea pulchella* (Table 8S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>)

Physiognomy and composition: Herbaceous stands dominated by *Nymphaea pulchella*.

Ecology: It occurs on wetland margins.

Association *Hydrolea spinosae-Limnocharietum flavae* ass. nov. Rangel & Cortés, in this contribution: Table 8S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus:** SU-140. 2B

Physiognomy and composition: Herbaceous stands dominated by *Limnocharis flava* and *Hydrolea spinosa*; associated species include *Justicia laevilinguis*, *Cyperus surinamensis*, *Cyperus odoratus*, *Vigna luteola*, and *Cyperus ligularis*.

Ecology: It occurs on wetland margins, in shallow pools, and swampy zones. The pH was 8, and the conductivity varied from 8 to 25 $\mu\text{S}/\text{cm}$. Although standing water disappears during the dry season, the vegetation remains.

Association *Nymphoideo indicae-Hydrocotyleetum umbellatae* ass. nov. Rangel & Cortés, in this contribution: Table 8S, <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>. **Typus:** C-80. 1

Physiognomy and composition: Herbaceous stands dominated almost exclusively by *Hydrocotyle umbellata*; associated species include *Luziola subintegra*, *Amaranthus australis*, *Nymphoides indica*, *Ipomoea triloba*, and *Nymphaea nouchali*.

Ecology: It occurs on wetland margins; pH varied from 6.9 to 12.6, and the conductivity ranged from 47 to 91 $\mu\text{S}/\text{cm}$ in the rainy season and from 59 to 204 $\mu\text{S}/\text{cm}$ in the dry season.

Association *Ludwigia erectae-Cyperetum blepharoleptos* ass. nov. Rangel & Cortés, in this contribution: Table 6A. **Typus:** C-OR18

Physiognomy and composition: Rooted herbaceous stands dominated by *Cyperus blepharoleptos* (= *Oxycaryum cubense*) and *Ludwigia erecta*; associated species include *Paspalum repens*, *Thalia geniculata*, and *Justicia laevilinguis*.

Ecology: It occurs on wetland margins and grows vigorously during the rainy season; the pH varied from 6 to 9.9, and the conductivity ranged from 9 to 91 $\mu\text{S}/\text{cm}$.

Community of *Leersia hexandra* (Table 6B)

Physiognomy and composition: Grasslands dominated exclusively by *Leersia hexandra*; *Ludwigia helminthorrhiza* and *Cyperus ligularis* are occasionally found.

Ecology: It occurs on wetland margins and stream-channel edges; the pH varied from 7.3 (rainy season) to 8.7 (dry season), and the conductivity ranged from 0.5 (rainy season) to 34 $\mu\text{S}/\text{cm}$ (dry season).

Association *Eleocharitetum interstinctae* Castroviejo & López 1985 (Table 6B)

Physiognomy and composition: Herbaceous stands dominated exclusively by *Eleocharis intersticta*, which is locally known as “juncal” because of its growth form.

Ecology: It occurs on wetland margins and flooded pools, with greater cover in the rainy season; the pH varied from 7.1 to 8, and the conductivity from 166 to 336 $\mu\text{S}/\text{cm}$.

Table 5. Floristic composition of the Class Pontederio azureae-Paspaletea repentis and other subordinate units (E).

Season	W	W	D	W	D	W	D	W	W	W	W	W	W	W	W	W	-	-	-	-	-	-	-	-	-	-	-	W	W	D	D	D	W	W	W	D	D	D	D	D	D																							
Cond. (µS/cm)	16	79	-	-	37	128	64	8	36	8	27	38	39	40	-	-	-	-	-	-	-	-	-	-	-	-	-	8	11	60	59	-	11	11	69	11	-	-	59	-	-	-	-																					
pH	7,22	7,64	-	-	9,1	7,3	8,22	8,02	6,98	8,52	7,7	6,97	7	6,89	-	7,03	-	-	-	-	-	-	-	-	-	-	-	8	6,9	-	6,9	-	7,4	7,3	6,7	7,5	-	-	6,9	-	-	-	-	-																				
Plot (m2)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	-	-	-	-	-	-	-	-	-	-	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9																				
Plot number	C-16	C-46	C-OR. 95	C- 01.1	MG- 52	JB-DC. 60	MG-42	SU- 126	C- 02.1	SU- 129	C- 05.3	C- 39.2	C- 38.2	C-35	SU- 62	SU- 71	C-01.2	Chimborazo 1	Rodeo 3	P. Ceiba 1	Rodeo 2	Ct.2	Bañó 3	Amarillo	Pr 8	Charco pescao 2	Muelas 1	Muelas 2	Castillos	SU- 119	SU- 12	ZPT. DC. 68	C-OR. 135	SU- 157.1	C- 11.2	C- 12.2.1	CO R.40	C- 09.1	C- 63.6	C- 63.3	C-OR. 134	C- 62.1	C- 64.4	C- 65.6	C- 69.9																			
	Class Pontederio azureae-Paspaletea repentis, Order Ludwigio helminthorrhizae-Paspaletalia repentis, Alliance Paspalo repentis-Ludwigion helminthorrhizae																																																															
Association	Paspalo repentis-Neptunietum oleraceae																												Ludwigio helminthorrhizae-Nymphoideetum indicae																																			
Species	Cover (%)																																																															
L. helminthorrhiza	3	15	2	10	15	30	30	10	50	10	10	30															20	0,5	30	50																																		
Paspalum repens	3					20	10															95	25	20	95	16	10	5	30	20	15	15	1															5																
Marsilea minuta	5								20	1																																			2					20														
C. blepharoleptos	55																				10																																											
Neptunia oleracea	5	8	10	10	10	10	30	45	50	70	15	40	20	70	60	60	80	0,5	0,5	0,5	1	1	1	1	2	3	5	5	60	0,5					30	0,5					0,5																							
Nymphaea ampla													50	30	50	10															10																																	
Ludwigia peploides																			1					1	1	0,5					1	3																																
Marsilea quadrifolia																			10																		1																											
Nymphaea nouchali																			50	1																																												
Nymphoides indica																			0,5																		20	60	60	50	30					60	60	40	30	50	50	25	60	50	30	30								
H. amplexicaulis																																													2					20														
Nymphaea pulchella																																													20					10														
Other species																																																																
Echinochloa crus-pavonis (C-16; 15); Leersia hexandra (MG- 52; 10); Phytolacca rivinoides (Amarillo); Nymphaea novogranatensis (CO R.40; 10); Cyperus odoratus (MG- 52; 10); Luziola subintegra (C- 38.2; 20); Hydrocotyle umbellata (Charco pescao 2; 5); Ipomoea aquatica (C- 63.3; 10)																																																																

-: No measurement; rainy season (W), dry season (D).

Syntaxonomy: The association was described by **Castroviejo and López** (1985) in “esteros” (seasonal lagoons) of the Venezuelan llanos and was assigned to the alliance *Eleocharidion interstinctae-mutatae*. Given that the characteristic and diagnostic species referenced in the alliance were not found in the Caribbean inventories, it was not possible to assign this unit to the aforementioned alliance.

Community of *Hydrolea spinosa* (Table 6B)

Physiognomy and composition: Herbaceous stands dominated exclusively by *Hydrolea spinosa*; associated species include *Justicia* sp., *Ipomoea subrevoluta*, *Funastrum glaucum*, *Persicaria punctata*, *Mikania* sp., and *Sagittaria lancifolia*.

Ecology: It occurs on wetland margins and in flood-prone areas, and expands appreciably during the dry season; the pH varied from 10.9 to 11.3, and the conductivity ranged from 33 to 84 $\mu\text{S}/\text{cm}$.

Alliance *Hymenachno amplexicaulis-Echinochloion polystachyae* all. nov. Rangel & Cortés, in this contribution: **Table 7. *Typus*:** *Hymenachno amplexicaulis-Echinochloetum polystachyae*

Physiognomy and composition: Rooted grassland-sedge stands dominated by *Echinochloa polystachya* and *Hymenachne amplexicaulis*.

Ecology: It occurs on wetland margins and in swampy zones. In the final stage of ecological succession, *Echinochloa polystachya* dominates almost exclusively; the pH varied from 7.2 (rainy season) to 10.2 (dry season), and the conductivity from 0.16 (rainy season) to 40 $\mu\text{S}/\text{cm}$ (dry season).

Ecology: It occurs on wetland margins and in swampy zones; the pH varied from 8 (rainy season) to 10.2 (dry season), and the conductivity from 8 (rainy season) to 40 $\mu\text{S}/\text{cm}$ (dry season).

Season	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Cond. (µS/cm)	23	23	23	23	23	86	23	23	86	91	86	23	23	10	9	9	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	6	6	6	6	6	6.3	6	6	6.3	8.8	6.3	6	6	9.9	8.4	8.7	-	-	-	-	-	-	-	-	-	-	-	-	-
Plot (m2)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	-	-	-	-	-	-	-	-	-	-	-	-	-
Plot number A	Negro 1	Respaldo 1	Respaldo 2	Chopo	C-OR. 29	C-OR. 10	C-OR. 18	PD 1	C-OR. 6	C-OR. 71	C-OR. 15	C-OR. 17	C-OR. 25	SU- 91	SU- 104.1	SU- 109	Ct 2	Ct 3	Rodeo 1	Ar 2	PD 2	Respaldo 4	El Coco 1	El Coco 2	Saba 1	Saba 3	Pr 9	Ar 1	Charco pescoso 1
	Class, Order and Alliance Undefined																												
Association	Ludwigia erectae-Cyperetum blepharoleptos																												
Species	Cover (%)																												
Cyperus blepharoleptos	80		40	50	85		95	90			50	95	95	70	60	60			1	95	90	80	10	60	5	5	10		
Ludwigia erecta	20	20	20	10	15	20	10	10	10	10							5	1	20	2	10	5		40			2	10	
Other species																													
Desmodium sp. (Chopo; 1); Odontadenia semidigyna (C-OR. 25; 1); Vigna longifolia (SU- 104.1; 3); Hydrocotyle umbellata (C-OR. 71; 1); Thalia geniculata (SU- 91; 8); Paspalum repens (SU- 109; 20); Limncharis flava (C-OR. 15; 1); Justicia laevilinguis (SU- 104.1; 8); Ludwigia peploides (Ar 2; 1)																													

[illegible]

17

Association *Nymphaeo novogranatensis-Echinochloetum polystachyae* ass. nov.
Rangel & Cortés, in this contribution: **Table 7. Typus:** SU-164. 1B

Physiognomy and composition: Rooted grassland-herbaceous stands dominated by *Echinochloa polystachya* and *Nymphaea novogranatensis*; associated species include *Hymenachne amplexicaulis* and *Leersia hexandra*.

Ecology: It occurs on wetland margins and in swampy pools; the pH varied from 7.9 (rainy season) to 10.2 (dry season), and the conductivity from 10 (rainy season) to 40 $\mu\text{S}/\text{cm}$ (dry season). Distribution: see **Table 2S (A-B)**, <https://racefyn.co/index.php/racefyn/article/view/4131/5424>.

Association *Echinochloo polystachyae-Louisielletum elephantipes* ass. nov. Rangel & Cortés, in this contribution: **Table 7. Typus:** SU-169. 2D

Physiognomy and composition: Rooted grassland-herbaceous stands dominated by *Echinochloa polystachya* and *Louisiella elephantipes*; associated species include *Hymenachne amplexicaulis*, *Persicaria glabra*, *Hydrolea spinosa*, and *Ipomoea subrevoluta*.

Ecology: It occurs on wetland margins and on the edges of channels; the pH varied from 7.2 (rainy season) to 10.2 (dry season), and the conductivity from 0.16 (rainy season) to 40 $\mu\text{S}/\text{cm}$ (dry season, although the most common value was 0.4).

Table 7. Floristic composition of the alliance *Hymenachno amplexicaulis-Echinochloion polystachyae* and its associations.

Season	D	W	D	D	D	W	D	D	D	D	W	D	D	D	D	D	D	D	W	D	D	D	D	D	D	D	D	
Cond. (µS/cm)	40	8	40	40	-	9	40	40	40	34	10	0,4	0,4	0,4	0,4	0,4	0,4	40	0,16	40	40	40	40	-	-	-	40	
pH	10,2	8	10,2	10,2	-	8.1	10,2	10,2	10,2	-	7,97	10,2	10,2	10,2	10,2	10,2	10	10,2	10,2	7,22	10,2	10,2	10,2	10,2	-	-	-	10,2
Plot (m2)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	
Plot number	SU- 168.1B	SU- 124	SU- 168.2B	SU- 170.5B	SU- 171.4B	SU- 54	SU- 163.2B	SU- 163.3B	SU- 164.1B	ZPT. DC-72	SU- 37B	SU-163.5D	SU-163.6D	SU-166.4D	SU-161.5D	SU-168.4D	SU-168.5D	SU-169.2D	SU- 168.3B	C-16	SU- 162.2D	SU- 170.6B	SU- 170.7B	SU- 170.8B	SU- 171.1B	SU- 171.2B	SU- 171.3B	SU- 167.4B
	Class and Order Undefined																											
Alliance	Hymenachno amplexycaulis-Echinochloion polystachyae																											
Association	Hymenachno amplexycaulis-Echinochloetum polystachyae					Nymphaeo novogranatensis-Echinochloetum polystachyae					Echinochloo polystachyae-Louisielletum elephantipes										Com. Echinochloa polystachya							
Species	Cover (%)																											
Echinochloa polystachya	70		60	40	70		20	30	5		5		10		5	70					50	60	10	50	70	80	10	
Hymenachne amplexycaulis			10	5	10	1					20				5	5	5											
Luziola subintegra	10	3																										
Cyperus blepharoleptos		60				30																						
Nymphaea novogratensis							10	10	5	10																		
Leersia hexandra									3	40	50																	
Louisiella elephantipes												50	60	70	70	60	60	40	10	75	10							
Hydrolea spinosa																				70								
Other species																												
Ludwigia leptocarpa (SU- 124; 25); Vigna repens (SU- 54; 10); Ipomoea subrevoluta (SU- 162.2D; 5); Cyperus odoratus (SU- 170.5B; 50); Persicaria glabra (C-16; 10)																												

:- No measurement; rainy season (W), dry season (D).

Community of *Echinochloa polystachya* (Table 7)

Physiognomy and composition: Homogeneous grasslands dominated by *Echinochloa polystachya*.

Ecology: It occurs on wetland shores and in swampy pools, especially in the dry season. The pH was 10.2, and the conductivity was 40 $\mu\text{S}/\text{cm}$.

Discussion and final considerations

Syntaxonomic arrangement

Submerged vegetation (one class, one order, two alliances, and five associations and communities).

Class (1) *Cabombo-Nymphaeetea*, order (1) *Utricularietalia folioso-junceae* - Alliance (1) *Utricularion folioso-junceae*. Associations (1) *Ceratophyllo demersi-Utricularietum foliosae* ass. nov., (2) *Utricularietum foliosae*, (3) community of *Cabomba caroliniana*. Alliance (2) *Najo argutae-Ceratophyllion demersi*

Associations (4) *Ceratophyllo demersi-Najadetum argutae*, (5) *Ceratophylletum demersi*.

Free-floating vegetation (two classes, two orders, two alliances; 12 associations and communities)

Class (2) *Lemnetea minoris*, order (2) *Lemnetalia aequinoctialis*

Alliance (3) *Lemnion minoris-aequinoctialis* all. nov., associations (6) *Pontederio crassipedis-Lemnetum aequinoctialis* ass. nov., (7) Community of *Wolffiella* aff. *lingulata*, (8) Community of *Lemna minor* and *Lemna aequinoctialis*, (9) Community of *Lemna aequinoctialis* and *Pistia stratiotes*.

Class (3) *Pistio stratiotis-Pontederietea crassipedis*, order (3) *Pistio stratiotis-Pontederietalia crassipedis*, alliance (4) *Pistio stratiotes-Pontederion crassipedis*, associations (10) *Salvinio auriculatae-Pontederietum crassipedis* ass. nov., (11) *Limnobio laevigati-Pontederietum crassipedis* ass. nov., (12) *Ricciocarpus natantis-Pontederietum crassipedis* ass. nov., (13) *Pontederietum crassipedis*, (14) *Pontederietum azureae*, (15) Community of *Pistia stratiotes* and *Pontederia crassipes*, (16) Community of *Lemna minor* and *Pontederia crassipes*, (17) *Pistio stratiotis-Salvinietum auriculatae* ass. nov.

Rooted floating-leaved vegetation (one class, two orders; three alliances; 34 associations and communities)

Class (4) *Pontederio azureae-Paspaletea repentis* cl. nov., order (4) *Ludwigio helminthorrhizae-Pontederietalia azureae* ord. nov., Alliance (5) *Ludwigio helminthorrhizae-Pontederion azureae* all. nov., associations (18) *Marsileo minutae-Pontederietum azureae* ass. nov., (19) *Aeschynomeno rudis-Pontederietum azureae* ass. nov., (20) *Ludwigio helminthorrhizae-Pontederietum azureae* ass. nov., (21) *Pontederio azureae-Echinochloetum polystachya* ass. nov., (22) Community of *Pontederia azurea* and *Paspalum repens*, (23) *Neptunio oleraceae-Pontederietum azureae* ass. nov., (24) *Pontederio azureae-Nelumbetum luteae* ass. nov., (25) *Pontederio azureae-Nymphaetum pulchellae* ass. nov., (26) *Pontederio azureae-Marsileetum vestitae* ass. nov., (27) *Pontederio azureae-Nymphaetum amplae* ass. nov., (28) *Pontederio azureae-Nymphaetum novogranatensis* ass. nov., (29) Community of *Hydrocotyle umbellata*, (30) *Pontederio azureae-Nymphoideetum indicae* ass. nov., (31) *Pontederio azureae-Hymenachnetum amplexicaulis* ass. nov., (32) *Pontederio azureae-Luzioletum subintegrae* ass. nov., (33) *Marsileo vestitae-Ipomoeetum aquaticae* ass. nov., (34) *Pontederio azureae-Ipomoeetum aquaticae* ass. nov.

Order (5) *Ludwigio helminthorrhizae-Paspaletea repentis* ord. nov., Alliance (6) *Paspalo repentis-Ludwigion helminthorrhizae* all. nov., associations (35) *Ludwigio sedioides-Marsileetum vestitae* ass. nov., (36) *Ludwigio peploides-Paspaletea repentis* ass. nov., (37) Community of *Ludwigia helminthorrhiza* and *Paspalum repens*, (38) *Ludwigio helminthorrhizae-Nymphoideetum indicae* ass. nov.

Class, order, and alliance not assigned, associations (39) *Nelumbetum luteae*, (40) Community of *Nymphaea novogranatensis*, (41) Community of *Nymphaea pulchella*,

(42) *Hydroleo spinosae-Limnocharetum flavae* ass. nov., (43) *Nymphoideo indicae-Hydrocotyleetum umbellatae* ass. nov., (44) *Ludwigio erectae-Cyperetum blepharoleptos* ass. nov., (45) Community of *Leersia hexandra*, (46) *Eleocharitetum interstinctae*, (47) Community of *Hydrolea spinosa*.

Alliance (7) *Hymenachno amplexicaulis-Echinochloion polystachyae* all. nov., associations (48) *Hymenachno amplexicaulis-Echinochloetum polystachyae* ass. nov., (49) *Nymphaeo novogranatensis-Echinochloetum polystachyae* ass. nov., (50) *Echinochloa polystachyae-Louisielletum elephantipes* ass. nov., (51) Community of *Echinochloa polystachya*.

Chorology and synecology

The submerged, floating, rooted, and emergent aquatic vegetation described in this study exhibits general similarities (floristic composition and structure) to the aquatic communities reported by **Rangel-Ch. and Arellano** (2008), **Cataño et al.** (2008), **Rangel-Ch.** (2010), **Schmidt-Mumm and Janauer** (2014), and **Pérez-V. et al.** (2015) for the Caribbean region, and to those from the Chocó biogeographic region and the Orinoquia region of Colombia (**Rangel-Ch.**, 2004; **Rangel-Ch. & Minorta-Cely**, 2014). When the comparison is extended to other Latin American and Caribbean countries, similarities can be found in the higher hierarchical units (class, order), reflecting the cosmopolitan distribution of many species typical of these environments.

Submerged aquatic vegetation dominated by *Ceratophyllum demersum* and *Utricularia foliosa* has been reported in different localities in Central America, the Caribbean, and South America (**Lot & Novelo**, 1988; **Martínez & Novelo**, 1993; **Rojas & Novelo**, 1995; **Galán-de Mera**, 1995, 2014; **Colonnello**, 1995, 1996; **Ocaña & Lot**, 1996; **Areces-M. et al.**, 1999; **Pivari & Pott**, 2008; **Da Costa & Nippes**, 2010).

In the Caribbean, *Utricularia foliosa* is a characteristic species of the class *Cabombo-Nymphaeetea*, order *Utricularietalia folioso-junceae*, alliance *Utricularion folioso-junceae*, in which it is associated with *Ceratophyllum demersum* in *Ceratophyllo demersi-Utricularietum foliosae* during the rainy season (pH 6.2) and in *Utricularietum foliosae* also during rainy periods in areas with high water transparency.

In addition to the syntaxonomic relationships mentioned above, *Ceratophyllum demersum* is the characteristic dominant species of the alliance *Najo argutae-Ceratophyllion demersi*, in which it dominates in the associations *Ceratophyllo demersi-Najadetum argutae* and *Ceratophylletum demersi* occurring in wetland areas with clear waters and good water-column transparency during both the dry and rainy seasons. **Colonnello** (1995) reported that in the Venezuelan llanos, communities of *Ceratophyllum demersum* decreased and sometimes disappeared during the rainy season. Communities dominated by *Najas arguta* have likewise been reported in the Ecuadorian Amazon and in the state of Tamaulipas, Mexico (**Martínez & Novelo**, 1993; **Terneus**, 2007).

Free-floating aquatic communities with a floristic composition similar to the *Wolffiella* aff. *lingulata* (class *Lemnetea minoris*) community, which predominates in sites with shallow waters and disappears during the rainy period, have been reported for the Brazilian Pantanal (**Heckman**, 1998), for the Orinoco delta (**Colonnello**, 1995), and in lagoons in Mexico (**Ramos & Novelo**, 1993; **Rojas & Novelo**, 1995). *Lemna aequinoctialis* dominates in shallow and highly eutrophic waters of the Bolivian Pantanal and in the Venezuelan llanos (**Galán-de Mera et al.**, 2006; **Galán-de Mera & Linares-Perea**, 2008; **Galán-de Mera**, 2014).

The associations *Pontederietum crassipedis* and *Pontederietum azureae* and other combinations included in the alliance *Pistio stratiotes-Pontederion crassipedis* of the class *Pistio stratiotis-Pontederietea* have been reported from oligotrophic to mesotrophic freshwater wetland environments in the Venezuelan llanos (**Castroviejo & López**, 1985; **Rial**, 2000; **Galán-de Mera et al.**, 2006; **Galán-de Mera & Linares-Perea**, 2008; **Galán-de Mera**, 2014), Cuba (**Borhidi**, 1991; **Reyes & Acosta**, 2007), Paraguay (**Galán-de Mera & Navarro**, 1992; **Mereles**, 2004), Mexico (**Ramos & Novelo**, 1993; **Rojas &**

Novelo, 1995; Ocaña & Lot, 1996; Zepeda-G. *et al.*, 2012), Bolivia (De la Barra, 2003; Pouilly *et al.*, 2004), Brazil (Bolós *et al.*, 1991; Murphy *et al.*, 2003), and the Western Andes of Peru (Galán-de Mera *et al.*, 2009).

Communities dominated by *Limnobium laevigatum* were reported by Areces-M. *et al.* (1999) in Cuba, by Colonnello (1995) and Galán-de Mera and Linares-Perea (2008) in Venezuela, and by Murphy *et al.* (2003) and Pivari and Pott (2008) in Brazil, in shallow, stagnant-water sectors with standing water even during the dry season. In our study area, the association *Limnobium laevigati-Pontederietum crassipedis* of the alliance *Pistio stratiotes-Pontederietum crassipedis* and the class *Pistio stratiotis-Pontederietea crassipedis* was recorded in swampy areas, especially during the dry season, with an average conductivity of 249 $\mu\text{S}/\text{cm}$.

Salvinia auriculata and species of *Lemna* were reported as dominant in the vegetation of esteros in the Venezuelan llanos in sites with high nutrient concentrations (Castroviejo & López, 1985; Colonnello, 1995; Pérez-V. *et al.*, 2015). In the Colombian Caribbean, *Salvinia auriculata* is associated with the alliance *Lemnion minoris-aequinoctialis* of the class *Lemnetea minoris* (free-floating vegetation), dominated by species of *Lemna* that become established in areas with still waters and elevated inputs of nitrogen and organic matter. The species also characterizes the associations *Salvinio auriculatae-Pontederietum crassipedis* and *Pistio stratiotis-Salvinietum auriculatae* of the class *Pistio stratiotis-Pontederietea crassipedis* in localities where human disturbance is evidenced by wastewater discharge and organic-matter inputs from livestock and agriculture.

Communities of rooted aquatic plants with floating leaves dominated by *Nelumbo lutea* have been reported in Puerto Rico, the Antilles, Cuba, Mexico, Venezuela, Brazil, and Peru (Galán-de Mera & Navarro, 1992; Martínez & Novelo, 1993; Galán-de Mera, 1995, 2014; Colonnello, 1995; Ocaña & Lot, 1996; Areces-M. *et al.*, 1999; Neiff *et al.*, 2000; De la Barra, 2003; Reyes & Acosta, 2007; Da Costa & Nippes, 2010; Mormul *et al.*, 2010; Reyes, 2012). In the Caribbean, two associations were characterized: *Pontederio azureae-Nelumbetum luteae* of the class *Pontederio azureae-Paspaletea repentis*, and *Nelumbetum luteae*; *Nymphoides indica* and *Nymphaea pulchella* appear as companion species.

In the alliance *Hymenachno amplexicaulis-Echinochloion polystachyae*, *Hymenachne amplexicaulis* and *Echinochloa polystachya* are widely dominant. This vegetation occurs along wetland margins and in swampy zones, and includes different associations in which *Louisiella elephantipes*, *Nymphaea novogranatensis*, *Leersia hexandra*, *Luziola subintegra*, and *Cyperus blepharoleptos* are codominant. In the final stage of succession, *Echinochloa polystachya* dominates. Communities dominated by *Hymenachne amplexicaulis* have likewise been reported in Mexico (Lot & Novelo, 1988; Martínez & Novelo, 1993; Ramos & Novelo, 1993; Zepeda-G. *et al.*, 2012), Venezuela (Sánchez & Vásquez, 1986; Colonnello, 1995, 1996; Rial, 2000; Galán-de Mera & Linares-Perea, 2008; Galán-de Mera, 2014), Brazil (Da Costa & Nippes, 2010; Mormul *et al.*, 2010; Schneider *et al.*, 2015), Bolivia (Fuentes & Navarro, 2000; De la Barra, 2003), and Paraguay (Neiff *et al.*, 2000).

In the association *Ludwigia erectae-Cyperetum blepharoleptos*, which grows very vigorously during the rainy season, *Cyperus blepharoleptos* (= *Oxycaryum cubense*) dominates, and *Paspalum repens*, *Thalia geniculata*, and *Justicia laevilinguis* appear as associated species; Galán-de Mera and Linares-Perea (2008) associated it with sediment infilling and, according to Pivari and Pott (2008), it constitutes *firmes* (floating islands) in the Brazilian Pantanal.

Conclusions

Among the aquatic vegetation groups examined in Colombian Caribbean wetlands, rooted floating-leaved vegetation was the most diverse, comprising one class, two orders, three alliances, and 34 associations. In the free-floating group, two classes, two orders, two alliances, and 12 associations were differentiated; and in the submerged vegetation, one

class, one order, two alliances, and five associations and communities were characterized. One class, two orders, five alliances, and 30 associations are syntaxonomic novelties. Richness, aspects of community structure, and changes associated with the filling and drawdown cycle of the wetlands are consistent with the patterns reported by **Colonnello** (1995), **Rial** (2000), **Matías et al.** (2003), and **Galán-de Mera et al.** (2006). The extent (cover) of the floating and rooted floating-leaved groups was greater during periods of rising and high waters, when these communities extended into deeper areas and covered almost the entire open-water surface. Some of these communities also occurred during the dry period, but only at flooded sites and with lower species richness. The associations included in the alliance *Utricularion folioso-junceae* of submerged vegetation and those dominated by *Nymphaea pulchella* and *N. novogranatensis* of the rooted floating-leaved group were not found in the inventories conducted during the dry periods, whereas communities dominated by *Hydrocotyle umbellata* (*Nymphoideo indicae-Hydrocotyleetum umbellatae*) and *Limnocharis flava* and *Hydrolea spinosa* (*Hydroleo spinosae-Limnocharietum flavae*) expanded.

In general, the aquatic vegetation of the Colombian Caribbean shows high floristic similarity to that of comparable environments in Central America, Mexico, the Antilles, and sectors of the Brazilian Pantanal, the Chaco, and the “savannas” of Bolivia and Paraguay.

Supplementary information

See the supplementary information in <https://raccefyn.co/index.php/raccefyn/article/view/4131/5424>

Acknowledgments

We thank the Regional Autonomous Corporation of the Sinú and San Jorge Valleys (CVS), the Regional Autonomous Corporation of Cesar (CORPOCESAR), and the Institute of Natural Sciences, Faculty of Sciences, National University of Colombia. We also thank the anonymous reviewers for their detailed work on the nomenclatural aspects.

Author contributions

O.R.Ch. participated in the fieldwork, taxonomic identification of the material, data analysis, and manuscript preparation. DCC directed and participated in the fieldwork, taxonomic identification of the material, data analysis, and final manuscript preparation. YG. participated in the fieldwork, interpretation of results, and final manuscript preparation.

Conflicts of interest

The authors declare no conflicts of interest.

References

- Areces-M., A.E., Weakley, A.E., LI, A.S., Sayre, X., Parrish, R.G., Tipton, J. D., Boucher, C.V.** (1999). *A Guide to Caribbean Vegetation Types: Preliminary Classification System and Descriptions*. The Nature Conservancy.
- Bolós, O., Cervi, A. C., Hatschbach, G.** (1991). Estudios sobre la vegetación del estado de Paraná (Brasil meridional). *Collectanea Botanica (Barcelona)*, 20: 79-182.
- Borhidi, A.** (1991). *Phytogeography and Vegetation Ecology of Cuba*. Akadémici Kiadó.
- Braun-Blanquet, J.** (1979). *Fitosociología: bases para el estudio de las comunidades vegetales*. H. Blume Ediciones.
- Castroviejo, S. & López, G.** (1985). Estudio y descripción de las comunidades vegetales del “Hato el Frio”, los llanos de Venezuela. *Memorias de la Sociedad de Ciencias Naturales La Salle*, 45, 79-151.
- Cataño, Y., Quiros-R., Arias-R, J., Novoa-P, J., Genes-L, F.** (2008). Estudio de la vegetación acuática en un área de inundación de la ciénaga Grande del Bajo Sinú, sector Purísima, Departamento de Córdoba, Colombia. *Revista de la Asociación Colombiana de Ciencias Biológicas*, 20, 34-47.

- Colonnello, G.** (1995). La vegetación acuática del delta del Orinoco (Venezuela). Composición florística y aspectos ecológicos (I). *Memorias de la Sociedad de Ciencias Naturales La Salle*, 55(144), 3-34.
- Colonnello, G.** (1996). Aquatic vegetation of the Orinoco River delta (Venezuela). An overview. *Hydrobiologia*, 340, 109-113.
- Cortés, D.V.** (2017). Vegetación estuarina y vegetación acuática de complejos cenagosos del Caribe colombiano. *Tesis de doctorado*. Instituto de Ciencias Naturales, Universidad Nacional de Colombia. <https://repositorio.unal.edu.co/items/6b34cd9b-23cb-48f7-97f2-7bee739907da>
- Cortés-C., D.V. & Rangel-Ch., J.O.** (2023). La vegetación acuática de las ciénagas en el Caribe de Colombia. En: J.O. Rangel-Ch. (ed.). *Colombia Diversidad Biótica XXI Tipos de vegetación en las regiones naturales de Colombia. Nuevos aportes* (pp 71-150). Universidad Nacional de Colombia, Instituto de Ciencias Naturales. Ministerio de Ambiente y Desarrollo Sostenible.
- Da Costa Moreira., H. J. & Nippes Braganza, H. B.** (2010). *Manual de identificação de plantas infestantes Arroz*. FMC Agricultural Products.
- De La Barra, N.** (2003). Clasificación ecológica de la vegetación acuática en ambientes lacustres de Bolivia. *Revista Boliviana de Ecología*, 13, 65-93.
- Frey, R.** (1995). Flora and vegetation of “Las piedritas” and the margin of Laguna Cáceres, Puerto Suárez, Bolivian pantanal. *Bulletin of the Torrey Botanical Club*, 122(4), 314-319.
- Fuentes, A. & Navarro, G.** (2000). Estudio fitosociológico de la vegetación de una zona de contacto Chaco-Cerrado en Santa Cruz (Bolivia). *Lazaroa*, 21, 73-109.
- Galán-de Mera, A.** (1995). Ensayo sintaxonómico sobre las comunidades vegetales acuáticas del Perú. *Arnaldoa*, 3, 51-58.
- Galán-de Mera, A.** (2014). La vegetación de las sabanas de los llanos de Venezuela. En: J. O. Rangel-Ch. (ed.). *Colombia Diversidad Biótica XIV. La región de la Orinoquia de Colombia* (pp 447-482). Instituto de Ciencias Naturales. Universidad Nacional de Colombia.
- Galán-de Mera, A. & Navarro, G.** (1992). Comunidades vegetales acuáticas del Paraguay occidental. *Caldasia*, 17, 35-46.
- Galán-de Mera, A. & Vicente-Orellana, J. A.** (2006). Aproximación al esquema sintaxonómico de la vegetación de la región del Caribe y América del Sur. *Anales de Biología*, 28, 3-27.
- Galán-de Mera, A., M.V. Rosa, Cáceres, C.** (2002). Una aproximación sintaxonómica sobre la vegetación del Perú. Clases, órdenes y alianzas. *Acta Botánica Malacitana*, 27, 75-103.
- Galán-de Mera, A., González, A., Morales, R., Oltra, B., Vicente-Orellana, J.** (2006). Datos sobre la vegetación de los Llanos occidentales del Orinoco (Venezuela). *Acta Botánica Malacitana*, 31, 97-129.
- Galán-de Mera, A. & Linares-Perea, E.** (2008). Datos sobre la vegetación de los humedales de América del Sur. De las Sabanas bolivianas a los llanos del Orinoco (Venezuela). *Acta Botánica Malacitana*, 33, 271-288.
- Galán-de Mera, A., Linares-Perea, E., Campos-de la Cruz, J., Vicente-Orellana, J.A.** (2009). Nuevas observaciones sobre la vegetación del sur del Perú. Del Desierto Pacífico al Altiplano. *Acta Botanica Malacitana*, 34, 107-144.
- Galán-de Mera, A., Beltrán, H., Campos, J., Linares, E., Montoya, J., Trujillo, C., Vicente-Orellana, J.** (2024). Diversidad de comunidades vegetales del Perú. Una revisión a través de una clasificación fitosociológica. *Arnaldoa*, 31(2), 211-239. <https://doi.org/10.22497/arnaldoa.312.31201>
- Heckman, C. W.** (1998). *The Pantanal of Pocone - Biota and Ecology in the Northern Section of the World's Largest Pristine Wetland*. Kluwer Academic Publishers.
- Izco, J. & Del Arco, M.** (2003). *Código Internacional de Nomenclatura Fitosociológica*. Universidad de la Laguna.
- Jaramillo-J., A., Rangel-Ch., J.O., Parra-S., L.N., Ruiz, D.A.** (2012). La estratigrafía de los sedimentos de fondo de ciénagas del Caribe y el registro de los cambios de clima en los últimos 4.900 años. En: J.O. Rangel-Ch. (ed.). *Colombia Diversidad Biótica XII. La región Caribe de Colombia* (pp 1-65). Universidad Nacional de Colombia, Instituto de Ciencias Naturales.
- Jaramillo-J., A., Villamizar-M, V., Calvo, J., Rangel-Ch, J.O., Parra-S, L.N.** (2013). Orígenes y análisis del territorio en las ciénagas de El Congo, Musanda, Doña María, El Sordo, Juncal, Baquero, Morales y Costilla (Sur del Cesar). En: J.O. Rangel-Ch. (ed.). *Colombia Diversidad Biótica XIII. Complejo cenagoso Zapatosa y ciénagas del Sur del Cesar. Biodiversidad, conservación y manejo* (pp 19-54). Universidad Nacional de Colombia, Instituto de Ciencias Naturales.

- Lazala, M. & Parra, L.N.** (2010a). Geología estructural y geomorfología. En: J.O. Rangel-Ch. (ed.). *Colombia diversidad biótica IX. Ciénagas de Córdoba: Biodiversidad-Ecología y manejo ambiental* (pp 15-21). Corporación Autónoma Regional de los Valles del Sinú y del San Jorge-CVS, Universidad Nacional de Colombia, Instituto de Ciencias Naturales.
- Lazala, M. & Parra, L.N.** (2010b). Sedimentología de ciénagas de los ríos Sinú y San Jorge, departamento de Córdoba, Colombia. En: J.O. Rangel-Ch. (ed.). *Colombia diversidad biótica IX. Ciénagas de Córdoba: Biodiversidad-Ecología y manejo ambiental* (pp 57-70). Corporación Autónoma Regional de los Valles del Sinú y del San Jorge-CVS, Universidad Nacional de Colombia, Instituto de Ciencias Naturales.
- Lindeman, J. C.** (1953). *The vegetation of the coastal region of Suriname*. Kemink en Zoon.
- Lot, A. & Novelo, A.** (1988). Vegetación y flora acuática del lago Patzcuaro. Michoacán, México. *The Southwestern Naturalist*, 33(2), 167-175.
- Martínez, M. & Novelo, A.** (1993). La vegetación acuática del estado de Tamaulipas, México. *Anales del Instituto Biológico de la Universidad Autónoma de México. Serie Botánica*, 64(2), 59-86.
- Matias, L., Amado, E., Nunes, E.** (2003). Macrofitas aquáticas da lagoa de Jijoca de Jericoacoara, Ceará, Brasil. *Acta Botanica Brasilica*, 17(4), 623-631.
- Mereles, F.** (2004). Los humedales de Paraguay: los principales tipos de vegetación. En: D. Salas-D., F. Mereles, A. Yanosky. (eds.). *Humedales de Paraguay* (pp 67-87). Comité Nacional de Humedales.
- Moreno-C, P., Cedujo-E, E., Capistran-B, A., Infante-M, D., López-R, H., Castillo-C, G., Pale-P, J., Campos-C, A.** (2010). Composición florística, diversidad y ecología de humedales herbáceos emergentes en la planicie costera central de Veracruz, México. *Boletín de la Sociedad Botánica de México*, 87, 29-50.
- Mormul, R. P., Alves Ferreira, F., Sala Michelin, T., Carvalho, P., Silveira, M. J., Magela Thomaz, S.** (2010). Aquatic macrophytes in the large, sub-tropical Itapu Reservoir, Brazil. *Revista de Biología Tropical*, 58(4), 1437-1452.
- Murphy, K. J., Dickinson, G., Thomaz, S. M., Bini, L. M., Dick, K., Greaves, K., Kennedy, M. P., Livingstone, S., McFerran, H., Milne, J. M., Oldroyd, J., Wingfield, R. A.** (2003). Aquatic plant communities and predictors of diversity in a sub-tropical river floodplain: the upper Rio Paraná, Brazil. *Aquatic Botany*, 77, 257-276.
- Navarro, G. & Maldonado, M.** (2005). *Geografía ecológica de Bolivia. Vegetación y Ambientes Acuáticos*. Fundación Simón I. Patiño.
- Neiff, J. J., Poi De Neiff, A. S. G., Patiño, C. A. E., Basterra De Chiozzi, I.** (2000). Prediction of colonization by macrophytes in the Yaciretá reservoir of the Paraná River (Argentina and Paraguay). *Revista Brasileira de Biología*, 60(4), 615-626.
- Ocaña, D. & Lot, A.** (1996). Estudio de la vegetación acuática vascular del sistema fluvio lagunar deltaico del río Palizada en Campeche, México. *Anales del Instituto de Biología de la Universidad Nacional Autónoma de México, Serie Botánica*, 67(2), 303-327.
- Pérez-V., N., Arias-Ríos, J., Quirós-Rodríguez, J.** (2015). Variación espacio-temporal de plantas vasculares acuáticas en el complejo cenagoso del Bajo Sinú, Córdoba, Colombia. *Acta Biológica Colombiana*, 20(3), 155-165.
- Pivari, M. O. & Pott, A.** (2008). Aquatic macrophytes of floating mats ("baceiros") in the Abobral and Miranda Pantanal Wetlands, Mato Grosso do Sul State, Brazil. *Acta Botanica Brasilica*, 22(2), 563-571.
- Pouilly, M., Beck, S. G., Moraes, M., Ibáñez, C.** (2004). *Diversidad biológica en la llanura de inundación del Río Mamoré*. Fundación Simón I. Patiño.
- Pozo-García, M. I., Posada-García, J. A., Caselles-Osorio, A.** (2022). Spatial and temporal variation of the macrophyte assemblage in Santo Tomás, a wetland in the Caribbean Colombian. *Acta Limnologica Brasiliensis*, 34, e22.
- Ramos-V., L. & Novelo-R., A.** (1993). Vegetación y flora acuáticas de la laguna de Yuriria, Guanajuato, México. *Acta Botánica Mexicana*, 25, 61-79.
- Rangel-Ch., J.O.** (2004). La vegetación del Chocó biogeográfico de Colombia. En: J. O. Rangel-Ch. (ed.). *Colombia Diversidad Biótica IV. La región chocoana de Colombia/Costa Pacífica* (pp 769-815). Instituto de Ciencias Naturales - Universidad Nacional de Colombia.
- Rangel-Ch., J. O.** (2010). Vegetación acuática. En: J. O. Rangel-Ch. (ed.). *Colombia Diversidad Biótica IX. Ciénagas de Córdoba: Biodiversidad, Ecología y Manejo ambiental* (pp 325-339). Instituto de Ciencias Naturales. Universidad Nacional de Colombia.

- Rangel-Ch., J.O. & Aguirre-C., J.** (1983). Comunidades acuáticas altoandinas – I Vegetación sumergida y de ribera en el Lago de Tota, Boyacá, Colombia. *Caldasia*, 13(65), 719 – 742.
- Rangel-Ch., J. O. & Velásquez, A.** (1997). Métodos de estudios de la vegetación. En: J. O. Rangel-Ch. (ed). *Colombia Diversidad Biótica II. Tipos de vegetación en Colombia* (pp 59-87). Instituto de Ciencias Naturales. Universidad Nacional de Colombia.
- Rangel-Ch., J. O. & Arellano, H.** (2008). *Vegetación acuática de las ciénagas Mata de Palma y La Pachita (Cesar)*. Informe técnico CORPOCESAR.
- Rangel-Ch., J. O. & Minorta-Cely, V.** (2014). Los tipos de vegetación de la Orinoquia Colombiana. En: J. O. Rangel-Ch. (ed.). *Colombia Diversidad Biótica XIV. La región de la Orinoquia de Colombia* (pp 533-612). Instituto de Ciencias Naturales. Universidad Nacional de Colombia.
- Reyes, O. & Acosta, F.** (2007). Principales fitocenosis en el Humedal del delta del río Cauto, Cuba oriental. I. Vegetación lacustre y herbazal de Humedal. *Foresta Veracruzana*, 9(1), 15-22.
- Reyes, J. O.** (2012). Clasificación de la vegetación de la Región Oriental de Cuba. *Revista del Jardín Botánico Nacional*, 32-33, 59-71.
- Rial-B, A.** (2000). Aspectos cualitativos de la zonación y estratificación de comunidades de plantas acuáticas en un humedal de los Llanos de Venezuela. *Memorias de la Fundación La Salle de Ciencias Naturales*, 60, 69-85.
- Rial-B, A.** (2013). Plantas acuáticas: aspectos sobre su distribución geográfica, condición de maleza y usos. *Biota Colombiana*, 14(2), 79-91.
- Rojas-M, J. & Novelo, A.** (1995). Flora y vegetación acuática del Lago de Cuitzeo, Michoacán, México. *Acta Botánica Mexicana*, 31, 1-17.
- Sánchez, L. & Vásquez, E.** (1986). Notas sobre las macrófitas acuáticas de la sección baja del río Orinoco, Venezuela. *Memorias de la Sociedad de Ciencias Naturales de la Salle*, 46, 127-155.
- Schmidt-Mumm, U. & Janauer, G.** (2014). Seasonal dynamics of the shoreline vegetation in the Zapotosa floodplain lake complex, Colombia. *Revista de Biología Tropical*, 62(3), 1073-1097.
- Schneider, B., Cunha, E.R., Marchese, M., Thomaz, S.M.** (2015). Explanatory variables associated with diversity and composition of aquatic macrophytes in a large subtropical river floodplain. *Aquatic Botany*, 121, 67-75.
- Sculthorpe, C. D.** (1985). *The biology of aquatic vascular plants*. Edward Arnold.
- Susach-C., F.** (1989). Caracterización y Clasificación Fitosociológica de la Vegetación de Sabanas del Sector Oriental de los Llanos Centrales Bajos Venezolanos. *Acta Biológica Venezuelica*, 12, 1-54.
- Terneus, E.** (2007). Las plantas acuáticas en el sistema lacustre-riberino Lagartococha, reserva de producción faunística Cuyabeno, Ecuador. *Actualidades biológicas*, 29(86), 97-106.
- Velásquez, J.** (1994). *Plantas acuáticas vasculares de Venezuela*. Consejo de Desarrollo Científico y Humanístico. Universidad Central de Venezuela.
- Vera-O., A., Rangel-Ch., J.O., Aymard, G.** (2019a). Flora y vegetación acuática de la serranía de Manacacias (Meta) Orinoquia colombiana. En: J.O. Rangel-Ch., M.G. Andrade-C., C. Jarro-F., G. Santos-C. (eds). *Colombia Diversidad Biótica XVII. La región de la Serranía de Manacacias (Meta) Orinoquia colombiana* (pp 235-246). Universidad Nacional de Colombia, Instituto de Ciencias Naturales. Parques Nacionales Naturales.
- Vera-O, A., Rangel-Ch., J.O., Aymard, G.** (2019b). Vegetación acuática del territorio sabanas y humedales de Arauca, Colombia. En: J.O. Rangel-Ch., M.G. Andrade-C., C. Jarro-F., G. Santos-C. (eds). *Colombia Diversidad Biótica XX. Territorio sabanas y humedales de Arauca (Colombia)* (pp 359-385). Universidad Nacional de Colombia, Instituto de Ciencias Naturales. Parques Nacionales Naturales de Colombia.
- Vergara, Y. & Velasco, F.J.** (1901 [1974 reimpresión]). *Nueva geografía de Colombia*. Banco de la República.
- Weber, H. E., Moravec, J., Theurillat, J. P.** (2000). International Code of Phytosociological nomenclature. 3rd. edition. *Journal of Vegetation Science*, 11, 739-768.
- Zepeda-G., C., Lot-Helgueras, A., Nemiga, X. A., Madrigal-Uribe, D.** (2012). Florística y diversidad de las ciénagas del río Lerma estado de México. México. *Acta Botánica Mexicana*, 98, 23-49.