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AQUATIC MACROPHYTES DIVERSITY IN THE LOWER DOCE RIVER BASIN, ESPÍRITO SANTO, BRAZIL

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Abstract: Macrophytes are plant organisms that live partially or totally submerged in water, being fixed and free. The Doce River is one of the main rivers in southeastern Brazil and, in 2015, it was hit by ore tailings from the Fundão dam burst in Mariana, Minas Gerais. This work aims to provide a floristic survey of macrophytes in the lower Doce River basin and to compare the species composition between lentic and lotic environments. Expeditions were carried out monthly from October 2018 to September 2019, in five stations in lotic and six in lentic environments. A total of 105 species belonging to 33 families of vascular plants were recorded, among them 14 are new occurrences for Espírito Santo state. Richest families were Poaceae (23 spp.) and Cyperaceae (22 spp.). Amphibious/emerging plants were the most representative (46 spp.). NMDS analysis revealed that the composition of the lotic and lentic environments are different.

Key-words: floristic; freshwater; lagoons; watershed; species distribution.

Plants with perennial or temporary life cycles that live in water bodies are usually macroscopic organisms that may be partially or completely submerged (Esteves 2011). Aquatic macrophytes are part of the main photosynthesizing organisms that inhabit lentic and lotic environments, being essential for producing organic matter and regulating nutrient dynamics in aquatic ecosystems (Pompêo 2017).

Macrophytes are divided into two large groups: (1) rooted-fixed species and (2) floating species (Pompêo 2017). The first morphophysiological group is responsible for assimilating nutrients from the sediment and making them available to other organisms within aquatic ecosystems. The latter captures and performs nutrient exchanges directly in the water column. For this reason, they are directly linked to water quality and to the evaluation of changes in macrophyte communities. Such changes can provide important information about the health of continental aquatic systems and for better methodological applications in environmental management and monitoring programs (Bianchini-Junior 2003).

Although freshwater represents about 20 % of the Brazilian territory, aquatic vegetation biodiversity has started to receive more attention and increased scientific interest in the mid-2000s, with an increasing number of studies about this biological group (Thomas & Bini 2003). These ecosystems are delicate and highly threatened by anthropization and present insufficient botanical studies (Pompêo 2017).

In Espírito Santo state, data specifically focused on plants in aquatic ecosystems are rare, with only one study performed by Souza *et al.* (2017)

in restinga phytophysiognomy. Considering the history of human occupation and economic growth, the Doce River, which is one of the most important rivers in southeastern Brazil and the main watershed in Espírito Santo, receives and transports tailings and effluents from economic activities, especially the ore industry (Wanderley *et al.* 2016).

Unfortunately, in November 2015, about 39 million cubic meters of metal-contaminated slurry polluted riverine and coastal waters after Mariana's tailing dam collapsed. After this catastrophic event and considering the lack of previous information, this paper aims to provide a floristic survey of macrophytes from the lower Doce river basin, after the rupture of the dam, comparing the floristic compositions of associated lotic and lentic environments.

The Doce river basin is one of the most important in eastern Brazil, encompassing 84,000 km², and is inserted in the Southeast Atlantic Hydrographic Region, including the states of Minas Gerais and Espírito Santo (Figure 1) (ANA 2016). The Doce river flows through about 900 km from its source in Minas Gerais to the Atlantic Ocean on the shores of Espírito Santo (ANA 2016).

Sampling expeditions to collect were performed at 11 stations (Figure 1) in 12 monthly campaigns from October 2018 to September 2019. Sampling stations (SS) were divided into lotic (5 SS) and lentic (6 SS) environments: four in the Doce river (LO1–Itapina – 19º31'39"S; 40º48'45"O, LO2 – Port of Linhares – 19º24'39"S; 40º4'26"O, LO3 – Povoação – 19º33'23"S; 39º51'26"O, and LO4 – Port of Regência – 19º38'21"S; 39º49'10"O), one in a tributary river (LO5 – Baixo Guandu river – 19º37'28"S; 41º1'4"O), three in lagoons (LE1lag – Areão – 19º34'17"S; 39º50'35"O, LE2lag – Areal – 19º35'9"S; 39º49'41"O, LE3lag – Monsaras – 19º33'31"S; 39º48'5"O) and three in lakes (LE4lak – 'Limão' – 19º33'26"S; 40º22'41'O, LE5lak –'Nova' – 19º20'58"S; 40º9'18"O, LE6lak – 'Juparanã' – 19º20'15"S; 40º5'43"O) (Supplementary material 1, 2).

Specimens were collected and processed according to standard plant taxonomy methods (Bridson & Forman 1998). For identification,

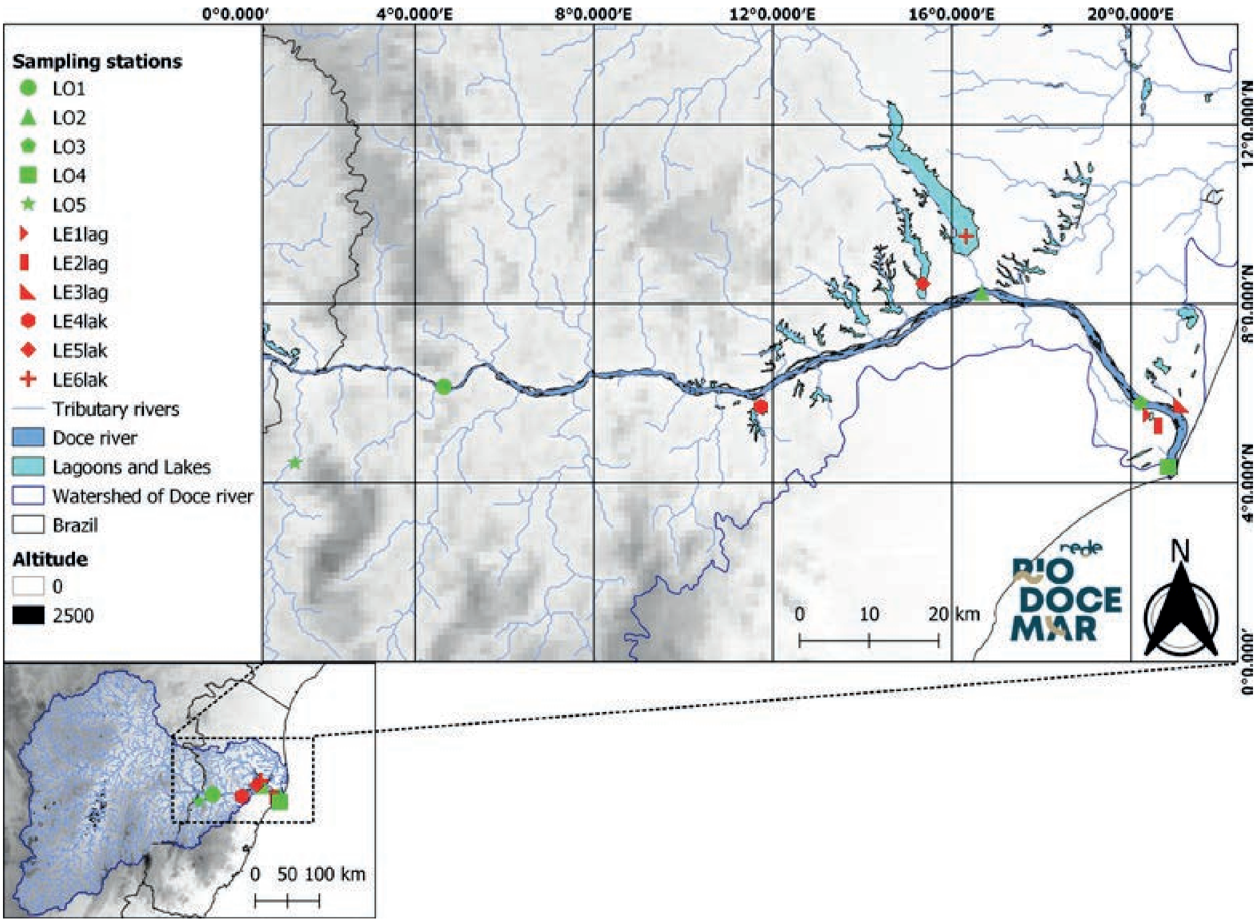

Figure 1. Map of sampling stations in the lower Doce river basin.

specialized literature (Cook *et al.* 1974; Irgang 1984; Martins *et al.* 1999; Longhi-Wagner *et al.* 2001; Lima *et al.* 2012; Pompêo 2017; Maciel-Silva *et al.* 2019) and websites (Flora do Brasil 2020) were consulted. Samples were deposited into the VIES Herbarium (Thiers 2020). Family circumscriptions follow APG IV (2016) for angiosperms and PPG I (2016) for seedless vascular plants. Scientific names with respective authors and conservation status follow IPNI (2020) and CNCFlora (2020), respectively.

We classified the life forms found conform with Irgang *et al.* (1984): Fixed submerged (FS), Free Submerged (FRS), Fixed Floating (FF), Free Floating (FFL), Amphibious (Amp), Emerging (Eme), and Epiphyte (Epi). Geographical maps were produced using QGIS 3.4.8 (QGis Development Team 2019). For floristic comparison between lotic and lentic environments, a presence/absence matrix for multivariate analysis was elaborated (Legendre & Legendre 2012) and ordering analysis, NMDS, was performed using the Bray-Curtis index in PAST 3.13 (Hammer *et al.* 2001), considering the number of different species collected at each sampling station.

A total of 105 species belonging to 65 genera and 33 families were recorded, of which 28 families and 95 species were Angiosperms and five families and 10 species were seedless vascular plants (Figure 2 to 5 and Table 1). Between the two environments analyzed here, 36 spp. Were recorded only in lentic environments, 27 spp. Occurred exclusively in lotic environments and 42 spp. Were shared between both, where the Guandu River (LO5) was the richest sampling station with 40 spp., followed by Monsaras Lagoon (LE3lag) with 38 species and Port of Linhares (LO2) with 31 spp. (Figure 6). Among the collected taxa, 99 were native and six were naturalized. *Pfaffia tuberosa*, *Enydra anagallis*, *Cyperus gardneri*, *Cyperus subsquarrosus*, *Eleocharis confervoides*, *Limnobium laevigatum*, *Utricularia hydrocarpa*, *Micranthemum umbrosum*, *Ludwigia torulosa*, *Cenchrus brownii*, *Cortaderia selloana*, *Luziola peruviana*, *Panicum dichotomiflorum*, and *P. stramineum* are new records for Espírito Santo state. Three species are considered endemic to Brazil: *Rhynchospora corymbosa*, *Stromanthe thalia*, and *Nymphaea lingulata*. Thirteen species had previously determined conservation status, of which 12 are categorized as Least Concern (LC) and *Sagittaria lancifolia* is considered Vulnerable (VU). Poaceae (23 spp.), Cyperaceae (22 spp.), Amaranthaceae (six spp.), and Nymphaeaceae and Onagraceae (four spp., each) were the richest families and *Cyperus* L. (10 spp.), *Panicum* L. (six spp.), *Eleocharis* R. Br., *Ludwigia* L. and *Nymphaea* L. (four spp., each), and *Polygonum* L. and *Utricularia* L. (three spp., each) were the richest genera.

The most representative life forms were amphibious/emerging (46 spp.), followed by exclusively amphibious (30 spp.) and fixed floating (10 spp.), which together corresponded to 80 % of the observed richness. The other life forms were represented by exclusively free floating (six spp.), exclusively emerging (five spp.), fixed/free floating (three spp.), fixed submerged (two spp.), and emerging/fixed floating *Centella asiatica*, amphibious/epiphytes (*Cyperus gardneri*) and epiphytes/free floating (*Utricularia gibba*) (Table 1).

Most of the species collected have a wide geographical distribution and lack conservation status avaliated (CNCFlora 2020), what may reflect the false need for their evaluation. *Sagittaria lancifolia*, although not endemic to Brazil and has a wide geographic distribution in the neotropical region, was assigned as Vulnerable (CNC Flora 2020) given its specificities and environmental requirements.

The NMDS ordering analysis (stress = 0.2273) showed that the composition of aquatic macrophytes in the lower Doce River basin is divided into two groups, corresponding to the lotic (in green) and lentic (in red) environments (Figure 7).

This separation is seen mainly in axis 1, with the species *Cyperus gardneri*, *Pfaffia glomerata*, *Sagittaria lancifolia*, *Salvinia auriculata* and *Cuphea melvilla* the ones that most contribute to this segregation, where *Pfaffia glomerata* occurs only in lotic environments and *Sagittaria lancifolia* only in lentic environments.

In aquatic ecosystems, plant composition can be directly related to abiotic and environmental variables, especially in relation to continental environments, which have different physical, chemical and biological variables (Thornton 1990, Pompêo 1999, Mormul *et al.* 2010). The various environmental variables that regulate these two

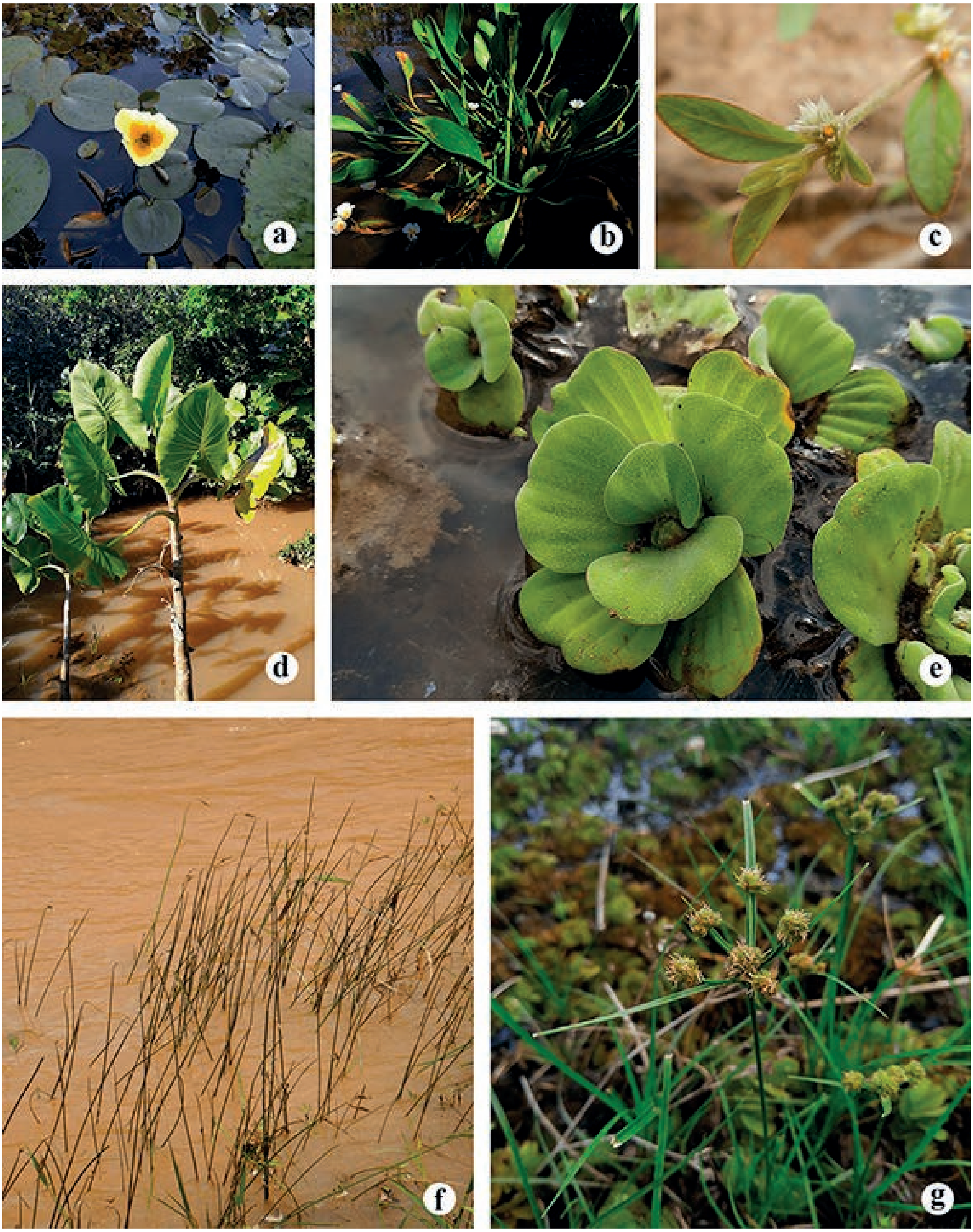

Figure 2. Aquatic macrophytes in the lower Doce basin. a. *Hydrocleys nymphoides* (Alismataceae), b. *Sagittaria lancifolia* (Alismataceae), c. *Alternanthera tenella* (Amaranthaceae), d. *Montrichardia linifera* (Araceae), e. *Pistia stratiotes* (Araceae), f. *Cyperus articulatus* (Cyperaceae), g. *Cyperus gardneri* (Cyperaceae).

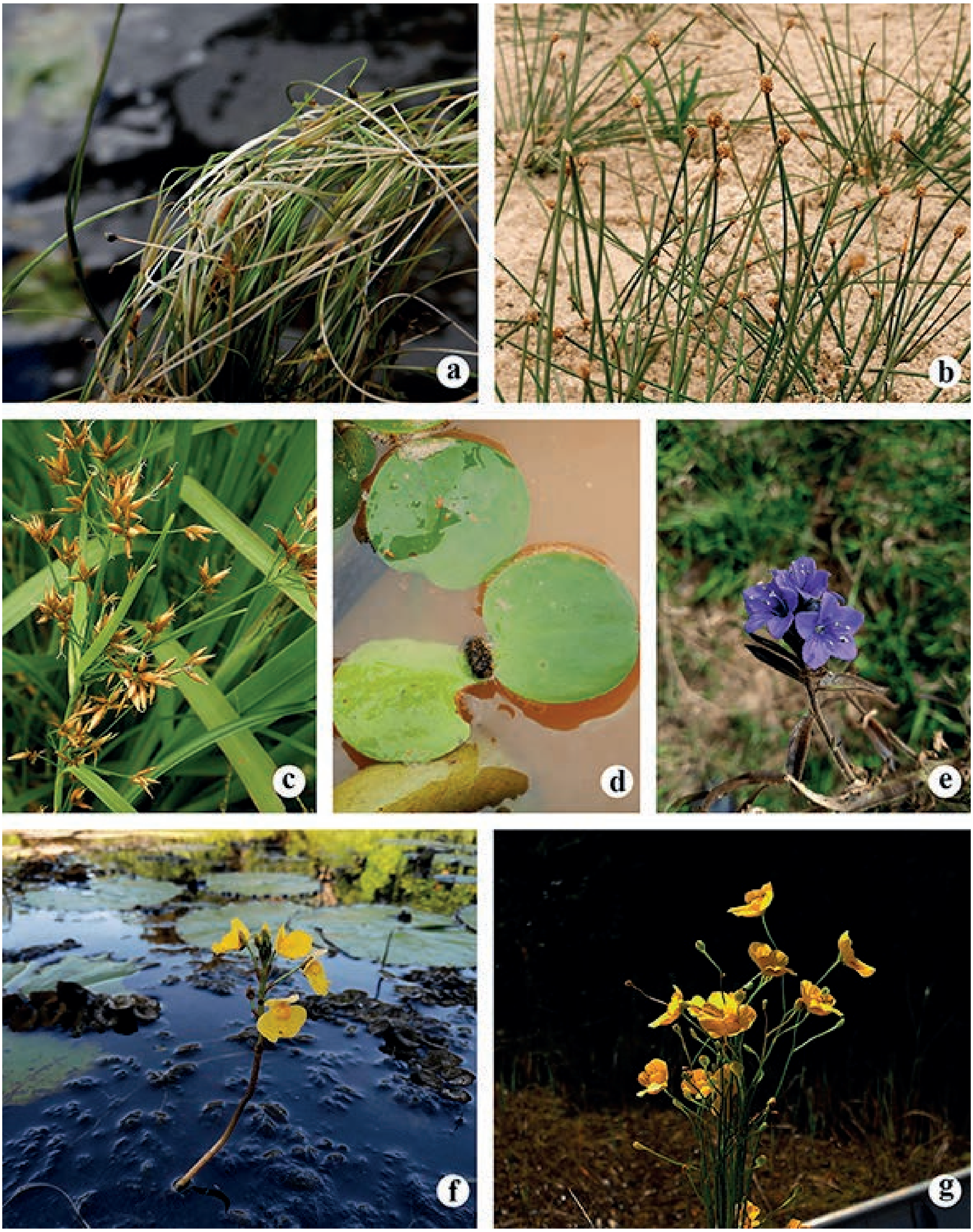

Figure 3. Aquatic macrophytes in the lower Doce basin. A. *Eleocharis confervoides* (Cyperaceae), b. *Eleocharis geniculata* (Cyperaceae), c. *Rhynchospora corymbosa* (Cyperaceae), d. *Limnobium laevigatum* (Hydrocharitaceae), e. *Hydrolea spinosa* (Hydroleaceae), f. *Utricularia foliosa* (Lentibulariaceae), g. *Utricularia gibba* (Lentibulariaceae).

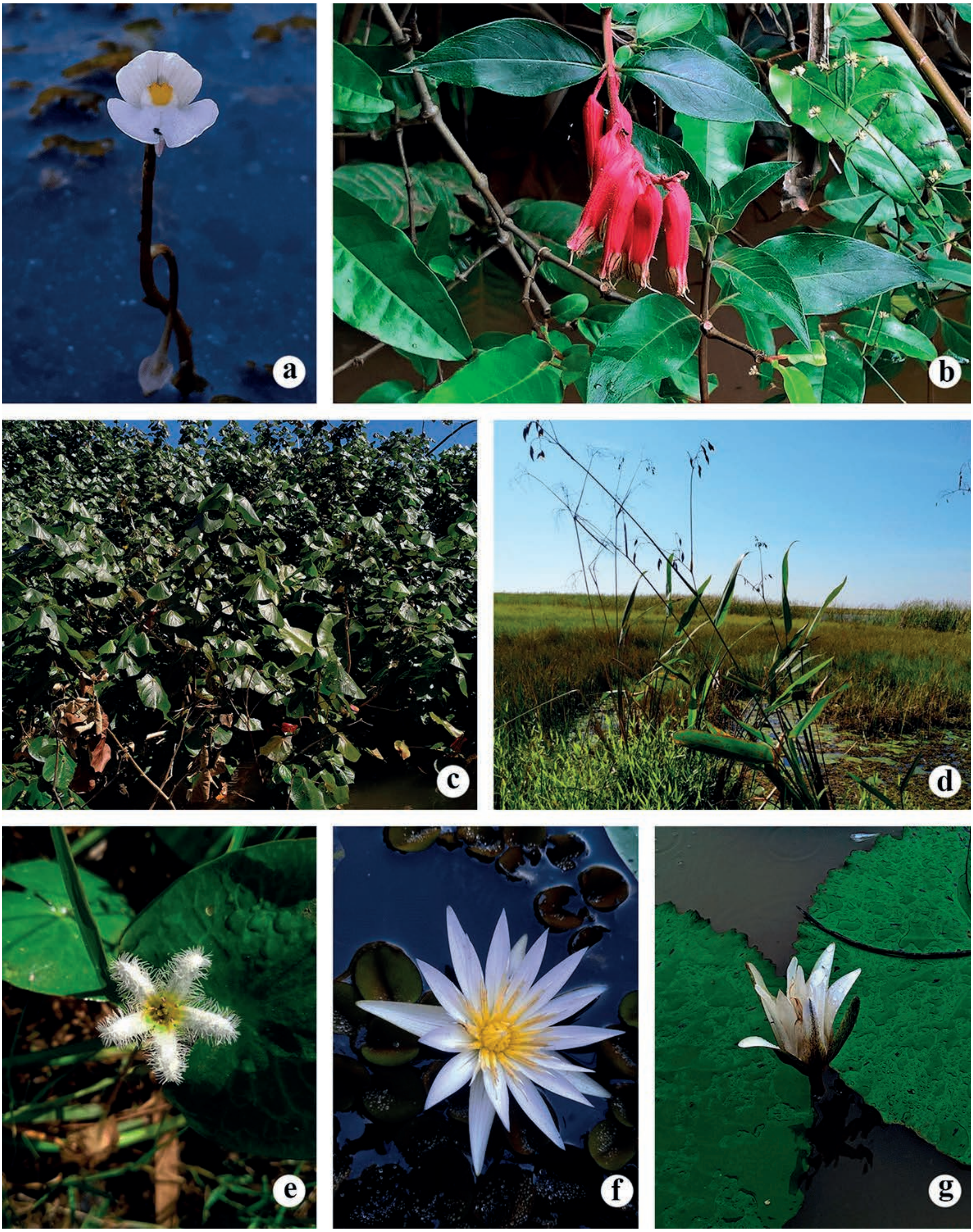

Figure 4. Aquatic macrophytes in the lower Doce basin. A. *Utricularia hydrocarpa* (Lentibulariaceae), b. *Cuphea melvilla* (Lytrhaceae), c. *Talipariti pernambucense* (Malvaceae), d. *Stromanthe thalia* (Marantaceae), e. *Nymphoides humboldtiana* (Menyanthaceae), f. *Nymphaea caerulea* (Nymphaeaceae), g. *Nymphaea pulchella* (Nymphaeaceae).

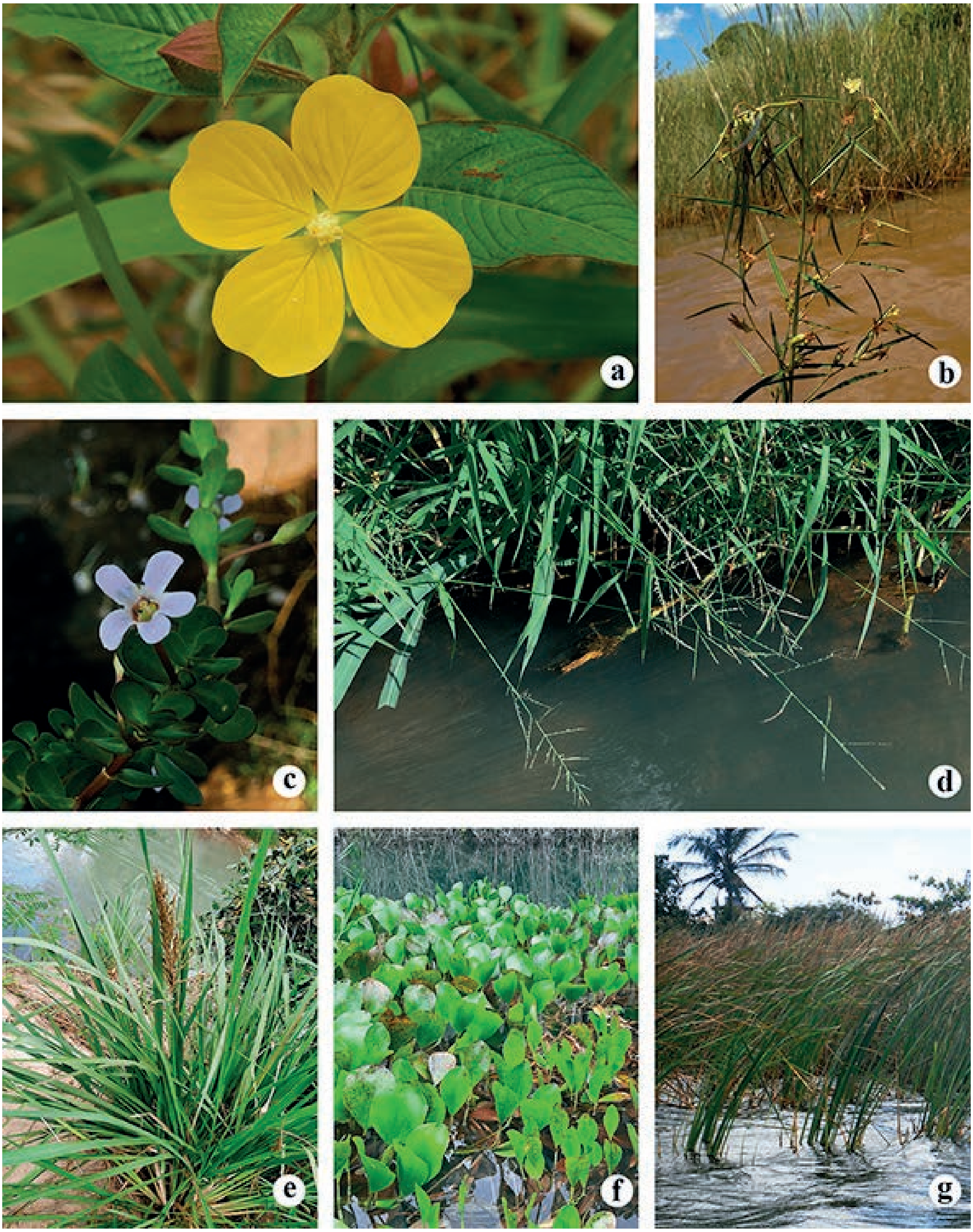

Figure 5. Aquatic macrophytes in the lower Doce basin. A. *Ludwigia octovalvis* (Onagraceae), b. *Ludwigia torulosa* (Onagraceae), c. *Bacopa monnieri* (Plantaginaceae), d. *Panicum aquaticum* (Poaceae), e. *Paspalum millegrana* (Poaceae), f. *Eichhornia azurea* (Pontederiaceae), g. *Typha domingensis* (Typhaceae).

Table 1. Checklist of aquatic macrophytes species of the lower Doce river basin. O = Origin: N = Native, Nz = Naturalized. LF = Life form: Amp = Amphibious, Eme = Emergent, Epi = Epiphytic, FF = Fixed floating, FFL = Free floating, FS = Fixed submerged, FRS = Free submerged. CS = Conservation of status: LC = Least Concern, VU = Vulnerable. Sampling stations: LO1 = Itapina, LO2 = Port of Linhares, LO3 = Povoação, LO4 = Regência of Port, LO5 = Guandu river – tributary, LE1lag = Areão lagoon, LE2lag = Areal lagoon, LE3lag = Monsaras lagoon, LE4lak = Limão lake, LE5lak = Nova lake, LE6lak = Juparanã lake.

Family/Species	O	LF	SC	Sampling stations										
				LO1	LO2	LO3	LO4	LO5	LE1lag	LE2lag	LE3lag	LE4lak	LE5lak	LE6lak
ALISMATACEAE														
Hydrocleys nymphoides (Willd.) Buchenau	N	FF	—								•			
Limnocharis flava (L.) Buchenau	N	Amp/Eme	—						•					
Sagittaria lancifolia L.	N	Eme	VU						•	•				
AMARANTHACEAE														
Alternanthera philoxeroides (Mart.) Griseb.	N	Amp	—	•	•	•	•				•			
Alternanthera tenella Colla	N	Amp	LC	•			•	•						
Blutaparon portulacoides (A.St.-Hil.) Mears	N	Amp	LC								•			
Hebanthe eriantha (Poir.) Pedersen	N	Amp	LC			•								
Pfaffia glomerata (Spreng.) Pedersen	N	Amp	LC	•	•	•	•	•						
Pfaffia tuberosa (Spreng.) Hicken	N	Amp	—	•										
AMARYLIDACEAE														
Crinum americanum L.	N	Amp /Eme	—							•				
APIACEAE														
Centella asiatica (L.) Urb.	Nz	Eme	—								•			
ARACEAE														
Montrichardia linifera (Arruda) Schott	N	Amp /Eme	—			•	•		•	•	•			
Pistia stratiotes L.	N	FFL	—		•									
ASTERACEAE														
Acmella oleracea (L.) R.K.Jansen	Nz	Amp	—				•							
Enydra anagallis Gardner	N	Eme	LC								•			
BLECHNACEAE														
Telmatoblechnum serrulatum (Rich.) Perrie *et al.*	N	Amp	—		•				•	•				
CABOMBACEAE														
Cabomba furcata Schult. & Schult. f.	N	FS	LC							•				

Table 1. Continues on next page...

Table 1. ...continued

Family/Species	**O**	**LF**	**SC**	**Sampling stations**										
				LO1	**LO2**	**LO3**	**LO4**	**LO5**	**LE1lag**	**LE2lag**	**LE3lag**	**LE4lak**	**LE5lak**	**LE6lak**
CLEOMACEAE														
Tarenaya spinosa (Jacq.) Raf.	N	Amp /Eme	—	•										
CYPERACEAE														
Calyptrocarya glomerulata (Brongn.) Urb.	N	Eme	—								•			
Cyperus articulatus L.	N	Amp /Eme	—					•		•				
Cyperus esculentus L.	Nz	Amp /Eme	—											•
Cyperus gardneri Nees	N	Amp /Epi	—		•							•		•
Cyperus haspan L.	N	Amp /Eme	—	•										
Cyperus hermaphroditus (Jacq.) Standl.	N	Amp /Eme	—										•	
Cyperus ligularis L.	N	Amp /Eme	—				•				•		•	
Cyperus luzulae (L.) Retz.	N	Amp /Eme	—	•			•	•			•	•		•
Cyperus polystachyos Rottb.	N	Amp /Eme	—				•	•		•				
Cyperus subsquarrosus (Muhl.) Bauters	N	Amp /Eme	—		•			•						
Cyperus surinamensis Rottb.	N	Amp /Eme	—		•		•	•						
Eleocharis acutangula (Roxb.) Schult.	N	Amp /Eme	—							•	•	•		
Eleocharis confervoides (Poir.) Steud.	N	Amp /Eme	—								•			
Eleocharis geniculata (L.) Roem. & Schult.	N	Amp /Eme	—					•				•	•	
Eleocharis interstincta (Vahl) Roem. & Schult.	N	Amp /Eme	—					•	•	•	•	•		
Fimbristylis cymosa R.Br.	N	Amp /Eme	—					•						
Fimbristylis miliacea (L.) Vahl	N	Amp /Eme	—				•	•						
Fuirena umbellata Rottb.	N	Amp /Eme	—					•	•	•				
Rhynchospora corymbosa (L.) Britton	N	Amp /Eme	—					•		•	•			
Rhynchospora holoschoenoides (Rich.) Herter	N	Amp /Eme	—						•	•		•		
Scleria gaertneri Raddi	N	Amp /Eme	—										•	
Scleria mitis P.J.Bergius	N	Amp /Eme	—			•			•	•		•	•	
ERIOCAULACEAE														
Tonina fluviatilis Aubl.	N	Eme	—						•			•		

Table 1. Continues on next page...

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Family/Species	O	LF	SC	Sampling stations										
				LO1	LO2	LO3	LO4	LO5	LE1lag	LE2lag	LE3lag	LE4lak	LE5lak	LE6lak
HYDROCHARITACEAE														
Egeria densa Planch.	N	FRS	—						•		•	•		
Limnobium laevigatum (Humb. & Bonpl. ex Willd.) Heine	N	FFL	—		•									
HYDROLEACEAE														
Hydrolea elatior Schott	N	Amp /Eme	—						•					
Hydrolea spinosa L.	N	Amp /Eme	—	•				•						
LENTIBULARIACEAE														
Utricularia foliosa L.	N	FFL	LC							•	•		•	
Utricularia gibba L.	N	Epi/FFL	—							•	•	•		
Utricularia hydrocarpa Vahl.	N	FFL	LC							•				
LINDERNIACEAE														
Micranthemum umbrosum (Walter ex J.F.Gmel.) S.F. Blake	N	Amp	LC								•			
Torenia thouarsii (Cham. & Schltdl.) Kuntze	N	Amp	—				•	•	•					
LYGODIACEAE														
Lygodium venustum Sw.	N	Amp	—				•						•	
Lygodium volubile Sw.	N	Amp	—		•	•			•		•			
LYTHRACEAE														
Cuphea carthagenensis (Jacq.) J.F. Macbr.	N	Amp	—					•						
Cuphea melvilla Lindl.	N	Amp	LC	•	•	•			•					•
MALVACEAE														
Talipariti pernambucense (Arruda) Bovini	N	Amp	—			•	•							
MARANTACEAE														
Stromanthe thalia (Vell.) J.M.A.Braga	N	Amp /Eme	—								•			
MENYANTHACAEAE														
Nymphoides humboldtiana (Kunh) Kuntze	N	FF/ FFL	—						•		•	•		

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Table 1. ...continued

Family/Species	**O**	**LF**	**SC**	**Sampling stations**										
				LO1	**LO2**	**LO3**	**LO4**	**LO5**	**LE1lag**	**LE2lag**	**LE3lag**	**LE4lak**	**LE5lak**	**LE6lak**
MOLLUGINACEAE														
Mollugo verticillata L.	N	Amp	—					•						
NYMPHAEACEAE														
Nymphaea caerulea Savigny	N	FF	—								•			
Nymphaea lingulata Wiersema	N	FF	—							•				
Nymphaea pulchella DC.	N	FF	—							•	•			
Nymphaea rudgeana G.Mey.	N	FF	—								•	•		
ONAGRACEAE														
Ludwigia erecta (L.) H.Hara	N	Eme/Amp	—				•	•						
Ludwigia leptocarpa (Nutt.) H.Hara	N	Amp /Eme	—								•		•	•
Ludwigia octovalvis (Jacq.) P.H.Raven	N	Amp /Eme	—	•	•		•	•	•			•		
Ludwigia torulosa (Arn.) H.Hara	N	Amp /Eme	—							•		•		
PLANTAGINACEAE														
Bacopa monnieri (L.) Pennell	N	Eme	—		•		•				•			
POACEAE														
Acroceras zizanioides (Kunth) Dandy	N	Amp /Eme	—	•			•						•	
Cenchrus brownii Roem. & Schult.	N	Amp	—					•						
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	N	Amp	—		•									
Echinochloa crusgalli (L.) P.Beauv.	N	Amp	—								•			
Eleusine indica (L.) Gaertn.	Nz	Amp	—					•						
Hildaea pallens (Sw.) C.Silva & R.P.Oliveira	N	Amp	—										•	
Hymenachne amplexicaulis (Rudge) Nees	N	Amp /Eme	—		•			•						
Hymenachne pernambucensis (Spreng.) Zuloaga	N	Amp /Eme	LC	•	•		•	•	•	•		•	•	
Luziola peruviana Juss. ex J.F.Gmel.	N	FF	—					•					•	•
Ocellochloa stolonifera (Poir.) Zuloaga & Morrone	N	Amp	—		•	•								
Panicum aquaticum Poir.	N	FF	—		•	•	•	•			•		•	•

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Family/Species	O	LF	SC	Sampling stations										
				LO1	LO2	LO3	LO4	LO5	LE1lag	LE2lag	LE3lag	LE4lak	LE5lak	LE6lak
Panicum dichotomiflorum Michx.	N	Amp /Eme	—	•				•					•	
Panicum gouinii E.Fourn.	N	FF	LC					•						•
Panicum millegrana Poir.	N	Amp /Eme	—	•	•	•	•	•			•	•		•
Panicum repens L.	Nz	FF	—	•	•			•			•	•	•	
Panicum stramineum Hitchc. & Chase	N	FF	—		•							•	•	
Parodiolyra micrantha (Kunth) Davidse & Zuloaga	N	Amp	—										•	
Paspalum millegrana Schrad. ex Schult.	N	Amp /Eme	—	•			•	•			•			
Paspalum pilosum Lam.	N	Amp /Eme	—	•						•			•	
Rugoloa pilosa (Sw.) Zuloaga	N	Amp /Eme	—							•				
Steinchisma laxum (Sw.) Zuloaga	N	Amp	—					•						
Urochloa brizantha (Hochst. ex A. Rich.) R.D.Webster	Nz	Amp	—	•			•	•			•		•	
Poaceae sp. 1	—	Amp /Eme	—		•		•			•		•	•	•
POLYGONACEAE														
Polygonum ferrugineum Wedd.	N	Amp /Eme	—	•	•		•	•						•
Polygonum hydropiperoides Michx.	N	Amp /Eme	—	•	•			•			•			
Polygonum punctatum Elliott	N	Amp /Eme	—					•	•					
PONTEDERIACEAE														
Eichhornia azurea (Sw.) Kunth	N	FF/FFL	—		•	•	•		•				•	•
Eichhornia crassipes (Mart.) Solms	N	FF/FFL	—		•	•	•		•					•
PTERIDACEAE														
Adiantum latifolium Lam.	N	Amp	—		•	•					•		•	
Ceratopteris thalictroides (L.) Brongn.	N	Amp /Eme	—				•	•	•		•		•	
RUBIACEAE														
Oldenlandia corymbosa L.	N	Amp	—			•								
SALVINIACEAE														
Salvinia auriculata Aubl.	N	FFL	—		•			•	•		•	•	•	•

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Table 1. ...continued

Family/Species	O	LF	SC	Sampling stations										
				LO1	LO2	LO3	LO4	LO5	LE1lag	LE2lag	LE3lag	LE4lak	LE5lak	LE6lak
Salvinia biloba Raddi	N	FFL	—	•	•		•	•			•	•	•	•
THELYPTERIDACEAE														
Christella dentata (Forssk.) Brownsey & Jermy	N	Amp	—		•									
Cyclosorus interruptus (Willd.) H. Ito	N	Amp	—							•				
Meniscium serratum Cav.	N	Amp	—		•	•								
TYPHACEAE														
Typha domingensis Pers.	N	Amp /Eme	—	•				•	•	•	•	•	•	
XYRIDACEAE														
Xyris macrocephala Vahl	N	Amp /Eme	—							•				

ecosystems directly influence continental aquatic biodiversity, especially of macromorphological organisms, such as macrophytes (Thomaz *et al.* 2003).

In addition to the richness of species, the lotic and lentic environments have a difference in relation to the abundance of the species life forms, since only the amphibious and amphibious/emerging forms of life were the most abundant in the lotic environment compared to the lentic environment. This is due to the nature of amphibious species that generally find favorable conditions at the edges of water bodies and have morphological adaptations that allow greater resistance to the detriment of hydrological variables in lotic environments (Neves *et al.* 2006).

The other forms of life, on the other hand, were found more frequently in lentic environments, mainly species that are entirely fluctuating in their life cycle and even those that seasonally present themselves in this way. Due to various hydrological conditions, lentic environments provide better habitats for fully emergent and epiphytic species, in addition to floating ones and their subdivisions (free, submerged and fixed) (Pompêo 2017).

The number of species presented here can be considered high, and may be related to the greater number of aquatic environments studied and sampling efforts (Supplementary material 3). The results presented here can be compared with Ferreira *et al.* (2010) who cataloged 37 species in three lagoons of the Rio Doce State Park, since in this study, 36 species were recorded that only occur in lentic environments; with Pivari *et al.* (2011) who registered 184 species when they surveyed the macrophytes for the 150 water bodies that belong to the lacustrine system of the Vale do rio Doce; with Souza *et al.* (2017) who reported 66 species of aquatic macrophytes between lotic and lentic environments Parque Estadual de Itaúnas, despite not designating the number of species found in each environment, and with Moura-Júnior *et al.* (2011), that despite the low richness found (43 species) for lotic and lentic environments and having been carried out in the Caatinga biome, in the Sobradinho reservoir, Bahia, found a vegetal composition between the two types of environments, as presented here in

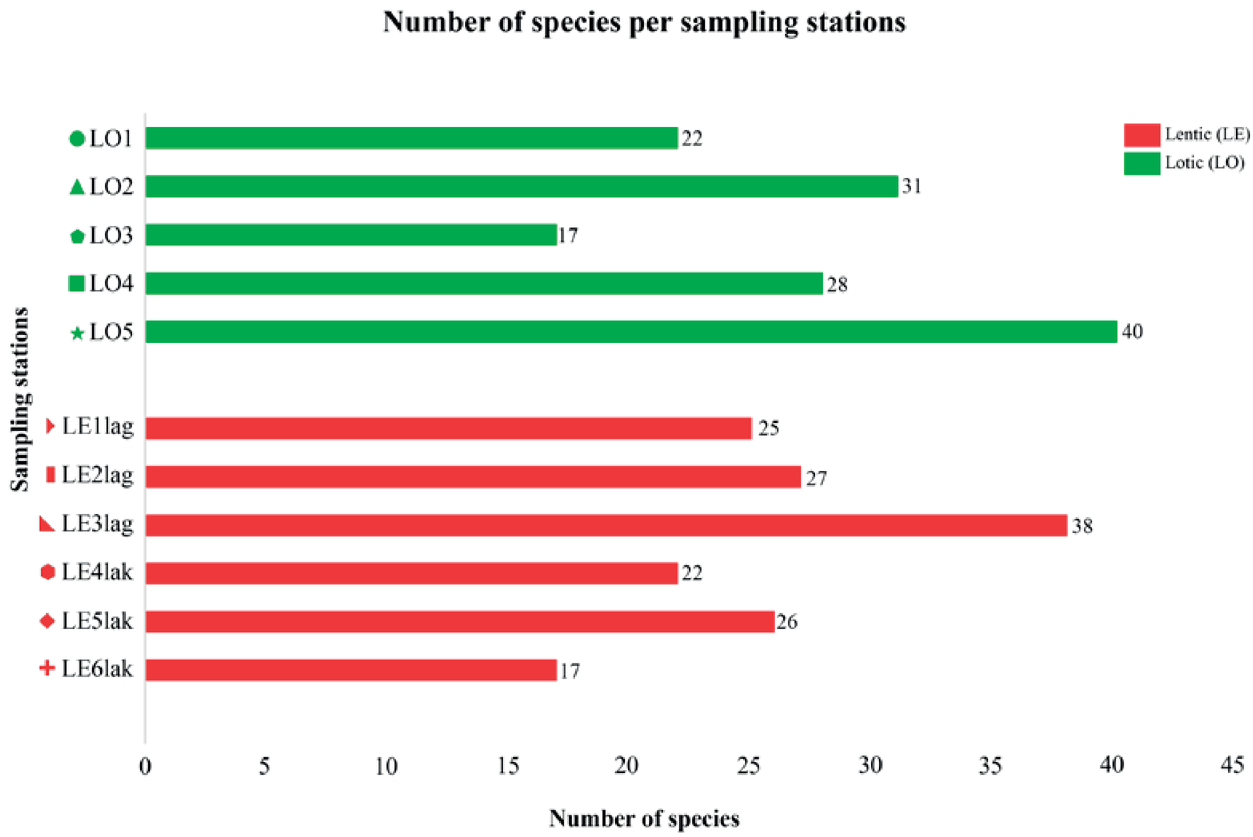

Figure 6. Number of species per sampling stations in the lower Doce basin.

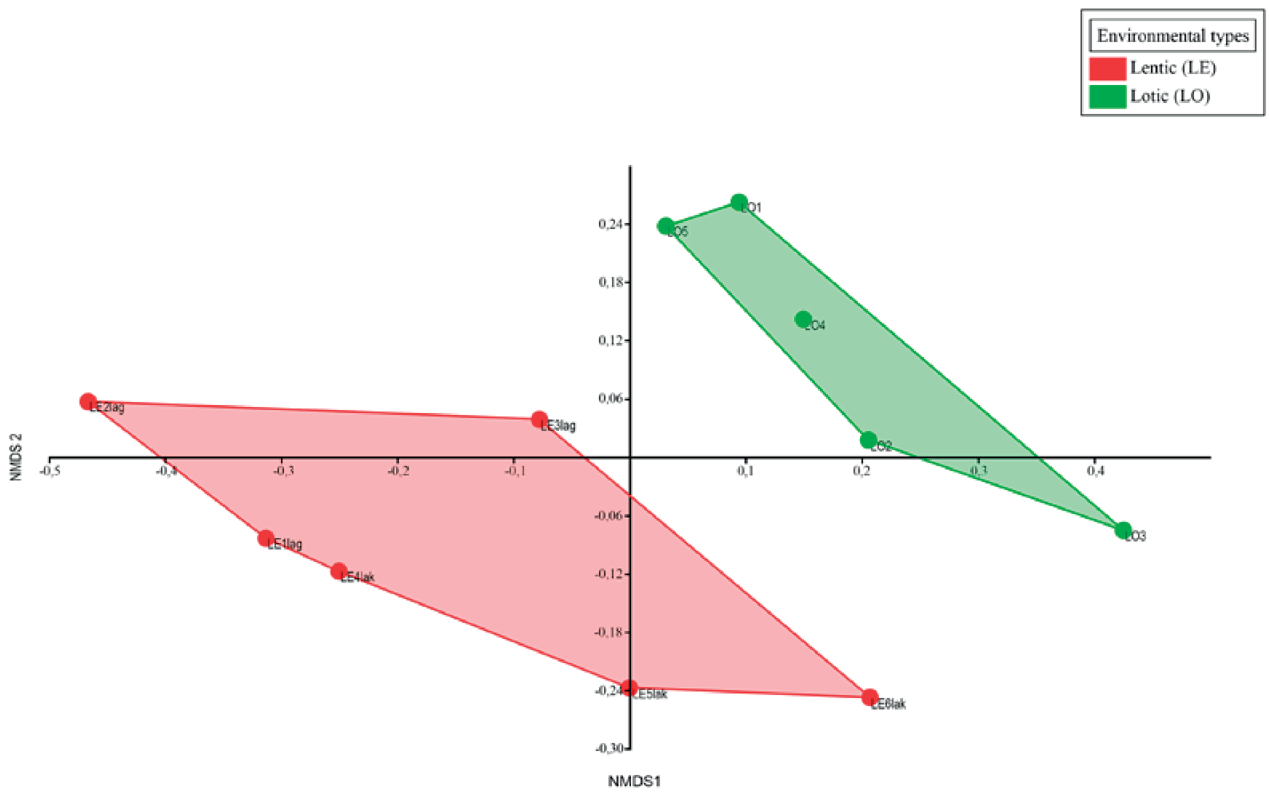

Figure 7. Non metric multidimensional scaling (NMDS) analysis based on species composition along environmental types. The stress was 0.2273.

this study. In common with all these mentioned studies, Cyperaceae and Poaceae are part of the most representative families, as also verified in this study.

The composition of aquatic macrophytes differs between the lotic and lentic environments in the lower Doce River basin, and revealed a high number of species. Furthermore, comparing the occurrence of life forms, it can be inferred that diversity is greater in lentic environments than in lotic environments. However, further studies must be carried out to corroborate this hypothesis. Unfortunately, no floristic studies were carried out in the lower Doce River before the Mariana dam burst, so we cannot compare or discuss how much (or if) the aquatic macrophyte richness has been affected or lost.

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