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Original Paper

Lagoons, rivers, weirs and their wet gardens in the semiarid: aquatic Eudicotyledons and Ceratophyllaceae of Ceará state, Brazil

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Abstract

Ceará state holds the second largest wetland extension in Northeastern Brazil and, thus far, there have been taxonomic studies developed about aquatic macrophytes richness for the clades of Monocots and Nymphaeales, and of two Eudicot families only. In this context, the present study is a synopsis of the aquatic representatives of Eudicotyledons and Ceratophyllaceae in Ceará state, providing further information about the biodiversity of aquatic ecosystems in the Brazilian semiarid. We present an updated survey based on material deposited at the EAC, IPA, R and RB herbaria and on images from digital platforms, including diagnostic descriptions, identification keys, photographs and comments about geographic distribution. We recorded 28 families, 43 genera and 82 species. The most representative families were Lentibulariaceae (12 spp.), Malvaceae (9 spp.), Plantaginaceae (9 spp.), Fabaceae (8 spp.) and Onagraceae (7 spp.), whilst Ceratophyllaceae was represented by one species only. Helophytes were the predominant growth form (64%), followed by the bottom-rooted emergent hydrophytes (20%), and Podostemaceae was the only family represented by haptophytes (4 spp.).
Key words: aquatic macrophytes, flora of Ceará, Northeastern Brazil, semiarid region, wetlands.

Resumo

O estado do Ceará é o segundo maior em extensão de áreas alagadas no nordeste Brasileiro e, até então, foram desenvolvidos estudos taxonômicos em riqueza de macrófitas aquáticas pertencentes aos clados de Monocotiledôneas e Nymphaeales, e apenas de duas famílias de Eudicotiledôneas. Nesse contexto, o presente estudo é uma sinopse dos representantes aquáticos de Eudicotiledôneas e Ceratophyllaceae do estado do Ceará, contribuindo para o conhecimento sobre a biodiversidade dos ecossistemas aquáticos no semiárido Brasileiro. Nós trazemos um levantamento atualizado baseado em material depositado nos herbários EAC, IPA, R e RB, bem como em imagens disponíveis em plataformas digitais, incluindo descrições diagnósticas, chaves de identificação, fotografias e comentários em distribuição geográfica. Nós registramos 28 famílias, 43 gêneros e 82 espécies. As famílias mais representativas são Lentibulariaceae (12 spp.), Malvaceae (9 spp.), Plantaginaceae (9 spp.), Fabaceae (8 spp.) e Onagraceae (7 spp.), enquanto Ceratophyllaceae está representada apenas por uma espécie. As helófitas são as formas de crescimento predominantes (64%), seguidas de hidrófitas enraizadas emergentes (20%), e Podostemaceae é a única família representada por haptófitas (4 spp.).
Palavras-chave: macrófitas aquáticas, flora do Ceará, Nordeste do Brasil, região semiárida, áreas alagadas.

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Introduction

The Brazilian angiosperms are represented by 237 families, comprising 33,099 species, with approximately 14% of these records indicated for the Caatinga domain (Flora do Brasil 2020, continuously updated). This data set is compatible with the global expectation of floristic richness for arid regions, which are commonly recognized as relatively simple ecosystems harbouring low species diversity (MacNeely 2003). Furthermore, angiosperms found in wetlands show significantly reduced taxa richness compared to the flora in terrestrial environments (Cook 1996), and is even lower in seasonal aquatic ecosystems of arid regions (Deil 2005).

In the Brazilian semiarid region, seasonal wetlands predominate, covering about 15,781 intermittent lagoons, with fairly heterogeneous distribution (Maltchik *et al.* 1999). In this region, Ceará presents the second largest extension of wetlands and the fourth highest number of lagoons, which are essential for the development of aquatic plant communities that experience dynamic climatic seasonality and have widely variable water columns in their habitats (Maltchik & Pedro 2000).

Remarkably, several unrelated taxa have been registered as main components of macrophyte communities in South American seasonal environments, belonging to Nymphaeales, Ceratophyllales and other distinct clades of Monocots and Eudicots (Deil *et al*. 2011). However, Eudicots contain the greatest diversity among Angiosperms with c. 75% of extant flowering plants (The Plant List 2020). One of the first studies developed by Cook (1996) indicated 41 dicotyledon families (except Nymphaeales) with representatives of aquatic plants and some that are restricted to aquatic environments, such as Hydrostachyaceae, Hydroleaceae, Menyanthaceae, Nelumbonaceae and Podostemaceae. Considering the species of aquatic vegetation in Brazil (Flora do Brasil 2020, continuously updated), Eudicots are represented by 38 families, with a substantial number of aquatic species in Podostemaceae (86 spp.), Lentibulariaceae (46 spp.), Rubiaceae (26 spp.), Plantaginaceae (18 spp.) and Fabaceae (16 spp.).

Thus far, the flora of the Ceará wetlands has been represented by the following families: Alismataceae (Matias & Souza 2011), Araceae (Andrade *et al.* 2013), Cabombaceae (Matias & Nascimento 2021), Hydrocharitaceae (Matias *et al.* 2017), Lentibulariaceae (Guedes & Matias 2020), Nymphaeaceae (Sousa & Matias 2013), Onagraceae (Nascimento & Matias 2021), Pontederiaceae (Sousa *et al.* 2018) and Potamogetonaceae (Matias 2020). In this context, the present study aims to provide further information about aquatic macrophytes and their diversity in Ceará state, adding to the understanding about the biodiversity of aquatic ecosystems in the Brazilian semiarid. Herein, we provide an updated survey and identification keys for families and species of aquatic Eudicotyledons and Ceratophyllaceae from the state, including short diagnostic descriptions, photographs and comments about geographic distribution.

Material and Methods

Specimens were surveyed using the Virtual Herbarium of Flora and Fungi (<https://specieslink.net/>) (INCT 2020), searching different keywords to filter collections from different types of wetlands (lagoons, ponds, weirs, rivers, streams) in Ceará state. From the list of species obtained, the botanical material deposited in the herbaria collections of EAC, IPA, R and RB were personally analysed under the stereoscope, as well as images from Virtual Herbarium REFLORA (<http://reflora.jbrj.gov.br>), Tropicos (2020) and Jstor Global Plants (<https://plants.jstor.org/>). Only species that fit Cook's (1996) definition of aquatic macrophytes were included in the final list. Then, this list was compared to the data of the Lista de Espécies da Flora do Brasil (<http://reflora.jbrj.gov.br>) (Flora do Brasil 2020, continuously updated) to verify occurrence records.

Nomenclatural data was updated based on information from IPNI (2020) and Flora do Brasil 2020 (continuously updated). Taxonomic literature of the botanical families helped confirm herbarium identifications and elaborate diagnostic descriptions, identification keys and comments. Taxonomic classification followed the APG IV (2016) and morphological terminology followed Harris & Harris (2001). Due to the volume of examined material, we decided to indicate only one voucher considered most representative (phenological elements) for each family, which was collected in the state of Ceará, Brazil. Growth forms were classified following Cook's categories (Cook 1996): (1) Hydrophytes: bottom-rooted submerged, bottom-rooted emergent, bottom-rooted emergent with floating leaves and/or stems, free-swimming submerged, haptophytes, free-floating emergent; and (2) Helophytes (amphibians).

Results and Discussion

In Ceará state, there are 28 families represented by 43 genera and 82 species of aquatic Eudicotyledon Angiosperms and Ceratophyllaceae (Tab. 1). The families with the greatest species richnesses were Lentibulariaceae (12 spp.), followed by Malvaceae (9 spp.), Plantaginaceae (9 spp.), Fabaceae (8 spp.) and Onagraceae (7 spp.). Ceratophyllaceae, sister group to the Eudicotyledons (APG IV 2016), is represented by only one species in the state: *Ceratophyllym demersum* L.

Table 1 – Aquatic Eudicotyledons and Ceratophyllaceae of Ceará state. (*) New records for the state (Flora do Brasil 2020, continuously updated). Growth forms (Cook 1996): RE = bottom-rooted emergent hydrophyte; RFL = bottom-rooted emergent hydrophyte with floating leaves and/or stems; FS = free-swimming hydrophyte; HAP = haptophyte hydrophyte; HEL = Helophyte.

Family	Species	Growth form
Acanthaceae	*Hygrophila costata* Nees & T.Nees	RE
	Justicia laevilinguis (Nees) Lindau	RE
Aizoaceae	*Sesuvium portulacastrum* (L.) L.	HEL
Amaranthaceae	*Alternanthera brasiliana* (L.) Kuntze	HEL
	Alternanthera tenella Colla	HEL
Araliaceae	*Hydrocotyle bonariensis* Lam. (*)	HEL
Asteraceae	*Eclipta prostrata* (L.) L.	HEL
Boraginaceae	*Euploca lagoensis* (Warm.) Diane & Hilger	HEL
	Heliotropium elongatum (Lehm.) I.M. Johnst.	HEL
Ceratophyllaceae	*Ceratophyllum demersum* L.	FS
Cleomaceae	*Tarenaya longicarpa* Soares Neto & Roalson	HEL
Convolvulaceae	*Ipomoea asarifolia* (Desr.) Roem. & Schult.	HEL
	Ipomoea carnea subsp. *fistulosa* (Mart. *ex* Choisy) D.F.Austin	RE
Euphorbiaceae	*Caperonia palustris* (L.) A. St.-Hil.	RE
Fabaceae	*Aeschynomene evenia* C.Wright	RE
	Aeschynomene filosa Mart. *ex* Benth.	RE
	Aeschynomene rostrata Benth.	RE
	Aeschynomene rudis Benth.	RE
	Discolobium hirtum Benth.	RE
	Neptunia oleracea Lour.	RFL
	Neptunia plena (L.) Benth.	RFL
	Sesbania exasperata Kunth	RE
Gentianaceae	*Schultesia guianensis* (Aubl.) Malme	HEL
Gesneriaceae	*Sinningia nordestina* Chautems, Baracho & Siqueira Filho	HEL
Hydroleaceae	*Hydrolea spinosa* L.	HEL
Lamiaceae	*Hyptis atrorubens* Poit.	HEL
	Mesosphaerum suaveolens Kuntze	HEL
Lentibulariaceae	*Utricularia adpressa* Salzm. *ex* A.St.-Hil. & Girard	HEL
	Utricularia cornuta Michx.	HEL
	Utricularia cutleri Steyerm.	HEL

Family	Species	Growth form
	Utricularia erectiflora A.St.-Hil. & Girard	HEL
	Utricularia foliosa L.	FS
	Utricularia gibba L.	FS
	Utricularia hydrocarpa Vahl	FS
	Utricularia pusilla Vahl	HEL
	Utricularia resupinata B.D.Greene *ex* Bigelow	HEL
	Utricularia simulans Pilg.	HEL
	Utricularia subulata L.	HEL
	Utricularia trichophylla Spruce *ex* Oliv.	HEL
Loganiaceae	*Spigelia anthelmia* L.	HEL
Lythraceae	*Ammannia latifolia* L.	HEL
	Cuphea campestris Mart. *ex* Koehne	HEL
	Cuphea impatientifolia A.St.-Hil.	HEL
Malvaceae	*Malachra fasciata* Jacq. (*)	HEL
	Malachra radiata (L.) L.	HEL
	Malvastrum tomentosum (L.) S.R.Hill	HEL
	Melochia pyramidata L.	HEL
	Melochia tomentosa L.	HEL
	Sida cordifolia L.	HEL
	Sida glomerata Cav.	HEL
	Sida spinosa L.	HEL
	Waltheria indica L.	HEL
Melastomataceae	*Pterolepis glomerata* (Rottb.) Miq.	HEL
Menyanthaceae	*Nymphoides humboldtiana* (Kunth) Kuntze	RFL
Onagraceae	*Ludwigia erecta* (L.) H.Hara	HEL
	Ludwigia helminthorrhiza (Mart.) H.Hara	RFL
	Ludwigia hyssopifolia (G.Don) Exell	HEL
	Ludwigia leptocarpa (Nutt.) H.Hara	HEL
	Ludwigia nervosa (Poir.) H.Hara	HEL
	Ludwigia octovalvis (Jacq.) P.H.Raven	HEL
	Ludwigia tomentosa (Cambess.) H.Hara	HEL
Plantaginaceae	*Angelonia biflora* Benth.	HEL
	Bacopa angulata (Benth.) Edwall	RE
	Bacopa aquatica Aubl.	RE
	Bacopa cochlearia (Huber) L.B.Sm.	RE
	Bacopa monnieri (L.) Wettst.	RE
	Scoparia dulcis L.	HEL
	Stemodia durantifolia (L.) Sw.	HEL
	Stemodia foliosa Benth.	HEL
	Stemodia maritima L.	HEL
Podostemaceae	*Apinagia richardiana* (Tul.) P.Royen	HAP

Family	Species	Growth form
	Apinagia riedelii (Bong.) Tul.	HAP
	Mourera fluviatilis Aubl.	HAP
	Tristicha trifaria (Bory *ex* Willd.) Spreng.	HAP
Polygalaceae	*Polygala appendiculata* Vell.	HEL
Polygonaceae	*Polygonum acuminatum* Kunth	RE
	Polygonum ferrugineum Weddell.	RE
	Polygonum hispidum Kunth	RE
Rubiaceae	*Borreria scabiosoides* Cham. & Schltdl.	HEL
	Borreria spinosa Cham. & Schltdl.	HEL
	Borreria verticillata (L.) G.Mey.	HEL
Sphenocleaceae	*Sphenoclea zeylanica* Gaertn.	HEL

Considering that 40 families, 106 genera and 348 species of Eudicotyledons are indicated for the aquatic vegetation in Brazilian flora (Flora do Brasil 2020, continuously updated), the Ceará wetlands are home to 30% of these species. The family with the lowest representativeness was Podostemaceae, with only 5% of the taxon recorded for the Brazilian aquatic vegetation, followed by Rubiaceae, Lythraceae and Fabaceae with 12%, 13% and 25%, respectively (Flora do Brasil 2020, continuously updated).

There are two new records for Ceará state (Flora do Brasil 2020, continuously updated): (1) *Hydrocotyle bonariensis* Lam. (Araliaceae), in temporary streams and permanent coastal lagoons near the metropolitan region; (2) *Malachra fasciata* Jacq. (Malvaceae), in permanent and temporary rivers in the northern part of the state, in weirs in the central part of the state and in temporary lagoons in the southern semiarid.

Regarding growth forms, 64% of the species are helophytes and 20% are bottom-rooted emergent hydrophytes. The helophytes are essentially terrestrial, typically found in marshy environments, where their photosynthetic parts tolerate long periods submerged or floating (Cook 1996). They are different from bottom-rooted emergent hydrophytes, which spend their whole life cycle in aquatic habitats, rooted in submerged substrate and with stems, leaves and inflorescences/flowers emerging above the water lamina (Cook 1996). Helophytes usually present morphological adaptations to the aquatic environment, such as well-developed aerenchyma and profusion of adventitious roots at the base of the stem, associated with an increase in the area of contact with the flooded and unstable soil surface (Sculthorpe 1967).

Higher representativeness of helophytes has already been reported for Northeastern Brazil, including other aquatic angiosperm groups (Moura-Júnior *et al.* 2013), and can be attributed to the fact that they are not limited to water bodies, as they are usually perennial species; while species with growth forms that strictly depend on water bodies in semiarid regions are often annuals with fast life cycles (Cook 1996; Tabosa *et al.* 2012). This is seen in the species of the genus *Borreria* G. Mey (Rubiaceae), which are also treated as selective hygrophytes, as they are found in many wet environments, but are not limited to them (Nepomuceno *et al.* 2018).

The bottom-rooted emergent hydrophytes with floating stems and/or leaves are represented by *Ludwigia helminthorrhiza* (Mart.) H.Hara, *Neptunia oleracea* Lour., *N. plena* (L.) Benth. and *Nymphoides humboldtiana* (Kunth) Kuntze. Moreover, the free-swimming hydrophytes, which are species with no roots or other fixing structures that grow completely submerged (Cook 1996), are represented by *C. demersum*, *Utricularia foliosa* L., *U. gibba* L. and *U. hydrocarpa* Vahl; but only have emerging inflorescences in *Utricularia*. Finally, haptophytes grow attached to rocky substrates under fast-flowing waters (Cook 1996) and are only represented by the Podostemaceae family, with all four species restricted to waterfalls in the highlands of Ceará state.

Taxonomic treatment

Identification key to the aquatic Eudicotyledon families and Ceratophyllaceae of Ceará state, Brazil

1. Hydrophyte free-swimming submerged plants 2
1'. Helophyte, hydrophyte bottom-rooted emergent or haptophyte plants 3
2. Leaves verticillate, without carnivorous traps ..... 7. Ceratophyllaceae
2'. Leaves alternate, with carnivorous traps (utricles) ..... 16. Lentibulariaceae
3. Flowers monochlamydeous (Caryophyllales) 4
3'. Flowers dichlamydeous 6
4. Plants succulent ..... 2. Aizoaceae
4'. Plants not succulent 5
5. Calyx with sepals scarious, hyaline; stamens connate ..... 3. Amaranthaceae
5'. Calyx with sepals membranaceous, opaque; stamens free ..... 26. Polygonaceae
6. Flowers dichlamydeous dialipetalous (Rosids) 7
6'. Flowers dichlamydeous gamopetalous (Asterids) 15
7. Leaves compound 8
7'. Leaves simple 10
8. Plants rheophytes ..... 24. Podostemaceae
8'. Plants bottom-rooted emergent or helophytes 9
9. Fruit silique, flowers tetramerous ..... 8. Cleomaceae
9'. Fruit legume, flowers pentamerous ..... 11. Fabaceae
10. Flowers monoclynous 11
10'. Flowers diclynous 14
11. Plants with latex ..... 10. Euphorbiaceae
11'. Plants without latex 12
12. Flowers solitary, axillary ..... 19. Malvaceae
12'. Flowers in racemose inflorescences 13
13. Leaves opposite ..... 18. Lythraceae
13'. Leaves alternate ..... 25. Polygalaceae
14. Flower perigynous ..... 20. Melastomataceae
14'. Flower epigynous ..... 22. Onagraceae
15. Ovary inferior 16
15'. Ovary superior 19
16. Flowers in capitulum ..... 5. Asteraceae
16'. Flowers in other types of inflorescences or solitary 17
17. Flowers diclinous; leaves peltate ..... 4. Araliaceae
17'. Flowers monoclinous; leaves not peltate 18
18. Leaves with stipules interpetiolar; inflorescence glomerular ..... 27. Rubiaceae

18’. Leaves without stipules; inflorescence spiciform .....28. Sphenocleaceae
19. Leaves subterraneous or submerged, modified into carnivorous traps (utricles or rhizophylls) .... 16. Lentibulariaceae
19’. Leaves aerial, not modified 20
20. Flowers actinomorphic.....21
20’. Flowers zygomorphic.....27
21. Leaves floating; flowers densely fimbriate.....21. Menyanthaceae
21’. Leaves emergent; flowers not fimbriate 22
22. Ovary with placentation apical..... 6. Boraginaceae
22’. Ovary with placentation axial or parietal 23
23. Ovary with placentation parietal .....12. Gentianaceae
23’. Ovary with placentation axial 24
24. Ovary biovulate per locule ..... 9. Convolvulaceae
24’. Ovary pluriovulate per locule.....25
25. Leaves alternate.....14. Hydroleaceae
25’. Leaves opposite or verticillate.....26
26. Flowers in inflorescence cyme scorpioid .....17. Loganiaceae
26’. Flowers solitary or fasciculate.....23. Plantaginaceae
27. Ovary with placentation parietal.....13. Gesneriaceae
27’. Ovary with placentation axial.....28
28. Plants aromatic; fruit schizocarp .....15. Lamiaceae
28’. Plants not aromatic; fruit capsule 29
29. Capsule with funicle ejaculator ....1. Acanthaceae
29’. Capsule without funicle ejaculator ....23. Plantaginaceae

1. Acanthaceae.

Identification key to the Acanthaceae of Ceará state, Brazil

1. Inflorescence cyme; flowers with many bracts and bracteoles; 4 stamens ..... 1.1. *Hygrophila costata*
1’. Inflorescence spiciform; flowers with one bract and two bracteoles; 2 stamens ....1.2. *Justicia laevilinguis*

1.1. *Hygrophila costata* Nees & T.Nees, Pl. Hort. Bonn. Icon. 2: 7-8. 1824. Fig. 1a

Herbs, bottom-rooted emergent hydrophytes, stem quadrangular. Leaves elliptical, base decurrent. Inflorescence cyme, axillary. Flowers white, inner surface glabrous, 4 stamens. This species occurs in sand banks close to lagoons and river springs, only in the southern part of the state.

Selected specimen: Crato, Floresta Nacional do Araripe, 23.V.1999, fl., *A.M. Miranda 3380* (EAC).

1.2. *Justicia laevilinguis* (Nees) Lindau., Bot. Jahrb. Syst. 19 (Beibl. 48): 20. 1894. Fig. 1b

Herbs bottom-rooted emergent hydrophytes, stem quadrangular. Leaves oblong-lanceolate. Inflorescence spiciform, secund, terminal. Flowers lilac with purple and white streaks on the lower corolla lip, two stamens. This species has few records in temporary lagoons and edges of weirs in the state.

Selected specimen: Aiuaba, Lagoa do Rosio, 28.VI.1981, fl. and fr., *P. Martins* (EAC10181).

2. Aizoaceae.

2.1. *Sesuvium portulacastrum* (L.) L., Syst. Nat. 10: 1058. 1759. Fig. 1c

Herbs helophytes, branches incumbent. Leaves coriaceous, opposite, linear or oblanceolate. Flowers lilac. Fruit pyxidium. This species is widely distributed on edges of the coastal lagoons in the state.

Selected specimen: Jijoca de Jericoacoara, APA de Jericoacoara, 7.III.1997, fl. and fr., *L.Q. Matias 16* (EAC).

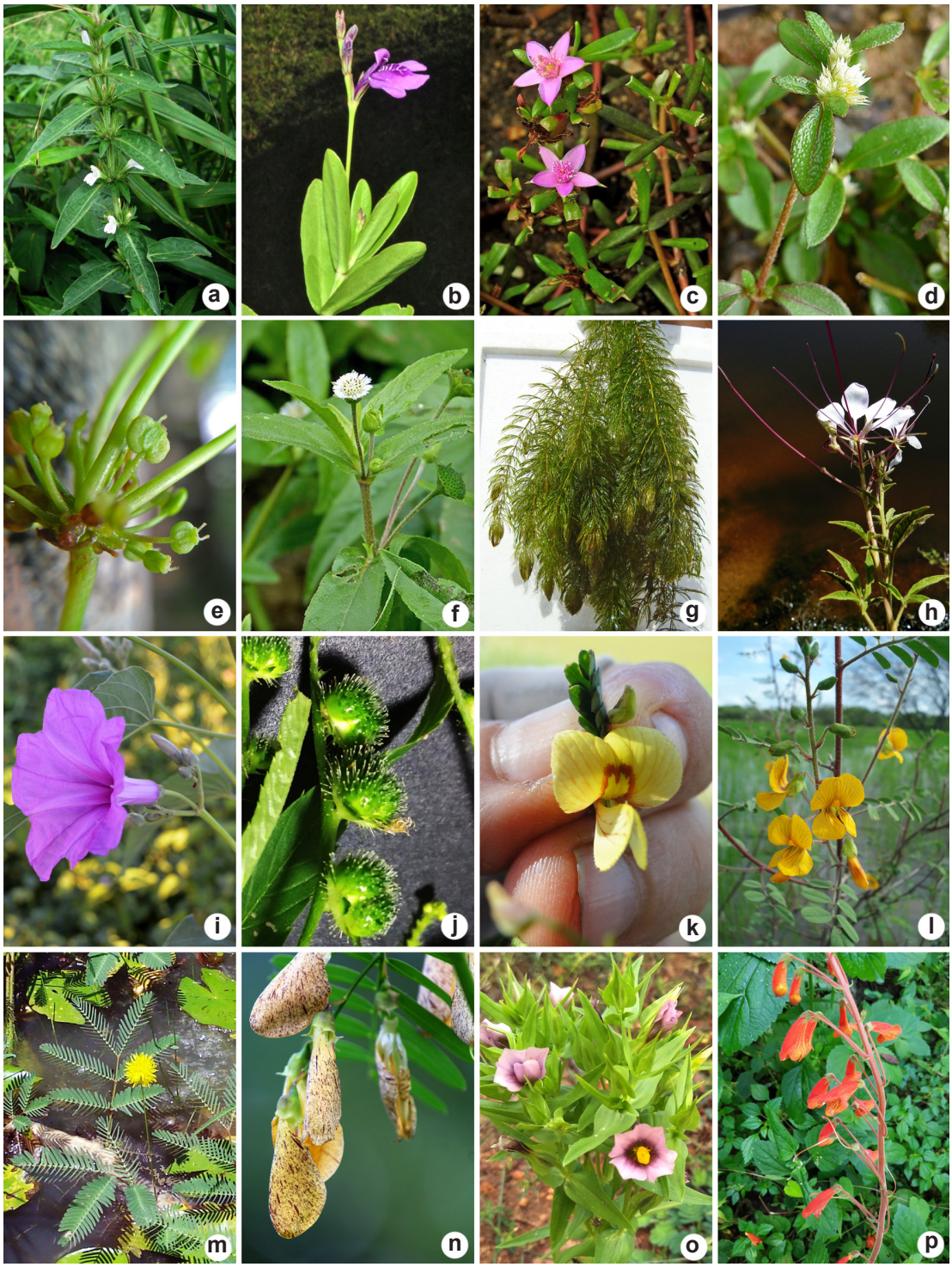

Figure 1 – a. *Hygrophila costata*; b. *Justicia laevilinguis*; c. *Sesuvium portulacastrum*; d. *Alternanthera tenella*; e. *Hydrocotyle bonariensis*; f. *Eclipta prostrata*; g. *Ceratophyllum demersum*; h. *Tarenaya longicarpa*; i. *Ipomoea carnea* subsp. *fistulosa*; j. *Caperonia palustris*; k. *Aeschynomene rudis*; l. *Discolobium hirtum*; m. *Neptunia oleracea*; n. *Sesbania exasperata*; o. *Schultesia guianensis*; p. *Sinningia nordestina*. (a. P. Schwirkowski; b. E.M. Almeida; c,f. A. Netto; d. A. Popovkin; e, g, h, k-m. L.Q. Matias; i. F.D. Santos; j. L.A. Moraes; n. G. Oliveira; o. F. Gomes-Silva; p. H. Redies).

3. Amaranthaceae.

IIdentification key to the Amaranthaceae of Ceará state, Brazil

1. Inflorescence stalked; flowers pedicellate..... 3.1. *Alternanthera brasiliana*
1'. Inflorescence sessile; flowers sessile .....3.2. *Alternanthera tenella*

3.1. *Alternanthera brasiliana* (L.) Kuntze, Revis. Gen. Pl. 2: 537. 1891.

Herbs helophytes, branches erect or prostrate. Inflorescence raceme, globose, stalked. Flowers white, pedicellate. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen:Canindé, Iguaçu, Riacho das Bananeiras, 26.VI.2008, fl. and fr., *M.F. Moro & M.O.T. Menezes 488* (EAC).

3.2. *Alternanthera tenella* Colla, Mem. Reale Accad. Sci. Torino 33: 131. 1828. Fig. 1d

Herbs helophytes, branches decumbent or prostrate. Inflorescence spike, globose, sessile. Flowers white, sessile. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Aiuaba, Estacão Ecológica de Aiuaba, Sítio Olho D'Água, 10.IV.1997, fl. and fr., *L.W. Lima-Verde et. al 680* (EAC).

4. Araliaceae.

4.1. *Hydrocotyle bonariensis* Lam., Encycl. 3: 153. 1783. Fig. 1e

Herbs helophytes, procumbent. Inflorescence umbel. Fruit with base emarginate-cordate. This species is a new record for the state, it occurs in coastal lagoons.

Selected specimen: Caucaia, Lagoa Amarela, 8.V.2011, fl. and fr., *A.S.F. Castro 2479* (EAC).

5. Asteraceae.

5.1. *Eclipta prostrata* (L.) L., Mant. Pl. 2: 286. 1771. Fig. 1f

Herbs helophytes, incumbent. Leaves sessile, entire, decussate, scabrous in both faces. Ray flowers white. Fruit cypsela with alveolate surface, pappus coroniform-fimbriate. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Beberibe, Lagoa do Uruaú, 16.V.2000, fl. and fr., *L.Q. Matias 286* (EAC).

6. Boraginaceae.

Identification key to the Boraginaceae of Ceará state, Brazil

1. Flowers solitary, supra-axillary; schizocarp with 4 nutlets.....6.1. *Euploca lagoensis*
1'. Flowers in scorpioid inflorescences; schizocarp with 2 nutlets .....6.2. *Heliotropium elongatum*

6.1. *Euploca lagoensis* (Warm.) Diane & Hilger, Bot. Jahrb. Syst. 125: 48. 2003. Fig. 2a

Herbs helophytes, branches glabrous or pubescent. Leaves narrowly-elliptical to oblong-elliptical. Flowers solitary, supra-axillary, lacinia elliptical. Fruit schizocarp piriform, four nutlets trigonal. This species occurs on the edges of temporary lagoons and weirs in the southern part of the state.

Selected specimen: Jaguaretama, 9.I.2011, fl., *A.S.F. Castro 2427* (EAC).

6.2. *Heliotropium elongatum* (Lehm.) I.M.Johnst., Contr. Gray Herb. 81: 18. 1928. Fig. 2b

Herbs helophytes. Leaves ovate to rhombic, bullate. Inflorescence scorpioid. Stigma clavate. Fruit schizocarp mitriform, two nutlets slightly bidentate. This species has few records in temporary lagoons in the state.

Selected specimen: Iguatu, 16.V.2010, fl., *L.R.O. Normando 332* (EAC).

7. Ceratophyllaceae.

7.1. *Ceratophyllum demersum* L., Sp. Pl. 2: 992. 1753. Fig. 1g

Herbs submerged free-swimming hydrophytes. Leaves whorled, dichotomously branched, margin serrate. This species is widely distributed in lagoons, weirs and rivers of the state.

Selected specimen: Varjota, Açude Araras, 30.VI.2010, fl. and fr., *J.R.A. Paiva 3* (EAC).

8. Cleomaceae.

8.1. *Tarenaya longicarpa* Soares Neto & Roalson, Syst. Bot. 2019. Fig. 1h

Shrubs helophytes. Leaves alternate, compound 5–7 leaflets, stipules spinose. Flowers white, nectar disk conical, stamens vinaceous, gymnophore elongate. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Iguatu, 13.V.2010, fl. and fr., *L.R.O. Normando 94* (EAC).

9. Convolvulaceae.

Identification key to the Convolvulaceae of Ceará state, Brazil

1. Herbs prostrate; leaves reniform ..... 9.1. *Ipomoea asarifolia*
1'. Shrubs erect; leaves lanceolate ..... 9.2. *Ipomoea carnea* subsp. *fistulosa*

9.1. *Ipomoea asarifolia* (Desr.) Roem. & Schult., Syst. Veg. 4: 251. 1819.

Herbs helophytes, prostrate. Leaves reniform. Inflorescence cyme, axillary. Flowers pink to purple, external sepals smaller than the internal ones. This species is widely distributed on edges of lagoons and weirs in the state.

Selected specimen: Caucaia, Lagamar do Cauípe, 3.XI.2013, fl., *L.Q. Matias 710* (EAC).

9.2. *Ipomoea carnea* subsp. ***fistulosa*** (Mart. *ex* Choisy) D.F.Austin, Taxon 26: 237. 1977. Fig. 1i

Shrubs bottom-rooted emergent hydrophytes. Leaves lanceolate. Inflorescence cyme, terminal. Flowers pale pink, sepals equal in size, rounded. This species has few records in temporary lagoons in the state.

Selected specimen: Iguatu, Lagoa do Saco, 14.V.2010, fl. and fr., *L.R.O. Normando 115* (EAC).

10. Euphorbiaceae.

10.1. *Caperonia palustris* (L.) A. St.-Hil., Hist. Pl. Remarq. Bresil 3-4: 245. 1825. Fig. 1j

Herbs bottom-rooted emergent hydrophytes, stem glandular-pubescent, no prickles. Leaves alternate, lanceolate or narrowly ovate. Flowers white. This species is a new record for the state and has few collections from temporary lagoons and edges of weirs in the state.

Selected specimen: Juazeiro do Norte, Açude dos Carneiros, 13.VI.2015, fl., *A.C. Albuquerque 73* (EAC).

11. Fabaceae.

IIdentification key to the Fabaceae of Ceará state, Brazil

1. Plants with horizontal stems, floating; leaves bipinnate 2
1'. Plants with vertical stems, emergent; leaves imparipinnate 3
2. Petiole with nectary orbicular ..... 11.7. *Neptunia plena*
2'. Petiole without nectary ..... 11.6. *Neptunia oleracea*
3. Fruit moniliform ..... 11.8. *Sesbania exasperata*
3'. Fruit loment 4
4. Loment spiral ..... 11.5. *Discolobium hirtum*
4'. Loment linear 5
5. Loment 1-2 articulate; flowers < 5 mm long ..... 11.2. *Aeschynomene filosa*
5'. Loment 3-14 articulate; flowers > 5 mm long 6
6. Loment articles semiorbicular ..... 11.3. *Aeschynomene rostrata*
6'. Loment articles quadrate 7
7. Leaflet margins serrate-ciliate; standard petal not recurved ..... 11.1. *Aeschynomene evenia*
7'. Leaflet margins entire; standard petal recurved ..... 11.4. *Aeschynomene rudis*

11.1. ***Aeschynomene evenia*** C.Wright, Anales Acad. Ci. Méd. Fís. Nat. Habana 5: 334. 1869.

Shrubs bottom-rooted emergent hydrophytes. Leaflets glabrous, margins serrate-ciliate, stipules peltate. Flowers yellow, standard petal narrowly elliptical, not recurved, apex acute. Fruit loment 6–14 articulate, articles quadrate. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Crato, Lagoa da Cotia, 11.VI.2015, fl., *A.C. Albuquerque 36* (EAC).

11.2. ***Aeschynomene filosa*** Mart. *ex* Benth. in Mart., *Fl. bras.* 15: 61. 1859.

Shrubs bottom-rooted emergent hydrophytes. Leaflets glabrous, margins serrate, stipules peltate. Flowers yellow, standard petal oblong-elliptical, not recurved, apex emarginate. Fruit loment 1–2 articulate, articles orbicular. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Iguatu, 11.V.2015, fl., *L. Ibiapina-Santos 44* (EAC).

11.3. ***Aeschynomene rostrata*** Benth. in Mart., *Fl. bras.* 15(1A): 60. 1859.

Shrubs bottom-rooted emergent hydrophytes. Leaflets glabrescent, margins entire, stipules peltate. Flowers yellow, standard petal orbicular, not recurved, apex emarginate. Fruit loment 3–5 articulate, articles semiorbicular. This species has only two records on edges of weirs in the state.

Selected specimen: Caridade, 25.VII.1988, fl., *E. Nunes* (EAC 15431).

11.4. ***Aeschynomene rudis*** Benth, Pl. Hartw. 116. 1843. Fig. 1k

Shrubs bottom-rooted emergent hydrophytes. Leaflets pubescent, margins entire, stipules subpeltate. Flowers yellow, standard petal orbicular, recurved, apex emarginate. Fruit loment 6–12 articulate, articles quadrate. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Aiuaba, Lagoa do Rosio, 31.V.1984, fl., *E. Nunes* (EAC12645).

11.5. ***Discolobium hirtum*** Benth. in Mart., *Fl. bras.* 15(1A): 73. 1859. Fig. 1l

Shrubs bottom-rooted emergent hydrophytes, branches vinaceous. Leaflets elliptical or obovate, colour of the margins different from the lamina. Flowers yellow, standard petal broadly obovate. Fruit loment spiral, seminiferous region with margin densely tuberculate. This species has few records in temporary lagoons and edges of weirs in the state.

Selected specimen: Caridade, Lagoa Contendas, 21.VI.2008, fl. and fr., *D.J.L. Sousa 7* (EAC).

11.6. ***Neptunia oleracea*** Lour., Fl. Cochinch. 2: 654. 1790. Fig. 1m

Herbs bottom-rooted emergent hydrophytes with floating leaves and/or stems. Petiole without nectary. Flowers heteromorphic, basal ones sterile with staminodes yellow. Fruit oblong, stipitate. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Canindé, 10.VI.2017, fl. and fr., *A.C. Albuquerque 181* (EAC).

11.7. ***Neptunia plena*** (L.) Benth., J. Bot. (Hooker) 4(31): 355. 1842.

Herbs bottom-rooted emergent hydrophytes with floating leaves and/or stems. Petiole with nectary orbicular. Flowers heteromorphic, basal ones sterile with staminodes yellow. Fruit oblong, stipitate. This species is widely distributed in temporary lagoons and edges of weirs in the state, often sympatric with *N. oleracea.*

Selected specimen: Iguatu, Sítio Solidão II, 12.V.2015, fl. and fr., *L. Ibiapina-Santos 78* (EAC).

11.8. ***Sesbania exasperata*** Kunth, Nov. Gen. Sp. (quarto ed.) 6: 534. 1823. Fig. 1n

Shrubs bottom-rooted emergent hydrophytes, branches striate. Leaflets linear, base asymmetric. Flowers yellow, calyx with lacinia triangular, standard petal with vinaceous blotches, keel petal falcate. Fruits moniliform, valve plan. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Iguatu, Lagoa do Baú, 11.V.2015, fl. and fr., *L. Ibiapina-Santos 29* (EAC).

12. Gentianaceae.

12.1. ***Schultesia guianensis*** (Aubl.) Malme, Ark. Bot. 3(12): 9. 1904. Fig. 1o

Herbs helophytes. Leaves lanceolate to linear-lanceolate. Flowers tubular, pink to brownish, pedicels short; calyx winged with lacinia symmetrical, scales membranous-translucent on the inner base of the calyx. This species is widely distributed in the state.

Selected specimen: Caucaia, Lagamar do Cauípe, 4.V.2013, fl. and fr., *D.L.S. Farias 72* (EAC).

13. Gesneriaceae.

13.1. *Sinningia nordestina* Chautems, Baracho & Siqueira Filho, Brittonia 52(1): 50. 2000. Fig. 1p

Herbs helophytes, vestigial tubers. Leaves ovate, pubescent. Flowers tubular, yellow-scarlet, pendant on ascending pedicels. This species is endemic to Northeastern Brazil, occurs on edges of rivers and springs, at high altitudes in the state.

Selected specimen: Ubajara, Parque Nacional de Ubajara, 5.V.2012, fl., *L.Q. Matias 661* (EAC).

14. Hydroleaceae.

14.1. *Hydrolea spinosa* L., Sp. Pl., ed. 2. 1: 328. 1762. Fig. 2c

Herbs helophytes, branches spinose, viscid-glandular. Leaves base cuneate, glandular-pilose. Inflorescence cyme, axillary. Flowers blue or purple. Fruit capsule ovoid. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Iguatu, 14.V.2015, fl. and fr., *L. Ibiapina-Santos 98* (EAC).

15. Lamiaceae.

Identification key to the Lamiaceae of Ceará state, Brazil

1. Inflorescence capituliform, globose; flowers surrounded by involucral bracteoles ..... 15.1. *Hyptis atrorubens*
1'. Inflorescence cyme with a terminal thyrse; flowers with bracteoles inconspicuous, not involucral ..... 15.2. *Mesosphaerum suaveolens*

15.1. *Hyptis atrorubens* Poit., Ann. Mus. Hist. Nat. 7: 466. 1806. Fig. 2d

Herbs helophytes, stems decumbent to erect. Bracts ovate, adpressed, not reflexed in fruits. Flowers white with pink spots, calyx lobes subulate separated by sinuses truncate, stylopodium present. This species occurs in wet areas in the northern part of the state.

Selected specimen: Caucaia, Lagoa da Barro, 5.XI.2006, fl., *A.S.F. Castro 1859* (EAC).

15.2. *Mesosphaerum suaveolens* Kuntze, Revis. Gen. Pl. 2: 525. 1891. Fig. 2e

Herbs or shrubs helophytes, viscous. Bracts leafy, with an axillary cyme. Flowers lilac or white, calyx tubular-campanulate in fruits, slightly compressed, lobes spinose. Fruit nutlet compressed, 2 per flower. This species is widely distributed in the state.

Selected specimen: Iguatu, 16.V.2010, fl. and fr., *L.R.O. Normando 261* (EAC).

16. Lentibulariaceae.

Identification key to the Lentibulariaceae of Ceará state, Brazil

1. Free-swimming submerged hydrophytes 2
1'. Helophytes 4
2. Corolla pink, palate yellow ..... 16.7. *Utricularia hydrocarpa*
2'. Corolla yellow, palate yellow 3
3. Scape inflated; pedicels deflexed in fruit ..... 16.5. *Utricularia foliosa*
3'. Scape not inflated; pedicels ascending in fruit ..... 16.6. *Utricularia gibba*
4. Bracts peltate 5
4'. Bracts basifixed 8
5. All vegetative parts with sticky, viscid-glandular trichomes ..... 16.3. *Utricularia cutleri*
5'. All vegetative parts not sticky, glabrous 6
6. Sepals with nerves prominent; spur twice as long as the lower corolla lip ..... 16.8. *Utricularia pusilla*
6'. Sepals with nerves not prominent or inconspicuous; spur as long as or slightly longer than the lower corolla lip 7
7. Leaves entire; inflorescence geniculate ..... 16.11. *Utricularia subulata*

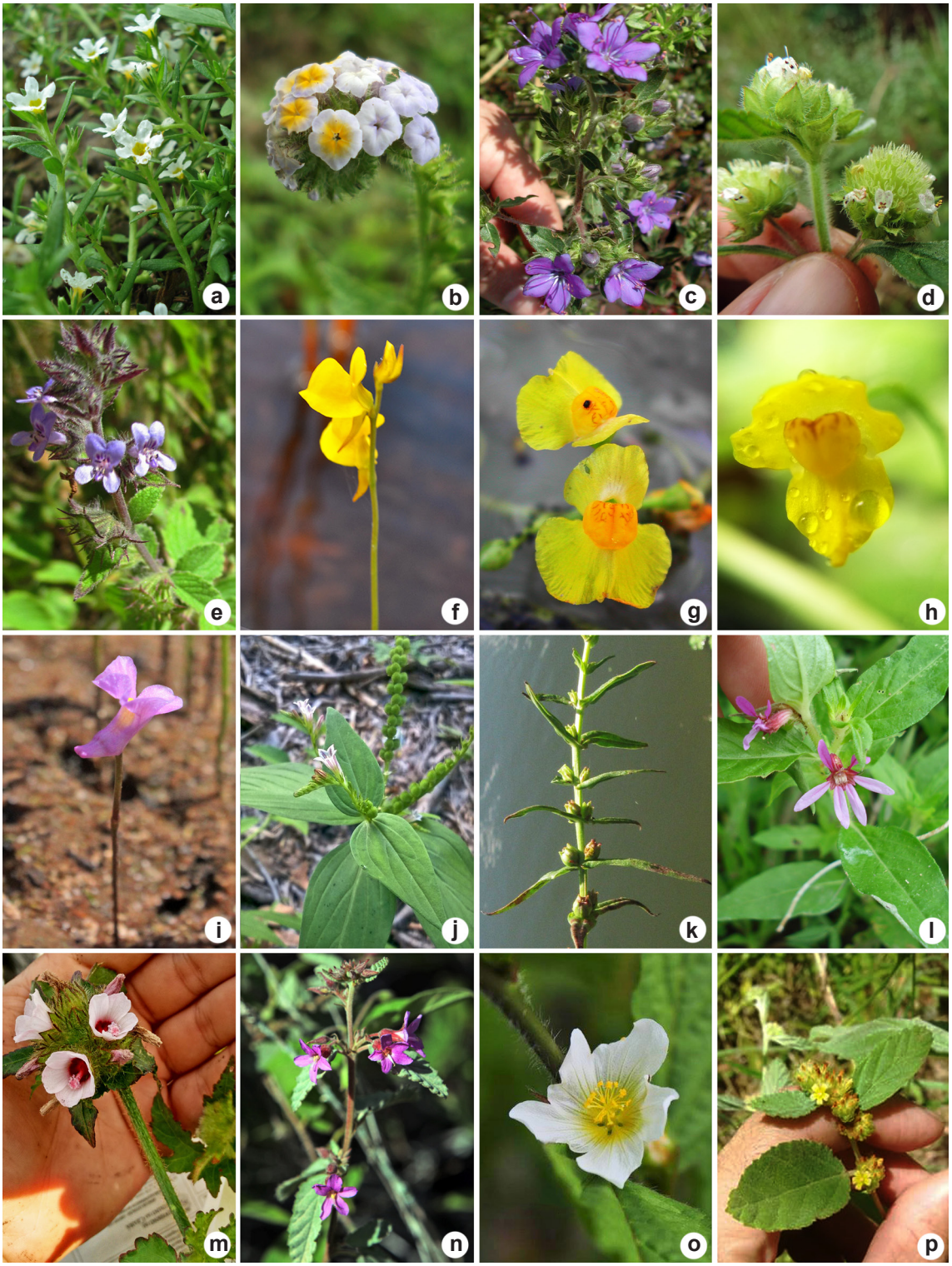

Figure 2 – a. *Euploca lagoensis*; b. *Heliotropium elongatum*; c. *Hydrolea spinosa*; d. *Hyptis atrorubens*; e. *Mesosphaerum suaveolens*; f. *Utricularia cornuta*; g. *U. foliosa*; h. *U. gibba*; i. *U. resupinata*; j. *Spigelia anthelmia*; k. *Ammannia latifolia*; l. *Cuphea campestris*; m. *Malachra radiata*; n. *Melochia tomentosa*; o. *Sida glomerata*; p. *Waltheria indica*. (a-c, l, m. L.Q. Matias; d, p. L.J. Leitão; e. A.J. Hierro; f, g, i. F.M. Guedes; h. H.P. Nascimento; j. A. Macedo; k. V. Sampaio; n. G. Heimen; o. H. Redies).

7’. Leaves pinnatifid; inflorescence straight..... 16.12. *Utricularia trichophylla*
8. Bracts, bracteoles and sepals with margins fimbriate .....16.10. *Utricularia simulans*
8’. Bracts, bracteoles and sepals with margins entire.....9
9. Bracts tubular .....16.9. *Utricularia resupinata*
9’. Bracts not tubular 10
10. Sepals with nerves prominent, ridged; pedicels not winged .....
..... 16.2. *Utricularia cornuta*
10’. Sepals with nerves not prominent; pedicels winged 11
11. Sepals membranaceous, margins plan, nerves conspicuous.....
.....16.1. *Utricularia adpressa*
11’. Sepals coriaceous, margins involute, nerves inconspicuous .....
..... 16.4. *Utricularia erectiflora*

16.1. *Utricularia adpressa* Salzm. *ex* A.St.-Hil. & Girard, Compte Rend. Hebd. Séances Acad. Sci., Ser. D. 7(21): 870. 1838.

Herbs helophytes. Flowers yellow, lower lip galeate, spur longer than the lower lip; pedicels winged; sepal nerves not prominent. This species has only one record in a coastal lagoon in the state.
Selected specimen: Aracati, 3.VIII.1859, fl. and fr., *F.F.A. Cysneiros* (R 3569).

16.2. *Utricularia cornuta* Michx., Fl. Bor. Am. 1: 12. 1803. Fig. 2f

Herbs helophytes. Flowers yellow, lower lip galeate, spur longer than the lower lip; pedicels not winged; sepal nerves prominent, ridged. This species has only one record in a coastal lagoon in the state.
Selected specimen: Jijoca de Jericoacoara, Lagoa de Jijoca, 20.VIII.2000, fl., *L.Q. Matias 311* (EAC).

16.3. *Utricularia cutleri* Steyerm., Bull. Torrey Bot. Club 79: 311. 1952.

Herbs helophytes, all vegetative parts with sticky, viscid-glandular trichomes. Bracts peltate, bracteoles absent. Flowers pale lilac, upper corolla lip triangular, lower lip crenate, spur slightly longer than the lower lip. This species has only two records in coastal lagoons in the state.
Selected specimen: Caucaia, 10.VI.1945, fl. and fr., *H.C. Cutler 8365* (MO).

16.4. *Utricularia erectiflora* A.St.-Hil. & Girard, Compte Rend. Hebd. Séances Acad. Sci., Ser. D. 7(21): 870. 1838.

Herbs helophytes. Flowers yellow, lower lip galeate, spur longer than the lower lip; pedicels winged; sepals coriaceous, nerves inconspicuous, margins involute. This species has few records in coastal lagoons in the state.
Selected specimen: Aquiraz, Lagoa do Tapuio, 14.VIII.2016, fl. and fr., *F.M. Guedes 8* (EAC).

16.5. *Utricularia foliosa* L., Sp. Pl. 1: 18. 1753. Fig. 2g

Herbs free-swimming submerged hydrophytes. Inflorescence scape inflated. Flowers yellow, lower lip bilobed, spur shorter than the lower lip; pedicels deflexed in fruits. This species is widely distributed in temporary/permanent lagoons and weirs in the state.
Selected specimen: Ubajara, 22.VI.2012, fl. and fr., *L.Q. Matias 690* (EAC).

16.6. *Utricularia gibba* L., Sp. Pl. 1: 18. 1753. Fig. 2h

Herbs free-swimming submerged hydrophytes. Inflorescence scape slender. Flowers yellow, corolla lips slightly trilobed, spur shorter than or as long as the lower lip; pedicels ascending in fruits. This species is widely distributed in temporary/permanent lagoons and weirs in the state.
Selected specimen: Caucaia, APA do Lagamar do Cauípe, 16.IV.2016, fl. and fr., *F.M. Guedes 3* (EAC).

16.7. *Utricularia hydrocarpa* Vahl, Enum. 1: 200. 1804.

Herbs free-swimming submerged hydrophytes. Inflorescence scape inflated. Flowers pink, palate yellow, lower lip bilobed, spur shorter than the lower lip; pedicels deflexed in fruits. This species has only one record in a temporary lagoon in the state.
Selected specimen: Caridade, Lagoa de Contendas, 8.III.2009, fl. and fr., *A.B. Tabosa 49* (EAC).

16.8. *Utricularia pusilla* Vahl, Enum. 1: 202. 1804.

Herbs helophytes. Leaves obovate-spatulate. Inflorescence with sterile bracts on the raceme axis.

Bracts peltate, bracteoles absent. Flowers yellow, lower lip trilobed, spur twice as long as the lower lip; sepal nerves prominent. This species has few records in temporary streams in the state.
Selected specimen: Ubajara, Sítio Feiras, 7.VI.2012, fl. and fr., *L.Q. Matias et al. 683* (EAC).

16.9. *Utricularia resupinata* B.D. Greene *ex* Bigelow., Fl. Bost. 3: 10. 1840. Fig. 2i

Herbs helophytes. Leaves cylindrical, articulated. Bracts tubular, bracteoles absent. Flowers solitary, lilac, lower lip resupinate and 3-crenate, spur shorter than the lower lip. This species has only one record in a coastal lagoon in the state.
Selected specimen: Aquiraz, Lagoa do Tapuio, 17.IX.2016, fl., *F.M. Guedes 10* (EAC).

16.10. *Utricularia simulans* Pilg., Not. Bot. Gart. Berl. 6: 194. 1914.

Herbs helophytes. Scales, bracts, bracteoles and sepals with margins fimbriate. Flowers yellow, lower lip orbicular, spur as long as the lower lip. This species has few records in coastal lagoons and streams in the state.
Selected specimen: Aiuaba, Sítio Vale do Boi, 5.IV.2000, fl., *E.B. Souza et al. 510* (EAC).

16.11. *Utricularia subulata* L., Sp. Pl. 1: 18. 1753.

Herbs helophytes. Leaves linear, entire. Inflorescence geniculate. Bracts peltate, bracteoles absent. Flowers yellow, lower lip trilobed, spur longer than the lower lip; sepal nerves not prominent. This species has few records in coastal lagoons and edges of weirs in the state.
Selected specimen: Aquiraz, Lagoa do Tapuio, 14.VIII.2016, fl. and fr., *F.M. Guedes 9* (EAC).

16.12. *Utricularia trichophylla* Spruce *ex* Oliv., J. Proc. Linn. Soc., Bot. 4: 173. 1860.

Herbs helophytes. Leaves linear, pinnatifid. Inflorescence straight. Bracts peltate, bracteoles absent. Flowers yellow, lower lip trilobed, spur as long as the lower lip; sepal nerves inconspicuous. This species has only one record in a temporary stream in the state.
Selected specimen: Ubajara, Sítio Feiras, 7.VI.2012, fl. and fr., *L.Q. Matias 682* (EAC).

17. Loganiaceae.

17.1. *Spigelia anthelmia* L., Sp. Pl. 1: 149. 1753. Fig. 2j

Herbs helophytes, stem fistulous. Leaves verticillate, sparsely scabrous. Inflorescences 3-7 grouped, scorpioid. Flower lilac to whitish, corolla infundibuliform, plicate. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Jaguaribe, Fazenda Mulungú, 8.VI.1943, fl. and fr., *P. Bezerra* (EAC614).

18. Lythraceae.

Identification key to the Lythraceae of Ceará state, Brazil

1. Flowers actinomorphic, campanulate-urceolate, not spurred ..... 18.1. *Ammannia latifolia*
1'. Flowers zygomorphic, tubular, spurred 2
   2. Floral tube densely strigose; ovary gibbous..... 18.2. *Cuphea campestris*
   2'. Floral tube with trichomes only on the nerves; ovary not gibbous ... 18.3. *Cuphea impatientifolia*

18.1. *Ammannia latifolia* L., Sp. Pl. 1: 119. 1753. Fig. 2k

Herbs helophytes. Inflorescences axillary, short pedunculated or sessile. Flowers pale pink or white, calyx lobes mucronate, appendages alternate to the calyx lobes, petals lacking or 1 to 4, stamens included, style thick, shorter than the ovary. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Icapuí, Morro Pintado, 12.X.2011, fl. and fr., *H.H.S. Gonzalez 37* (EAC).

18.2. *Cuphea campestris* Mart. *ex* Koehne in Mart., *Fl. bras.* 13(2): 265. 1877. Fig. 2l

Herbs helophytes. Leaves gradually decreasing in size towards the apex of the plant. Flowers with tube dorsally pink, ventrally green, densely strigose, dorsal petals pink to purple, ventral petals lighter (lilac to white), ovary gibbous. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Caridade, Lagoa Contendas, 21.VI.2008, fl., *D.J.L. Sousa 9* (EAC).

18.3. *Cuphea impatientifolia* A.St.-Hil., *Fl. bras.* Merid. 3: 113. 1833.

Herbs helophytes. Leaves abruptly decreasing in size towards the apex of the plant. Flowers with tube vinaceous, trichomes only on the nerves, petals purple, ovary not gibbous. This species has few records in temporary lagoons and edges of weirs in the state.

Selected specimen: Aiuaba, Lagoa do Rosio, 28.IV.1981, fl. and fr., *P. Martins* (EAC 10162).

19. Malvaceae.

Identification key to the Malvaceae of Ceará state, Brazil

1. Styles and stigmas twice the number of the carpels.....2
1'. Styles and stigmas isomerous with the carpels.....3
2. Epicalyx 9–12-bracteolate.....19.2. *Malachra radiata*
2'. Epicalyx absent.....19.1. *Malachra fasciata*
3. Epicalyx 3-bracteolate.....19.3. *Malvastrum tomentosum*
3'. Epicalyx absent.....4
4. Fruit capsule.....5
4'. Fruit schizocarp.....7
5. Style geniculate at base, fruit 1-carpelar.....19.9. *Waltheria indica*
5'. Style straight, fruit 5-carpelar.....6
6. Leaves glabrous to glabrescent, petiole caniculate.....19.4. *Melochia pyramidata*
6'. Leaves pubescent, petiole terete.....19.5. *Melochia tomentosa*
7. Leaves base cordate; schizocarp with 6–12 mericarps.....19.6. *Sida cordifolia*
7'. Leaves base obtuse; schizocarp with 5 mericarps.....8
8. Leaves alternate distichous; mericarps glabrous.....19.7. *Sida glomerata*
8'. Leaves alternate spiral; mericarps pilose.....19.8. *Sida spinosa*

19.1. *Malachra fasciata* Jacq., Collectanea 2: 352. 1788.

Herbs helophytes. Bracts conduplicate, base cordate or subcordate. Flowers white, axillary, epicalyx absent, sepals long-aristate. This species is a new record for the state, collected in different wet habitats throughout the state.

Selected specimen: Iguatu, 18.V.2010, fl., *L.R.O. Normando 558* (EAC).

19.2. *Malachra radiata* (L.) L., Syst. Nat. (ed. 12) 2: 459. 1767. Fig. 2m

Herbs helophytes. Bracts expanded, base obtuse or rounded. Flowers pink, terminal-, epicalyx 9–12 bracteolate, sepals acute. This species has few records to the southern parts of the state.

Selected specimen: Iguatu, Lagoa do Baú, 11.V.2015, fl., *L. Ibiapina-Santos 34* (EAC).

19.3. *Malvastrum tomentosum* (L.) S.R.Hill, Brittonia. 32: 466. 1981.

Shrubs helophytes. Stipule margins entire. Bracts bifid and bracteoles filiform. Flowers with epicalyx 3-bracteolate, staminal tube pubescent. Fruit mericarp 3-aristate. This species has few records in temporary lagoons and edges of weirs in the state.

Selected specimen: Aiuaba, Estação Ecológica, 22.VI.1982, fl., *F.A. Viana* (EAC 11889).

19.4. *Melochia pyramidata* L., Sp. Pl. 2: 674. 1753.

Herbs helophytes. Leaves glabrous to glabrescent. Inflorescences axillary, cyme glomerular. Flowers lilac. Capsule pyramidal. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Iguatu, 12.V.2015, fl. and fr., *L. Ibiapina-Santos 65* (EAC).

19.5. *Melochia tomentosa* L., Syst. Nat. (ed. 10.) 2: 1140. 1759. Fig. 2n

Herbs helophytes. Leaves pubescent in both faces. Inflorescences axillary, cyme glomerular.

Flowers lilac. Capsule pyramidal. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Crato, Açude Umari, 12.VI.2015, fl., *A.C. Albuquerque 63* (EAC).

19.6. *Sida cordifolia* L., Sp. Pl. 2: 684. 1753.

Herbs helophytes. Leaves base cordate, alternate spiral. Flowers yellow, orangish, pale rose or salmon, styles and stigmas 6–12. Fruit mericarp 6–12, 2-aristate. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Iguatu, 16.V.2010, fl., *L.R.O. Normando 249* (EAC).

19.7. *Sida glomerata* Cav., Diss. 1: 18. 1785. Fig. 2o

Herbs helophytes. Leaves base obtuse, alternate distichous. Inflorescence glomerular, congest, axillary, subsessile. Flowers calyx blackish and indurate in fruit, styles and stigmas 5. Fruit mericarp 5, glabrous, short spinescent. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Iguatu, Baixio dos Bastos, 15.V.2010, fr., *L.R.O. Normando 203* (EAC).

19.8. *Sida spinosa* L., Sp. Pl. 2: 683. 1753.

Herbs helophytes. Leaves base obtuse, alternate spiral, petioles spinose at base. Flowers pale yellow or white, style and stigmas 5. Fruit mericarp 5, pilose, 2-aristate. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Fortaleza, Lagoa da Maraponga, 11.VII.2018, fl. and fr., *V.S. Sampaio 554* (EAC).

19.9. *Waltheria indica* L., Sp. Pl. 2: 673. 1753. Fig. 2p

Shrubs helophytes. Leaves trichomes stellar. Flowers homostyle, ovary 1-carpelar, style geniculate at base. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Iguatu, 15.V.2010, fl. and fr., *L.R.O. Normando 159* (EAC).

20. Melastomataceae.

20.1. *Pterolepis glomerata* (Rottb.) Miq., Comm. Phytogr. 2: 78. 1840. Fig. 3a

Herbs or subshrubs helophytes. Leaves strigose, trichomes simple. Flowers petals 4, hypanthium with vascularized projections branched, stamens dimorphic, anthers 4 yellow and 4 lilac. This species has few records in the on edges of streams and flooded fields in the state.
Selected specimen: Caucaia, APA Lagamar do Cauípe, 21.VII.2008, fl. and fr., *D.J.L. Sousa 23* (EAC).

21. Menyanthaceae.

21.1. *Nymphoides humboldtiana* (Kunth) Kuntze, Revis. Gen. Pl. 1891. Fig. 3b

Herbs bottom-rooted emergent hydrophytes with floating leaves and/or stems. Inflorescence umbella. Flowers white with centre yellow, petals densely fimbriate, anthers sagitate, nigrescent. This species is widely distributed in temporary/permanent lagoons and weirs in the state.
Selected specimen: Beberibe, Lagoa Osório, 2.IX.2014, fl. and fr., *L.Q. Matias 720* (EAC).

22. Onagraceae.

IIdentification key to the Onagraceae of Ceará state, Brazil

1. Plants prostrate; flowers white ..... 22.2. *Ludwigia helminthorrhiza*
1'. Plants erect; flowers yellow 2
2. Flower petals 5 or 6 ..... 22.4. *Ludwigia leptocarpa*
2'. Flower petals 4 3
3. Petals elliptical ..... 22.3. *Ludwigia hyssopifolia*
3'. Petals obovate or orbicular 4
4. Leaves membranaceous; petals obovate 5
4'. Leaves coriaceous; petals orbicular 6
5. Seeds orbicular; raphe inflated ..... 22.6. *Ludwigia octovalvis*
5'. Seeds ovoid; raphe not inflated ..... 22.1. *Ludwigia erecta*
6. Capsule clavate; seeds oblong, extremities curved ..... 22.5. *Ludwigia nervosa*
6'. Capsule obconic; seeds elliptical, extremities not curved ..... 22.7. *Ludwigia tomentosa*

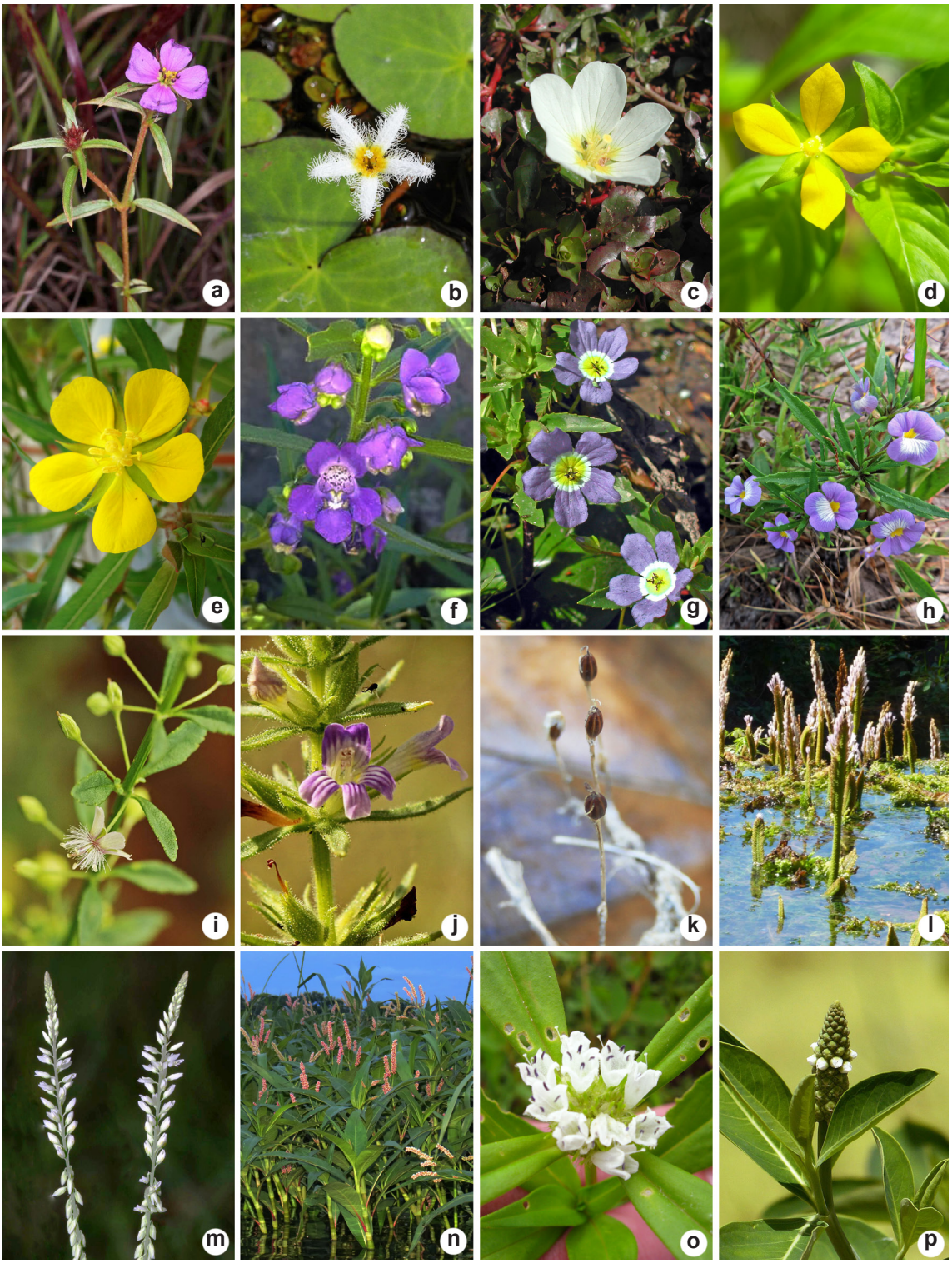

Figure 3 – a. *Pterolepis glomerata*; b. *Nymphoides humboldtiana*; c. *Ludwigia helminthorrhiza*; d. *L. hyssopifolia*; e. *L. leptocarpa*; f. *Angelonia biflora*; g. *Bacopa aquatica*; h. *B. cochlearia*; i. *Scoparia dulcis*; j. *Stemodia durantifolia*; k. *Apinagia riedelii*; l. *Mourera fluviatilis*; m. *Polygala appendiculata*; n. *Polygonum acuminatum*; o. *Borreria scabiosoides*; p. *Sphenoclea zeylanica*. (a. M. Mercadante; b, n. F.M. Guedes; c-e. H.P. Nascimento; f. M. Branco; g, k, o. L.Q. Matias; h. L.J. Leitão; i. M. Vandenberghe; j. H. Redies; l, p. A. Netto).

22.1. *Ludwigia erecta* (L.) H.Hara, J. Jap. Bot. 28: 292. 1953.

Herbs or shrubs helophytes, erect. Leaves membranaceous. Flowers yellow, petals 4, obovate. Capsule cylindrical. Seeds ovoid, raphe not inflated. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Missão Velha, 23.V.2017, fl. and fr., *H.P. Nascimento 7* (EAC).

22.2. *Ludwigia helminthorrhiza* (Mart.) H.Hara, J. Jap. Bot. 28: 292. 1953. Fig. 3c

Herbs bottom-rooted emergent hydrophytes with floating leaves and/or stems, prostrate. Leaves subcoriaceous. Flowers white, petals 5, obovate. Capsule cylindrical. Seeds ovoid, raphe not inflated. This species is widely distributed in temporary/permanent lagoons and edges of weirs in the state.
Selected specimen: Várzea Alegre, Lagoa Azul, 10.VI.2015, fl., *A.C. Albuquerque et al. 19* (EAC).

22.3. *Ludwigia hyssopifolia* (G.Don) Exell, Garcia de Orta 5: 471. 1957. Fig. 3d

Herbs or shrubs helophytes, erect. Leaves membranaceous. Flowers yellow, petals 4, elliptical. Capsule cylindrical. Seeds ovoid, raphe not inflated. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Missão Velha, 23.V.2017, fl. and fr., *H.P. Nascimento 8* (EAC).

22.4. *Ludwigia leptocarpa* (Nutt.) H.Hara, J. Jap. Bot. 28: 292. 1953. Fig. 3e

Herbs or shrubs helophytes, erect. Leaves membranaceous. Flowers yellow, petals 5-6, obovate. Capsule cylindrical. Seeds ovoid, embedded in horseshoe-shaped endocarp, raphe not inflated. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Caucaia, Lagamar do Cauípe, 16.IV.2016, fl., *H.P. Nascimento 2* (EAC).

22.5. *Ludwigia nervosa* (Poir.) H.Hara, J. Jap. Bot. 28: 293. 1953.

Herbs or shrubs helophytes, erect. Leaves coriaceous. Flowers yellow, petals 4, orbicular. Capsule clavate. Seeds oblong, extremities curved, raphe not inflated. This species has only one record in the southern part of the state.
Selected specimen: Serra do Araripe, 1838, bud. and fr., *G. Gardner 1598* (IPA).

22.6. *Ludwigia octovalvis* (Jacq.) P.H.Raven, Kew Bull. 15(3): 476. 1962.

Herbs or shrubs helophytes, erect. Leaves membranaceous. Flowers yellow, petals 4, obovate. Capsule cylindrical. Seeds orbicular, raphe inflated. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Jijoca de Jericoacoara, 5.V.2000, fl. and fr., *L.Q. Matias 261* (EAC).

22.7. *Ludwigia tomentosa* (Cambess.) H.Hara, J. Jap. Bot. 28: 294. 1953.

Herbs or shrubs helophytes, erect. Leaves coriaceous. Flowers yellow, petals 4, orbicular. Capsule obconic. Seeds elliptical, raphe not inflated. This species has only one record in the southern part of the state.
Selected specimen: Jardim, 1838, fl. and fr., *G. Gardner 1949* (IPA).

23. Plantaginaceae.

Identification key to the Plantaginaceae of Ceará state, Brazil

1. Sepals unequal 2
1'. Sepals equal 5
    2. Leaves obovate ..... 23.5. *Bacopa monnieri*
    2'. Leaves linear to linear-lanceolate 3
        3. Dorsal sepal cochleariform ..... 23.4. *Bacopa cochlearia*
        3'. Dorsal sepal plan 4
            4. Stems quadrangular, narrowly winged ..... 23.2. *Bacopa angulata*
            4'. Stems cylindrical, not winged ..... 23.3. *Bacopa aquatica*
                5. Corolla bigibbous ..... 23.1. *Angelonia biflora*
                5'. Corolla not gibbous 6
                    6. Corolla tetramerous, rotaceous ..... 23.6. *Scoparia dulcis*
                    6'. Corolla pentamerous, bilabiate 7

7. Flowers in inflorescences, spiciform, terminal ..... 23.7. *Stemodia durantifolia*
7'. Flowers solitary, axillary 8
8. Bracteoles present ..... 23.9. *Stemodia maritima*
8'. Bracteoles absent ..... 23.8. *Stemodia foliosa*

23.1. ***Angelonia biflora*** Benth., Prodr. 10: 254. 1846. Fig. 3f

Herbs helophytes. Inflorescence with some flowers geminate. Bracts foliaceous, falcate to subfalcate. Flowers with corolla bigibbous. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Aiuaba, Lagoa do Rosilho, 28.IX.1998, fl. and fr., *I.M. Andrade 281* (EAC).

23.2. ***Bacopa angulata*** (Benth.) Edwall, Bolm. Comiss. Geogr. São Paulo 13: 176. 1897.

Herbs bottom-rooted emergent hydrophytes. Stems quadrangular, winged. Leaves linear to linear-lanceolate. Flowers purple or white, dorsal sepal plan, ovate. This species has few records in temporary lagoons and flooded fields in the state.
Selected specimen: Caucaia, Lagamar do Cauípe, 4.V.2013, fl., *D.L.S. Farias 61* (EAC).

23.3. ***Bacopa aquatica*** Aubl.Hist. Pl. Guiane 1: 129. 1775. Fig. 3g

Herbs bottom-rooted emergent hydrophytes. Stems cylindrical, not winged. Leaves linear to linear-lanceolate. Flowers pale lilac or white with a yellow centre, dorsal sepal plan, ovate. This species has few records in temporary lagoons, rivers and flooded fields in the state.
Selected specimen: Caridade, Lagoa Contendas, 23.V.2009, fl. and fr., *A.B. Tabosa 41* (EAC).

23.4. ***Bacopa cochlearia*** (Huber) L.B.Sm., Contr. Gray Herb. 117: 38. 1937. Fig. 3h

Herbs bottom-rooted emergent hydrophytes. Stems quadrangular, not winged. Leaves linear to linear-lanceolate. Flowers rose pink, dorsal sepal cochleariform. This species is assessed as Endangered (Kutschenko 2013), endemic to coastal lagoons and rivers of the state.
Selected specimen: Eusébio, Rio Pacoti, 9.VIII.2001, fl., *A.S.F. Castro 1010* (EAC).

23.5. ***Bacopa monnieri*** (L.) Wettst., Nat. Pflanzenfam. 67: 77. 1891.

Herbs bottom-rooted emergent hydrophytes. Stems cylindrical, not winged. Leaves obovate. Flowers lilac or white, dorsal sepal plan, ovate. This species has few records in permanent coastal lagoons in the state.
Selected specimen: Caucaia, Lagamar do Cauípe, 27.IV.2013, fl. and fr., *D.L.S Farias 36* (EAC).

23.6. ***Scoparia dulcis*** L., Sp. Pl. 1: 116. 1753. Fig. 3i

Herbs helophytes. Stems quadrangular, glabrous, sparsely glandular-punctate. Flowers tetramerous, corolla white or pale lilac, rotaceous, with a tuft of trichomes. This species is widely distributed in temporary/permanent lagoons and edges of weirs in the state.
Selected specimen: Beberibe, Lagoa de Uruaú, 16.V.2000, fl., *L.Q. Matias 277* (EAC).

23.7. ***Stemodia durantifolia*** (L.) Sw., Observ. Bot. 240. 1791. Fig. 3j

Herbs helophytes, erect to ascending. Leaves sparsely glandular-pubescent. Bracteoles absent. Flowers sessile, in inflorescences, spiciform, terminal. This species has few records in temporary lagoons, riverbanks and weirs in the state.
Selected specimen: Iguatu, 13.V.2010, fl. and fr., *L.R.O. Normando 82* (EAC).

23.8. ***Stemodia foliosa*** Benth., J. Bot. (Hooker) 2: 46. 1840.

Herbs helophytes, erect. Leaves sparsely glandular-pubescent. Bracteoles absent. Flowers pedicellate, solitary, axillary. This species is widely distributed in the state.
Selected specimen: Crato, Açude Umari, 12.VI.2015, fl., *A.C. Albuquerque 49* (EAC).

23.9. ***Stemodia maritima*** L., Syst. Nat. (ed. 10) 2: 1118. 1759.

Herbs helophytes, prostrate or decumbent. Leaves pubescent. Bracteoles present. Flowers solitary, axillary, sessile. This species is widely distributed in temporary lagoons and edges of weirs in the state.
Selected specimen: Ipu, Rio Acaraú, 13.XI.2010, fl., *J.R.A. Paiva 15* (EAC).

24. Podostemaceae.

Identification key to the Podostemaceae of Ceará state, Brazil

1. Leaves tristichous; flowers surrounded by membranous leaves ..... 24.4. *Tristicha trifaria*
1'. Leaves not tristichous; flowers surrounded by spathellae 2
    2. Leaves with papillae on the adaxial surface ..... 24.3. *Mourera fluviatilis*
    2'. Leaves without papillae 3
        4. Fruit with valves 3-ribbed, one long and two short ..... 24.1. *Apinagia richardiana*
        4'. Fruit with vales 3-ribbed, all long ..... 24.2. *Apinagia riedelii*

24.1. ***Apinagia richardiana*** (Tul.) P.Royen, Meded. Bot. Mus. Herb. Rijks Univ. Utrecht 107: 44. 1951.

Herbs haptophytes. Leaves pinnatilobed, elliptical or rhomboid, nerves prominent. Flowers axillary, tepals 4–10, stamens 2–6, staminodes 3–7, ovary ribs inconspicuous. Fruit elliptical, valves 3-ribbed, one long and two short. This species has two records in streams at high altitudes in the state.
Selected specimen: Serra de Baturité, 19.VIII.1937, fl. and fr., *J. Eugenio 702* (RB).

24.2. ***Apinagia riedelii*** (Bong.) Tul., Ann. Sci. Nat. Bot. sér. 3, 9: 98. 1849. Fig. 3k

Herbs haptophytes. Leaves pinnate, distal segments filiform. Flowers axillary or terminal, tepals 3–4, stamens 2, staminodes 8, ovary 8-ribbed, conspicuous. Fruit elliptical, valves 3-ribbed, all long. This species is a new record for the state, collected in a stream at high altitude.
Selected specimen: Ubajara, Parque Nacional de Ubajara, Cachoeira Rio das Minas, 5.V.2012, fl., *L.Q. Matias 671* (EAC).

24.3. ***Mourera fluviatilis*** Aubl., Hist. Pl. Guiane 1: 582. 1775. Fig. 3l

Herbs haptophytes. Leaves cuneiform with papillae on the adaxial surface, apex irregularly divided. Inflorescence spiciform. Flowers lilac, tepals 10–30. This species has only one record in a stream at high altitudes in the state.
Selected specimen: Ubajara, Cachoeira do Boi Morto, 23.IX.1978, fl., *A. Fernandes* (EAC 5022).

24.4. ***Tristicha trifaria*** (Bory *ex* Willd.) Spreng., Syst. Veg. 16: 1-22. 1824.

Herbs haptophytes, prostrate. Leaves tristichous. Flowers axillary or terminal, surrounded by membranous leaves, tepals 3. This species has few records in streams at high altitudes in the state.
Selected specimen: Redenção, 13.IX.1935, fl., *F.E. Drouet 2735* (US).

25. Polygalaceae.

25.1. ***Polygala appendiculata*** Vell.-Fl. Flumin. 292. 1829. Fig. 3m

Herbs helophytes, glabrous. Inflorescence raceme spiciform. Seeds obovate, without appendages, without a crown of trichomes at the base. This species has few records in coastal lagoons in the state.
Selected specimen: Caucaia, APA Lagamar do Cauipe, 29.X.2000, fl., *D.J.L. Sousa 60* (EAC).

26. Polygonaceae.

Identification key to the Polygonaceae of Ceará state, Brazil

1. Ochrea apex foliaceous, revolute ..... 26.3. *Polygonum hispidum*
1'. Ochrea apex truncate, not revolute 2
    2. Plant pubescent; perianth accrescent, not glandular ..... 26.1. *Polygonum acuminatum*
    2'. Plant glabrous; perianth not accrescent, glandular ..... 26.2. *Polygonum ferrugineum*

26.1. ***Polygonum acuminatum*** Kunth, Nov. Gen. et Sp. Pl. 2: 178. 1817. Fig. 3n

Herbs or subshrubs bottom-rooted emergent hydrophytes, pubescent or strigose. Ochrea greenish, margins strigose, apex truncate, not revolute. Flowers perianth accrescent, not glandular. This species has only two records in permanent lagoons at high altitudes in the state.
Selected specimen: Ubajara, Lagoa do Poço, 7.XI.2007, fl. and fr., *L.Q. Matias 539* (EAC).

26.2. *Polygonum ferrugineum* Weddell., Ann. Sci. Nat. 3, 13: 252. 1849.

Herbs or subshrubs bottom-rooted emergent hydrophytes, glabrous. Ochrea ferruginous, margins glabrous, apex truncate, not revolute. Flowers perianth not accrescent, glandular. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Juazeiro do Norte, 13.VI.2015, fl., *A.C. Albuquerque 80* (EAC).

26.3. *Polygonum hispidum* Kunth, Nov. Gen. Sp. Pl. 2: 178. 1817.

Herbs or subshrubs bottom-rooted emergent hydrophytes, hispid. Ochrea greenish, margins hispid, apex foliaceous, revolute. Flowers perianth, not accrescent, not glandular. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Várzea Alegre, Lagoa Azul, 10.VI.2015, fl. and fr., *A.C. Albuquerque 14* (EAC).

27. Rubiaceae.

Identification key to the Rubiaceae of Ceará state, Brazil

1. Leaves opposite; brachiblasts absent ..... 27.1. *Borreria scabiosoides*
1'. Leaves pseudoverticillate; brachiblasts present 2
   2. Glomerules globose; calyx lobes spatulate ..... 27.3. *Borreria verticillata*
   2'. Glomerules hemispherical; calyx lobes narrowly triangular ..... 27.2. *Borreria spinosa*

27.1. *Borreria scabiosoides* Cham. & Schltdl., Linnaea 3: 318. 1828. Fig. 3o

Herbs helophytes, decumbent. Leaves opposite, brachiblasts absent. Inflorescence glomerular, the terminal one hemispherical. Flowers with calyx lobes triangular. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Iguatu, 17.V.2010, fl., *L.R.O Normando 529* (EAC).

27.2. *Borreria spinosa* Cham. & Schltdl. *ex* DC., Prodr. 4: 542. 1830.

Herbs helophytes, erect. Leaves pseudoverticillate, brachiblasts present. Inflorescence glomerular, the terminal ones hemispherical. Flowers with calyx lobes spatulate, glabrescent. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Ubajara, Parque Nacional de Ubajara, 3.VIII.2011, fl., *E.K.S. Brandão et al. 53* (EAC).

27.3. *Borreria verticillata* (L.) G.Mey., Prim. Fl. Esseq. 83. 1818.

Subshrubs helophytes, ascending. Leaves pseudoverticillate, brachiblasts present. Inflorescence glomerular, the terminal ones globose. Flowers with calyx lobes narrowly triangular, pilose. This species is widely distributed in temporary lagoons and edges of weirs in the state.

Selected specimen: Jijoca de Jericoacoara, Lagoa do Meio, 5.V.2000, fl., *L.Q. Matias 238* (EAC).

28. Sphenocleaceae.

28.1. *Sphenoclea zeylanica* Gaertn., Fruct. Sem. Pl. 1: 113. 1788. Fig. 3p

Subshrubs helophytes. Stems fistulose. Inflorescence spiciform, fusiform, terminal. Flowers sessile, white, pentamerous, tubular. This species is exotic and has records in coastal lagoons in the state.

Selected Specimen: Iguatu, Lagoa do Saco, 14.V.2010, fl., *L.R.O. Normando 126* (EAC).

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