



Original Paper

Flora of Ceará, Brazil: Cabombaceae

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Abstract

The present study analyzed taxa of the family Cabombaceae occurring in the state of Ceará. Only *Cabomba* species was represented, with *C. aquatica* and *C. haynesii* recorded in the state. Populations occur in permanent and temporary lentic environments, such as lagoons and shores of lotic systems. This work presents taxon identification keys, morphological descriptions, illustrations, comments and geographic distribution data.

Key words: aquatic plants, arid regions, Nymphaeales, wetlands.

Resumo

O presente estudo analisou os táxons da família Cabombaceae que ocorrem no estado do Ceará. Somente espécies de *Cabomba* foram representados, com *C. aquatica* e *C. haynesii* tiveram registros para o estado. As populações ocorrem em ambientes lênticos permanentes e temporários como lagoas e margens de sistemas lóticos. Este trabalho apresenta chaves de identificação dos táxons, descrições morfológicas, ilustrações, comentários e dados de distribuição geográfica.

Palavras-chave: plantas aquáticas, regiões áridas, Nymphaeales, áreas inundadas.

Introduction

The aquatic environments in the state of Ceará are temporary or permanent, with significant species richness, including representatives of Alismataceae with 13 species (Matias & Souza 2011), Araceae with 7 spp. (Andrade *et al.* 2013), Hydrocharitaceae with 9 spp. (Matias *et al.* 2017) and Pontederiaceae with 10 spp. (Souza *et al.* 2018), in addition to the marine phanerogams that are represented by 3 species (Matias *et al.* 2017). Eudicotyledoneae include approximately 130 aquatic taxa present in the state. Among the basal groups, the order Nymphaeales has only Nymphaeaceae and Cabombaceae with representatives in Brazil, with seven species of *Nymphaea* described for the Ceará state (Souza & Matias 2013) and with an indication for the occurrence of 3 species of *Cabomba* (Pellegrini 2020).

In natural environments, populations of *Cabomba* cover tropical and warm temperate climate zones of the Neotropics, in lentic or lotic, alkaline or acidic environments, and whose seasonality does not imply a limiting factor since the populations are adapted to conditions of water fluctuation and feature rapid growth during the rainy season (Ørgaard 1991). *Cabomba* species can develop in eutrophic, aquatic environments (Huang *et al.* 2017) as well as contaminated waters; therefore, they are commonly studied for potential use in phytoremediation systems of pesticides and heavy metals (Olette *et al.* 2008). Furthermore, *Cabomba* populations are reported as biotic agents causing changes in aquatic communities in regions of North America where their introduction has occurred (Hogsden *et al.* 2007) and, on the Australian continent, control measures have been employed in vulnerable environments (Biosecurity Act 2014).

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Cabombaceae has been positioned in a monophyletic group with Nymphaeaceae, and apomorphies of Cabombaceae include alternate phyllotaxis of floating leaves, placement of submerged leaves and presence of hairs on emergent surfaces of the leaves or petioles (Taylor 2008). Pollination systems are diverse in Cabombaceae, with fly pollination present in *Cabomba* species, while anemophily arose recently in *Brasenia*; this implies the development of an apomorphic stylar extension, which in *Brasenia* became greatly elongated to produce a much larger stigmatic surface, in addition to different patterns of pollen-tube development and fertilization (Taylor & Williams 2009). Bee pollination was reported by Vogel (1998).

The species of Cabombaceae can be identified by stems with dimorphic leaves characterized by floating, entire, peltate leaves and submerged, divided leaves with linear lobes. The trimerous perianth, monocolpate pollen, apocarpous gynoecium and two, connate cotyledons are also diagnostic characters of Cabombaceae (Simpson 2010).

Five species of Cabombaceae occur in Brazil: *C. aquatica* Aubl., *C. caroliniana* A. Gray, *C. furcata* Schult. & Schult., *C. haynesii* Wiersema and *C. schwartzii* Rataj (Pellegrini 2019). All species ranging from North through South of Brazil, except *C. schwartzii* that is an endemic species from Amazon region (Pellegrini 2019). There are floristic surveys of Rio de Janeiro (Correia & Bove 2017), Bahia (Lima *et al.* 2012), São Paulo (Feres & Amaral 2003), and the State with the highest number of species is Bahia (4 spp.). This work aims for a floristic study of Cabombaceae of Ceará state in order to update geographic distribution and to provide morphological and taxonomic data to improve the knowledge about the Brazilian flora.

Materials and Methods

For the floristic survey, we collected information on samples collected from 2000 to 2018 and deposited in the EAC Herbarium (Prisco Bezerra Herbarium) as well as from records of the speciesLink database (CRIA 2001, ongoing) and the Reflora-Virtual Herbarium (2018). Specialized journal articles, such as Ørgaard (1991) and Jacobsen & Ørgaard (1989) were consulted to identify the botanical specimens. The description of Cabombaceae as a whole follows Wiersema (1997) and genus follows Fassett (1953) and Ørgaard (1991). The scientific plant names are in conformity with the International Plant Names Index

- IPNI (continuously updated). The morphological terms follow Radford *et al.* (1974). The geographic distribution map was elaborated using QGIS 3.2.3 based on data of samples from wetlands located within the coordinates 02°46'–07°52'S and 37°14'–41°26'W (IPECE 2017).

Results and Discussion

The species *C. aquatica* and *C. haynesii* occur in Ceará state and their populations are common in coastal lentic environments, reservoirs and pools of the semiarid region. The indication of occurrence of *Cabomba caroliniana* A.Gray var. *caroliniana* (Pellegrini 2019) to Ceará state was not confirmed, as there are until now no records in the speciesLink database and Reflora-Virtual Herbarium.

Taxonomy

Cabombaceae Rich. ex A.Rich. - Dict. Class. Hist. Nat. [Bory] 2: 608. 1822 [31 Dec 1822]; nom. cons.

Aquatic plants, bottom-rooted emergent, perennials, rhizomatous. Adventitious roots at proximal stem sections, air chambers conspicuous in vegetative portions of plant. Rhizomes branched, slender. Leaves arising from erect stems, submersed and floating, stipules absent, laticifers commonly present. Submersed leaves (*Cabomba*) opposite or whorled, palmately dissected. Floating leaves alternate, peltate, linear to broadly elliptic, sometimes with sagittate base (*Cabomba*), margins entire. Inflorescences distal on the emergent shoot, cymoses. Flowers monoclinal, protogynous, diurnal, borne at or above water surface; perianth usually trimerous, petals alternate with sepals, persistent in fruit; androecium with 3–36 stamens, rarely more; anthers with longitudinal dehiscence; gynoecium 1–2–18-carpellate, inversely club-shaped or swollen on one side; ovary 1-locular; placentation laminar; 1-pluriovulate; stigma capitate or linear-decurrent. Fruit an aggregate of achenes or follicles, leathery. Seeds without aril, endosperm sparse, perisperm abundant, embryo minute, 2-cotyledons.

Cabombaceae is represented in Brazil by aquatic herbs of the genera *Cabomba* Aubl. (BFG 2015, 2018). In addition, the fossil taxon *Pluricarpellatia peltata* B. Mohr, Bernardes-de-Oliveira & David W. Taylor has been found in southern Ceará in the Crato Formation (Mohr *et al.* 2008). *Brasenia* and *Cabomba* diverged in the Cretaceous Period about 31–10 mya (Bell *et al.* 2010) or 109–52 mya (Wikström *et al.* 2001), while *Pluricarpellatia* is estimated to have lived 115 mya

(Mohr *et al.* 2008). The monotypic genus *Brasenia* (*B. schreberi* J.F.Gmel.) is spread across temperate and tropical regions of Africa, Asia, Australia and North America, while *Cabomba* species can be found throughout the Neotropics (Cook 1996). Only one genus and total five species and two varieties in the Brazilian flora and four taxa are indicated to the Brazilian Northeast (Pellegrini 2019).

Cabomba Aubl., Hist. Pl. Guiane 1: 321, t. 124. 1775.

Herbs with stems smooth, slender, incumbent and emergent along the apical region, terete, submerged surfaces of stems with a thin, mucilaginous layer, emergent segments are pubescent at nodes. Leaves dimorphic, opposite, whorled or alternate, petiolate, glabrous to pubescent, green to red; submersed leaves rounded to depressed-ovate, palmatisect with 3–7 primary branches, each primary branch divided into di-trichotomous segments, terminal segments linear, oblong or spatulate, apex mucronate; floating leaves peltate, rounded, wide-ovate, elliptical, trullate, sagittate or linear, red to green. Inflorescences cymose, emergent; flowers axillary. Flowers actinomorphic, pedicellate, floating before anthesis, emergent at anthesis and submerged post-anthesis; pedicels pubescent, growing post-anthesis, inflexed or reflexed in fruit; sepals 3,

petaloid, elliptical, oblong or obovate, the base cuneate, the apex acute, rounded or emarginate, persistent in fruit; petals 3, unguiculate, oblong, spatulate, obovate, elliptical, with a couple of marginal appendices or lobes, including a yellow spot and internal nectaries near the base, apex acute to rounded, persistent in fruit; stamens 3–6, free, filaments laminar, glabrous, anthers basifixed, oblong, thecae 2, dehiscence longitudinal; gynoecium apocarpous, carpels 2–4, unilocular, ovules 1–5, placentation laminar, style short, stigma capitate and papillose. Fruit an aggregate of achenes, oblong to ovoid, rostrum apical. Seeds globose, elliptical or oblong. Seeds globose, ellipsoid or oblong, surface tuberculate.

A diagnostic character of *Cabomba* flowers is a couple of yellow spots with nectariferous glands on the basal lobes of white or yellow petals (Erbar 2014), while *Brasenia* has purple petals without lobes (Wiersema 1997). In addition, *Cabomba* has dissected submersed leaves and linear-elliptic floating leaves, their submersed parts are barely coated with mucilage; while *Brasenia* possesses only entire, broadly elliptic floating leaves and their submersed parts are heavily coated with mucilage (Wiersema 1997). Diptera, mainly flies (Schneider & Jeter 1982), and bees (Vogel 1998) are the pollinators of flowers of *Cabomba*.

Taxonomic identification key to species Cabombaceae do Ceará

1. Submerged leaves palmatisect with divisions three-dimensionally ramified, emergent leaves wide-elliptical to oval; flowers yellow 1. *Cabomba aquatica*
- 1'. Submerged leaves palmatisect with divisions in one plane, emergent leaves narrow elliptical to sagittate; flowers white to pale pink 2. *Cabomba haynesii*

1. *Cabomba aquatica* Aubl., Hist. Pl. Guiane 1: 321. 1775. Fig. 1a-d

Submerged leaves opposite, reniform to ovate, 2–2.5 × 3–3.5 cm, palmatisect, three-dimensionally ramified, segments with acute apex, petiole glabrous, 1–2.3 mm long; floating leaves peltate, elliptical to oval, 1.4–2.5 × 1.2–2.2 cm, petiole pubescent, 1–2.3 cm long. Flowers 1.5–2.3 cm diam., pedicel 1.5–4 cm long; sepals yellow, 6–8 × 3–5 mm, oblong to elliptical, base trullate, apex rounded; petals yellow, 8–5 × 5–7 mm, elliptical to spatulate, base lobed, lobes ca. 0.8 mm long, apex rounded; stamens 6, filaments 1.5–2 mm long, straight, anther 0.5–0.7 mm long, oblong; carpels 2, 6–8 mm long. Achene ca. 3 mm long.

Material examined: Aquiraz, Lagoa do Catú, 11.X.2011, fl., *LQ Matias et al. 614* (EAC). Fortaleza, Parque do Cocó, trilha das ninféias, 7.VIII.2011, fl. and fr., *LQ Matias 605* (EAC). Iguatu, lagoa do paredão, 15.V.2019, *LRO Normando et al. 179* (EAC). Trairi, Rio Trairi, 14.IV.2006, fl., *ASF Castro 1729* (EAC). Paraipaba, 25.I.1996, *ASF Castro 94* (EAC).

Cabomba aquatica can be identified by its rounded, emergent leaves and inflorescences with bright yellow flowers. The species occurs in all states of the Brazilian North and Northeast, as well as in the Southeast (Rio de Janeiro, Espírito Santo, São Paulo) and South (Paraná) (Pellegrini 2020). Populations occur in several wetlands situated in the shoreline region, such as lagoons and “lagamares” (lentic environments formed by

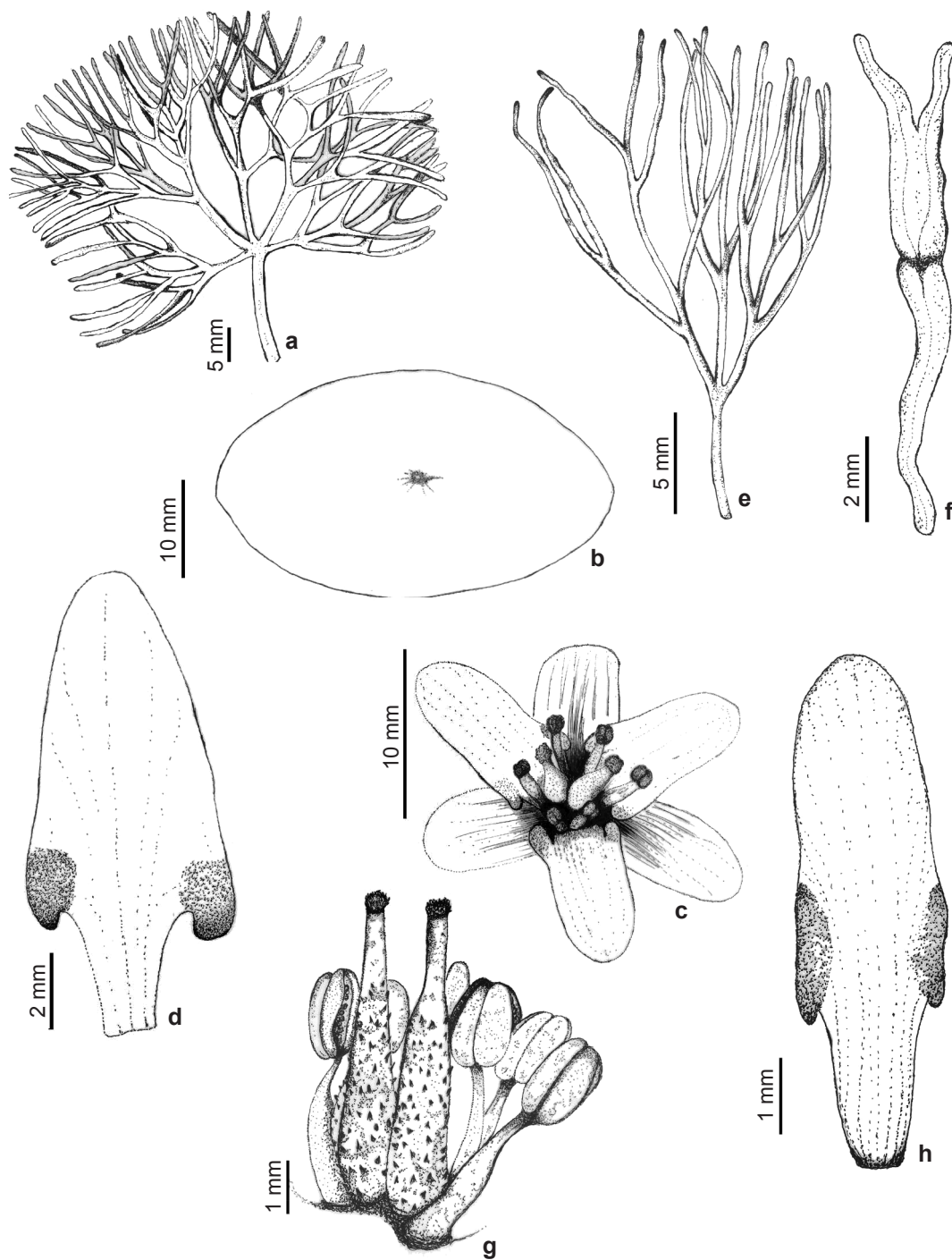


Figure 1 – a-d. *Cabomba aquatica* – a. submerged leaf with 5 primary branches; b. floating leaf; c. flower; d. petal. e-h. *Cabomba haynesii* – e. submerged leaf with 3 primary branches; f. floating leaf; g. detail of androecium and gynoecium; h. petal. [a-d. LQ Matias 605 (EAC); e-h. LRO Normando 525 (EAC)].

the interception of coastal rivers by sand dunes) in Ceará state (Fig. 2).

2. *Cabomba haynesii* Wiersema, Ann. Missouri Bot. Gard. 76: 1167. 1989. Fig. 1e-h

Submerged leaves opposite, reniform to ovate, $0.5\text{--}0.9 \times 1.4\text{--}1.8$ cm, palmatisect with divisions in one plane, petiole glabrous, 0.5–0.8 mm long; floating leaves peltate, alternate, narrow-elliptical to sagittate, $1.4\text{--}2.5 \times 1.2\text{--}2.2$ cm, petiole pubescent, 1.8–2.4 cm long. Flowers 1–1.5 cm diam., pedicel 1.5–1.8 cm long; sepals white to pale pink, $6\text{--}7 \times 3\text{--}4$ mm, oblong to elliptical, base trullate, apex rounded; petals white to pale pink, $5\text{--}6 \times 2\text{--}3$ mm, oblong to elliptical, base lobed, lobe ca 0.25 mm, apex rounded; stamens 6, filaments ca. 1.5 mm long, straight, anther ca. 0.5 mm long, oblong; carpels 2, ca. 3 mm long. Achenes 2.5–3 mm long.

Material examined: Iguatu, Lagoa do Governo, 17.V.2010, fl., *LRO Normando et al.* 525 (EAC); Lagoa das Cajás, 18.V.2010, fl., *LRO Normando et al.* 528 (EAC); Lagoa do Muncuzá, 15.V.2010, fl., *LRO Normando et al.* 490 (EAC).

Cabomba haynesii can be identified by its sagittate, floating leaves, white or pale pink perianth and yellow spot at the base. Although

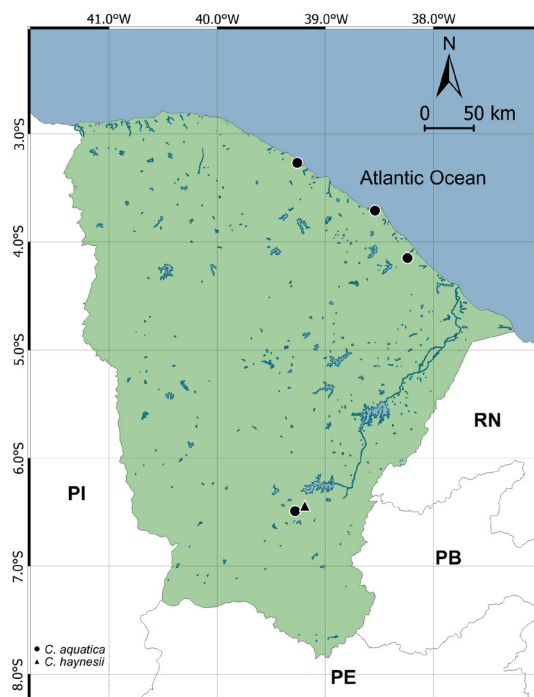


Figure 2 – Map of geographical distribution of *Cabomba* populations in Ceará state.

Lima *et al.* (2014) cited that the number of stamens remained at three in populations of *C. haynesii*, Wiersema (1989) described the rare occurrence of 6 stamens in some flowers, as occurs in populations of Ceará. The species is present in several region of Brazil: the North (Pará), Northeast (Ceará, Bahia), Southeast (Minas Gerais, Espírito Santo, São Paulo) and Central-West (Mato Grosso, Mato Grosso do Sul) (Pellegrini 2020). The populations occur in temporary and permanent, lentic environments of the semiarid region of Ceará state (Fig. 2).

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