# Aquatic plants in the freshwater artificial lagoons in Ciego de Avila, Cuba
# Plantas acuáticas en lagunas artificiales de agua dulce en Ciego de Ávila, Cuba

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## Abstract

Seven artificial freshwater lagoons (L1-L7) were studied in Ciego de Ávila, Cuba. They were characterized using different genetic, hydrologic, and morphologic criteria. All the environments were young and lagoons of anthropogenic origin; one is a temporary pond (L.1), and the others are permanent. A floristic list was made to identify the plants present in delineated parcels at the borders of the lagoons. The identified taxa were classified according to their origin and presence in Cuba, growth form, usefulness for humans, response to anthropic impacts, and conservation status. Forty-nine (49) species from 44 genera and 34 families were recorded. Most species (27 and 26, respectively) were identified at L.3 and L.6 (lagoons formed in old stone quarries used to construct the local airport). The least(seven) at L.1. Exotic and synanthropic plants prevailed, and invasive species were abundant, which indicates the transition through the early stages of ecological succession. 31 % of autochthonous plants and 2 % of endemic plants were recorded. 4 % is critically endangered. 39 % of these plants are medicinal, 29 % ornamental, 12 % are phytoremediators, and 4 % are frequently used in folklore-related practices. Plants that live in the freshwater environments of Ciego de Avila municipality have diverse characteristics, values, and uses that increase the environmental services of these ecosystems.

**Key words**: invasive plants; ecosystems; *Eichhornia*; *Utricularia*; wetlands

## Resumen

Se estudiaron siete lagunas artificiales de agua dulce (L1 – L7) en el municipo de Ciego de Ávila (Cuba), los cuales se caracterizaron según criterios genéticos, hidrológicos y morfológicos. Todas son lagunas, de origen antrópico, relativamente recientes. Una de ellas es semipermanente (L.1) y las restantes son permanentes. A partir de la identificación de las plantas presentes en parcelas delineadas, desde los bordes de las lagunas, fue confeccionada una lista florística. Los taxones identificados fueron catalogados según su origen y presencia en Cuba, hábito de crecimiento, utilidad para el hombre, comportamiento ante el impacto antrópico y estado de conservación. Se registraron 49 especies pertenecientes a 44 géneros y 34 familias. En L.3 y L.6 (lagunas ubicadas en las Canteras del aereopuerto) se identificó el mayor número de especies (27 y 26 respectivamente) y en L.1, el menor (7). Predominaron plantas exóticas y sinantrópicas y abundaron las invasoras, lo cual indica el tránsito por etapas tempranas de la sucesión ecológica. No obstante, se detectó un 31 % de plantas autóctonas y un 2 % de endemismo. Un 4 %se encuentran amenazadas de extinción, clasificadas en Peligro Crítico. El 39 % tiene uso medicinal, el 29 % ornamental, el 12 % son fitorremediadoras y el 4 % aparecen frecuentemente incorporadas a prácticas folclóricas. Las plantas asociadas a estas lagunas artificiales del municipio de Ciego de Ávila presentan condiciones, valores y usos diversos, lo que incrementa los servicios ambientales de estos ecosistemas.

**Palabras clave**: plantas invasoras; ecosistemas; *Eichhornia*; *Utricularia*; humedales

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## Introduction

The aquatic flora of freshwater environments, whether lentic or lotic, permanent or temporary, is vital. It is the basis of the food chain, and its presence favors the reproduction of other species, for which it is also a feeding ground. The capacities of these plants to filter and purify water are indicators of habitat type and help understand the functionality of lagoons (Madriñán et al., 2017). However, the aquatic flora may be problematic to the food chain due to the substances and compounds that it absorbs (Posada-García, 2016).

Some species of aquatic plants have medicinal properties (Behera and Satapathy, 2020), and others are used as biofertilizers (Ramírez *et al.,* 2021). However, some aquatic plants are also negatively related to human and animal health because they favor the growth and reproduction of some organisms as culicids and mollusks, intermediate hosts of parasites that cause dangerous diseases (Posada-García, 2016).

Studies of aquatic plants in freshwater environments in Cuba are scarce (Plasencia-Fraga, 2008). These habitats have been considered among the most altered for decades (Vales et al., 1998). One of the first studies on aquatic plants in Cuba was conducted in lagoons and saltmarshes of the western and central portions of the island (Uphof, 1924). Later, some studies on the vegetation of diverse freshwater environments of the entire country were made (Ponce de León, 1955; Plasencia-Fraga, 1982; Plasencia-Fraga, 1992; Torranzo-Linares, 1993). In recent years, other authors compiled information on aquatic plants from two important botanic gardens (Maldonado-González, 2010; Pérez-Hernández, 2016) and western Cuba (Pérez-Hernández, 2013; Vilamajó-Alberdi *et al.,* 2010). However, although in the Ciego de Ávila province, La Leche and La Redonda lagoons have been the most studied freshwater lagoons, no studies have been published on the flora and vegetation of these water bodies. There is also no information on this region's freshwater artificial lagoons' aquatic flora.

A complete inventory of the natural resources of any region is vital for their conservation and sustainable use, as well as for understanding them. For this reason, the main objective of this study is to make an inventory of plants associated with artificial freshwater lagoons of the municipality of Ciego de Ávila and suggest alternatives for the sound management and rational use of the most economically and ecologically important of these plants.

## Materials and methods

The province of Ciego de Ávila is located in Central Cuba and borders to the west with Sancti Spíritus province, to the east with Camagüey province, to the north with Los Perros and Buenavista bays, and to the south with the Gulf of Ana María.

The municipality of Ciego de Avila is located at the center of a calcareous plain that stretches from the town of Júcaro on the southern coast to the city of Morón near the northern coast. The region has an area of 444,36 $km^2$ with flat relief, and a height above mean sea level of 27 meters. Hydrologically, the region is regarded as poor; it has few rivers and streams, most temporary (Brown *et al.,* 2017).

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The studied freshwater lagoons were characterized according to the genetic, hydrologic, and morphologic criteria proposed by Jocou and Gandullo (2020). The genetic criterion was based on the natural and anthropogenic causes that originated these freshwater lagoons. The hydrologic criterion was based on the hydrologic regime (semi-permanent or permanent) and water stream movement (lentic or lotic). For the morphologic criterion, the water surface area of the lagoons (in $km^2$) was considered. The area of each lagoon was calculated using remote sensing methods (A Sentinel image 2A was downloaded, and the area was measured using the Q-Gis software). Based on this information, all studied sites were classified as freshwater lagoons: Vista Alegre lagoon (L.1), La Turbina lagoon (L.2), and five old stone quarries near the local airport (L.3, L.4, L.5, L.6 and L.7) (figure 1).

L.1 lagoon is in the western part of the city of Ciego de Ávila; L.2 is in a semi-natural park in the city's center; the rest of the lagoons are on the eastern part of the city, far from the most populated areas (table 1).

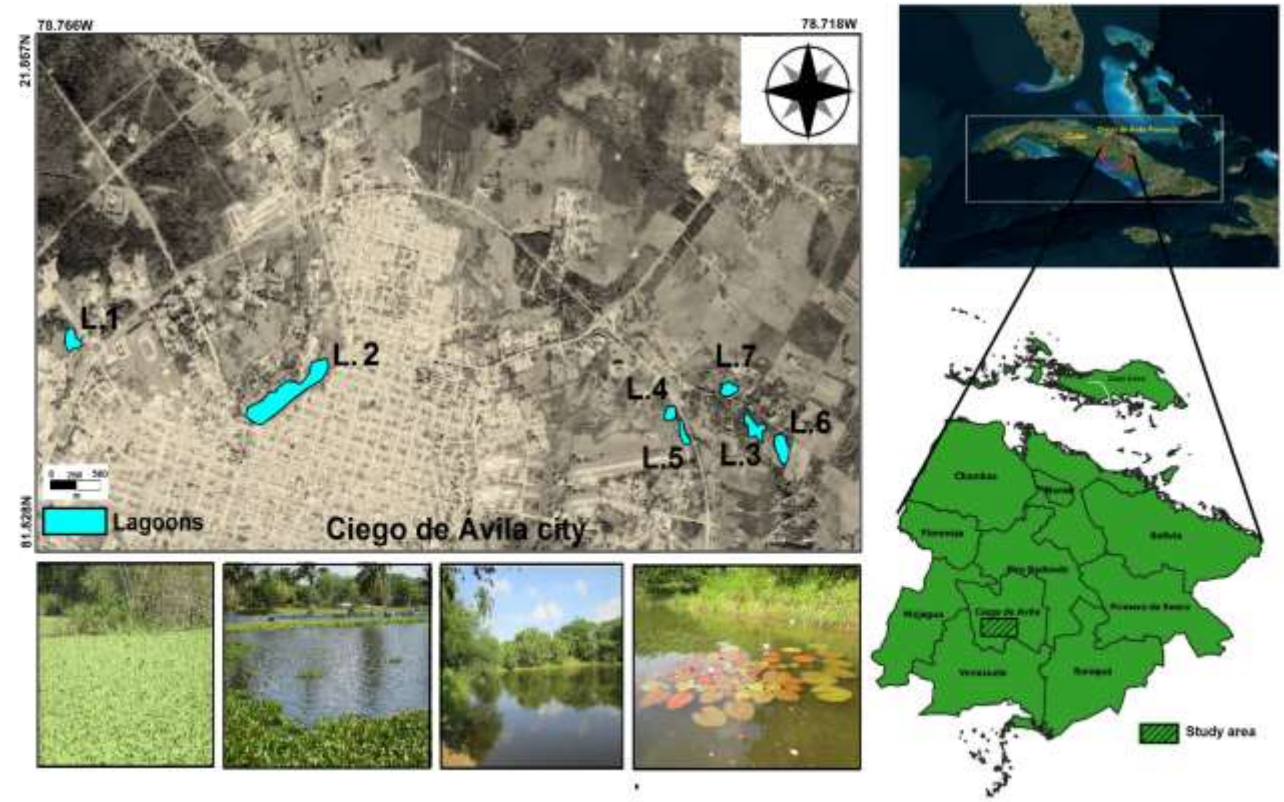


Figure 1. Study area in the Ciego de Ávila municipality, Cuba. Localization of studied artificial freshwater lagoons. L1: Vista Alegre. L2: La Turbina. L3-L7: Canteras del Aeropuerto lagoons.

Table 1. Some data of studied artificial freshwater lagoons.

| Lagoons | | Coordinates | Height above sea level (m) | Water area (km²) |
|---|---|---|---|---|
| Vista Alegre | (L.1) | 21°51'9″N-78°46′39″W | 56 | 0,0129 |
| La Turbina | (L.2) | 21°50'51′′N-78°45′43″W | 46 | 0,0865 |
| Cantera del Aeropuerto L.3 | (L.3) | 21°50'45′′N-78°72′65″W | 53 | 0,059 |
| Cantera del Aeropuerto L.4 | (L.4) | 21°50'46′′N-78°72′54″W | 26 | 0,008 |
| Cantera del Aeropuerto L.5 | (L.5) | 21°50'35′′N-78°73′20″W | 24 | 0,019 |
| Cantera del Aeropuerto L.6 | (L.6) | 21°50'35′′N-78°43′26″W | 45 | 0,0118 |
| Cantera del Aeropuerto L.7 | (L.7) | 21°50'75′′N-78°72′53″W | 32 | 0,0456 |

The inventory of plants associated with the lagoons was made (observing environmental conditions and plants) using transects one meter wide and twenty meters long established at the borders of the lagoons (Pérez-Hernández, 2016). The plants inside each lagoon were collected with hooks designed for this purpose and, in some cases, directly by the researchers. Fieldwork was done between 2020 and 2021, during the wet season (May to October) and during the dry season (November to April). During fieldwork, visual identification was used to identify taxa in the study area preliminarily. Some samples were herborized, and many pictures of the plants were taken for final taxonomic identification. Samples were compared with preserved plant specimens of the "Julián Acuña Galé" (HIPC) herbarium of the University of Camagüey, using identification keys from the literature and consulting other plant researchers. The taxonomy and nomenclature proposed by Greuter and Rankin (2017) were used for identification. All taxa were classified following various criteria. For the classification of plant origin and presence in Cuba, two criteria were used: autochthonous (specifying whether they were endemic or not) and non-autochthonous (detailing whether they are cultural or have naturalized) (Acevedo-Rodríguez & Strong, 2012; Ricardo *et al.,* 1995). Plants were classified as trees, shrubs, and herbs using the growth form criterion. The potential value of aquatic plants for humans was evaluated using the criteria proposed by Acuña (1970), Méndez-Santos *et al.* (2000). and Roig (1965;

1974). This assessment considered various criteria: forest value, medicinal use, animal food, craft use, agricultural use, folklore practices, ornamental use, and fiber sourcing. For a broader evaluation of medicinal uses, other references were revised (Abdul-Manap *et al.,* 2019; Arshad *et al.,* 2020; Behera & Satapathy, 2020; Dyera-Forestryana, 2020; Hazarika *et al.,* 2021; Heredia-Díaz *et al.,* 2018; Liau *et al.,* 2021; Nayaka *et al.,* 2020; Pratyusha *et al.,* 2012; Salatino *et al.,* 2007; Teixeira *et al.,* 2017). The use of these plants as phytoremediators was evaluated according to the criteria of Eid *et al.* (2020), Liu *et al.* (2021), Muthusaravanan *et al.* (2020), and Nash *et al.* (2019). Plant response to anthropogenic impacts and synanthropism were evaluated following the criteria of Ricardo *et al.* (1995); invasive potential (of exotic species) as proposed by Oviedo Prieto & González-Oliva (2015) and conservation status according to González-Torres *et al.* (2016).

## Results

L.1 lagoon is considered anthropic and semi-permanent. The other six studied lagoons L.2 – L.7) are anthropic and permanent. L.2 lagoon (shallow and permanent) originated from an old ballast quarry dating back to the 19th century, which was closed in 1935 due to the appearance of a spring and a significant amount of precipitation related to the 1932 hurricane (Cabrera-Sánchez, 2010). According to Cabrera-Sánchez (pers.comm), the origin of L.1 lagoon is unknown; the other lagoons (L.3 – L.7) formed from stone extraction to construct the local airport during the first two decades of the 20th century. There is no objective evidence of present morphology and status. Groundwater could be the principal water source of these lagoons (L.3 – L.7). Rainfall is another water source, which, combined with the closed morphology, creates ideal conditions for permanent water accumulation.

The small area and variety of the environmental conditions of the freshwater lagoons studied cause their limited diversity of habitats with scarce but interesting flora. All taxa found in the surveyed lagoons were identified to the species level, with a high degree of certainty (except *Sabal palmetto* (Walter) Lodd. ex Schult. & Schult.f). There was uncertainty regarding the characters of this plant, which could be similar to those described for *Sabal maritima* (Kunth) Burret.

This study registered 49 plant species of 44 genera and 34 families. Only three families were present in all the lagoons (Onagraceae, Poaceae, and Salviniaceae) (figure 2). The highest number of plant species were identified at L.3 and L.6 lagoons, while the lowest number of plant species (seven) was recorded at L.1. The number of plant species identified at the borders of the lagoons was higher than inside the lagoons (figure 3).

In L.1, *Pistia stratiotes* L. was predominant (it covered most water area). At L.2 lagoon, *Eichhornia crassipes* (Mart.) Solms covers most of the lagoon water area all year long. L.3 lagoon is divided into four parts. The predominance of species at this lagoon varied according to its parts. In one portion, *Nymphoides indica* (L.) *Kuntze* was dominant in the dry and wet seasons, while *E. crassipes* was dominant elsewhere. During the dry season, *Hydrocotyle umbellata* L. and *Potamogeton illinoensis* Morong were dominant in the fourth and third parts, respectively.

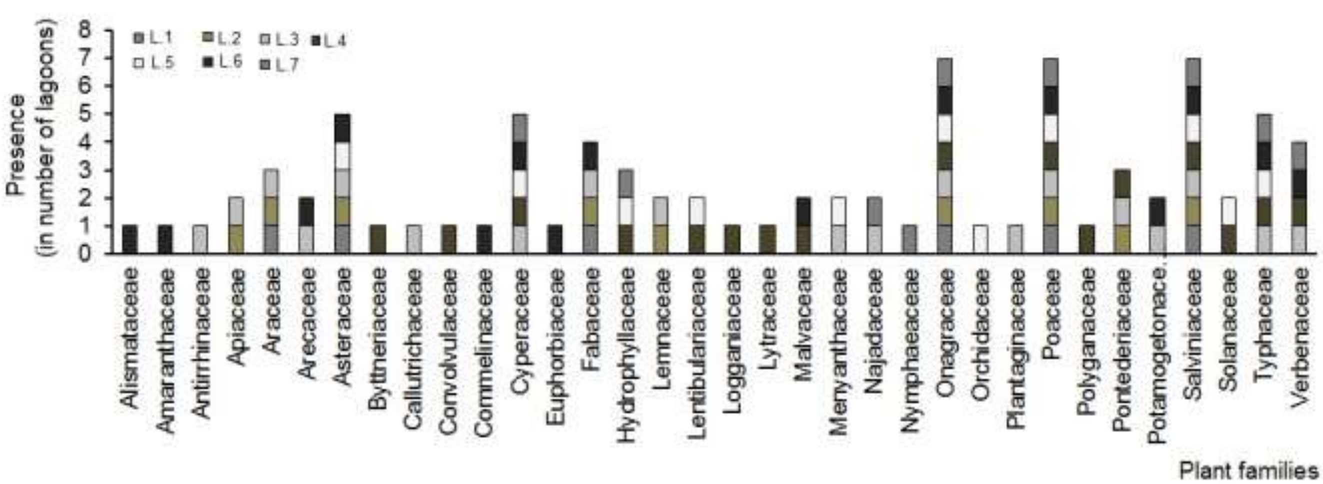


Figure 2. Distribution of identified plant families at each studied freshwater artificial lagoon. L1: Vista Alegre. L2: La Turbina. L3-L7: Canteras del Aeropuerto lagoons.

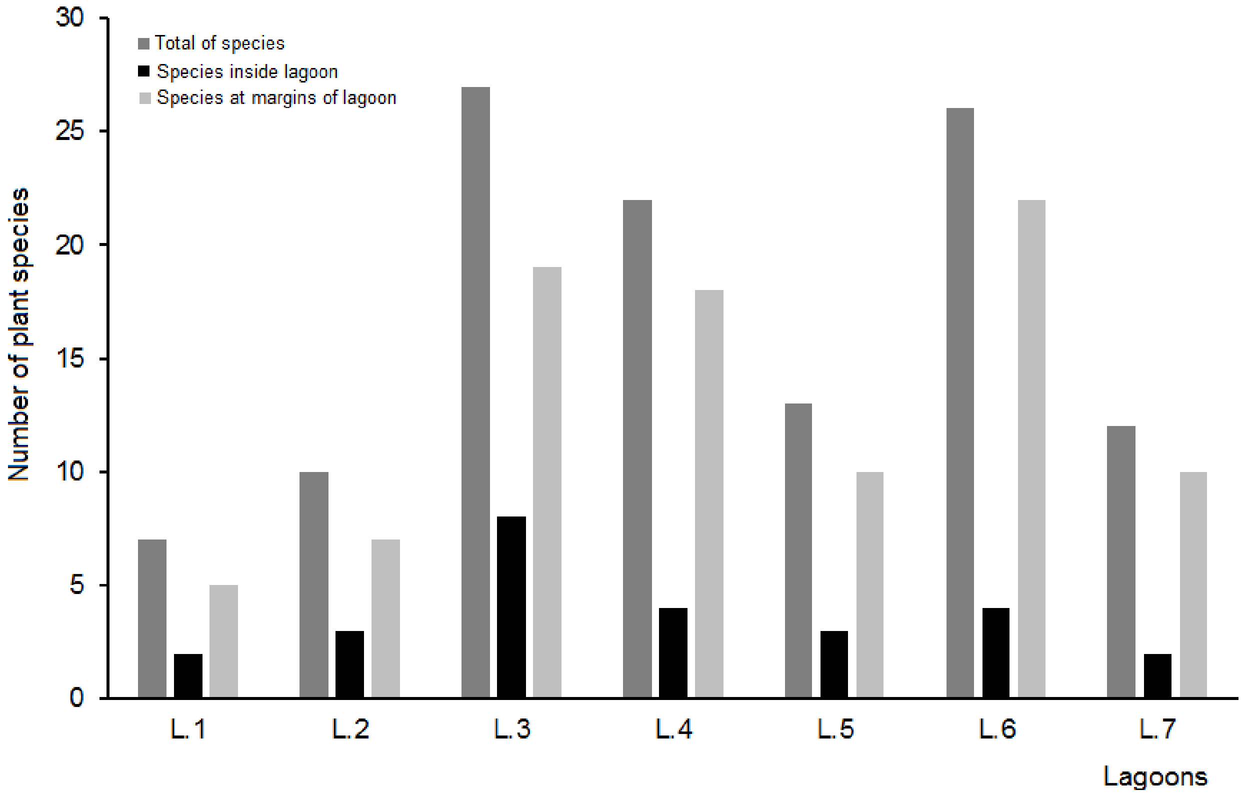


Figure 3. Number of identified plant species at borders and inside each studied artificial freshwater lagoon and total number of identified plant species. L1: Vista Alegre. L2: La Turbina. L3-L7: Canteras del Aeropuerto lagoons.

*Salvinia auriculata* Aubl. was dominant in L.4 lagoon all year long, coinciding with *Utricularia gibba* L. during the dry season. Both species were present in L.5 lagoon, too. In L.5 lagoon, two species (*Koanophyllon villosum* (Sw.) R. M. King & Rob, and *Bletia purpurea* (Lam.) were dominant all year long. In L.6 lagoon, *P. illinoensis* was the dominant species, particularly during the dry season. Four specimens of *S. palmetto* (two adults and two young) were observed at this lagoon. At L.7 lagoon, *Nymphaea ampla* (Salib.) DC. was dominant during the wet season.

Of the identified species, no autochthonous plants (69 %) were dominant; among them, 97 % were naturalized, and 12 % were classified as invasive plants, particularly *P. stratiotes* and *E. crassipes*, regarded as exotic invasive plants. Both species are classified as more noxious and subject of concern in Cuba (Oviedo-Prieto & González-Oliva, 2015).

Autochthonous plants represent only 31 % of all the species, with an endemism of 2 % (*Koanophyllon villosum* (Sw.). The 4 % (*U. gibba* and *S. palmetto*) are species included in the category of Critically Endangered (LC) (González-Torres et al., 2016).

Of the recorded plants, 29 % had ornamental use, 39 % medicinal uses, 12 % were phytoremediators, 6 % had forestal value, 4 % are regarded as a source of fiber, and the same percentage is used in folklore practices (particularly religious rituals), craftmanship and agriculture; only 2 % of the plants are used as animal food (table 2). Plants with ornamental, medicinal, and phytoremediation uses were present in all the lagoons (figure 4).

Table 2. Plant species inventory in studied artificial freshwater lagoons of Ciego de Ávila, EN: endemic, NEN: non-endemic, EN: Endémica. NEN: No endémica. Growth form: H-Herbs, T: Tree, S-Shrub. Utility: F-Forest. M- Medicinal. Af-Animal feed. C-Craft use, Ag-Agriculture, Fu- Folkloric, Or-Ornamental, Fi- Fiber potential, Ph- Phytoremediation. Anthropic Impact: ES-Expansive synanthropic, IS- Invasive synanthropic, NS- No synanthropic. Conservation: CE-Critical Endangered and LC-Least Concern (IUCN, 2022).

| **Plant species** | **Presence in Cuba** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Autochthonous** | | **Non Autochthonous** | | | | |
| | **EN** | **NEN** | **Naturalized** | **Cultural** | **Growth form** | **Utility** | **Anthropic impact and conservation** |
| ALISMATACEAE | | | | | | | |
| *Sagittaria intermedia* Micheli | | | | x | H | Or. | NS |
| AMARANTHACEAE | | | | | | | |
| *Alternanthera sessilis* (L.) R. Br. Ex DC | | | x | | H | M. | ES |
| ANTIRRHINACEAE | | | | | | | |
| *Stemodia maritima* L. | | | x | | H | M. | NS |
| APIACEAE | | | | | | | |
| *Hydrocotyle umbellata* L. | | | x | | H | M. | ES |
| ARACEAE | | | | | | | |
| *Pistia stratiotes* L. | | x | | | H | Or., Ph., Ag., M. | IS |
| ARECACEAE | | | | | | | |
| *Sabal palmetto* (Walter) Lodd. ex Schult. & Schult.f. | | x | | | T | F., Or. | NS, CE, LC |
| *Roystonea regia* (Kunth) O. F. Cook | | | x | | T | Or. C. Fu. Ph | ES |
| ASTERACEAE | | | | | | | |
| *Koanophyllon villosum* (Sw.) R. M. King & H. Rob. subsp. villosum | x | | | | H | Or., M. | NS |
| *Eclipta prostrata* (L.) L | | | x | | H | M. | ES |
| *Spilanthes urens* Jacq | | | x | | H | | ES |
| *Pluchea carolinensis* (Jacq.) G. Donm. | | | x | | S | Or., M., Fu. | ES |
| BYTTNERIACEAE | | | | | | | |
| *Melochia nodiflora* Sw. | | x | | | H | F. | ES |
| CALLITRICHACEAE | | | | | | | |
| *Callitriche peploides* Nutt. | | x | | | H | Or. | NS |
| CONVOLVULACEAE | | | | | | | |
| *Ipomoea pes-caprae* (L.) R. Br. | | x | | | H | | ES |
| COMMELINACEAE | | | | | | | |
| *Commelina rufipes* Seub | | x | | | H | | NS |
| CYPERACEAE | | | | | | | |
| *Cyperus flexuosus* Vahl | | | x | | H | | NS |
| *Cyperus imbricatus* Retz | | | x | | H | | NS |
| *Fuirena simplex* | | | x | | H | | NS |
| *Oxycaryum cubense* (Poepp. & Kunth) Palla | | | x | | H | | NS |
| *Eleocharis interstincta* (Vahl) Roem. & Schult | | x | | | H | | ES |
| *Eleocharis geniculata* (L.) Roem. & Schult | | | x | | H | | NS |
| EUPHORBIACEAE | | | | | | | |
| *Croton argenteus* L. | | x | | | S | M. | IS |
| FABACEAE | | | | | | | |
| *Dichrostachys cinerea* (L.) Wight & Arn | | | x | | S | F., M. | IS |
| *Aeschynomene sensitiva* Sw. | | x | | | S | | ES |
| HYDROPHYLLACEAE | | | | | | | |
| *Hydrolea spinosa* L. | | x | | | H | M. | NS |

| Plant species | Presence in Cuba | | | | | | |
|---|---|---|---|---|---|---|---|
| | Autochthonous | | Non Autochthonous | | | | |
| | EN | NEN | Naturalized | Cultural | Growth form | Utility | Anthropic impact and conservation |
| LEMNACEAE | | | | | | | |
| *Lemna perpusilla* Torr. | | | x | | H | Fr. | IS |
| LENTIBULARIACEAE | | | | | | | |
| *Utricularia gibba* L. | | | x | | H | | NS, CE, LC |
| LOGANIACEAE | | | | | | | |
| *Spigelia anthelmia* L. | | | x | | H | Or., M. | ES |
| LYTRACEAE | | | | | | | |
| *Ammannia latifolia* L. | | | x | | H | Or. | ES |
| MALVACEAE | | | | | | | |
| *Sida cordifolia* L. | | x | | | H | M. | ES |
| *Malachra capitata* (L.) L. | | x | | | H | M. | ES |
| *Malachra fasciata Jacq.* | | x | | | H | M. | ES |
| MENYANTHACEAE | | | | | | | |
| *Nymphoides indica* (L.) Kuntze | | x | | | H | Or.,M. | NS |
| NAJADACEAE | | | | | | | |
| *Najas marina* L. | | | x | | H | Or. | NS |
| NYMPHAEACEAE | | | | | | | |
| *Nymphaea ampla* (Salib.) DC. | | | x | | H | Or. | NS |
| ONAGRACEAE | | | | | | | |
| *Ludwigia peploides* (H. B. K.) Raven | | | x | | H | | NS |
| *Ludwigia peruviana* (C. Wright ex Griseb.) M. Gómez | | | x | | H | Ph. | NS |
| ORCHIDACEAE | | | | | | | |
| *Bletia purpurea* (Lam.) | | | x | | H | Or. | ES |
| PLANTAGINACEAE | | | | | | | |
| *Bacopa monnieri* (L.) Pennell var. Monnieri | | | x | | H | M. | ES |
| POACEAE | | | | | | | |
| *Brachiaria mutica* (Forssk.) Stapf. | | | x | | H | | IS |
| POLYGONACEAE | | | | | | | |
| *Persicaria maculosa* var. argentea Gray. | | | x | | H | | NS |
| PONTEDERIACEAE | | | | | | | |
| *Eichhornia crassipes* (Mart.) Solms | | | x | | H | Or.,Ph., C., M., Af., Fu., Ag. | IS |
| POTAMOGETONACEAE | | | | | | | |
| *Potamogeton illinoensis* Morong | | | x | | H | | NS |
| SALVINIACEAE | | | | | | | |
| *Salvinia auriculata* Aubl | | | x | | H | Fr. | NS |
| SOLANACEAE | | | | | | | |
| *Physalis angulata* L. | | | x | | H | M. | NS |
| TYPHACEAE | | | | | | | |
| *Typha domingensis* Pers Kunth | | | x | | H | Fr. | ES |
| VERBENACEAE | | | | | | | |
| *Phyla stoechadifolia* (L.) Small | | | x | | H | | NS |
| *Phyla nodiflora* (L.) Greene | | | x | | H | M. | ES |
| *Stachytarpheta angustifolia* (Mill.) Vahl | | | x | | H | | NS |

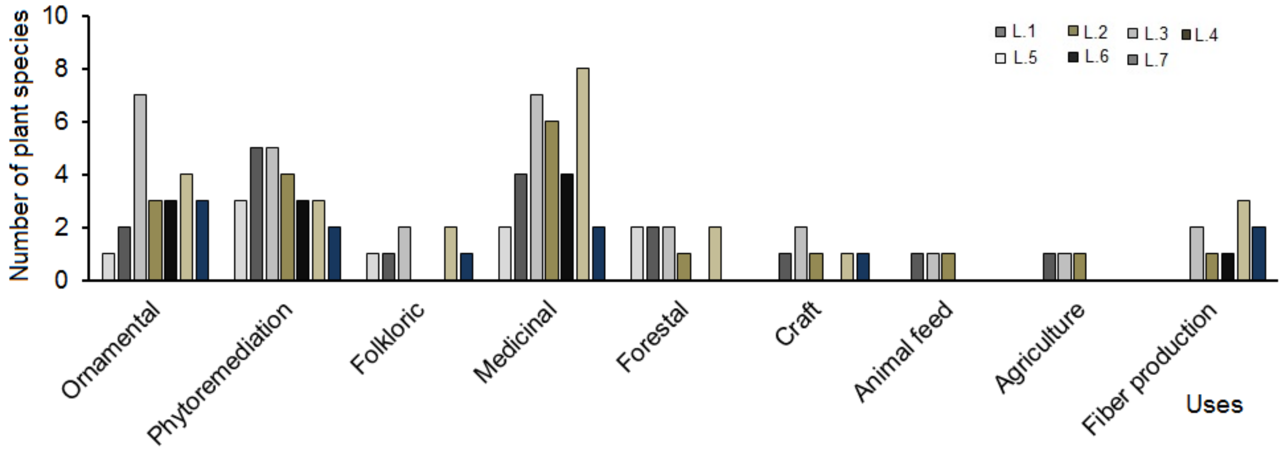


Figure 4. Number of identified plant species per use at each studied freshwater artificial lagoon. L1: Vista Alegre. L2: La Turbina. L3-L7: Canteras del Aeropuerto lagoons.

## Discussion

Other important values have been described for some of the lagoons studied. For instance, Gutiérrez-Domenech *et al.* (2012) found a noteworthy paleontological site at L.4 lagoon, with abundant fossils that could be exploited for geotourism activities and other uses. The value (from the holistic point of view) of the studied freshwater lagoons could help to increase environmental awareness in the municipality, including the educational sector, due to the proximity of these water bodies to the most important economic and social site of this region.

Although L.3 and L.6 are not the largest of the studied lagoons, they were characterized by presenting the most significant structural complexity, which may be one of the reasons why they have the largest number of species. Also, these lagoons are more distant (compared with L.1 and L.2) from the center of the city of Ciego de Ávila and consequently do not receive sewage discharges from the city system. These conditions could explain the number of plant species and the prevalence of certain species. However, in L.3 lagoon, plants that are common in oligotrophic conditions, such as *P. illinoensis* (Hardion *et al.,* 2021), were registered, which indicates an environment rich in heavy metals (as *E. crassipes*) (Mehmood *et al.,* 2009; Muthusaravanan *et al.,* 2020). At the same lagoon (L.3), *H. umbellata was* registered, which according to Liu *et al.* (2021), tolerates high levels of cadmium (Cd). At L.4 and L.5 lagoons, *S. auriculata* was recorded. According to some authors, this species is a bioaccumulative macrophyte (particularly with Zinc), and its presence indicates heavy metals in aquatic environments (Negrão *et al.,* 2021). The presence of some of these plants at L.3, L.4, and L.5 could suggest certain levels of anthropic pollution. In L.6 and L.7 lagoons, these indicator species did not prevail.

Among the identified invasive aquatic plants is *P. stratiotes*, native to tropical America but distributed worldwide (Henry-Silva *et al.,* 2008). In Cuba, this plant is classified as invasive, noxious, and a transformer species (Oviedo-Prieto and González-Oliva, 2015). It occupies most of the water area in L.1. Despite these negative effects on local ecology, this plant (before growing excessively) has environmental benefits such as water oxygenation, fixation of carbon dioxide, recycling, nutrient absorption, regulation of water temperature, light and sediment transport, and occasionally contributes to decreasing suspension of solid particles and pollution (Chang-Gutiérrez and Huamán-Taype, 2019; Trisilawati *et al.,* 2020). In addition, this species can be used as a biofertilizer due to its capacity to store considerable contents of nitrogen (N) and phosphorus (P) (Abdo and Da Silva, 2000; Henry-Silva *et al.,* 2008). *P. stratiotes* could be helping the ecological functioning at L.1 lagoon as a phytoremediating plant due to its ability to absorb heavy metals such as Cd and Zn (Muthusaravanan *et al.,* 2020). In addition, *P. stratiotes* has some active organic compounds with antiseptic use (Tyagi and Agarwal, 2017). Cook (1990) considered this plant one of the most important in the world.

Another identified invasive and transformer plant was E. crassipes (Oviedo-Prieto and González-Oliva, 2015). This plant is native to South America, specifically the Amazon River, but is present worldwide (Ito *et al.,* 2020). The excessive growth of this plant has blocked rivers, lakes, and reservoirs, affecting fluvial navigation, swimming, and fishing. This plant causes a decrease in sunlight penetration into the water, affecting oxygenation and submerged plants. Furthermore, the excessive growth of *E. crassipes* (it can double its population in 12 days) has impacted biological diversity in the water bodies. This species is classified by some authors (Lowe *et al.,* 2004) as one of the 100 most noxious plants in the world. However*, E. crassipes* is considered by Cook (1990) as one of the most important plants worldwide because it is bioabsorbent (Kalam *et al.,* 2019), phytoremediator (Nash et al., 2019), an animal food source (de Vasconcelos et al., 2016); apt for composting (Goswami *et al.,* 2017), biogas production (Sarto *et al.,* 2019) and as biofertilizer, due to its high contents of nitrogen, phosphorus, and potassium (Goswami *et al.,* 2017). Some authors reported that this plant could be used in healthcare procedures (Sharma *et al.,* 2020) because of its anticancer properties (Aboul-Enein *et al.,* 2014; Tyagi and Agarwal, 2017).

Both species (*P. stratiotes* and *E. crassipes*) are abundant in the studied lagoons L.1 and L.2. In L.2 lagoon (which receives sewage discharges), when *E. crassipes* grows excessively and begins to cover most of its water area, it is extracted manually and deposited on the margins of the lagoon or sent to final disposal. Both disposal methods are evironmentally questionable (disposed of plants could contaminate groundwaters) because this species may absorb high levels of heavy metals and nutrients (Mehmood *et al.,* 2009; Muthusaravanan et al., 2020). More research could be done on the potential uses of these plants to know more about their agricultural uses (Ito *et al.,* 2020; Behera and Satapathy, 2020). However, local authorities must work on management actions that improve the utilization of these plants and their appropriate and safe final disposal.

One of the most interesting plants registered in these freshwater lagoons was *U. gibba* (Critically Endangered (CE), as country categorization (González-Torres *et al.,* 2016) and Least Concern (LC) IUCN, 2022). In Cuba, it covers an area of less than 10 km$^2$. This limited area is decreasing, and consequently, its habitat. (González-Torres *et al.,* 2016). However, according to Panfet-Valdés (2008), *U. gibba* is distributed almost in the entire country. Our study recorded this species for the first time in Ciego de Ávila. During all the samplings, *U. gibba* was observed to be associated with *S. auriculata*. This association could be unique (a topic for future ecological studies) because *U. gibba* is a rare and uncommon species that lives mainly in polluted environments.

Another Critically Endangered (CE) country categorization (González-Torres *et al.,* 2016) and Least Concern (LC) (IUCN, 2022) species (*S. palmetto*) was found in these lagoons. However, more in-depth studies are being conducted to corroborate its identity. In Cuba, their populations are restricted to areas of less than 10 km$^2$ of fragmented habitats. The main conservation issues are habitat area and quality (González-Torres *et al.,* 2016). *S. palmetto* is a solitary palm species that forms groups in freshwater habitats and coastal zones. Its distribution range stretches from North Caroline to South Florida (USA), The Bahamas, and Cuba. It is a long-lived and slow-growing tree that reaches a height of 12 meters (some specimens can reach up to 24 meters). This species has a high tolerance to drought and strong winds and is widely adaptable to low-nutrient soils (Brown et al., 2011). In Cuba, only its fruit's potential as a source of oil has been studied (Rodríguez-Leyes *et al.,* 2007). This species was only observed at L.6 lagoon.

The plants associated with the artificial freshwater lagoons, already naturalized in Ciego de Ávila, have diverse conditions, values, and uses that could influence the environmental services of these aquatic ecosystems. The study of these plant species could be replicated in other of the country's aquatic ecosystems to increase knowledge of these species and their economic and social uses. We recommend implementing management actions regarding the final disposal of *E. crassipes* at L.2 lagoon and conservation actions to protect *U. gibba* and *S. palmetto* if identification of the latter is corroborated.

## Conflict of interest

The authors have declared no conflicts of interest for this article.

## Contribution of the authors

Leslie Hernández Fernández, Isidro E. Méndez, José Gerardo Vázquez, Roberto González de Zayas and José Carlos Lorenzo Feijoo: conceptualization, writing, editing, methodological design development, data collection and data analysis, and financing acquisition.

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