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Article information

Article title

Ex-situ growth protocol for the invasive macrophyte *Pontederia crassipes*

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Keywords

Eichhornia crassipes; mesocosm; experimental reproducibility; growth rate: invasive alien species

Related research article

None.

Abstract

Pontederia crassipes is known for its asexual reproduction and rapid growth. Outside its native range, it has been identified as an environmental threat, while it has also been widely used for ex-situ phytoremediation. To understand both its invasive potential and its phytoremediation capacity, it is necessary to examine the environmental factors that favor its growth beyond those already described in the literature, such as water temperature and nutrient availability. Previous studies also suggest that alkalinity, conductivity, dissolved oxygen, salinity, water depth, pH and water transparency influence its performance. These variables help define the species niche and highlight the importance of distinguishing between its fundamental niche, the full set of abiotic conditions that support growth and its realized niche, which reflects biotic interactions and local constraints. However, the scientific literature does not yet provide sufficient description of the ex-situ experimental conditions required for the successful cultivation of this aquatic plant in controlled settings. This protocol therefore reports the results and lessons learned from a series of mesocosm experiments. By standardizing procedures and documenting growth outcomes, the protocol enhances reproducibility, facilitates comparisons across studies and supports both basic and applied research on *P. crassipes.*

Graphical abstract

Specifications table

Subject area	Environmental Science

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More specific subject area	Aquatic Ecology / Applied Botany
Name of your protocol	Growth of *Pontederia crassipes* under mesocosm controlled experiment.
Reagents/tools	**Reagents:** Ammonium dihydrogen orthophosphate Potassium nitrate Calcium nitrate tetrahydrate Magnesium sulfate heptahydrate Boric acid Copper (II) sulfate pentahydrate 99%+ Zinc sulfate heptahydrate 99.5% Manganese (II) chloride tetrahydrate Molybdenum acid (≥85% MoO_3) Titriplex® III (ethylenedinitrilotetraacetic acid disodium salt dihydrate) EDTA Potassium hydroxide Ferrous Sulphate **Tools:** Analytical Balance. Conductivity, Temperature, and Salinity portable meters: ProfiLine Cond 3320 (WTW, Weilheim, Germany) pH portable meter: ProfiLine pH 3310 (WTW, Germany) Dissolved Oxygen portable meter: ProfiLine Oxi 3310 (WTW, Germany) Skalar San++ Continuous Flow Analyzer (Skalar Analytical, Breda, Netherlands) for nutrients analysis Air Pump o enhances water mixing
Experimental design	Two independent experiments were conducted using the same design and salinity treatments. In the first experiment, 5 plastic boxes (the experimental units) were used, each containing six stolons (pseudo-replicates). This resulted in a total of 30 stolons. The second experiment used the same design, but with each box containing three plants, resulting in a total of 15 plants. The box was defined as the experimental unit, whereas the individual plants/stolons within each box were considered pseudo-replicates. All plants/stolons were grown in the same sediment source to minimize variation due to substrate.
Trial registration	Not applicable.
Ethics	Due to its invasive behavior, experiments involving this species require prior authorization and safety handling. In the case of Portugal this authorization was required from the Institute for Nature Conservation and Forests (ICNF).
Value of the Protocol	Standardizes the mesocosm experiment for assessing *Pontederia crassipes* biomass growth rate. Enables reproducibility of results by different researchers under varying conditions. Facilitates investigation of environmental parameters (e.g., salinity, pollutants) relevant to specific research questions.

Background

Pontederia crassipes (Mart.), formerly *Eichhornia crassipes* (Mart.) Solms and commonly known as water hyacinth, is a free-floating aquatic plant widely recognized for its rapid growth and high invasive potential (Wang et al., 2016). Native to South America, it was first recorded outside its natural range in New Orleans in 1884 (Penfound & Earle, 1948). Since then, it has been reported as an invasive species on five continents, excluding Antarctica (EPPO, 2008). It is considered among the 100 world's worst invasive alien species by IUCN (Lowe et al., 2000) and in 2023, it

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was identified as one of the major threats to global biodiversity (IPBES, 2023). Conversely, it has also been used for phytoremediation purposes, particularly to treat industrial effluents under ex-situ conditions (Monroy-Licht et al., 2024). Moreover, its biomass has been utilized for a variety of purposes (Nandiyanto et al., 2024). Although both sexual and asexual reproduction have been described in the literature, to the best of our knowledge, the enabling conditions for reproduction of this species under ex-situ settings are not sufficiently documented (Table 1). Addressing this knowledge gap is essential to ensure experimental reproducibility and thereby advance scientific research following the FAIR (Findable, Accessible, Interoperable, and Reusable) principles of Open Science (Wilkinson et al., 2016). To this end, the first step was to analyze the available literature on mesocosm experiments targeting biomass production, including studies on constructed wetlands and phytoremediation. Table 1 summarizes the findings of ten mesocosm studies, which ranged in duration from 22 to 150 days. The table shows the use of different container volumes (100–1000 L) and temperature ranges (5–35 °C). In terms of hydrological conditions, the growth medium included artificial nutrient water, well water, pond water, lake water and wastewater, with a retention time mostly ranging from one to six weeks. Nutrient concentrations ranged from 0.05 to 28 mg/L for nitrogen and from 0.05 to 8.86 mg/L for phosphorus. In addition to variability in experimental setup, initial biomass varied from 15 to 680 g dry weight per m^2, while in one experiment, the authors used plant length (cm) rather than biomass. While most authors report on plant biomass, the description of the included plant organs is not sufficiently clear, with some studies referring to shoots and others only to plants, without providing detailed measurement criteria. Overall, the literature reveals a heterogeneity of protocols, as well as short-term and low representativeness and incomplete reporting of conditions. The lack of standardized reporting with sufficient detail to enable the validation and reproducibility of experimental conditions must be addressed to foster progress in this field of research. The main objective of this protocol is to share a set of *ex situ* growth experiments with *Pontederia crassipes* and clearly demonstrate the most and least effective methods to support progress in this field.

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1 **Table 1**. Comparative summary of mesocosm experiments testing the effects on biomass growth of *Pontederia crassipes* from the literature. NA means absence of information.

Growth indicator	Mesocosm experiment	Duration	Hydrological conditions				Nutrient source	Nutritional conditions			Growth rate			Reference
		(days)	Volume (L)	Temperature (ºC)	Retention time (weeks)	Water circulation		Nitrogen (mg L^{-1})	Phosphorus (mg L^{-1})	micronutrients (mg L^{-1})	T0 (g DW m^{-2})	Tf (g DW m^{-2})	Rate (g DW m^{-2} day^{-1})	
Whole plant (Petiolo+lamina+steam+root)														
Net productivity (dry weight)	1	84	300	26ºC-28ºC	1	daily by submersible pump	constructed wetlands	20	5	NA	445	2303	0.0193	Reddy & Tucker 1982
	2	100	1000	NA	1	no information	concret valvus with nutrient medium	10.5	3.1	K: 8.4 Ca: 26.4 Mg: 5.6 Fe: 0.3 Mn: 0.0	680	3300	14.25	Reddy 1984
	3	80	1000	NA	1	12h by submersible pump	artificial water prepared with nutrients	21	3.1	Fe: 4 Cu: 0.2 Mn: 1.5 B: 0.04 Mo: 0.02 S:	500	2000	0.0173	Reddy & Debusk, 1984
	4	83	1000	15ºC-33ºC	1	daily by submersible pump	well water	0.05	3	K: 25 Fe: 4 Cu: 0.2 Mn: 1.5 B: 0.04 Mo: 0.02 S: 3	225	2000	0.0263	Reddy et al., 1989
	5	96	1000	5ºC-35ºC	1	daily by submersible pump	well water	20	0.06	K: 25	225	830	0.0147	Reddy et al., 1990
	6	22 *in two seaons	500-1000	17.8ºC-24.8ºC	48 h and 60 h	NA	wastewater from residencials home that has passed through a primary sedimentation	20	7.5	K: 16.5	48	225	0.0112	Ho & Wong , 1994
	7	56	200	15ºC -25ºC	1	NA	well water	5	0.05	K: 23 Ca: 20 Mg: 5.0 Fe: 0.60 B: 0.51 Mn: 0.52 Zn: 0.05 Cu: 0.02 Mo: 0.01	30	120	0.0248	Xie et al., 2004
	8	105	300	NA	6	NA	constructed wetlands	28	7.7	NA	plant with 20 cm	NA	NA	Jayaweera et al., 2008
	9	42	100	23.5ºC-28.8ºC	1	NA	lake water	0.6	0.05	NA	15	235	0.042	You et al., 2014
	10	150	104	NA	1		pond water	0.58	8.86	NA	260	405.83	0.0112	Kumwimba et al., 2017

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What is well known: Sexual reproduction in this species occurs through seeds (Barrett, 1980), while asexual reproduction occurs via vegetative propagation (Bock, 1969; Thomaz 2025). A small portion of plant's horizontal stem, known as a stolon, may break due to physical or biological agents and act as a propagule capable of producing new individuals. Under favorable conditions, such as optimal temperature and nutrient availability, the plant can cover large areas of the water surface within just a few weeks (Wang et al., 2016). This rapid proliferation has negative ecological impacts, including oxygen depletion and consequent fish mortality (Villamagna & Murphy, 2010), increased water evaporation (Sasaqi et al., 2019), and reduced biodiversity due to sunlight blockage and decreased net productivity (Wu & Ding, 2020). In economic terms, it results in high costs associated with control and management strategies (Harun et al., 2021). Socially, it affects local communities that depend on aquatic ecosystems (Harun et al., 2021). The remaining knowledge gap lies in determining the optimal conditions for propagation to both manage the spread of *P. crassipes* and explore potential sustainable applications, as well as in developing effective control strategies (Djihouessi et al., 2023). For instance, none of the above-mentioned studies addressed the role of stolons or reported the challenges of maintaining this species under controlled mesocosm conditions.

This protocol emphasizes the value of mesocosm experiments as controlled systems for studying the growth dynamics of *P. crassipes*, highlighting the limitations and opportunities these systems offer for advancing basic and applied research on the ecology of invasive species.

Description of protocol

1 Site collection

Collecting the material

Pontederia crassipes was collected from the Pateira de Fermentelos freshwater lagoon in Aveiro, Portugal (40°34'48"N, 8°31'12"W) in September and October 2024. Two independent experiments were conducted using different *Pontederia crassipes* propagules: stolon and whole plant. Both experiments were initiated separately in late autumn 2024. Separate collections were made for each propagation type. Knowing the plant's life cycle in the collection area is important for planning the collection according to its availability in the ecosystem.

Experimental units were standardized by selecting plants with comparable leaf numbers and sizes. They were then conditioned in plastic bags and transported to the laboratory. The material should be collected when the species reaches its peak biomass.

Note: the plants should be carefully placed in water to maintain humidity during transportation to the laboratory.

2 Material and Equipment

Sample

- Stolon and whole plant
- Select and collect healthy plants of similar sizes, measured by fresh weight.
- Plastic transport plants to the laboratory.

Equipment

- Analytical Balance.
- Conductivity, Temperature, and Salinity portable meters: ProfiLine Cond 3320 (WTW, Weilheim, Germany)
- pH portable meter: ProfiLine pH 3310 (WTW, Germany)
- Dissolved Oxygen portable meter: ProfiLine Oxi 3310 (WTW, Germany)
- Skalar San++ Continuous Flow Analyzer (Skalar Analytical, Breda, Netherlands) for nutrients analysis
- Air Pump o enhances water mixing.

Material

- 20 Polypropylene 30L containers (size : 400 x 300 x 243mm).

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- Graph paper to take a picture and measure plants structures.
- Syringes and Glass filter (GF 0.45 µm) for solution nutrients analysis
- Volumetric glassware for solution preparation (beakers and volumetric flasks)

Reagents

Table 2: Reagents for Hoagland nutrient solution

Reagente	**Chemical Formula**	**Chemical Abstracts Service (CAS)**
Ammonium dihydrogen orthophosphate	(NH4) H2PO4	7722-76-1
Potassium nitrate	KNO_3	7757-79-1
Calcium nitrate tetrahydrate	Ca(NO3)2 4 H2O	13477-34-4
Magnesium sulfate heptahydrate	MgSO4 · 7H2O	10034-99-8
Boric acid	H_3BO_3	10043-35-3
Copper (II) sulfate pentahydrate	$CuSO_4$ * 5 H_2O	231-847-6
Zinc sulfate heptahydrate	$ZnSO_4 \cdot 7H_2O$	7446-20-0
Manganese (II) chloride tetrahydrate	$MnCl_2$	13446-34-9
Molybdic acid	H2MoO4	7782-91-4
Eethylenedinitrilotetraacetic acid disodium salt dihydrate (EDTA)	$C_{10}H_{14}N_2O_8$*2Na*2H_2O	6381-92-6
Potassium hydroxide	KOH	1310-58-3
Ferrous Sulphate	$FeSO_4.7H_2O$	7782-63-0

3. Experimental procedures

3.1 Cleaning the plants

In the laboratory, the stolons should be identified on the plants and cut between the two nodes, leaving roots, without leaves, and allowing new leaves to grow (Figure 1). As stolons may become detached from the parent plant due to mechanical forces resulting from disturbances in the aquatic environment (Thomaz, 2025), the potential for producing new plants from these detached stolons was investigated. For whole plant propagules, a plant containing only one rosette (a group of floating leaves with a crown-like stem, and submerged roots) were used.

Before placing them in the solution, they should be washed with tap water to remove residues and undesirable organisms. To ensure consistency in the experiment, it is important to standardize the size and weight of the stolons and plants.

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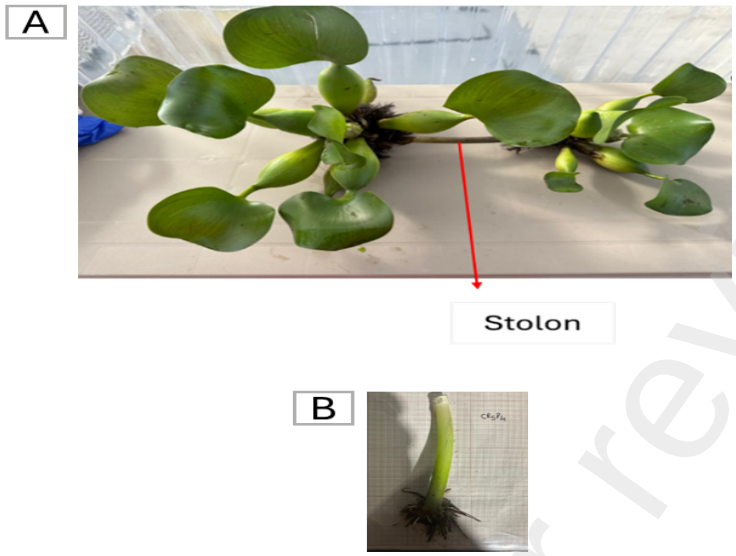

Figure 1: *Pontederia crassipes* in detail of the vegetative structure of stolon joining the two plants (A) and only stolon (B) used in this experiment.

The plant units used in the experiment were selected to ensure morphological and physiological uniformity. They had an average size of 450.86 ± 172.22 cm² (length × height), four leaves and a total biomass per plant of 36.34 ± 13.23 g, and their stolon biomass (13.64 ± 7.52 g) and length (14.33 ± 5.05 cm) were also within these ranges. Prior to placement in the mesocosms, the roots were carefully washed to eliminate any organisms or debris adhering to them that could potentially affect the ecological balance of the system.

3.2 Preparing the solution

The growth medium was based on Hoagland's nutrient solution (Hoagland 1950), modified for use in aquatic mesocosms. The preparation involved the following:

Table 3: Adapted Hoagland Solution nutrients components

Hoaglands Stock Solutions (SS)	Stock Solution Concentration	Volume SS in Final Hoagland Solution
Macro nutrients SS		
1	1.00M $NH_4H_2PO_4$	1ml/L
2	1.00M KNO_3	6ml/L
3	1.00M $Ca(NO_3)_2$ $4H_2O$	4ml/L
4	1.00M $MgSO_4 \cdot 7H_2O$	2ml/L
Micro nutrient SS		
5	2.86g H_3BO_3 /1L 0.08 g $CuSO_4$.5 H_2O /1L 0.22g $ZnSO_4 \cdot 7H_2O$ /1L 1.81g $MnCl_2$ /1L 0.02g H_2MoO_4 /1L	1ml/L
Iron stock		
6	26.1g EDTA /1L	0.25ml/L

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First, the six different stock solutions were prepared using distilled water and stored in a refrigerator at 4 °C. These stock solutions formed the basis for preparing the Hoagland nutrient solution. Subsequently, 200 litres of Hoagland solution were prepared by diluting the appropriate volumes of each stock solution with purified tap water from a V2Pure 360 RO System (TMC, Hertfordshire, UK). To ensure complete homogenization of the solution components, it is important to maintain continuous water circulation using a pump.

3.3 Acclimatation time

To avoid death resulting, stolon and plants were placed in an opaque polypropylene box (internal volume:400 x 300 x 243mm) with 15 L of Hoagland's solution before starting the experiments for one week. Continuous aeration was utilized to enhance oxygen and water flow and reduce the boundary layer around the plants.

3.4 Daily monitoring

To avoid anomalous results, water quality parameters were measured daily throughout the experiment at the experiment, between10:00 and 12:00h.

3.5 Nutrient analyses

Water samples were filtered using a syringe and glass fiber (GF, 0.45 µm) filters before and after solution renewal. The Hoagland solution was partially renewed while the plants remained under acclimatisation conditions. Each week (Acclimatisation, Week 1, Week 2, and Week 4), half of the solution (7.5 L out of 15 L) was removed and replaced with an equal volume of fresh Hoagland solution. This procedure is necessary to restore the nutrients that were taken up by macrophytes. Distilled water was also added as needed to compensate for natural evaporation. Concentrations of dissolved nutrients were determined using a Skalar San++ Continuous Flow Analyzer (Skalar Analytical, Breda, Netherlands), following standard automated colorimetric methods:

- Ammonium (NH_4^+-N): Modified Berthelot reaction
- Orthophosphate (PO_4^{3-}-P): Total UV-digestible phosphate
- Nitrogen oxides (NO_x-N): Total UV-digestible nitrate + nitrite

Calibration curves were established for each nutrient as follows: 0–25 µmolL for ammonium; 0–10 µmolL for orthophosphate; and 0–50 µmolL for nitrogen oxides. To ensure concentrations fell within the calibration ranges, samples were diluted by factors of 167 for ammonium and orthophosphate and 501 for nitrogen oxides. Concentrations were expressed as limits of quantification (LOQ): 252 µmol N/L for ammonium, 117 µmol P/L for orthophosphate and 651 µmol N/L for nitrogen oxides. A certified reference material (Seawater QC3179) was analyzed to ensure analytical accuracy, with acceptable recovery ranges.

Dissolved inorganic nitrogen (DIN) was calculated as the sum of NH_4^+-N and NO_x-N. The calculation for each nutrient in the water was done using the formula:

Concentration of nutrient in water= (Nutrient initial in water – Nutrient final) * Volume (Hoagland Solution volume total).

3.6 Biomass measurements

Total Biomass

Fresh biomass was assessed at three time points during the experiment. Initially (day 1, acclimatization period), all plants and stolons were weighed. After one week (week 1), one stolon and one plant per experimental unit were removed, weighed for fresh biomass determination, and dried; these samples were not returned to the system.

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At the end of the experiment (week 3), all remaining plants and stolons were harvested and weighed to determine their fresh biomass."

Relative growth rate

The relative growth rate (RGR) is a widely used parameter for describing population dynamics and seasonal responses in ecosystems. It is particularly important because it normalizes plant growth according to initial biomass, enabling reliable comparisons; the initial biomass has a strong effect on plant growth performance. Growth measurements were conducted at different times: during the acclimatization week, the first week and the third week. After one week, one stolon and one plant for each mesocosm were removed from each experimental unit, dried and weight. The same procedure described for fresh biomass determination was applied here. The relative growth rate (RGR, day^{-1}) of *P. crassipes* can then be estimated is the following equation (Hoffmann et al., 2002) for total plant dry mass:

$$RGR = (\ln M_n - \ln M_n\text{-}1) * t^{-1}$$

M_n= total dry mass in the present week,
M_n-1=total dry mass in the previous week, and
t=time in days

A brief description of water parameters, nutrient analyses and biomass measurements is presented in the following scheme (Figure 2).

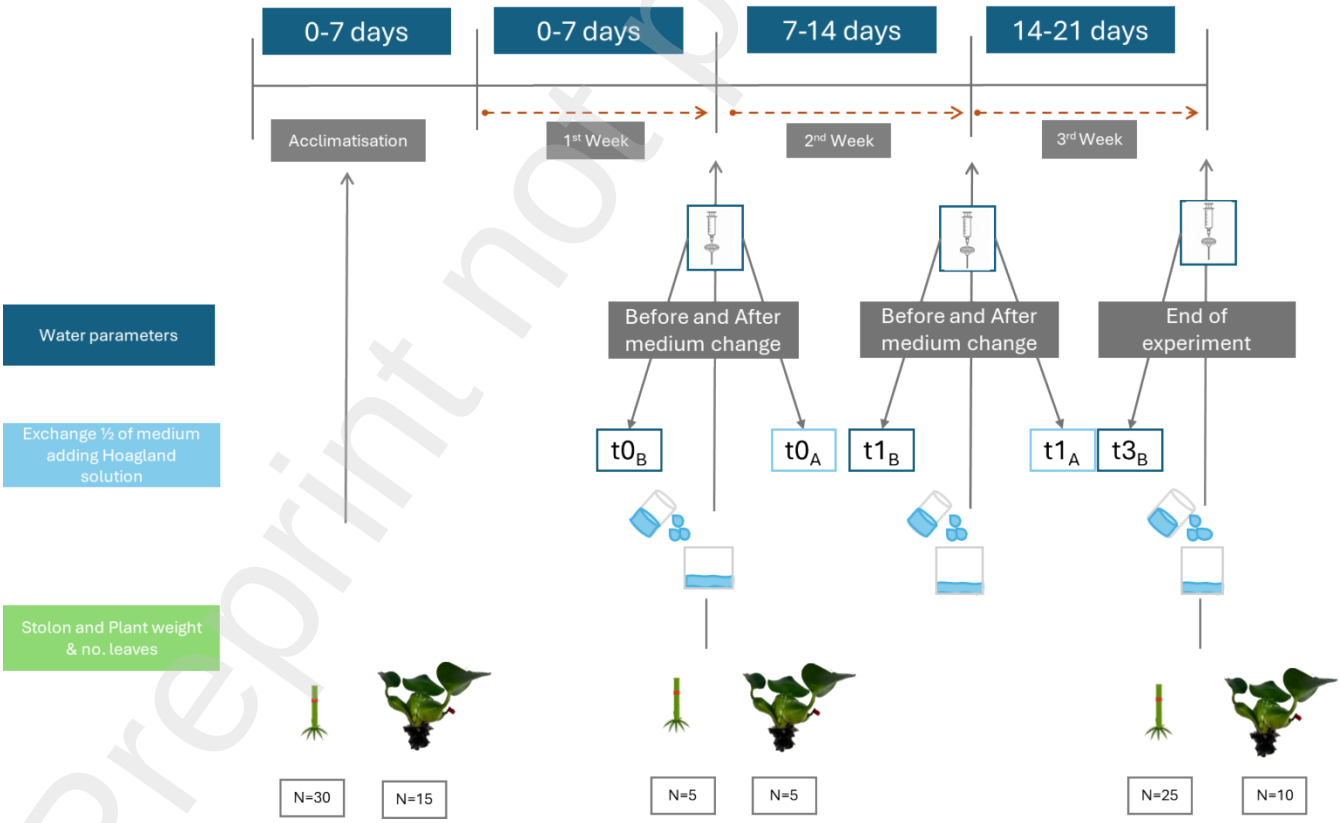

Figure 2: Schematic representation of the experimental protocol, summarizing water parameter monitoring, nutrient analyses, and biomass measurements.

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Protocol validation

The present study examined the growth of *Pontederia crassipes*, revealing contrasting physiological responses between stolons and whole plants. During the acclimatisation phase, 72.5% of the stolons (biomass total mean 13.17±3.91 g, and size=13.71±3.95 cm) produced new leaves. However, over a 14-day period, the sample exhibited visible signs of stress, such as discoloration and tissue degradation (see Figure 3). No significant changes in total biomass were observed over the experiment, suggesting that stolons did not regenerate new plants during the period studied. Furthermore, green coloration in the water of all experimental tanks indicated cyanobacterial proliferation, which may have negatively affected plant growth through cyanotoxins, since these compounds impact macrophytes (Zhang et al., 2022)

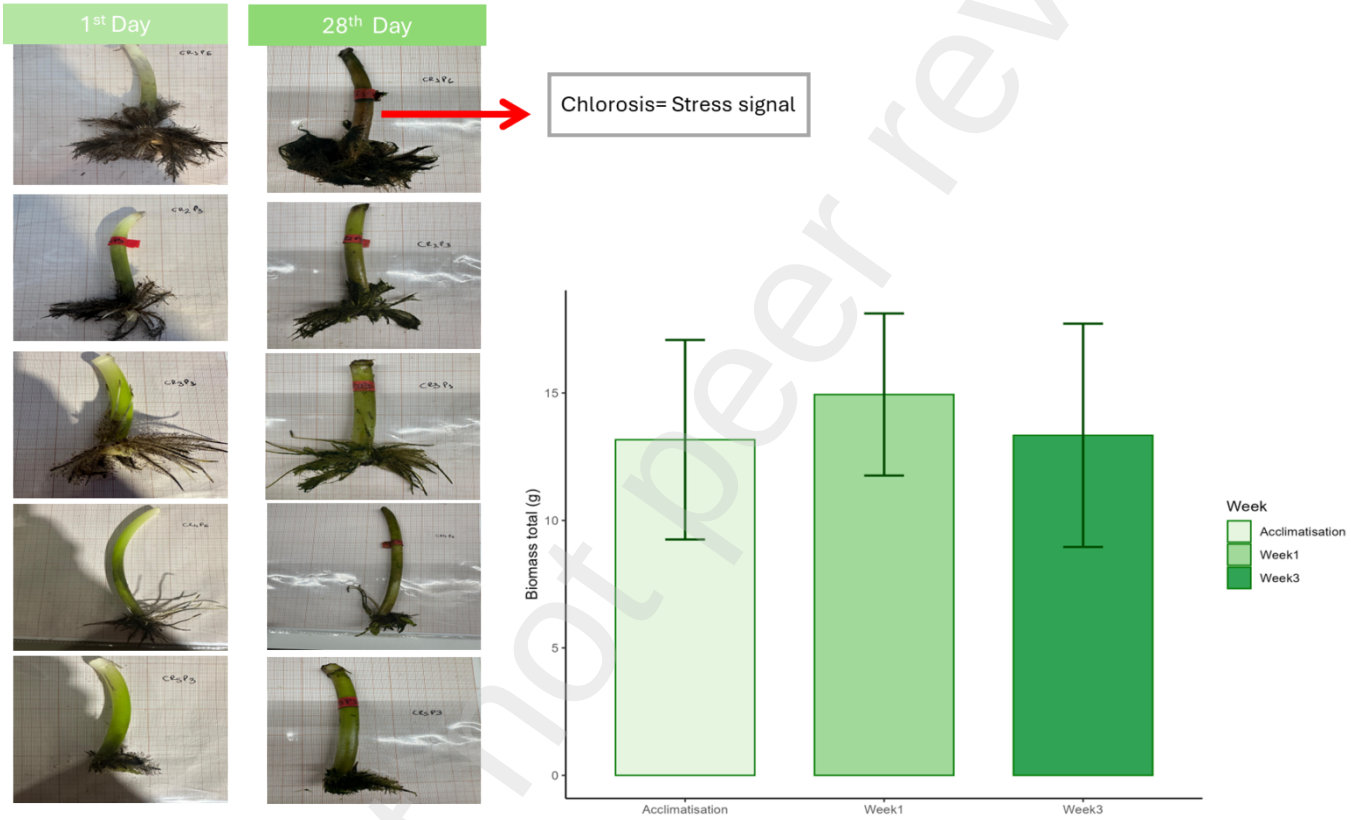

Figure 3: Presentation of *Pontederia crassipes* stolon on the first and last day of experiment and biomass total (g) weeks under mesocosm experiment.

Conversely, experiments conducted on entire plants demonstrate alterations in net biomass overtime. The initial phase of growth occurs during the first week, followed by a decline in the third week. Evidence of these values was manifest in the production of new leaves. The RGR has been found to remain relatively constant (Figure 4). The values obtained from this study did not demonstrate any significant differences.

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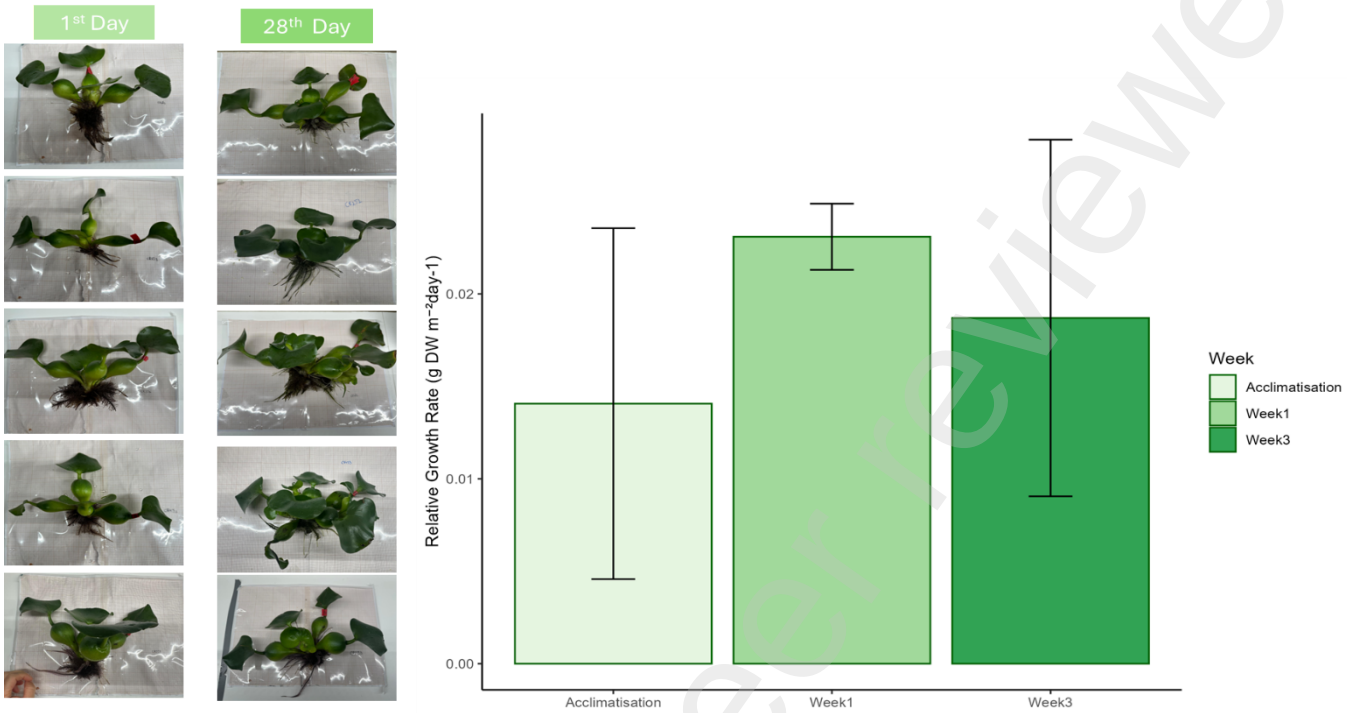

Figure 4: Presentation of *Pontederia crassipes* whole plant before and after exposure under mesocosm experiment and Relative Growth rate (g dw d^{-1}) during mesocosm.

Table 4. Biomass Total and relative growth rate (RGR) of *Pontederia crassipes* and stolon and whole plant in mesocosm experiments (mean ± SD), including *F* and *p* values

Plant part	**Week**	**n**	**Biomass total**			**RGR**		
			mean±sd (g)	*F*-value	*p*-value	mean±sd (g dw d^{-1})	*F*-value	*p*-value
Stolon								
	Acclimatisation	30	13.167 ± 3.914			0.006 ± 0.014		
	1st Week	5	14.940 ± 3.180	0.5235	0.5954	0.015 ± 0.023	6.487	0.002956
	3rh Week	25	12.921 ± 4.289			-0.003 ± 0.004		
Whole plant								
	Acclimatisation	15	33.415 ± 12.879			0.020 ± 0.036		
	1st Week	5	46.866 ± 21.569	12.436	0.0001	0.016 ± 0.089	0.13509	0.874225
	3rh Week	10	72.717 ± 25.606			0.027 ± 0.017		

Monitoring water parameters in mesocosm experiments is crucial because stolons (Figure 5) and plants (Figure 6) can significantly alter physical and chemical conditions, including oxygen levels, pH levels, conductivity and salinity. Changes to these parameters can directly influence ecological processes, the interpretation of treatment effects, and the reproducibility of the experiment.

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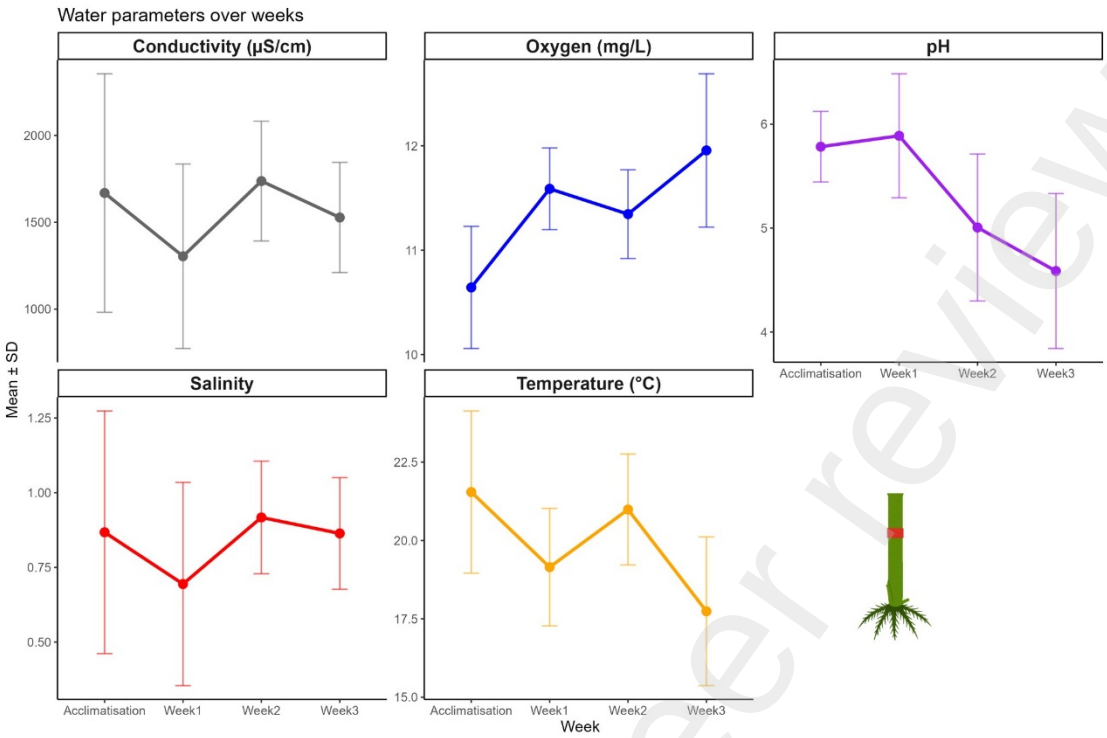

Figure 5: Parameters of water in stolon of *Pontederia crassipes* over weeks during mesocosm experiment.

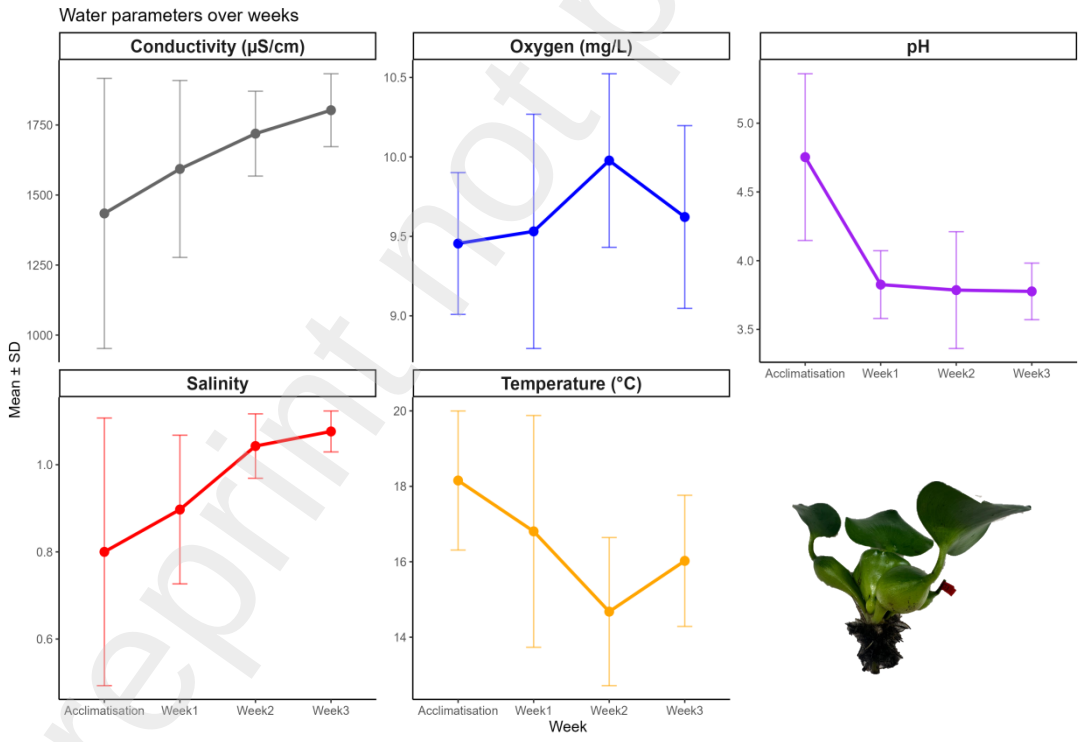

Figure 6: Parameters of water in whole plant of *Pontederia crassipes* over weeks during mesocosm experiment.

The concentration of nutrients in the water is a key factor in the growth and development of plant structures (Figure 7). Monitoring these parameters indicates the availability of resources and provides insight into how well the plants can take up and release nutrients. This directly influences mesocosm dynamics and overall water quality.

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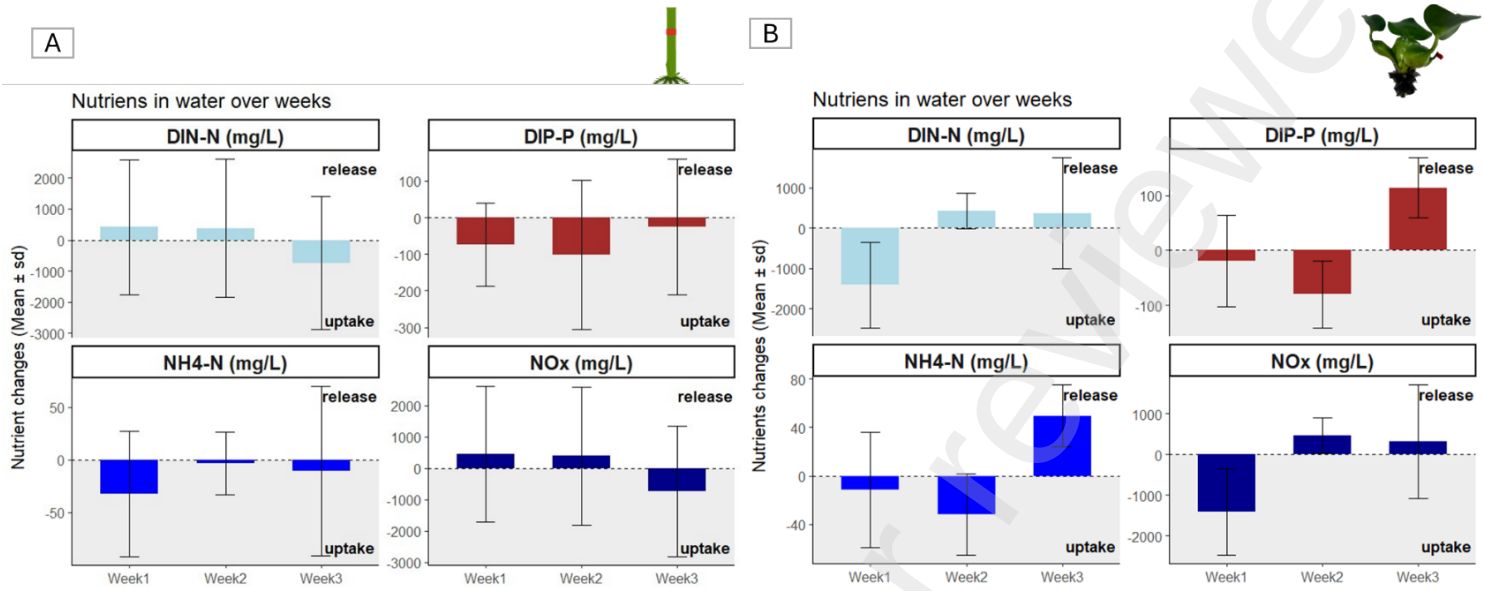

Figure 7: Results of nutrient changes calculated as the difference between consecutive sampling times (every 7 days from day 7 to day 28), were used as an indicator of plant uptake.in stolon (A) and (B) in whole plant of *Pontederia crassipes* .

This protocol does not intend to represent a unique standardized way for *P crassipes* growth experiments, but to showcase what are the main points that should be reported for the setting up a mesocosm to ensure comparability of results. Authors should clearly detail all the steps of the experimental set-up, namely the physical and chemical conditions, plus the aim of the study, *i.e.,* if study targets the whole aquatic plant or different plant organs (leaves, stem, root, stolon), including a detail description of the initial plant/organs characteristics and the metrics (e.g., biomass, length, number of new leaves). Safety procedures and waste handling practices must also be in place and duly reported to prevent the accidental release of plant material into the environment.

Limitations

The limitations of this experiment consist of the stolon starting to decompose after 10 days. This may have occurred due to the cutting off of the stolon node, which could have impacted this vegetative growth and impeded its development. It is important to note that the root is responsible for absorbing nutrients, but it was not large enough for this structure.

CRediT author statement

Letícia da Silva Brito was responsible for the methodology of preparing the material, collecting the plants, analyzing the plant measurements, and writing and correcting the first draft. **Ana Isabel Lillebø** and **Heliana Teixeira** were guided through the conceptualization and methodology research processes, as well as the validation and editing stages. **Sidinei Magela Thomaz** was responsible for validation and editing.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Supplementary material *and/or* additional information [OPTIONAL]

A summary of the experiment with the stolons, which were repeated three times, is provided below. Adjustments such as the acclimatization period and aeration were made in the last experiment. A summary of the standardization of each experiment is included in the table below.

Table 5: Comparative data from stolon and whole plants in mesocosms experiments under salinities levels.

Repetition	Plant Part	Water volume (L)	Box Size (mm)	Days	Replicates	Acclimatisation time (days)	Initial Weight (g)	Final Weight(g)
1	Stolon	10	270×170×170	20	12	22	10	*
2	Stolon	10	270×170×170	22	6	7	13.64	14.61
3	Stolon	20	400 x 300 x 243	32	6	7	13.64	13.96
4	Whole plant	20	400 x 300 x 243	32	3	7	36.64	73.74

*All stolon died

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Title:Ex-situ growth protocol for the invasive macrophyte *Pontederia crassipes*
Authors: Brito, Letícia; Thomaz, Sidinei M; Teixeira, Heliana; Lillebø Ana

Table 1. Comparative summary of mesocosm experiments with *Pontederia crassipes* from the liter

Growth indicator	Mesocosm experiment	Duration	Hydrological conditions		
		(days)	**Volume** (L)	**Temperature** (ºC)	**Retention time** (weeks)
Whole plant (Petiolo+lamina+steam+root)					
Net productivity (dry weight)	1	84	300	26ºC-28ºC	1
	2	100	1000	NA	1
	3	80	1000	NA	1
	4	83	1000	15ºC-33ºC	1
	5	96	1000	5ºC-35ºC	1
	6	22 *in two seaons	500-1000	17.8ºC-24.8ºC	48 h and 60 h
	7	56	200	15ºC -25ºC	1
	8	105	300	NA	6
	9	42	100	23.5ºC-28.8ºC	1
	10	150	104	NA	1

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	Nutrient source	Nutritional conditions		
Water circulation		**Nitrogen** (mg L^{-1})	**Phosphorus** (mg L^{-1})	**micronutrients** (mg L^{-1})
daily by submersible pump	constructed wetlands	20	5	NA
no information	concret valvus with nutrient medium	10,5	3,1	K: 8.4 Ca: 26.4 Mg: 5.6 Fe: 0.3 Mn: 0.0
12h by submersible pump	artificial water prepared with nutrients	21	3,1	Fe: 4 Cu: 0.2 Mn: 1.5 B: 0.04 Mo: 0.02 S:
daily by submersible pump	well water	0,05	3	K: 25 Fe: 4 Cu: 0.2 Mn: 1.5 B: 0.04 Mo: 0.02 S: 3
daily by submersible pump	well water	20	0,06	K: 25
NA	wastewater from residencials home that has passed through a primary sedimentation	20	7.5	K: 16.5
NA	well water	5	0,05	K: 23 Ca: 20 Mg: 5.0 Fe: 0.60 B: 0.51 Mn: 0.52 Zn: 0.05 Cu: 0.02 Mo: 0.01
NA	constructed wetlands	28	7,7	NA
NA	lake water	0,6	0,05	NA
	pond water	0,58	8,86	NA

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Growth rate			Reference
T0 (g DW m^{-2})	**Tf** (g DW m^{-2})	**Rate** (g DW m^{-2} day^{-1})	
445	2303	0,0193	Reddy & Tucker 1982
680	3300	14,25	Reddy 1984
500	2000	0,0173	Reddy & Debusk, 1984
225	2000	0,0263	Reddy et al., 1989
225	830	0.0147	Reddy et al., 1990
48	225	0,0112	Ho & Wong , 1994
30	120	0,0248	Xie et al., 2004
plant with 20 cm	NA	NA	Jayaweera et al., 2008
15	235	0,042	You et al., 2014
260	405,83	0,0112	Kumwimba et al., 2017

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