Warm temperatures increase biomass production of seedling: Implication for management of *Ludwigia hexapetala* and *Ludwigia peploides* subsp. *montevidensis*

Morgane B. Gillard¹,², Brenda J. Grewell¹, Caryn J. Futrell¹, Carole Deleu³, Gabrielle Thiébaut²

¹ USDA-ARS Invasive Species and Pollinator Health Research Unit, Department of Plant Sciences, University of California, Davis
² UMR ECOBIO, University of Rennes 1, France
³ UMR IGEPP, University of Rennes 1, France
Climate change, an indirect influence of humans on ecosystems

Introduction

Climate change, an indirect influence of humans on ecosystems

Increase of greenhouse gas emission

+1 to +4°C by 2100

Precipitations

Extreme events

RCP 2.6

RCP 8.5

Global surface temperature change (°C)

(IPCC, 2013)

Increase of greenhouse gas emission

RCP 2.6

RCP 8.5
Biological invasions, a direct influence of humans on ecosystems

Increase of intercontinental exchanges  ➔ displacement of some species (voluntary or involuntary)

Species introduced outside of its native range = exotic species

Some introduced species can become invasive
The case of freshwater ecosystems

- Climate change
  - Hydrological regimes
  - Drying up and flooding
  - Temperature

- Biological invasions
  - Multiple sources of introduction of exotic aquatic species (Strayer, 2010)
  - Hydrosystems connectivity: dispersion facilitated

15 freshwater species in the list of the 100 « worst » invasive species (Lowe et al., 2004)

First links in food webs: primary producers
The importance of understanding the reproduction of invasive species

- The establishment of an exotic plant species is determined by the effectiveness of recruitment and reproduction of new ramets or genets, critical to successful colonization and invasive spread

→ Knowledge about reproduction are crucial information for developing risk assessment and management strategies
Two congeneric species invasive in Europe and in North America

- **Ludwigia hexapetala**
  - (Uruguayan primrose-willow)
  - Decaploid
  - \(2 = 80\)

- **Ludwigia peploides**
  - subsp. *montevidensis*
  - (Creeping water primrose/ Floating primrose willow)
  - Diploid
  - \(2 = 16\)
Two types of reproduction for the invasive Ludwigia

- Invasive *Ludwigia* taxa spread mainly clonally (limited genotypic variation) except in disturbed areas (Okada et al., 2009)

- Combining clonal and sexual reproduction represents an advantage to face changing conditions

- Few information about the sexual reproduction of these taxa

What is the impact of warmer temperatures on the germination, early seedling survival and growth of *L. hexapetala* and *L. peploides*?

Hypothesis: Warmer temperature favor the performances of the two taxa
Introduction

Materials & Methods

Collection sites in California

- Russian River @ Asti
- Laguna de Santa Rosa
- Sage Creek – Napa River Watershed
- Spring lake

Legend:
- Russian River
- Tributaries & Lakes
- Russian River Watershed

Map showing collection sites in California with specific locations marked:
- L. hexapetala
- L. peploides
Introduction

Materials & Methods

Collection sites in France

@ the Loire River

- Ile du château
- Ile Joli Cœur
- Les Raguins

L. hexapetala ▲
L. peploides ●

Port de Vallières

Map of France showing collection sites:
- Ile du château
- Ile Joli Cœur
- Les Raguins

Near the Loire River:
- St.-Gengoult
- Tour

Map scale: 0 100 240 km

3 km
Reciprocal transplant experiment

**L. hexapetala ▲**
**L. peploides ●**

- 2304 seeds
- 12 capsules per population
- Sowing: May-June 2016
- Davis (CA, USA) +5.6°C
- Rennes (France)

Experimental gardens

- CA (CA, USA)
- FR (France)
- California
- France

(Ruaux, 2008)
Introduction

Materials & Methods

Trait response measurements

Monitoring 3 times a week for 47 days

1, 2, 3, ...

After 47 days:

- Ungerminated seeds: Test of embryo viability
- Seedlings:

  Shoots and roots

  length
  dry biomass
Germination characteristics

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<tr>
<th>L. hexapetala</th>
<th>L. peploides</th>
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<td><img src="image1.png" alt="Germination Graph" /></td>
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Climate effect + Provenance effect

Temperature increase

Germination velocity ↑

Germination percentage ↑ or =

Gillard et al. (2017) Frontiers in Plant Science
Embryo viability and seedling survival

- Embryo viability of ungerminated seeds
  - L. hexapetala: No effects
  - L. peploides: Climate effect positive or negative, depending on seeds provenance

- Seedlings survival
  - L. hexapetala: negative climate effect
  - L. peploides: negative climate effect

Gillard et al. (2017) Frontiers in Plant Science
Seedling characteristics

No climate effect on the length of shoots and roots

Roots more ramified and/or thicker

Gillard et al. (2017) Frontiers in Plant Science
In the end, does warmer climate favour invasive *Ludwigia* taxa?

Warmer temperatures:
- Germination velocity $\uparrow$
- Germination % $\uparrow$ or $\approx$
- Seedling biomass $\uparrow$
- Seedling survival $\downarrow$

In average, total biomass produced = **6.7-fold greater** under warmer climate

$\rightarrow$ Warmer climate = favorable

Gillard et al. (2017) *Frontiers in Plant Science*
Implications for management

Under Oceanic-type climate

- In the future:
  Establishment from sexual propagules, with higher biomass production as temperature increase

Under Mediterranean-type climate

- Currently:
  Invasive *Ludwigia* taxa grow easily and fast from the seeds they produce

- In the future:
  Increase of habitat disturbance
  → Recruitment from seed bank facilitated?

Climate warming may increase the invasiveness of *L. hexapetala* and of *L. peploides*

Seed production and the existence of seed banks need to be taken into account in management plans
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